GEOLOGY OF ALLAMAKEE COUNTY.

BY

SAMUEL CALVIN.

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INTRODUCTION.

SITUATION AND AREA.

Allamakee county has the distinction of occupying the extreme northeastern corner of Iowa. Its eastern boundary follows the sinuous channel of the Mississippi river. On the north the county joins Minnesota, and the bounding line coincides with the parallel of 43 degrees and 30 minutes, north latitude, as located by the United States engineers and marked by monuments in 1849. The adjoining counties in Iowa are Winneshiek on the west, and Clayton on the south.

Allamakee county includes fifteen complete congressional townships, and fractions of several others that are incomplete on account of the meandering of the Mississippi river along the eastern border. Although there are five tiers of townships, numbered from 96 N. to 100 N. inclusive, the length of the county from north to south is but little more than twenty-nine miles. In making the government surveys the north line of the tier of townships numbered 100 N., was made to coincide with the northern boundary of the state, the parallel of 43 degrees and 30 minutes. It so comes about, therefore, that sections 1 to 6 in each of these townships measures only a small fraction of a mile from north to south, the actual dimensions in this direction being only about eleven rods in place of the standard three hundred and twenty. The total area included within the boundaries of the county is approximately six hundred and fifty square miles and is divided into eighteen civil townships.

PREVIOUS GEOLOGICAL WORK.

The earliest geological investigations that embraced any portion of Allamakee county were conducted under the direction of Dr. David Dale Owen. In the autumn of the year 1839, Dr. Owen, with a large party of assistants, explored the mineral lands of Iowa, Wisconsin and Illinois, but the work of the party did not on this occasion include any territory north of the mouth of the Wisconsin river. No portion of Allamakee, therefore, fell under the observation of the geologist until about ten years later, when the work of Owen and his assistants was extended northward to the national boundary, and covered portions of Minnesota, Wisconsin, Iowa, Illinois, Missouri and Nebraska. In his report to the Commissioner of the General Land Office, published in 1852, Dr. Owen mentions the finding of lead at some points between the mouth of the Yellow river and the upper Iowa, while the picturesque features of the valley of the latter stream are charmingly set forth in connection with the discussion of the Lower Magnesian Limestone*.

To Dr. B. F. Shumard, one of the heads of sub-corps on Owen's Survey in 1848 and 1849, was assigned the task of examining the geological structure of the region north of the mouth of the Wisconsin, and in his report there are many references to points lying within the limits of Allamakee county. Sections showing the thickness of the formations exposed at Lansing, Painted Rock, the mouth of Village creek, and the mouth of Yellow River, according well with the results of more recent and more accurate measurements, are given on the plate marked Section No. 3, S†.

The next investigator to enter this territory was Professor James Hall, who as State Geologist of Iowa, made a reconnoissance along the Mississippi river from the northern boundary of the state to Keokuk, in the autumn of 1855. In the portion of his report devoted to the general geology of Iowa, Professor Hall makes a few incidental references to points in Allamakee county‡. These references occur in connection with the discussion of the formations from the Potsdam (Saint Croix) to the Trenton inclusive.

In the same volume Professor Whitney has a report on Allamakee county occupying about three pages, while in the portion of the volume devoted to economic geology there are references to mining operations on Mineral Creek§.

In the report of Dr. C. A. White, on the geology of Iowa, there are some scattered references to Allamakee county in the

* Report of a Geol. Surv. of Wis.; Iowa and Minn, by David Dale Owen, pp. 63. 65 and 66.

†Ibid. See also pp. 502-504 of same volume.

‡Report on the Geol Sur. of Iowa, Prof James Hall, State Geologist, and J. D. Whitney, chemist and mineralogist, Vol. I. Part 1, 1858, p. 47; et seq.

§Ibid., pp. 317-320, and p. 460.

chapter on general geology, the most direct relating to mining operations near New Galena*.

Allamakee county is included in the driftless area of the Upper Mississippi valley, described by Chamberlin and Salisbury†, and it also falls within the region so fully discussed by McGee in his memoir on the Pleistocene history of northeastern Iowa‡. In this memoir there are frequent references to geological phenomena exhibited within the limits of the county under consideration. No detailed account, however, such as would meet the requirements of a reasonably complete geological survey, has heretofore been attempted.

PHYSIOGRAPHY.

TOPOGRAPHY.

The topography of Allamakee county presents some striking differences from the general surface configuration that prevails over the greater part of Iowa and adjacent states. These differences arise from the fact that this county lies within the driftless area of the upper Mississippi valley, while nearly all the rest of the state belongs to the region that has been deeply covered with glacial drift. Within the driftless area the topographic forms are the result of solution and mechanical erosion, acting on beds of limestone, shale and sandstone, during all the ages that have elapsed since the region was elevated above sea level. It is true that the peculiarities of topography that now characterize the driftless portion of Iowa once characterized, to a greater or less extent, the entire surface of the state. But in comparatively recent times, geologically speaking, the deeply scarred and furrowed surface that resulted from long exposure to the agents of erosion, was profoundly modified, except in the driftless area; and its ancient topography was completely obscured by a mantle of glacial detritus. The drift is simply morainic material, worn from rock ledges and spread out by the

*Rept. on the Geol. Sur. of the State of Iowa, etc., by Charles A. White, M. D., Vol. I, p. 173, 1870.

†Sixth Ann. Rep. of the U. S. Geol. Sur., Washington. 1885.

‡The Pleistocene History of Northeastern Iowa, by W. J. McGee, Eleventh Ann. Rept. U. S. Geol. Sur, pp. 204-205, 368 and 548.

mechanical effects of the flowing ice sheet that overran a large portion of northern North America just before the beginning of the present era. In the portions of the state affected by glacial action the ice streams planed down the pre-existing ridges and choked up the old valleys with rubbish resulting from preglacial rock-decay, or from the immediate waste and wear of the rocky ledges over which the glaciers flowed. In the drift regions, therefore, the ancient irregularities of the surface were levelled up in times comparatively recent. Since the retreat of the ice the agents of erosion have been more or less effectively at work, scarring and carving the surface of the drift-covered portions of Iowa, but the time has been too short to produce marked irregularities, much less to restore the bold forms of relief that characterized the preglacial topography.

In Allamakee county there is no mantle of drift. There are no indications of invasion by glaciers. The topographic characteristics imposed by long-continued action of solution and mechanical erosion have never been obscured or modified in any essential or fundamental degree. The surface, therefore, is gashed and furrowed in every direction by an intricate system of ramifying erosion channels. Some small areas in the southwestern part of the county are comparatively level. Ludlow and Union Prairie townships present more of the usual features of Iowa topography than any other portions of the county. Elsewhere throughout the county topographic forms are bold. Rounded, steep-sided ridges, with gorges and ravines sharply angled at the bottom, prevail, except in or near the valleys of the main drainage streams.

Looked at in the larger way we may regard the surface of the county, as carved into a few undulations of comparatively great size determined by the position of the principal drainage channels and the intervening divides. At the parting of the surface waters between the Oneota river and Village creek, there extends a long sinuous crest, broken by a few unimportant depressions, and determining the location of the wagon road for the greater part of the distance between Waukon and Lansing. This is the highest crest of the county, and the point called Iron hill, a few miles northeast of Waukon, easily overtops every elevation included within the sweep of the horizon. Different parts of this divide receive different local names. Its eastern part is the Lansing ridge, while the middle portion is known as Lycurgus ridge.

The watershed between Village creek and Paint creek extends east from Waukon, and is followed by the roadway leading through Elon and Dalby. The divide between Paint creek and Yellow river forms a rather sharp crest that is known in part as the Mount Cherry ridge. Postville is situated on the high land south of the Yellow river, while a crest that lies partly in Iowa and partly in Minnesota marks the summit of the divide north of the Oneota. The crest between the Oneota river and Village creek is not only higher than any other in the county, but, beyond that fact, it contains the highest land, at corresponding distances from the Mississippi river, between Saint Paul and the Gulf of Mexico.

Standing on the summit of this divide one looks away across a series of ridges, apparently rising to the same horizontal plane until earth and sky blend in the undefined haze of the far off horizon. The summits of these higher ridges coincide with an old peneplain or plain of base-levelling. Near the close of the Cretaceous period the agents of erosion had removed all material that stood above the level at which the streams were capable of transporting rock detritus and the country was reduced to an unbroken expanse of low, level, marshy lands traversed by sinuous channels in which the sluggish water flowed with scarcely perceptible current.

After the completion of the Allamakee peneplain, the region was elevated, at least 700 feet, above its former position, and the streams quickly cut their channels down to the new base level, leaving the intervening divides to be brought down more slowly by the smaller and less energetic lateral currents. The flat bottom of the Oneota valley, and the corresponding plane to which the other streams have cut, mark the position of a new peneplain to which the divides will all be brought down, provided the present drainage relations are long continued. Everywhere the sides of these ridges are already deeply scarred and furrowed by the initial branchlets of the secondary water courses belonging to the modern system of drainage.

The sculpturing referred to is repeated, not only on all the main divides, but, on a smaller scale it appears on all the secondary ridges between the different affluents of the principal streams, and even on all the ridges of less than secondary rank, until there is scarcely a quarter section of unbroken land in the typically driftless portion of the county outside the base-leveled flood plains of the larger rivers. The crests of the higher divides rise in some instances more than six hundred feet above the bottom of the valleys, and so the surface of the water at the mouth of the Oneota, or of Yellow river, has an altitude that is actually less than midway between the tops of the ridges and the level of the Gulf at the mouth of the Mississippi. Since the streams ran on the plane of the present watersheds, they have cut their valleys more than half way down to sea level.

To the traveler who has previously been acquainted with the topographic forms of Iowa only as they are developed in the drift-covered portions of the state, the extremes of relief and the intricacies and peculiarities of the topography of the driftless area come in the nature of a surprise. The deep valleys, the high bluffs, the water-carved ridges, every topographic form, indeed, are each and all wholly unique, for the other parts of the state furnish nothing with which they can in any way be compared. The gorges, canyons with high, frowning walls, dome-like hills, and other peculiarities which the region presents, have led with much reason to speaking of Allamakee county as "The Switzerland of Iowa."

DRAINAGE.

Oneota River.—The Oneota, or as it is commonly called, the Upper Iowa, is the principal river of Allamakee county. It enters the county from the west not far from the southwest corner of Hanover township, and thence pursues a sinuous course northeastwardly to near New Albin, where it joins the intricate network of channels and wider expanses, composing the labyrinth of lakes and bayous that occupy the broad flood plain of the Mississippi, between Lansing and the northern boundary of the state.

The valley of the Oneota river is broad, flat-bottomed, and occupied by farms of exceptional fertility. The width of the valley averages about a mile, the range being from less than half a mile to nearly three miles. The valley is everywhere bounded by steep bluffs that are crowned throughout the whole course of the stream in Allamakee county by bold mural escarpments of heavy bedded limestone. The height of the bluffs ranges from 250 to 400 feet, the greatest height being found in the vicinity of New Albin. The average height exceeds 300 feet, and yet from the summit of the bluffs bordering the valley, the land still rises in swells and ridges, separated by water-cut gorges and ravines, up to the crests of the divides which have an elevation above the river of more than 500 feet. Nowhere in Iowa, outside the driftless region, are such striking irregularities in the surface configuration, such surprising examples of water-carved relief.

The bottom of the Oneota valley, as already intimated, is flat, and the river meanders from side to side through a rich deposit of alluvium that receives continual accretions through periodic overflow. In the eastern half of its course in Allamakee county the stream has long since cut its channel to base level, and there is no longer any tendency to lower the valley by erosion.

Formerly, indeed, the base level was much below what it is at present. The land stood relatively higher with reference to the waters of the Mississippi. Both the Oneota and the Mississippi scoured out their channels to a greater depth than obtains now; but owing to the choking up of the gorge of the larger stream, probably by silt brought down by the Wisconsin river, the waters along the eastern border of Allamakee occupy a higher relative position than before, and in place of cutting their channels deeper, have recently been filling them with sediments. The Oneota has thus since the close of the glacial period filled its valley near the mouth to a depth of forty or fifty feet.

Since the stream reached base level the principal changes in the valley have been produced through the effects of erosion, solution, and general weathering of the steep cliffs or walls that limit it on either side. The cliffs have been lowered as a result of the wastage perpetually taking place upon their summits; they have been gradually separated farther and farther, and the valley has widened, as a result of weathering and consequent wastage on their exposed faces. Furthermore, they have been intersected by numerous lateral gorges and ravines, and so in places have been carved into a series of jutting rounded prominences that seem to encroach upon the valley. Not infrequently the projecting headlands have been cut transversely by the agents of erosion, so as to produce a series of isolated buttes. These are usually round-topped hills more than three hundred

Figure 1. The "Elephant"—a hill of circumdenudation with Oneota river at its southern base.

feet in height, broad at the base and sloping gradually to a summit capped almost invariably with ledges of heavy bedded Oneota limestone which, on one or another side of the butte, presents vertical frowning walls twenty, thirty, or even fifty feet in height. The buttes usually have a base elliptical in outline, but so far as observed there is no constant relation between the axes of the ellipses and the direction of the valley. The plain on which the buttes stand coincides with the bottom of the valley; the buttes are masses of the original sediments of the region that have escaped the effects of destructive agencies, standing on a base level of erosion. They all illustrate what Chamberlin has so well called topographic old age. Examples of such isolated buttes as are here described are found in the Elephant Bluff, near the center of Section 32, Tp. 100 N., R. V W.; Mount Hope, in section 34 of the same township; Owl's Head Bluff, in sections 1 and 2 of Tp. 99 N., R. V. W., and a number of others on the south side of the valley, between Owl's Head and the mouth of the Oneota. (Figures 1 and 2.)

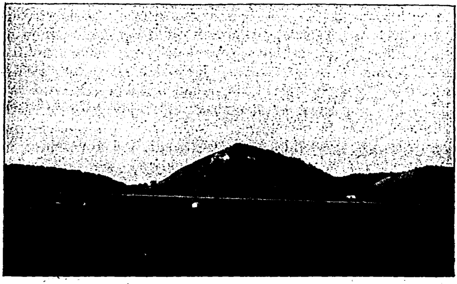


Figure 2. Mount Hope—a hill of circumdenudation standing on the base-levelled flood plain of the Oneota river. Height above the river, 320 feet.

The topographic features bordering the valley of the Oneota proper are repeated on a smaller scale, and with some modifications, along the tributary valleys that enter from the north and south. The main tributary is Bear creek which, just before joining the Oneota, receives the waters of Waterloo creek. These two streams bring their tribute from the northwest. Both have cut their channels deep into the alternating strata of limestones and sandstones, and have formed valleys that, in their lower courses, are miniatures of the valley of the Oneota. The valleys become less and less deep as they are followed toward the sources of their respective streams, but even at the boundaries of the county the eroded gorges, in which these streams flow, are hemmed in by walls more than a hundred feet in height. Lateral gorges again cut these walls into a succession of swelling prominences; and if the lateral gorges are traced to their origin, they will be found to begin in a multitude of divaricating channels—dry most of the year, and from a foot or two to a yard in depth—away up three, four, or five hundred feet above the valley of the Oneota, near the summits of the divides.

Other streams from the north and south come to swell the waters of the Oneota; but their dichotomously branched valleys—beginning in small erosion furrows near the summits of the dividing ridges, the whole system being spread out fan-like upon the surface with the final twigs indefinitely multiplied—are all simply repetitions of the valleys already described. The Oneota and its larger branches have cut their channels down almost or quite to base level; but the smaller lateral gorges ascend toward the divides at a steep grade, and down these, in times of heavy rains or melting snows, the waters rush with tremendous energy. Immense numbers of rock fragments are in consequence detached from the bottom and sides of the channel, and, carried along by the force of the stream, are finally spread out in a fan-shaped talus wherever the current emerges upon a plain of gentler slope. Excepting some small areas in the southwest, all the public roads of the county are, by force of the irregular topography, obliged to follow either the ridges or drainage channels without respect to section lines or points of the compass. In the valleys the small areas of tillable land are too precious to be used for highway purposes, and so the roadways are crowded to the extreme edge of the arable space, where abrupt slope or frowning wall meets the level plain. A journey over such a road is attended by the unpleasant experience, recurring every few rods, of ascending and descending the slopes of uncompacted fan-shaped piles of rock fragments carried out by recent torrents from the small lateral ravines that cut into the sides of the valley.

The Oneota river throughout the whole course in Allamakee county runs over a bed of Saint Croix sandstone. In the bluffs and sides of the valley, near the mouth of the stream, the Saint

Croix has an exposed thickness of three hundred and twenty feet.

The river enters Allamakee from Winneshiek county between bluffs in which the Saint Croix sandstone rises to a height of sixty or seventy feet. From the mouth to the west line of the county the heavy bedded Oneota dolomite imparts some of the most picturesque features of the bounding walls of the Oneota valley. Along the middle and lower course of the stream the bluffs are crowned with jutting crags and buttresses, and frowning precipices of light colored Oneota limestone underlain by from one hundred to three hundred feet of crumbling Saint Croix sandstone; but in the western part of Hanover township the vertical escarpments of the dolomite begin not far above the level of the stream.

If one starts from the mouth of Bear creek and goes northwest to the summit of the Waterloo ridge, near the northeast corner of section 18, Tp. 100 N., R. VI W., he will pass in succession over one hundred feet of Saint Croix sandstone, two hundred and fifty feet of Oneota limestone, eighty feet of Saint Peter sandstone, and one hundred feet of Trenton limestone. In this thickness of 530 feet of strata there are many lines of springs. The plane of contact between the Oneota limestone and the Saint Croix sandstone is an important water-bearing horizon, and is marked by many large springs in the neighborhood of Quandahl, Dorchester, and at a multitude of other points in the intricate system of valleys and ravines into which the surface of the northern half of Allamakee county has been carved.

Springs occur occasionally at the junction of the Oneota and Saint Peter, and again, between the Saint Peter and the Trenton; but one of the most important water-bearing horizons is found at the upper surface of a bed of shales from fifty to seventy feet above the base of the Trenton limestone. While the quality of water is unsurpassed, the supply is copious, and during even moderately dry weather all the rivulets and creeks, and even the larger streams, are fed exclusively by springs. The spring creeks have not eroded the channels in which they run. Other agencies have excavated the gorges and valleys, and the spring began to flow only when the ordinary processes of erosion had cut the valleys down to the successive water-bearing horizons.

Village Creek begins in a series of springs north of Waukon. The shale bed near the base of the Trenton determines the level at which the waters emerge. The stream flows first over a bed of Trenton limestone, but immedately north of Waukon it cuts down to the level of the Saint Peter sandstone. Two and a half miles farther east it enters a fairly well developed valley bounded by cliffs of Oneota limestone, and thence to its mouth, a short distance below Lansing, it follows a steep-walled valley overlooked by frowning cliffs and battlements of Oneota. Soon after entering Center township the whole thickness of the Oneota is cut through, and from this point to its confluence with the Mississippi the stream flows in a channel sawed into strata of the Saint Croix sandstone. Beginning near Waukon in a number of rivulets supplied by small springs, with a channel at first that a modest foot-bridge might easily span, Village creek gathers volume from the tribute of numerous spring-fed affluents, until, swollen to the dimensions of a fair-sized creek, it finally escapes from its gorge between bluffs four hundred feet in height. Sandstone of the Saint Croix stage makes up the bluff three-fourths of the way from base to summit, and the Oneota limestone forms a cap one hundred feet in thickness. The lateral gorges and ravines opening into the valley of Village creek are, as usual in all the driftless region, dichotomously branched, and have their ultimate origin in a palmate system of shallow furrows away up near the summits of the dividing ridges. The Oneota river and Village creek are nearly parallel, and both trend northeast.

Paint Creek has its origin not far from the headwaters of Village creek. It begins as two main branches, one originating in a series of springs in and near the city of Waukon, the other rising about a mile to the southwest. The springs issue from the Trenton, and both branches flow for some distance over exposed beds of this limestone. The gradient of the valley is steep, so that at the union of the two branches, about two and a half miles southeast of Waukon, the channel has cut well down into the Saint Peter sandstone. For six or eight miles, following the course of the creek, the Saint Peter sandstone gives character to the walls of the valley. The slopes are gentle, the bluffs are low and rounded, and pastures extend in long, easy curves down to the very margin of the stream. The slopes that were originally wooded are now, for the most part, cleared, and are not too steep to be cultivated. Between two and three miles above Waterville the steep descent carries the bottom of the valley below the upper level of the Oneota limestone, and the bluffs assume a more precipitous character on account of the crags and castles and jutting ledges resulting from erosion of the heavy bedded dolomite. At Waterville the cliffs, composed entirely of Oneota limestone, rise almost vertically to a height of one hundred and fifty feet above the stream. Three miles below Waterville, not far from the southeast corner of Paint Creek township, the bottom of the valley is excavated in strata of the Saint Croix sandstone, but the towering ledges of the Oneota, ever rising higher and higher relatively to the surface of the water, accompany the stream until it emerges upon the low flood plain of the Mississippi at Waukon Junction. At the Junction the bluffs are nearly three hundred and fifty feet in height, one hundred and fifty feet being made up of Saint Croix sandstone, and the beds of passage by which transition is made to the nearly two hundred feet of Oneota with which these majestic cliffs are crowned. Paint creek and Village creek begin near together, but they at once diverge, one flowing toward the northeast, the other toward the southeast, with an ever-widening space between them. Like other streams of Allamakee county, the main supply of water in Paint creek during periods of normal flow, comes from a multitude of springs. Delicious water, clear, cool, refreshing, wells out from the hillsides in generous volume at all the water-bearing horizons, and each spring-fed rivulet rushes off, sometimes with clamorous haste, to add its tribute to the axial stream.

Yellow River stands next in importance to the Oneota among the streams of Allamakee county. It has its sources in a number of diverging branches that rise in the southeastern part of Winneshiek county and in Ludlow and Post townships of

Allamakee. In midsummer, or during times of drouth, the main channel above Myron, in Post township, is a dry, rock-strewn river bed. All the water supplied by the tributary rivulets disappears in crevices of the much-fissured Trenton formation in which the channel is cut. Among the people living in this region it is believed that the water, losing itself in the fissures of the bedded limestone, reappears in what is known as the "Rise of the Yellow river," a very large spring which occurs on the land of Mr. Livingood near Myron (Tp. 96 N., R. VI W., sec. 3, Sw. qr., Nw. ¼). While the source of the water supply in the spring may be altogether different from what is locally believed there is here discharged a volume of water sufficient to form a creek ten or twelve inches in depth and three or four yards in width. A short distance from its source the creek flows into the channel of Yellow river and, from that point on, the bed of the stream, even in the dryest weather, is never destitute of water. The "Rise" of the river is located at the foot of a cliff of Trenton limestone seventy or eighty feet in height. The spring has been flowing in practically its present position for an indefinite period. The cliff is receding, if at all, very slowly. Its face is covered with moss and ferns. Vines clamber over the jutting edges of limestone. Trees several inches in diameter have gained a foothold at different heights of the nearly vertical scarp; and an elm, almost eighteen inches in diameter, grows within two or three feet of the base.

Like all other streams of Allamakee county, the Yellow river is dependent on springs for the normal flow in dry weather. To the midsummer traveler the springs in all these valleys are a constant joy, their number and size are a perpetual surprise. The Yellow river increases in volume by additions of generous and never-failing supplies of purest spring water from the "Rise" above Myron, till its current is checked and its characteristics, as a spring-fed stream, are lost amid the post-glacial mud beds near its mouth. From the west line of the county to near the eastern edge of Post township the Yellow river flows in a bed excavated in layers of Trenton limestone. Below Myron, in sec. 2, Tp. 96 N., R. VI W., the gorge, cut entirely in Trenton limestone, is two hundred feet in depth. The point at which the stream cuts through the Trenton and strikes the upper surface of the Saint Peter sandstone, is a short distance west of the eastern line of Post township. At Werhan's mill, less than two miles east of the township line, the river bed is fifty feet below the summit of the Saint Peter, while about a mile farther down it cuts into the upper layers of the Oneota limestone. From a point a mile or so from Werhan's the dip of the strata coincides for a time very nearly with the slope of the river bed, for at Smithfield, in the eastern part of Franklin township, the Oneota limestone rises only twenty feet above the level of the water. Above Werhan's the dip is toward the southwest. Between Smithfield and Ion the inclination of the strata is again toward the southwest, and the river cuts deep into the massive beds of the Oneota, so that below Ion the gorge has vertical walls of the buff colored dolomite one hundred and fifty feet in height. (Figure 3.) About two miles below Ion

Figure 3 Canyon of Yellow river below Ion.

the Yellow river cuts through the Oneota into the Saint Croix sandstone. At the mouth of the river the junction of the Saint Croix and Oneota is eighty feet above the surface of the water, and the bluff that overlooks the Yellow river and the Mississippi has a height of two hundred and ninety feet.

For some distance from the mouth, three miles or more by the windings of the stream, the channel was formerly somewhat lower than at present. It had been scoured out down to a different base level from that which now obtains. Owing, however, to the ponding back of the waters of the Mississippi during the closing portion of the glacial period, or to the relative rise of the waters from some other cause, a new base level was established, higher than the old, and the stream has deposited beds of clay to adjust its plane of erosion to the new conditions.

STRATIGRAPHY.

General Relations.

The indurated rocks of Allamakee county all belong to two periods; the Cambrian, and the Ordovician or Lower Silurian. The taxonomic relations of the strata are expressed in the subjoined table.

SYSTEMS.	SERIES.	STAGES.
Ordovician.	Trenton.	Galena limestone. Trenton limestone.
	Canadian (?).	Saint Peter sandstone. Oneota limestone.
Cambrian.	Potsdam.	Saint Croix sandstone.

Geological Formations.

CAMBRIAN.

SAINT CROIX SANDSTONE.

In Allamakee county only the upper or later division of the Cambrian system is represented. All the Iowa Cambrian therefore, belongs to the Potsdam series and to the stage called by Professor N. H. Winchell the Saint Croix sandstone. The Saint Croix beds, as they are seen in Iowa, are exposed only in the sides of bluffs, or in the bottom of erosion valleys. Nowhere do they rise to the tops of the higher bluffs bordering the valleys, much less to the summits of the chief divides.

Distribution.—The Saint Croix sandstone is exposed in the high cliffs and mural precipices facing the Mississippi river along the whole eastern border of the county. It is seen in the sides of the valley of the Oneota river throughout the whole course of this stream in Allamakee, forming everywhere the lower portion of the walls of the valley. At Gabbet's Point it rises three hundred feet above the level of the river, and from this point its elevation with reference to the stream becomes less and less until at the western boundary of the county its upper surface is only a few feet above the water in the channel. It may be traced along Village creek at ever-diminishing altitudes above the stream to near the west line of Center township. In the valley of Paint creek the Saint Croix is last seen in the southwest quarter of section 36, Tp. 97 N., R. IV. W., while along the Yellow river the sandstone dips beneath the level of the valley in section 20, Tp. 96 N., R. III W. Below the points where the Saint Croix disappears in the principal valleys it is more or less conspicuous in the valleys of all the tributary streams. It is found, for example, along Bear creek, as far as Quandahl, and in the bluffs overlooking Waterloo creek it extends up to Dorchester. Indeed, the space the Saint Croix occupies, when represented on the map, is seen to be exceedingly irregular, for it consists of narrow linear, and many times dichotomously branched areas corresponding to all the portions of the main valleys and their dendritic ramifications, that lie below the level of the upper limit of the sandstone.

Thickness.—At New Albin the Saint Croix sandstone rises to a height of three hundred and twenty feet above the grade of the Chicago, Milwaukee & St. Paul Railway. From New Albin to Lansing the trend of the bluffs overlooking the flood plain of the Mississippi is nearly parallel to the strike of the strata, so that at Mount Hosmer, the eminence above Lansing, the Saint Croix sandstone falls but little below the altitude which it attains at the northern limit of the county. At Lansing the exposed thickness of the Saint Croix may be set down at three hundred feet. For some distance below Lansing the bluffs continue to trend nearly parallel to the strike, and the top of the Saint Croix maintains an altitude approximately three hundred feet above low water in the Mississippi. At the bend below Heytman's Station the bluffs assume a direction nearly parallel to the dip of the strata, and from this point on to the southern boundary of Allamakee county the altitude of the Saint Croix rapidly diminishes. At Harper's Ferry the upper limit of the sandstone is about one hundred and eighty feet above the river. At Waukon Junction it has descended to one hundred and forty feet, and at the mouth of Yellow river it only rises eighty feet above low water level.

The three hundred feet of Saint Croix sandstone, exposed in the bluffs from New Albin to Heytman's Station, represents only a part of the entire thickness of this formation. In boring the wells which supply the city of Lansing with water the drill penetrated layer after layer of sandstone, in all respects similar to that exposed in the bluffs, to a depth of seven hundred feet below the level of the water in the river. Adding to the amount below the water level the amount exposed in the bluffs, it will be seen that the Saint Croix has a thickness at Lansing of one thousand feet—a thickness that agrees well with observations made on this formation by Chamberlin and Irving in Wisconsin. In the wells at Lansing, at the base of the sandstone, the well borers encountered a hard crystalline rock that effectually resisted all efforts to penetrate it with the drill. They had evidently reached the westward extension of the Baraboo quartzite, a vitrified or metamorphic sandstone of Algonkian age that forms the Baraboo ranges of Wisconsin and is well exposed at Devil's Lake. In many localities in the Wisconsin river valley a sandstone, known in Wisconsin as the Postdam sandstone, but equivalent to what is here called the Saint Croix, may be seen resting directly upon the quartzite. Wherever, indeed, the base of the Saint Croix has been seen in the upper Mississippi valley it has usually been found in contact with quartzite of the same character as that composing the Baraboo ranges, and there can be little doubt that it was this same quartzite that made further drilling impracticable in the well at Lansing.

Lithological Characters.—As to lithological characters the portion of the Saint Croix sandstone exposed in Iowa is very variable. A description, omitting minute details and dealing in a general and large way with the exposures of this formation at Lansing, will convey some idea of its more prominent characteristics. The facts to be presented are illustrated in part in the following section:

1. For forty feet above the level of the river the sandstone is not exposed.

2. Beginning at forty feet above the water level and extending up to eighty feet, is an assemblage of beds varying very greatly in some respects. The sandstone is definitely stratified, it is quite incoherent, the prevailing colors are sombre—mostly dark grays or browns—but there are some narrow bands of green alternating with bands and interrupted streaks of yellow; and cross-bedding, particularly in the greenish layers, is a common characteristic.

3. Number three of the section is a bed six feet in thickness, resembling closely the underlying layers. It is somewhat harder, though portions are quite friable. The prevailing colors are shades of brown and yellow, but there are some thin green bands that, as in number two, are obliquely laminated.

4. Number four is a bed eight feet in thickness, somewhat shaly, yellow in color, and made up of thin, horizontal laminæ that break up into small angular flakes.

5. Lying upon the thin yellow beds of number four is a harder layer, gray in color and two feet in thickness.

6. Following number five is an assemblage of harder beds, varying as to their general characteristics, and twenty-four feet in thickness. Some of the beds are massive and contain more or less calcareous matter, others are more distinctly laminated. Dull, dirty colors predominate, but there are bands of red, brown, gray and yellow. Near the top of six, yellow predominates, and there is a gradual transition to the soft, yellow, calcareous shales of number seven. The massive, firmer beds of number six have been quarried somewhat extensively for building stone.

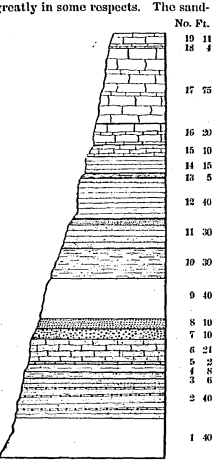


Fig. 4. Section at Lansing, Iowa.

7. Number seven is a continuation of the upper part of number six and itself grades up imperceptibly into number eight. Ten feet in thickness is

assigned, rather arbitrarily, to this member of the section. The layers are yellow in color, horizontally laminated, fine in texture, quite distinctly calcareous, and are easily split into moderately thin leaves along the planes of lamination. About the middle of this member the calcareous shales contain the remains of trilobites and a few linguloid brachiopods. Of the trilobites, *Dikelocephalus minnesotensis* Owen, is the species most abundantly represented, but there are occasional fragments of an Illænurus, differing from *Illænurus quadratus* Hall, in the form and other characters of the glabella. In general the trilobites are represented only by impressions of dismembered portions of the dorsal exoskeleton, but in two specimens of Illænurus the glabella and thoracic segments retain their normal, relative position.

8. This is lithologically very similar to the last. The beds are slightly more compact and, so far as observed, they contain no fossils. The color and general characteristics of the strata are identical with seven.

9. For forty feet above number eight the hillside is sodded over.

10. When the strata are again exposed there occurs a body of strata thirty feet in thickness, consisting of yellowish sandstone, partly soft and unstratified, sometimes harder and showing planes of bedding, all very irregular and varying both laterally and vertically in color and hardness.

11. Above the last are beds grayish in color, varying sometimes to yellow, made up of coarse, rolled quartz grains, irregularly cross-bedded; the sand becoming coarser toward the top, with shadings of brown and red and with varying degrees of hardness from the most friable to beds having a fair degree of induration. Thickness thirty feet.

12. Following eleven the rock becomes firmer, finer grained, still occasionally cross-bedded, and hard enough to stand in vertical cliffs. Prevailing colors are gray and yellow. Thickness forty feet.

13. Then follows a more friable bed, five feet in thickness, yellow and brown in color with some thin bands of gray.

14. Above thirteen there are fifteen feet of beds of passage, some quite arenaceous, others made up of sand cemented with a relatively large amount of calcium and magnesium carbonate. The beds are harder than most of those below; they are fine-grained, resist the weather and tend to form vertical escarpments along sides of the bluffs.

Above the level of number fourteen, three hundred feet above the surface of the river at low water, Mount Hosmer and all the neighboring bluffs, are made up of the dolomitic beds of the Oneota limestone. The foregoing description is intended only to give a very general conception of the characteristics of the Saint Croix sandstone as it is exposed at Lansing. With few exceptions the several beds of this formation vary in character laterally, so much so, that sections taken quite near together would differ greatly in minor details. This whole complex mass of arenaceous strata throughout its entire thickness of a thousand feet, is simply a shore deposit laid down in shallow water upon a subsiding sea bottom.

The rate of subsidence was not uniform, sometimes it was faster, and again it was slower, so that the position of any given point in the area covered by the sandstone—the site of Mount Hosmer for example—was continually changing with reference to the shore line of the land area from which the sediments were derived.

Furthermore, the movements of the sea bottom affected the ocean currents, causing them to flow sometimes in one direction and again in another. The rate of the erosion whereby the sands were furnished may well have varied with variations in the altitude of the land above sea level, as well as in the volume of rainfall, and the consequent energy of the resulting streams. At all events some causes combined to bring about perpetual changes in the nature of the deposits laid down at any given point, as well as often to produce quite different contemporaneous deposits at points not very far removed from each other.

The assemblage of beds represented by the upper part of six, all of seven, and all of eight, on the section, page —, are fairly constant over considerable areas. The sediments are fine, largely chemical, rather than mechanical, and they were laid down in quiet water, in a deeper sea that had the bottom unvexed by waves or currents. These beds represent a time of more rapid subsidence and remoter shores. The beds in question are more calcareous in the valley of the Oneota river than they are at Lansing. The calcareous constitutent increases in relative amount as the beds are traced westward until at the point where they are last seen in the Oneota valley, near the west line of Union City township, they assume the character of an earthy, thin bedded dolomite.

The fossil-bearing portion of this series represents the fifth trilobite bed of Owen; while the whole assemblage of evenly bedded calcareous strata, about thirty-five feet altogether, is the equivalent of the Saint Lawrence limestone of Winchell, as re-defined in the second volume of final reports of the Geological and Natural History Survey of Minnesota*, while it is also

*The Geol. of Minn. vol. II of Final Report; by N. H. Winchell, pp. xxi and xxii. Saint Paul, 1888.

the equivalent of the Mendota limestone of Irving, as given in the Geological Reports of Wisconsin*.

In the section at Lansing there are above the level of the calcareous beds one hundred and sixty feet of variable sandstones which are the stratigraphical equivalents of the Jordan sandstone of Winchell, and of the Madison sandstone of Irving.

A blue calcareous shale was observed near the base of the bluffs not far from New Albin. If this is present at Lansing, it lies below the level of the exposed portion of the section. It is possible that this may be the western extension of the blue, calcareous shale reported by Chamberlin as a member of the Potsdam series (Saint Croix) in eastern Wisconsin†. Only a few feet of the shale were seen at a single point above the roadway leading into New Albin from the west.

The Saint Croix sandstone as here defined is equal to the Potsdam sandstone of Hall, White, Chamberlin and McGee, as the term is used in referring to the geology of Iowa, Wisconsin and Minnesota; but it cannot be affirmed that it is equivalent to the Potsdam of New York. It embraces all that is included under the terms Potsdam sandstone, Mendota limestone and Madison sandstone in some of the writings of Irving. It is the same as the Saint Croix sandstone as finally delimited by Winchell, embracing, however, at the same time, his Saint Lawrence limestone and Jordan sandstone, which, in the second volume of reports, he associates with the lower sandstones in the Saint Croix formation. The whole assemblage of strata, so far as Iowa is concerned, represents continuous deposition under practically unchanged conditions. For a short time, during the deposition of the unusually calcareous strata associated with the trilobite-bearing beds, the off-shore conditions that must have existed somewhere throughout the whole time represented by the thousand feet of sediments, became possible, on account of unusually rapid subsidence, over northeastern Iowa and the adjacent parts of Wisconsin and Minnesota. During this short period trilobites and lingulas migrated into the region that thus offered a favorable environment; but their time of occupancy

*Geol. of Wisconsin, vol. II, p. 535. 1877.

†Geol. of Wisconsin, Vol. II, p. 262.

was short, for the old conditions of shallow water, rapid currents, coarse sediments and proximate shores were again introduced, and the progress of deposition went on much as before the unusual subsidence. When the greater subsidence that marked the close of the Saint Croix and the introduction of the Oneota took place, the Cambrian trilobites had disappeared and the sea became populated anew by an incursion of Ordovician types related to the fauna of the Calciferous sandrock of New York.

ORDOVICIAN.

ONEOTA LIMESTONE.

The Oneota limestone is one of the most conspicuous and at the same time one of the most important of the geological formations in Allamakee county. It lies directly and conformably upon the Saint Croix sandstone, the transition from one formation to the other being made through some fifteen or twenty feet of calciferous sandstone. Owen correctly describes some of the beds of passage as "Magnesian Limestone with glitering crystalline facets, and calcareo-siliceous oölite, produced by rounded grains of quartz encased in calcareous cement*." The sand grains indeed are coated with a number of successive layers of calcareous material, and the rock, on fresh fracture, often presents all the appearance of a true oölite.

The Oneota limestone was first described by Owen, and in his reports of 1849 and 1851 it was called the Lower Magnesian limestone†. This name has been retained by White, Chamberlin, Irving and some others who have studied the geological formations of the upper valley of the Mississippi, though Hall in his geology of Iowa refers to this formation as the Calciferous sandstone. Winchell in his latest rectification of the Cambrian and lower Ordovician strata in Minnesota, divides Owen's

*Owen's Geol. Sur. of Wis., Iowa and Minn., Phila., 1852, p. 52. The "Sixth trilobite bed" evidently corresponds to the beds of passage between the Saint Croix and the Oneota.

†In the Report of a Geol. Exploration of Iowa, Wisconsin and Illinois made in the autumn of the year 1839, Second Edition 1844, Owen frequently refers to this formation as the "lower magnesian limestone," (pp. 21 and 31) but the term is used descriptively and not as a specific name. The term is also used in figures 6 and 7, Pl. I, of the same volume, but whether as a specific or as a merely descriptive term, cannot be inferred.

Lower Magnesian limestone into (1) the Main Body of Limestone, (2) the New Richmond Beds (sandstone), and (3) the Shakopee Limestone. The term "The Main Body of Limestone," he adopts from Irving. McGee claims that the "Main Body of Limestone" is the only part of Owen's Lower Magnesian limestone to which the original name could now, with any propriety be applied. He claims further that the original name "is objectionable in that its correlative element has become meaningless since the division of the original Upper Magnesian into three formations" and so he proposes to call the assemblage of strata between the top of the Saint Croix and Irving's New Richmond sandstone the Oneota limestone, a term derived from the Indian name of the river along which the formation attains its typical development*. The part of Owen's Lower Magnesian limestone that corresponds to the New Richmond sandstone and Shakopee limestone of the Minnesota geologists McGee refers to the Saint Peter sandstone. Hall and Sardeson would unite under the somewhat comprehensive name of the Magnesian Series of the Northwestern states, all the strata from the base of Winchell's Saint Lawrence limestone to the top of the Shakopee of the same author†. The stratigraphical divisions and faunal changes occurring between the limits mentioned are fully recognized; but the fact that the beds represent continuous deposition during a period characterized by the recurrence of conditions that alternately favored the deposition of dolomite and sandstone, has induced these authors to group all the strata referred to under one comprehensive term.

The New Richmond sandstone of Minnesota and Wisconsin is represented in Allamakee county by a number of inconstant, thin arenaceous beds that are interstratified with dolomite. Above the uncertain sandstone layers the formation is wholly dolomitic up to the base of Owen's Saint Peter sandstone. There does not seem, therefore, to be any call for formational divisions in this part of the geological column in Iowa; and

*McGee. Pleistocene History of Northeastern Iowa. Eleventh Ann. Rep. U. S. Geol. Surv., p. 333.

†The Magnesian Series of the Northwestern States. By C. W. Hall and L. W. Sardeson, Bull. Geol. Soc. of Am., Vol. II, pp. 167-198.

though McGee's name, Oneota limestone, is adopted in the reports of the present Iowa Geological Survey, it is modified to the extent of making it co-extensive with the Lower Magnesian limestone of Owen. It will thus include all the dolomitic beds with the thin layers of intercalated sands up to the base of the purely quartzose deposit that distinctively and beyond question belongs to the Saint Peter sandstone. The sandstone beds thus included in the Oneota, as compared with the beds of dolomite are wholly subordinate in importance up to the limit here indicated. The lower ones at least are furthermore lithologically different from the Saint Peter in being firmer and more conpact and in having the sand grains enlarged by secondarily deposited silica that has assumed the crystalline form and causes a characteristic sparkling in the sunshine owing to the reflection of light from numerous crystalline facets. Moreover these thin, intercalated arenaceous layers differ in number, thickness and in stratigraphical position in different localities, so that any effort to unite them with the Saint Peter sandstone would require the use of a line of separation between the two formations that could be defined only with much difficulty. On the other hand the base of the great body of incoherent sands that undoubtedly belong to the stage of the Saint Peter, presents a plane that is fairly constant and easily recognized.

Apart from the thin beds of sandstone that occur in it at different elevations, the Oneota formation is made up of more or less massive layers of dolomite. The colors range from white to buff or yellow. Beginning ten or fifteen feet above the Saint Croix sandstone there are thirty or forty feet of evenly bedded, fine-grained limestone in layers varying from three inches to three feet in thickness. Above this there are occasional beds suitable for quarry stone, but in general the rock is massive, with few planes of bedding, and these are irregular and often many feet apart. The massive beds are rather coarse, vesicular, rough and gritty to the feel, and highly charged along certain planes with concretionary nodules and irregular masses of chert. The last fifty or sixty feet in ascending towards the Saint Peter sandstone are characterized by the presence of beds of sand and shale interstratified with the magnesian limestone. The sandstone layers, as already noted, differ as to number and position in different localities, and it does not seem possible to recognize any one as sufficiently constant to mark a definite horizon. It is in the last fifty or sixty feet that the Iowa equivalents of the New Richmond sandstone and the Willow river limestone of Wisconsin, or the New Richmond sandstone and Shakopee limestone of Minnesota are found. It is the last fifty or sixty feet that McGee would unite with the Saint Peter sandstone, but apparently the true relations of the beds under consideration are with the underlying body of dolomite.

Surface Distribution.—The Oneota limestone crowns all the bluffs along the Mississippi from New Albin to McGregor in Clayton county. It forms the castles and pillars and high buttressed walls that give grandeur and character to the picturesque scenery along the whole valley of the Oneota river and its affluents in Allamakee county. In the valley of Village creek it extends with its usual characteristics from the mouth to near the intersection of the stream with the line that passes north and south through the middle of Makee township. On Paint creek it forms conspicuous bluffs and precipices along the sides of the valley to a point a mile and a half above Waterville. Above Waterville the cliffs of Oneota gradually diminish in height until they fade out on account of the formation passing beneath the level of the rounded contours and gentler slopes indicative of the region underlain by the Saint Peter sandstone. Along Yellow river the frowning walls and precipices of Oneota are conspicuous to a short distance below Volney. Above this point the upper surface of the Oneota rises but little above the level of the river. Owing to the easily eroded character of the overlying Saint Peter the sides of the valley are characterized by gentle slopes nd low rounded swells that are in marked contrast with the bolder relief produced by the more obdurate magnesian limestone when exposed, as it is farther down the stream, to a greater thickness. The upper surface of the Oneota finally disappears below the level of the river in section 4, Tp. 96 N., R. V W., a short distance below Werhan's mill.

Concerning its distribution at the surface outside the bottoms and steep walls of the valleys, the Oneota limestone occupies a number of very irregularly shaped isolated areas that altogether defy anything like ready or brief description. All are in the northeastern half of the county. In many cases they are small, island-like patches crowning rounded eminences, again they are narrow, sinuous, fringing belts following the irregular contours upon the long slopes that separate the tops of the precipitous cliffs facing the valleys from the summits of the more or less distant divides. Sometimes the areas are individually large enough to embrace a number of productive farms, as erosion has produced broad shelf-like plateaus between the crumbling sands of the Saint Croix on the one side and the Saint Peter on the other.

Thickness.—In thickness the Oneota limestone ranges from 200 to 250 feet. The average is probably about 230 feet. It is most fully developed along the Oneota, or Upper Iowa river, and its branches. Nowhere, so far as observed, is the whole thickness to be seen in a single section. At some points there may be nearly or quite 200 feet included between the roadway at the foot of the steep-sided bluffs and the top of the battlemented ledges that frown down from the summit. The layers of limestone decay unequally through the effects of weathering, and though the walls of the valley seem almost vertical, some portions of the section are always concealed by sod or talus. In the perpendicular faces of the projecting summit ledges, continuous sections of forty, fifty or even sixty feet are often exposed, and in the dry rocky channels that in rainy weather carry tumultuous torrents from the higher slopes, we may make out the succession of beds for a hundred feet or more. It is a very unusual thing, however, to find a continuous natural section exposing half the thickness of the formation.

In the bluffs about one mile below the mouth of Bear creek (Tp. 100 N., R. VI W., sec. 36, Se. qr., Se. ¼), we have the following typical section, beginning at the level of the roadway that follows the valley:

		FEET.
4.	Oneota limestone, partly concealed by talus, and partly exposed in projecting vertical ledges forty or fifty feet in height	180
3.	Beds of passage, partly arenaceous and partly calcareous, some of the layers made up of rounded sand grains cemented with dolomite	15
2.	Hard layers of concretionary sandstone, the mamillary and botryoidal sandstone of Owen (Saint Croix)	15
1.	Soft Saint Croix sandstone, sometimes cross-bedded, but more frequently without stratification planes of any kind; brown and yellow in color	100

Fauna of the Oneota Limestone.—The Oneota limestone is quite barren so far as relates to fossil remains. Throughout the greater part of its thickness one may search indefinitely without finding any evidence of the existence of life while the beds of dolomite were forming. Dr. White* says that "the only fossils that have been found in this formation in Iowa are, so far as known, a few traces of the stems of crinoids found near McGregor." Whitney†, speaking of indications of organic life in the Lower Magnesian (Oneota) limestone, says that "In Iowa, indeed we have observed nothing of the kind." Owen, in his report on the Geological Survey of Iowa, Wisconsin and Minnesota, p. 60, enumerates a few genera that are represented in this formation but does not give localities. Whitfield describes a few species from the Lower Magnesian of Wisconsin in the Geology of Wisconsin, Vol. IV. Professor N. H. Winchell found Orthoceras, Ophileta and Pleurotomaria in cherty beds of this formation in Minnesota. In the proceedings of the Philadelphia Academy of Science for 1870, Meek describes a species of Raphistoma from the horizon of this limestone in Minnesota. So far as relates to Iowa, the largest collection illustrating the fauna of the Oneota limestone was made partly in Allamakee, and partly in Clayton county, by Mr. F. H. Luthe, formerly of McGregor. This collection was studied and described by Calvin‡.

The recognizable forms included: Murchisonia, species undetermined. Tryblidium, species undetermined, *Metoptoma alta*

*Report of the Geology of Iowa, vol. I, pp. 173-174.

†Hall's Geology of Iowa, p. 337.

‡Bul. from Lab. Nat. Hist. of State University of Iowa, vol. II, No. 2, pp. 189-193. American Geologist, vol. X, pp. 144-148.

Whf., *Straparollus claytonensis* Calvin, *S. pristininiformis* Calvin, *Raphistoma pepinense* Meek, *R. multivolvatum* Calvin, *R. paucivolvatum* Calvin, *Holopea turgida* Hall, *Orthoceras primigenium* Vanuxem, and *Cyrtoceras luthei* Calvin. In addition to the genera and species enumerated above Mr. Luthe's collection contained a few imperfectly preserved masses resembling in structure some forms of the Stromatoporoidea. All the specimens in the collection came from thin bands and irregular masses of chert that are more or less common throughout the upper half of the Oneota. With the exception of a single imperfect specimen of *Straparollus claytonensis* none of the species mentioned above are at present known from the masses of limestone making up the main part of the Oneota, or from the intercalated sandstones and shales in the upper part of the formation.

In the limestone portions of the Oneota, however, up near the top of the formation, there are beds that are composed wholly of large laminated concretion-like masses that bear a striking resemblance to some forms of Stromatoporoids. The individual masses vary from a few inches up to several feet in diameter. The largest individuals were seen in a road cutting on the north side of Yellow river a short distance below Volney. At this point there were some that were two or three feet in thickness and eight or ten feet in horizontal diameter.

Objects having a similar structure, but obviously much smaller than those observed in Iowa, have been described by Professor N. H. Winchell from about the same horizon in Minnesota. Professor Winchell refers the specimens to Hall's genus Cryptozoon and proposes for one of the larger forms which has a diameter of only about sixteen inches, the specific name *Cryptozoon minnesotense.* There may yet be reasonable doubt as to whether these problematic structures are really organic. The individuals tend to split into concentric portions along the planes of lamination. The upper surface, taking it as a whole, is generally convex, but the surface of each lamina is molded into a great number of comparatively small low rounded elevations that vary from half an inch to more than two inches in diameter.

Taxonomic Relations.—On stratigraphical grounds Professor James Hall and others have referred the Lower Magnesian (Oneota) limestone to the same horizon as the Calciferous sand rock of New York and Vermont. It may now be referred to the same horizon on paleontological evidence. *Metopotoma alta* Whitfield, *Holopea turgida* Hall, and *Orthoceras primigenium* Vanuxem, are species common to the eastern Calciferous and the western Oneota. Tryblidium and Murchisonia are represented in the western formation by species that are very similar to representatives of the same genera on the Vermont shore of Lake Champlain, if they are not indeed identical. The species of the other genera from the chert beds of the Oneota bear a close resemblance to species from the Calciferous beds of Vermont. There can be little doubt as to the essential equivalence of the two formations. At Fort Cassin and other points in the Champlain valley the beds that furnish a fauna essentially equivalent to that of the Oneota limestone pass up without stratigraphical interruption into beds that furnish *Asaphus canalis* Conrad, and other species that show decided affinities with forms from the Birdseye and Trenton limestones of New York. The relations of the Calciferous sandrock of the Champlain valley are paleontologically more intimate with the overlying Trenton than with the underlying Potsdam. The formation belongs to the Ordovician or Lower Silurian and not to the Cambrian, and the same statement may be made with respect to its equivalent, the Oneota limestone in northeastern Iowa.

SAINT PETER SANDSTONE.

General Description.—The term Saint Peter sandstone will be used here in the sense in which it has been employed by Owen, Hall, White and all other writers on the geology of the region under consideration except McGee. As already noted McGee proposes to unite with the Saint Peter so much of the underlying formation as represents the Shakopee limestone and New Richmond sandstone of Minnesota. Limiting the term in accordance with its original application, the Saint Peter sandstone of Allamakee county embraces a body of but slightly coherent arenaceous deposits having an average thickness of about eighty feet, and lying between the fairly well defined summit of the Oneota and the very definitely marked bed of shale that is found everywhere throughout the county at the base of the Trenton. The formation is made up almost entirely of water-worn grains of quartz. The amount of foreign matter mingled with the quartzose sand is so small that in many cases it may be left out of consideration. While some of the beds, however, are pure white, the great bulk of the formation is more or less tinged with shades of brown, red or yellow, owing to the presence of small amounts of ferric oxide in different degrees of hydration. The colors are often very bright and distinct, and in this respect are in marked contrast with the dingy shades that characterize the greater part of the Saint Croix.

The Saint Peter sandstone is in some places practically as incoherent as when the beds were first laid down in the Ordovician sea. In portions exposed to the weather for some time the constituent sand grains become more or less cemented at and near the surface, but on breaking through the thin crust it is found that the unexposed beds have suffered so little change since they were first deposited, that fragments two inches in diameter may be crushed in the hand, or the whole body of sand may be dug out easily with the spade. At a large proportion of the localities where the Saint Peter is exposed the sandstone is so far indurated as to admit of being taken out in blocks, but the blocks may easily be knocked to pieces with the hammer, or they may be crushed with a comparatively small amount of pressure. In a few instances the beds are sufficiently hard to serve very well as building stone, and in some places they are quarried and used in making foundations for barns and other similar structures. On the land of Mr. Fred Hansesmeier (Tp. 98, N., R. V W., sec. 27, Se. qr., S. ½), about three miles east of Waukon, there are ledges of Saint Peter sandstone curiously mottled and streaked with bright red, mingled with patches of pure white. These ledges are hard enough for use as building stone and they have been so used to a limited extent.

Near Mr. Heffner's (Tp. 96 N., R. V W., sec. 14, Sw. qr., Nw. ¼), there are vertical ledges of Saint Peter sandstone that have weathered into massive, irregular detached blocks, three to ten feet in diameter, and piled one on another like some example of heavy masonry. The sandstone at this exposure is hard enough for use in ordinary walls and foundations. Other similar examples occur throughout the county, but in general the Saint Peter sandstone has so little cohesion as to be altogether unfit for use as building stone.

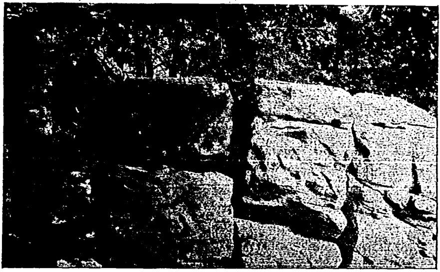


Figure 5. Effect of weathering on hard beds of Saint Peter sandstone near Heffner's.

The upper portion of the Saint Peter formation, for a few inches only below the plane of contact with the basal shale of the Trenton, often becomes very highly charged with iron oxide. The overlying Trenton limestone contains a considerable amount of pyrites together with some ferric oxide and ferrous carbonate. It has suffered decay on a large scale as a result of solution. For unmeasured periods the meteoric waters, on their way to the channels of drainage, have flowed over the surface or found their way into innumerable cracks and crevices that intersect the beds of limestone, and have dissolved and carried away the calcium carbonate to an extent that is hardly conceivable. The insoluble residue contained, among other things, the pyrites of iron with which the limestone was charged, and this mineral, after undergoing oxidation, has been carried down and deposited in the uppermost layers of the insoluble Saint Peter sandstone. On some long slopes that still show beds of Trenton limestone above the Saint Peter, and where for an indefinite period solution has been more effective than mechanical erosion in disintegrating and removing the indurated rocks, the sandstone often projects beyond the general contour and forms a terrace having its horizontal surface coincident with the plane of contact between the two formations. As compared with the limestone the siliceous deposit is relatively insoluble, and so decays but slowly if at all from the effects of solution. The ferruginous deposit in and upon its surface layer enables the sandstone to resist for a time the rather feeble effects of mechanical erosion, and thus is brought about the unusual phenomenon of a hard, compact limestone receding, as a result of wastage, more rapidly than a friable sandstone.

Topographic Features.—The ferruginous stratum in the uppermost part of the Saint Peter is best developed in regions over which the Trenton has been almost, or altogether, removed. In some places from which the limestone has been completely stripped, there are knobs and ridges of Saint Peter sandstone rising forty or fifty feet above the plain on which they stand, showing at the summit the hard ferruginous band that was developed beneath the slowly vanishing Trenton, still preserving a record of the exact position once occupied by the base of this formation. An excellent typical example of such protected outlying masses of the upper portion of the Saint Peter is found in the small, conical hill which rises abruptly from the level of the surrounding region near the northeast corner of section 19, in the western part of Lansing township. The height is forty feet above the roadway that passes near its base. The sides are too steep for cultivation and so a portion of the original forest has been permitted to occupy its summit and lateral slopes, a fact that adds to the apparent elevation when the hill is seen from a distance. The crown of the hill is protected by a thin layer of hard ferruginous sandstone with enough of the cementing ferric oxide to entitle it to rank as a fair grade of iron ore.

A little farther to the southeast, in section 20 of the same township, a church has been built in a conspicuous situation on the west end of a long, narrow, wooded ridge, that like the knoll in section 19 is made up of the upper part of the Saint Peter sandstone protected by a relatively thin but highly indurated layer cemented with ferric oxide. There are many similar outlying masses of the upper half of the Saint Peter in the southeastern part of French Creek township and the western part of Lansing. In sections 27, 34 and 35 of Makee township there are examples of the same kind, while in the southeast quarter of section 6 of Taylor township, there are some prominent wooded ridges of Saint Peter sandstone illustrating the same geological and topographical phenomena. Such ridges, hills, and bosses of sandstone as those above noticed, are indeed characteristic features of the topography in all the portions of the county that lie just outside the edge of the receding Trenton limestone.

Distribution.—The area occupied by the Saint Peter sandstone does not admit of accurate description. It occurs in long, narrow, sinuous belts around the margin of the region covered by the Trenton limestone. There are outlying patches here and there. Seldom do the continuous areas occupied by this formation have a width of two or three miles. More frequently they are mere narrow bands along hill sides with a horizontal extent limited to a few yards. With the possible exception of Ludlow and Post, the plane in which the sandstone lies is intersected by the strongly undulated surface at numerous points in every township of the county; and one traveling in any direction, except along the crests of the dividing ridges or following the troughs of the main drainage valleys, encounters exposures of it every few miles.

Fauna of the Saint Peter Sandstone.—Thus far in Iowa the Saint Peter sandstone has afforded no traces of fossils. In the Fourth Annual Report of the Geological and Natural History Survey of Minnesota, page 41, Prof. N. H. Winchell describes a small linguloid brachiopod from the upper part of the formation, near Fountain, Fillmore county, Minnesota, under the name of

Lingulepis morsensis. Prof. Chamberlin, in the Geology of Wisconsin, vol. II, page 288, mentions the discovery of Scolithus tubes in beds of the Saint Peter in eastern Wisconsin. In the Bulletin of the Minnesota Academy of Sciences, vol. III, No. 3, page 318, Sardeson gives a list of fossils from the Saint Peter sandstone near Minneapolis. The collections embrace casts of Gasteropods and Lamellibranchs belonging to the genera Maclurea, Murchisonia, Cypricardites and Modiolopsis. The fauna of the Saint Peter as indicated by Sardeson's collection is closely related to that of the Trenton, if not identical with it, and lends support to the views of those geologists who would correlate the Saint Peter of the Upper Mississippi with the Chazy of New York.

The porous character of the entire formation in Iowa, and the lack of cohesion among its constituent particles, do not afford conditions favorable to the preservation of organic remains. Even had the sea, during the age of the sandstone, abounded in organic types with skeletal parts, capable under favorable circumstances of becoming fossilized their preservation till now in such a deposit as the Saint Peter would be highly improbable. On the other hand it is more than probable that the conditions attending the laying down of the sandstone precluded the development of any extensive fauna so long as the work of deposition was in progress. The mechanical action of the strong and constant currents necessary to wash and assort the material as it was brought down from the land and free it completely from all clayey and other finely comminuted particles that must necessarily have been present in the original products of land erosion, could scarcely fail to make it well nigh impossible for sensitive types of life to exist within the area of sedimentation.

TRENTON LIMESTONE.

THE SAINT PETER SHELL LIMESTONE OF OWEN.

In Allamakee county the Saint Peter sandstone ends abruptly without noticeable change of characters. It is followed in ascending order by a bed of bluish or greenish shale that constitutes the lowest member of the Trenton formation. This basal shale, five or six feet in thickness, is followed by beds of limestone that in most localities are at first dolomitic; but in some places they exhibit the usual characteristics of the calcareous beds belonging to the typical Trenton. There are no beds of passage. The line of juncture between the Saint Peter and Trenton is probably the most definitely marked geological horizon in all northeastern Iowa.

General Description.—The Trenton limestone is a term applied to an assemblage of strata that vary considerably among themselves and yet, when viewed as a whole, present a fairly consistent series of physical and paleontological characteristics. Some of the beds are calcareous shales, others are shaly limestones, some are dolomites, while still others are nearly pure accumulations of calcium carbonate. The formation begins with the bed of shale already mentioned, five or six feet in thickness, and resting conformably on the Saint Peter sandstone. This basal shale is seen in all parts of the county wherever the contact of the two formations is exposed; and southeast of a line drawn from Postville to New Albin it is invariably followed by beds of dolomite, having an aggregate thickness of twenty or twenty-five feet. This dolomite is the equivalent of the Lower Buff beds of the Wisconsin geologists*. As developed in Iowa the dolomitic beds are in heavy layers from six inches to three feet in thickness, and afford a very excellent quality of building stone. They are well seen in the valley of Paint creek, about two miles below Waukon. In section 6, of Paint creek township, they are exposed, and have furnished the material used in building the walls of the West Paint Creek Norwegian Lutheran church and other structures of less importance. While they are a fairly constant feature of all the natural sections that include this part of the geological column, the most instructive exposure, and the one that best illustrates the character of these dolomitic beds, was observed near the point where the wagon road intersects the south line of the southwest quarter of section 10 in Franklin township. At this exposure the beds in question are made up

*Geology of Wisconsin, vol. II, page 291.

of very hard, compact, yellow magnesian limestone, with few or no fossils. They have been quarried to a limited extent, and are capable of furnishing blocks three feet in thickness and of almost any desired dimensions as to length and width.

Above the Lower Buff beds the Trenton limestone of Allamakee county presents a great variety of lithological characters. There is a continual alternation of limestone and shales, the limestone, on the whole, predominating. As a rule the limestone is dark colored, with dull blue and slaty shades in the unleached portions of the beds. In texture it is fine grained, compact, and breaks often with conchoidal fracture. The beds are usually thin, from three to six inches being the ordinary thickness, though some beds may attain a thickness of ten or twelve inches. Layers that seem perfectly compact when taken from the quarry often break up into thin laminæ after exposure to the weather. The effect of weathering is well seen in all the exposed cliffs of this formation. Owing to cleavage of the

Figure 6. Effect of weathering on exposed ledges of Trenton limestone. Exposure on Saw Mill creek, north of Postville.

original strata along the planes of lamination the cliff appears to be made up of beds only an inch or two in thickness, while the laminæ, resulting from such cleavage, are again broken vertically into small fragments six or eight or ten inches in diameter. (Figure 6.)

Beds presenting fairly uniform characteristics over a large area begin about thirty feet above the base of the formation and have a thickness of between thirty and forty feet. They consist of thin layers of limestone alternating with shales, the limestone layers being very irregular in their distribution and often having a very limited lateral extent. Shale is greatly in excess as compared with the limestone, and the whole bed, argillaceous and calcareous portions alike, is highly fossiliferous. The thin calcareous layers that occur in the shale are usually nothing more than masses of brachiopod shells and bryozoans—sometimes broken and comminuted, not infrequently entire—all cemented into a compact limestone. Fossils occur also in great numbers, and in the most perfect state of preservation in the argillaceous portions of the bed, and are freed from the matrix by weathering wherever the shales are exposed. The upper portion of the shale bed is highly charged with calcareous nodules, along with which it contains, among other monticuliporoids, immense numbers of the small, mostly hemispherical, coral-like bryozoans that were formerly known as *Chætetes lycoperdon*, but which may now probably be referred to *Prasopora simulatrix* Ulrich. Weathered out of the shale or lying partly embedded upon the surface of the calcareous laminæ the collector may obtain beautiful examples of *Orthis subæquata* Con., *O. bellarugosa* Con., *O. tricenaria* Con., *Platystrophia biforata*, small variety resembling in form *P. acutilirata* Con., *Strophomena rugosa* Rafinesque, *S. incurvata* Shepard, *Rhynchotrema ainsliei* N. H. Winchell, *R. inæquivalvis* Castelnau, and many other species characteristic of the lower Trenton. The beds under consideration contain some layers of very fine argillaceous shale which, being impervious to water, determine the position of numerous springs along the slopes upon which this shale outcrops. When the dip of the strata is normal—that is, toward the southwest—the springs occur on the north and east sides of the valleys.

Above the shale bed there occurs a body of hard limestone with layers from three to six inches in thickness. Fossils are less plentiful than in the calcareous layers associated with the underlying shale. The rock is firm, fine grained, blue or slaty in color on fresh fracture, but weathers, on exposure, to various shades of gray or buff. These beds are quarried near Waukon and elsewhere, and some of the layers afford a very durable building stone. Great care, however, must be used in making the selection, for some beds that appear to be perfectly firm and homogeneous, split badly into thin laminæ and then crumble into small angular fragments upon continued exposure to the weather.

Limestone of essentially the same character as that quarried near Waukon occurs, with slight variations and occasional interruptions by thin beds of shale, to near the upper limit of formation. North of Postville, in the southeast quarter of section 20 of Postville township, we find first an exposure of yellowish, soft limestone with much chert, which doubtless represents the lower beds of the Galena. Below the Galena there are twelve or fifteen feet of bluish shales with no fossils and then there follows in descending order about sixty feet of fossiliferous shales and shaly limestones. The main body of the Trenton limestone, about 150 feet in thickness, and exhibiting what may be called the typical characteristics of the formation lies between the base of the shales and shaly limestones seen north of Postville, and the top of the fossiliferous shales exposed near Waukon. Between these two limits the formation is predominantly calcareous, and some of the beds furnish a fairly good quality of building stone.

Distribution and Relation to Drainage.—The Trenton limestone is distributed most extensively in the southwestern part of Allamakee county. It is practically continuous over Post and Ludlow townships, but the ramifying valleys of Village creek, Paint creek and Yellow river cut iuto the eastern margin of the area occupied by this formation and divide it into a series of irregular narrow belts that coincide with the crests of the higher ridges. The three streams mentioned above all have their origin within the Trenton area, but they do not flow far before cutting through to the underlying formations. On the other hand the Oneota or Upper Iowa river runs over the

Saint Croix sandstone throughout its whole course in Allamakee. North of the Oneota the Trenton limestone occupies the higher elevations in Waterloo and Union City townships.

The Trenton limestone is very extensively fissured, and the fissures communicate one with another over areas of considerable extent. The surface waters are drained into these subterranean fissures through numerous funnel-shaped "sink holes" that vary from a few yards to forty or fifty yards in diameter. These singular, basin-shaped depressions in the surface constitute one of the constant and characteristic features of the Trenton area and might serve as a reliable guide in tracing the distribution of the formation under consideration even if there were no other indications of its presence. In the region about Rossville the "sinks" are particularly numerous aud seem actually to crowd each other in some of the fields and pastures. The area underlain by Trenton limestone has most perfect drainage, so much so that wet land, even in seasons of most copious rainfall, is something altogether unknown. The waters that find their way into the fissures of the Trenton reappear, at least in part, in the springs that well out from the sides of every valley and furnish the constant supply for all four of the main drainage streams.

The Fauna of the Trenton.—The Trenton fauna is too extensive to be discussed here except in a very general way. The strata of the Trenton afford the earliest, and in some respects the best examples among the Paleozoic strata of Iowa, of organically formed limestones. Many of the beds are nothing but consolidated masses of the comminuted skeletons of brachiopods and other marine types of animals. The rate at which the strata accumulated on the bottom of the old Trenton sea depended on the rate at which successive generations of shell-bearing animals secreted calcareous skeletal parts during life and contributed the same at death as an addition to the slowly growing beds of limestone. The exuviæ of animals were piled up simply where the creatures lived and grew and died, and the remains of each generation buried out of sight the more or less fragmentary skeletons of the next preceding.

In the Trenton fauna brachiopods predominate with respect to numbers, both of individuals and of species; the greatest expansion of the class taking place in the families Strophomenidæ and Orthidæ. Among mollusks there are only a few Lamellibranchs. Gasteropods are comparatively numerous, the genera Raphistoma, Maclurea, Subulites and Murchisonia being the most characteristic. Orthoceras, Cyrtoceras and Trochoceras are the prevailing genera of the Cephalopoda. Trilobites are very rare within the limits of Allamakee county, a fact not easy to explain, when we consider the abundance of fragmentary remains belonging to this group in certain beds of the Trenton in Fayette, Howard and some other counties only a short distance to the westward. A single pygidium of *Asaphus (Ptychopyge) ulrichi* Clark, remarkable in having the furrows defining the constituent segments unusually distinct, was found associated with *Lingula iowensis* Owen, near the top of the limestone portion of the formation north of Postville, and the head and thorax of *Ceraurus pleurexanthemus* Green, was collected from the second shale bed near Waukon.

In the shales which lie almost immediately beneath the Galena limestone, north of Postville, there occurs an interesting fauna, markedly distinct from the faunas of the beds below, and characterized by the presence of *Rafinesquina minnesotensis* N. H. Winchell, *Orthis (Plectorthis) kankakensis* McChesney, a distinct variety of *Orthis (Plæsomys) subquadrata* Hall, and what seems to be an undescribed species, related to the last, but differing from *O. subquadrata* in the much finer and much more numerous costæ ornamenting the surface of both valves. This fauna resembles in some respects the fauna referred by the geologists of Minnesota to the Hudson river shales; but in Allamakee county it occurs beneath the Galena limestone, while Hudson river shales are not found until an altitude more than a hundred feet higher is reached. About six miles southwest of the point where the species noted above were collected, there are some prominent ridges containing at the summit heavy beds of Niagara limestone, while at the base there are occasional exposures of shales of the Maquoketa or Hudson river stage. In the dolomite quarries of Mr. Wilkes

Williams, near the northeastern corner of Fayette county, the Niagara limestone is taken out down to its junction with the shales, but there are no exposures of these shales in Allamakee county.

GALENA LIMESTONE.

The Galena limestone plays a very unimportant part in the stratigraphy of Allamakee county. It is only at a few points along the southern border of the county that this formation is seen at all. The basal portions only are present, and they follow conformably the alternating beds of shale and limestone that mark the close of the Trenton. North of Postville (Tp. 96 N., R. VI W., sec. 20, Se. qr.), the wagon road cuts through some soft, yellowish, chert-bearing beds of limestone that represent the earlier layers of the Galena stage. At this point the deposits are worthless, considered economically, but about half a mile south of Postville, in Clayton county, there is an exposures of the Galena that has been quarried on a small scale for building purposes. In the southwest quarter of section 25 and along the western boundry of section 36 in Franklin township (Tp. 96 N., R. V W.), there are exposures of Galena limestone of finer texture than those seen farther west, while in Clayton county, a short distance north of Luana, as well as north of Monona, the formation is evenly bedded, and occurs in hard, compact layers varying from six to ten inches in thickness. At these points it has been quarried somewhat extensively, and for all ordinary uses it affords building material of very excellent quality. The formation is again seen in the southwest quarter of section 32, Linton township (Tp. 96 N., R. IV W.). There are here several exposures and all present the usual characteristics of the lower portions of the formation. Without specifying the individual outcrops farther it is sufficient to say that this limestone is developed in Allamakee county only on the upper portions of the divide south of Yellow river, from Postville to near the western border of Fairview township. Only the basal members of the formation are thus included within the limits of the county. The Galena limestone in Allamakee is of little economic importance. It contributes no special features to the topography. Its altitude above the level of the water in Yellow river is about 300 feet. Very few fossils were observed in beds of the Galena stage in the region here under discussion. But one species indeed, the *Rhynchonella perlamellosa* Whitfield, was found in condition for satisfactory identification.

No deposits of indurated rocks younger than the Galena were observed in Allamakee, although it is quite certain that the Maquoketa shales and the Niagara limestone originally overspread a large portion, probably all, of the county. Three miles south of the county line, on the Williams estate (Tp. 95 N., R. VI W., sec. 19, and Tp. 95 N., R. VII W., sec. 24), a conspicuous ridge rising abruptly above the level of the plain to the north is found to be constructed of Maquoketa shales capped by some twenty feet of massive Niagara limestone. The ridge in question is simply an outlier made up of portions of strata of the formations named which have escaped the effects of solution and mechanical erosion whereby the surrounding country has been stripped of deposits aggregating probably hundreds of feet in thickness. There are reasons for believing that the whole of Allamakee county lay beneath sea level and was the theater of active processes of sedimentation until at least the close of the Silurian.

SUPERFICIAL DEPOSITS.

SOILS.

Many causes have united to produce the soils of Allamakee county. In the first place practically all the rocks that overspread this, as well as every other county of Iowa, were made up of a mixture of soluble and insoluble materials. Of these rocks the limestones contain the largest amount of soluble matter, the shales and sandstones the least. As soon as the region was elevated above sea level, at or near the close of the Silurian, the sedimentary deposits were promptly attacked by meteoric waters as well as by the chemically active constituents of the atmosphere. Mechanical erosion was probably feeble at first, for the region rose but little above the sea; but the chemical action of the agents named, as they came in contact with the newly exposed surface, or penetrated deeply into the strata along cracks and fissures, had the effect, within the zone of their activity, of removing the soluble constituents of the strata and leaving the insoluble clay, sand, nodules of chert, iron oxide and whatever else was incapable of passing readily into solution, as an unconsolidated residuum. It was of such disintegrated materials, the product of rock decay, that the first soil of the region was composed. When, later in geological times, the terrestrial surfaces became clothed with vegetation, and generations of plants of greater or less luxuriance grew and perished in succession, organic acids taken up by the percolating ground waters greatly accelerated the processes of rock disintegration, and rapidly increased the depth of the assemblage of incoherent materials that, in popular speech, is called soil. The roots of the plants insinuating themselves into the cracks and crevices of the rocks and growing there, had the effect of forcing the rock masses apart and affording freer entrance to the agents of solution. Strains resulting from diurnal or seasonal alternations of temperature opened up new lines of successful attack that were immediately utilized by the agents of destruction. And thus the rocks slowly wasted away under the influences noted, and the insoluble residual products constituting the soil tended to increase in thickness. But another agent was at work, and it had the effect of reducing the thickness of the mantle of disintegrated material. If such materials could increase in thickness undisturbed, they would, in time, effectually protect the undecayed portions of the strata beneath from destructive influences, and thus put an end to further progress in rock disintegration. But the surface waters exercise mechanical effects as well as chemical, and so the loose surface materials were in part removed by erosion and transportation. By such removal the agents of solution and disintegration had fresh portions of the rocky strata brought within the sphere of their activity. Through the combined effects of disintegration, erosion and transportation, layer after layer of the original sediments covering Allamakee county has been stripped off and carried away. At the mouth of the Oneota river the aggregate thickness of the beds so removed cannot be less than twelve hundred feet.

The amount of residual, insoluble matter in the rocks of Allamakee county, taking the sandstones, shales and limestones all together, would probably, according to observations made by McGee, exceed half the bulk of the original beds. Nowhere, however, is there found any very considerable thickness of residual detritus in the position in which it was produced. The average thickness on the divides and slopes probably does not exceed ten feet. For a short distance back from the Mississippi the recent changes in the base level of the drainage streams has led to the silting up of the valleys. Near the mouths of the rivers, therefore, we find superficial deposits with a thickness of forty, fifty or even sixty feet; but these are largely the result of transportation and redeposition; they are secondary and alluvial, not truly residual. It will be seen therefore that the present thin mantle of residual clays is but a small fraction of the entire product of rock decay which the region has suffered; and that the work of erosion and transportation has in the long run very nearly kept pace with the work of rock disintegration.

Geologists are indebted to Mr. McGee for the revival of the term "geest" to designate the residual products resulting from the disintegration of rocks in place. The geest of Allamakee county conforms to the rule observed everywhere else—that is, it varies in character and composition according to the nature of the underlying rocks. The most typical geest is found in those parts of the county underlain by the Oneota and the Trenton limestones. The decay of the Saint Croix and the Saint Peter formations produces a residual soil composed simply of incoherent sand.

The soils underlain by one or the other of the great limestone formations is a tenaceous, ferruginous clay, sometimes rich enough in ocher to constitute a fair grade of mineral paint, containing in its lower parts imperfectly decayed, highly corroded, iron-stained fragments of limestone, while scattered throughout its entire thickness are grains of sand, nodules of chert, silicified fossils and whatever else of an insoluble character was contained in the original beds. The geest derived from the Oneota limestone may be studied to advantage at Waterville, while that from the Trenton may be seen at numerous points about Waukon. Although the two formations differ very greatly in lithological characters, there are no very obvious differences in their residual products. The limestone immediately underlying the geest, particularly in the Trenton area, is usually very much pitted and corroded, and iron-stained to a depth of eight or ten or even twenty feet, while the geest is found to have insinuated itself into all the pockets and fissures and irregular openings of every kind as far at least as there are signs of decay.

The geest, which by itself constitutes a very poor soil for agricultural purposes, is after all but one of the elements making up the superficial deposits of the county. Everywhere, at least in all places from which it has not been subsequently removed by erosion, there occurs the comparatively recent Pleistocene deposit called loess. The loess rests upon the geest and sometimes grades into it imperceptibly. It is thickest in the southwestern part of the county and becomes more scanty toward the northeast. The loess was derived chiefly from the drift that overspread the greater part of Iowa in the early part of the Pleistocene. It may be in part wind-driven dust carried from the dried verdureless surface of drift covered plains after the retreat of the glacial ice. Such plains existed only a few miles west of Allamakee county. In part the loess may be sediment deposited from turbid water. However it was carried, and however laid down, it differs from geest in being much less tenacious, less ferruginous and less highly oxidized. A foundation of geest with a top dressing of loess makes almost the ideal soil, as the magificent crops of the region of which Waukon is the center, annually testify. When rains are excessive the water passes through the porous loess and leaves the surface not only in condition for easy cultivation, but for such absorption of gases and distribution of moisture as best contribute to the nourishment of plants. In seasons of drought the geest retains moisture which by capillary attraction is brought up within reach of the growing vegetation.

Geest and loess make up the upland soils of the county. The flood plains of the rivers, particularly along the Oneota and its tributaries, are occupied by a rich, mellow, alluvial soil of wonderful fertility. From the mouth of Bear Creek to the Mississippi the Oneota valley, during the spring and summer months, is one great hot bed in which varieties of corn that seldom ripen in ordinary situations north of Kansas or Missouri, make prodigious growth and easily attain full maturity before the advent of the usual autumn frosts. The alluvial deposits of the valley from the confluence of Bear Creek to the mouth of the Oneota seem even now to be increasing in thickness by periodic increments of loam, rich in organic matter, laid down during times when the river overflows its flood plain.

There is no drift, properly speaking, in Allamakee county. The loess is to a large extent a secondary product of the drift. In the southwestern townships there is more or less of overwash from the drift margin to the westward. Granitic bowlders having a diameter of from two to three feet have by some means been carried as far east as Makee township, and fragments of crystalline rocks of every size, from the dimensions of the largest bowlders observed down to the smallest pebbles, are strewn along the main valleys. Even Iron Hill, the highest point in the county, has a soil charged with numerous small pebbles of foreign origin. The high lands therefore as well as the valleys received some products of the drift that could only have been transported by moving water; but aside from the loess the drift products constitute a very inconsiderable portion of Allamakee soils.

In connection with the subject of superficial deposits mention should be made of certain comparatively recent accumulations of rather coarse materials, such as sand and gravel, that are found not only in the principal drainage valleys, but also occasionally in those of secondary importance. The materials in question are usually stratified. They may take the form of ridges, as, for example, the narrow ridge of stratified sand between Bear creek and the Oneota near the confluence of the two streams, or they may cling to the valley sides and produce well marked terraces. The valley of the Oneota affords the best examples of such deposits. Their thickness, measured from the level of the flood plain to the flattened summit is from fifty to sixty feet. One of these deposits may be seen in a valley now carrying a stream of insignificant proportions, just west of Lansing. The accumulations under consideration may probably all be grouped under the name of postglacial terraces. They date doubtless from the time of rapid melting of the ice toward the close of the glacial period. The Oneota river at this time was somewhat exceptionally situated as compared with other streams of the county. The upper part of its drainage area was occupied by ice. Immense volumes of water, set free by melting, must have taxed the carrying capacity of its valley of erosion, and the amount of comminuted rock debris passing down to the Mississippi was limited only by the transporting power of the stream. In the eddies, and along the inner sides of the several curves of the winding valley, the suspended rock detritus was thrown down in large volume; and it is the mere shreds and remnants of such accumulations that now constitute the terraces under consideration.

Geological Structure.

DEFORMATIONS.

Allamakee county is traversed from southeast to northwest by what McGee has called the Snymagil anticlinal. The result is that many anomalies and surprises are met with in tracing the outcrops of strata from point to point along the sides of the intricate system of valleys that lie in the path of this fold. These anomalies furthermore have been rendered all the more puzzling by reason of the fact that the slopes of the sides of the anticline are in some places very gentle and at other places they are unexpectedly steep, while the phenomena are still further complicated by the development of small secondary folds at the points that have been subjected to the greatest amount of dynamic strain.

The greatest variation in the dip of the limbs of the folds occurs apparently on the northeast side of the axis, and the locality where the most pronounced anomalies occur, so far as observed, lies three or four miles east of Waukon. For example, there are several points in the northeast quarter of section 35 in Makee township at which the contact of the Saint Peter with the Trenton is exposed having an elevation above sea level of about 1 200 feet, while less than half a mile to the northeast there is a series of exposures along the juncture of the two formations with the altitude 150 feet lower. The exposed layers of Trenton above the Saint Peter show a steep inclination to the northeast. On the opposite side of the crest the strata are for a mile or two nearly level and then dip to the southwest at the rate of about thirty-five feet to the mile.

There is evidently a well developed synclinal trough along the line marking the least altitude of the upper surface of the Saint Peter sandstone, for northeast of that line the strata rise for a short distance at the rate of seventy-five feet to the mile. Within about a mile and a half the dip changes again to normal.

The effects of the same anticlinal with its correlated synclinal on the northeast side of the axis are very marked in the neighborhood of Quandahl. The anticlinal axis lies a short distance to the southwest of Quandahl, and hence at the village all the strata dip strongly to the northeast. The south side of the valley of Bear creek is characterized by a horizon of springs that issue near the line of contact between the Oneota and the Saint Croix. Contrary to experience in parts of the county where the dip is normal, there are no springs on the north side of the valley. The strata retain their northeast dip until the bottom of the synclinal trough is reached. The position and direction of this trough would nearly coincide with a line projected from the northeast corner of section 18 through the center of section 19 in Waterloo township. Northeast of that line the dip is to the southwest. At first the rate is forty feet to the mile, but farther from the bottom of the fold the rate per mile is only about twelve feet.

Many other flexures and departures from the ordinary dip were noted, but the purpose for which the survey was prosecuted precluded such detailed investigation as would be necessary to determine the direction of the several folds, the amount of departure from normal dip, or the extent of territory involved in each case. It is enough to say that the several strata do not lie in planes inclined at a uniform angle, but that they are deformed by flexion and crumpling to an extent hitherto unsuspected. Foldings in Iowa strata may yet have an economic significance, although no such claim can be made for those of Allamakee county. Successful oil and gas wells are as a rule those only that are drilled along the crests of anticlinal folds, and folds in strata that lie higher in the geologic series than those of Allamakee may some time be proved to be productive sources of both oil and gas.

EXPLANATION OF PLATE.

In plate one is represented a geological section along a line drawn from New Albin to Postville. The section should be read from left to right, beginning at the top of the plate. The numbers refer to the different formations as follows:

1, 2 and 3. SAINT CROIX SANDSTONE.
- 2. Beds equivalent to the Lawrence limestone of Minnesota.
- 3. Beds equivalent to the Jordan sandstone of Minnesota.

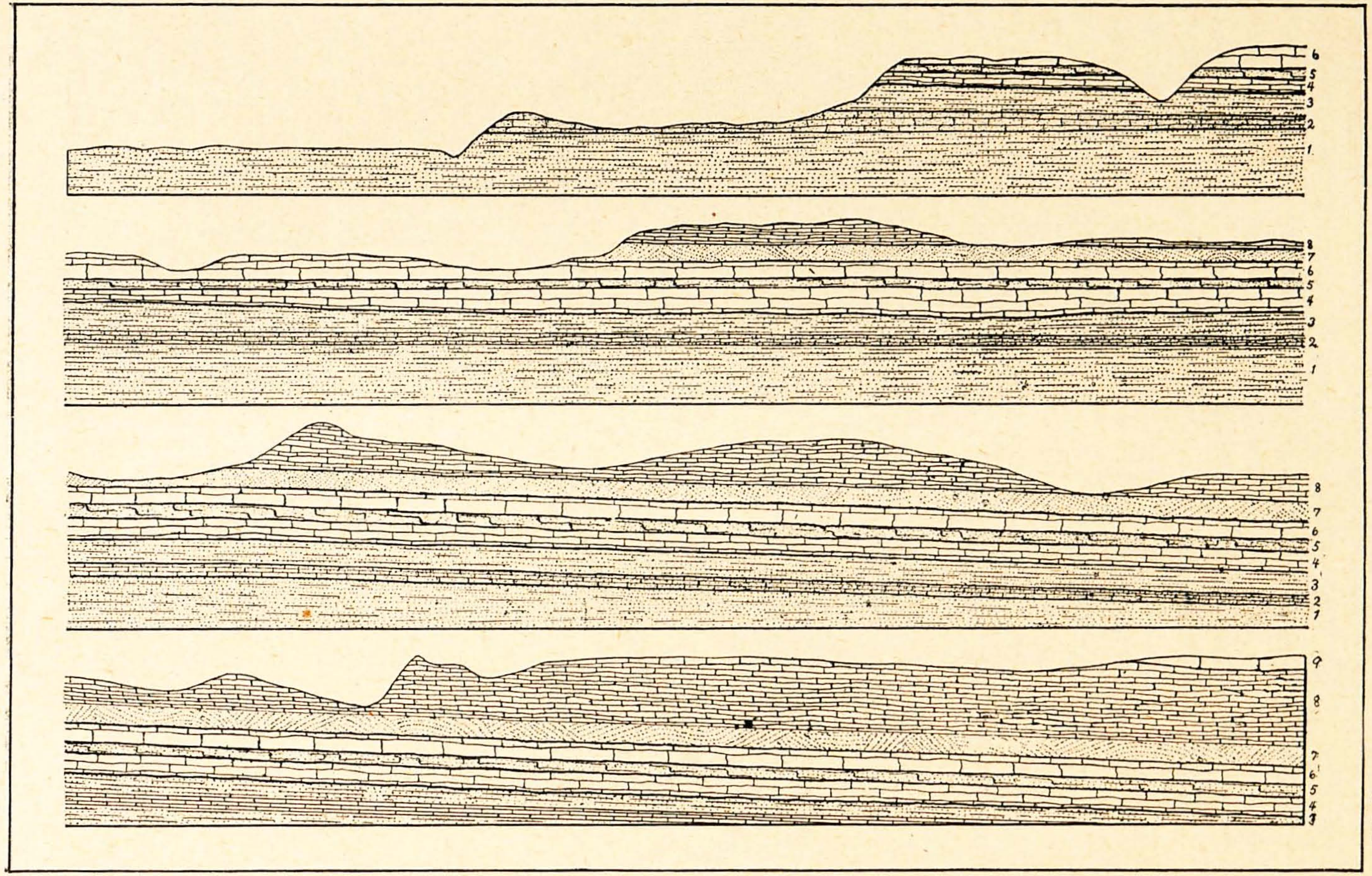
4, 5 and 6. ONEOTA LIMESTONE.
- 5. Intercalated sandstone beds representing the New Richmond sandstone of Minnesota.
- 6. Beds equivalent to the Shakopee limestone of Minnesota.

7. SAINT PETER SANDSTONE.
8. TRENTON LIMESTONE.
9. GALENA LIMESTONE.

ECONOMIC PRODUCTS.

BUILDING STONES.

All the formations of indurated rocks in Allamakee county afford quarry stones that have been employed for building purposes. Some of these quarry products would be ranked as of rather inferior quality, but on the other hand some of the best building stone to be found within the limits of the state occurs in Allamakee.



GEOLOGICAL CROSS-SECTION IN ALLAMAKEE COUNTY.

Saint Croix Sandstone.—As already noted there are beds in the Saint Croix sandstone at Lansing, from 100 to 125 feet above the level of the river, that have been quarried for building purposes. The quarry beds lie beneath the yellowish, shaly, somewhat calcareous, trilobite-bearing layers that are the equivalent of the Saint Lawrence limestone of the geologists of Minnesota. The sand of which they are chiefly composed is cemented with calcium carbonate, and the fissures that intersect the strata have their sides coated with a thin crust of stalagmite. The same beds are exposed at numerous points west of Lansing and in the Oneota valley. The material they afford is fit only for the commonest uses. In general it may be said that the quarries in the Saint Croix sandstone have no commercial value.

Oneota Limestone.—A few feet above the contact of the Saint Croix with the Oneota the dolomite, for a thickness of about thirty feet, becomes evenly and regularly bedded, the rock is fine grained, and the layers vary from three to thirty-six inches in thickness. The value, however, of this portion of the formation as a source of quarry stone is not the same in all parts of the county. At New Albin, Lansing, Harpers Ferry, and generally in the eastern portion, the beds referred to are worked more or less extensively, but the product would rank only as of medium grade. In the northwestern part of the county the beds at the same geological level are finer grained, more compact, and are capable of affording material for fine masonry unexcelled by any limestone in the Mississippi valley. The region in which the quarry stone of the Oneota is best developed lies around Dorchester. Topographically it is very rough, and at present is inaccessible except by wagon. Quarries have not been worked except on a very small scale. Quarrying has been done, however, somewhat extensively by the natural agencies of erosion. Great blocks thus detached and precipitated to the plain were observed at a number of points. In some cases the blocks have split into slabs of varying thickness, with smooth, parallel faces ten or fifteen feet in length and almost as many in width. The undecayed condition of these masses after long exposure under most unfavorable conditions demonstrates their durability. There are many natural exposures affording an opportunity to observe the quality of the quarry stone which the Oneota will some time furnish, among which may be mentioned those near the northeast corner of section 16 in Hanover township (Tp. 99 N., R. VI W.), those in the southwest quarter of section 10, and in the northwest quarter of section 13 in Waterloo township (Tp. 100 N., R. VI W.), and others in section 18 of Union City township (Tp. 100 N., R. VI W.). (Figure 7).

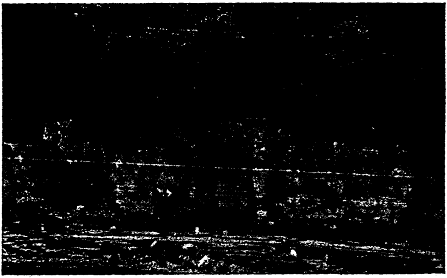


Figure 7. Natural exposure of Oneota limestone northeast of Dorchester.

With only a few exceptions, the Oneota limestone above the beds described occurs in massive layers not easily quarried, and the rock is too coarse and vesicular to be of any value except for the roughest kinds of masonry. Near the summit of the formation, as already described, occurs the intercalated beds of sandstone that represent the New Richmond sandstone of Minnesota and Wisconsin. The sand grains are cemented by secondarily deposited silica which gives to these beds an important element of durability. The beds break readily into prismatic blocks. The stone would be valuable were it not that the aggregate thickness of the beds is too small to justify their being worked except by the simplest and most inexpensive methods.

They may from time to time supply local needs on a small scale.

The Saint Peter Sandstone is in general an uncemented mass of quartzose sand. It is too incoherent as a rule to be considered as a building stone. Nevertheless there are a few exposures in which silica deposited from solution, or iron oxide carried into the mass by infiltration from above, has consolidated the beds sufficiently to justify their use for building purposes. Where iron oxide is the cementing agent the beds are curiously streaked and mottled, bright red and nearly pure white patches being intermingled in ways most fantastic and irregular. Such an exposure is found near the middle of the south half of section 27 in Makee township (Tp. 98 N., R. VI W.), about three miles east of Waukon. An exposure affording an illustration of Saint Peter sandstone consolidated by siliceous cement occurs in the Nw. ¼, Sw. qr., sec. 14, Tp. 96 N., R. V W., where the sandstone stands in vertical cliffs thirty or forty feet in height, and in some cases weathers into angular massive blocks so piled together as to resemble titanic masonry. There are numerous other similar exposures, but those mentioned will serve respectively as types of their kind.

Trenton Limestone.—The quarry stone afforded by the Trenton limestone is so variable in quality as to make it difficult to characterize it. A small proportion of it is very excellent, a large portion is exceedingly poor and unreliable. At no place can a quarry be opened that will afford material uniformly good. In an exposure of fifteen or twenty feet there may be a single layer, eight or ten inches in thickness, that has the qualities desired in a building stone, while all the rest is worthless. Above the thin shale bed that rests on the Saint Peter, and which marks everywhere the base of the Trenton, there are from fifteen to twenty-five feet of rather thick-bedded, yellowish limestone resembling dolomite—the Lower Buff beds of the Wisconsin geologists. These beds are exposed about two miles below Waukon in the valley of Paint creek. They are seen on the land of John Fossum in Prairie Creek township (Tp. 97 N., R. IV W., sec. 6, Sw. qr.). The exposure affording the most massive beds was seen near the southwest corner of the Se. ¼, Sw. qr., sec. 10., Tp. 96 N., R. V W. Here the layers are compact, more than two feet in thickness, and would furnish good material for bridge piers and similar heavy work. While the "Lower Buff beds" of the Trenton have the desired element of durabiliy their texture disqualifies them for use except in any but the rougher kinds of masonry.

About seventy-five feet above the base of the Trenton there are beds that are quarried somewhat extensively near Waukon as well as at other points in the portions of the county covered by this formation, The layers here are fine grained, dark gray or slate in color; but they have the disadvantage of being thin, and many of them break up, first along the planes of lamination and then into small angular pieces, on exposure to the weather. With proper selection excellent building material may be obtained, but it often necessitates the handling and discarding of an immense amount of rubbish. Quarries are also worked on a small scale north of Postville within a hundred feet of the top of the formation, but it may be said that, as a whole, the Trenton limestone of Allamakee county will never be commercially important as a source of building stone.

The Galena Limestone of Allamakee county affords no quarry stone, although only a short distance south of the Clayton-Allamakee line the towns of Monona and Luana are supplied with excellent material for ordinary local needs from this formation.

ORNAMENTAL STONES.

Certain compact layers of the Trenton limestone, made up largely of fragments of brachiopods and bryozoans cemented with what was originally fine calcareous mud, are capable of taking a fine polish and have been used to a limited extent in making table tops, mantles, fancy paper weights and other objects for indoor decoration, in the manufacture of which marble may be employed. All the pores and interstices of the original rock and its contained fossils have been filled with infiltrated calcite. There is usually quite a difference in the shades and gradations of color between the ground mass and the embedded fossils; but on the whole the effect is very pleasing and it is quite possible that the manufacture of polished stone for decorative purposes may become an important industry. The beds most suitable for grinding and polishing occur as rather thin layers of very fossiliferous limestone embedded in blue clay. They begin about forty feet above the base of the formation, and occur, sometimes at rather short intervals, through a thickness of twenty-five or thirty feet. Good exposures may be found in the washes and gullies on section 8, and also near the center of section 19, of Makee township. The same beds are exposed about the middle of the east line of section 18 in Waterloo township. Indeed, owing to the remarkable topography of the county, there is scarcely a section occupied by Trenton limestone that does not afford exposures of the fosssiliferous slabs under consideration.

LIMES.

Allamakee county abounds in limestone, and lime has been made on a small scale at a great many localities. The best lime is that made from the Oneota dolomite. The massive vesicular, most completely dolomitized beds near the middle of the formation, are best adapted to the manufacture of lime. It is from these that the Waterville lime is made, the work of lime burning having been carried on here for several years by Mr. O. C. Frok. Six or seven kilns are burned annually and there are from three to four hundred bushels in each kiln. The quality of the lime is good and a much larger product would find a ready market. Lime made from the Trenton limestone is regarded with little favor. A few small, hastily constructed kilns have been built within the Trenton area to supply immediate local needs, but none of them have been operated continuously for any considerable length of time. The Oneota of Allamakee county is capable of affording material for the manufacture of a high grade of lime in quantities sufficient to supply an empire.

HYDRAULIC LIME AND CEMENT.

Limestones containing from ten to twenty per cent of clay may furnish a quality of lime that has the property of setting under water. If the limestone is magnesian, that is, if part of the calcium carbonate has been replaced by magnesium carbonate, a smaller amount of clay will be sufficient to impart hydraulic properties to the lime. Many portions of the Trenton limestone are more or less argillaceous, and samples might be easily selected that, on analysis, would show the proper admixture of silica, alumina, iron, and calcium and magnesium carbonates to make a good water lime, but the difficulty would be in finding a sufficiently large body of limestone of uniform quality at any one place to justify the outlay necessary to begin the work of manufacturing. One exception may be made to this statement. The "Lower Buff beds," that rest on the basal shale of the Trenton, have a thickness of from fifteen to twenty feet; they are fairly uniform in quality; if one may judge from chemical analysis alone, these beds would furnish a good hydraulic lime. Silica, alumina, iron, and magnesium carbonate are present in essentially the same proportions as in rocks from which hydraulic cement has successfully been made.

CLAYS.

The clays of Allamakee county may be divided into three divisions, namely, loess, residual clays or geest, and clays of primary origin, or shales, that were laid down as part of the original sedimentary terrains. Some phases of the loess in the southwestern part of the county are suitable for the manufacture of ordinary brick. It is seldom that a sufficient body of geest is present at any given point to make it commercially important. The clays deposited as part of the original sediments are found in all the formations except the Saint Peter sandstone. Some are of excellent quality and well adapted to the manufacture of the better grades of pottery. Most of them are of little importance on account of the fact that the beds are too thin to support manufactures on any profitable scale.

In the Sw. ¼, Ne. qr., sec. 9, Tp. 100 N., R. IV W., there is exposed in a road cutting a bed of light colored shale belonging to the Saint Croix sandstone. The geological position of the bed is about two hundred feet below the summit of the formation. A thin bed of gritty shale occurs near the top of the Oneota, but the Saint Croix and Oneota shales, so far as observed, do not require further notice.

Clays, valuable so far as quality is concerned, but often commercially unimportant by reason of the thinness of the deposits, occur at different levels in the Trenton limestone. At the very base of the Trenton, resting directly on the Saint Peter sandstone, is a bed of clay about six feet in thickness. At many of its exposures this clay is of very excellent quality. It is overlain by the rather massive layers of the "Lower Buff beds" of the Trenton, and could therefore be easily mined to a limited extent. By a proper selection of localities material for the manufacture of pottery, paving brick, tile and a number of other clay products might easily be obtained. The exposures of this basal shale are very numerous. It may be seen at all points along the exceedingly sinuous line that marks the contact of the Saint Peter with the Trenton. It is exposed on the road leading north from Waukon on both sides of Village creek. In the valley of Paint creek, about two miles below Waukon, it appears at the surface. The best example of this clay for use in making pottery was seen in the Sw. ¼, Sw. qr., sec. 8, Tp. 98 N., R. V W., in the valley of a tributary of Silver creek. But the exposures are too numerous to be mentioned in detail. This clay bed is one of the most persistent members of the Trenton and may be studied equally well within a short distance of the Iowa-Minnesota line in Waterloo township, near the southern limit of the county in Linton township, or at the eastern extremity of the narrow tongue of Trenton, that lies along the summit of the Lansing ridge (Tp. 99 N., R. IV W., sec. 29, Se. qr., Se. ¼).

Another shale-bearing horizon begins about forty feet above the base of the Trenton and continues through a thickness of thirty feet, but while some of the clay is of superior quality and suited to a variety of purposes, the shale lies in rather thin beds interstratified with highly fossiliferous limestone. Some of the clay beds are rendered useless by reason of the additional fact that they contain fossil corals, bryozoans, and calcareous nodules in considerable abundance and more or less evenly distributed.

A third clay-bearing horizon in the Trenton occurs near the summit of the formation. This is perhaps the most important commercially, for the body of workable clay is in some cases from ten to twenty feet in thickness. Exposures of the upper clays are found in the southeast quarter of section 20 of Post township, about two miles north of Postville, and other exposures occur wherever the undulating surface intersects this same geological plane in the hillsides south of Yellow river. This clay is not worked in Allamakee, but at Clermont in Fayette county it has been utilized for many years in the manufacture of drain tile and cream-colored brick of excellent quality.

The only clay products at present manufactured in the county are ordinary building brick made from the loess and geest at Waukon. Messrs. A. N. and N. H. Peck have operated a brick yard at this point for a number of years. For the last ten years the average annual output has been about 300,000; in 1894 the product reached about 600,000. The bricks are made with a two-horse power "Quaker" machine having a daily capacity of 20,000. The machine, however, is not worked to its full capacity. With steam power and a force of seven men and two boys the output while operating is only about 10,000 daily.

SANDS.

Glass Sand.—Sands suitable for the manufacture of window glass, plate glass, table glassware and the like are found abundantly in the Saint Peter sandstone. It is true that the larger part of this formation is streaked and otherwise stained with iron oxide, but certain portions of the beds, capable of supplying many carloads annually for an indefinite period, are pure and white as pulverized rock crystal, and well adapted to the manufacture of a high grade of glass. The pure white quartzose material seen in the sand pit on the farm of Mr. James Dougherty (Tp. 99 N., R. V W., Se. qr., Se. ¼) affords a good illustration of the quality of the glass sands that occur at numerous points throughout this county. It is characteristic of the whiter portions of the Saint Peter sandstone that they are so loose and incoherent that they may be excavated with a shovel almost as easily as a modern bed of dry river sand.

Building Sand.—Both the Saint Croix and the Saint Peter sandstones are in places easily excavated, and the material has been used as building sand. The supply is unlimited and the distribution so general that very few portions of the county are very far removed from available sand pits. The sand from the formations named is usually too fine, when used alone, to make the best grade of mortar; but when mixed with a certain proportion of coarse river sand it serves an excellent purpose.

IRON.

Hæmatite and Limonite.—The geest resulting from the decay of the Trenton and Oneota limestones is rich in iron oxide. It also often contains nodules and masses of impure clayey limon-

Figure 8. Iron Ore Pit at Iron Hill.

ite or hæmatite; but in general the amount of iron is too small to have any commercial significance. There are, however, two or three points within the Trenton area at which ore, partly true hæmatite and partly the hydrated form called limonite, occurs in considerable amount, and may some time be worked at a profit. The ore beds are on the highest points near Waukon, the principal body occurring at Iron hill in section 17 of Makee township (Tp. 98 N., R. V W). Ore here exists in the form of large concretionary boulder-like masses mixed with ocherous clay. Some of the concretions disintegrate more or less, so that the interstices are often filled with a granular ocher, consisting of hæmatite with some admixture of clay. This could be easily separated by washing and would serve excellently for mineral paint. Pits have been opened at various points to test the quality and depth of the deposit, the results indicating that the ore beds have a thickness of from twenty-five to forty feet.

Another body of ore occurring in Makee township is found on a very prominent outlook in the southeast quarter of section 27. Ore also is found in Paint Creek township, near the northwest corner of section 6. The ore body at Iron hill is, however, the one that is most likely to become commercially valuable.

As already noted the beds of ore that have attracted attention all lie on high points—the highest, indeed, in the entire county. They are all underlain by from fifty to a hundred feet of Trenton limestone, with the exception that, on the south side of Iron hill, the ore comes down so as partly to overlap the Saint Peter sandstone.*

At all points mentioned the ore is a comparatively thin veneer lying over the hill top. The general trend of the ore-capped ridges is east and west. The relation of the ore to the ridge is unsymmetrical, for the thickest part of the body is south of the summit, and the distance below the summit to which it descends is greater on the southern than on the northern slopes.

Like the geest the hæmatite was originally a constituent part of the sedimentary strata that have disappeared from the region through the combined action of erosion and the agents concerned in producing rock disintegration and decay. Unlike

*NOTE.—In the *Pleistocene History of Northeastern Iowa, Eleventh Annual Report of the United States Geological Survey*, p. 548, McGee speaks of the iron ore three miles northeast of Waukon as if it were a part of the residuum resulting from the decomposition of Oneota limestone. At all the points where these deposits occur the Oneota terrain lies deeply buried out of sight, more than a hundred feet below the level of the ore beds, and could have contributed nothing to the residual products resting on the surface, the geest, however, it is not a true residual product, but is rather a result of secondary processes whereby the ferruginous material normally present in the geest has been collected and massed together at a few favored points. Iron hill, the highest eminence in the county, has by far the largest body of ore. The amounts present at the other points observed are less; and the least important ore body is on a hill that is lower than either of the other two. The relation is doubtless largely accidental, but at first sight there would seem to be some connection between altitude and the conditions favoring the concentration of the hæmatite. A possible explanation of the facts observed will be given further on.

That the ore beds here discussed are not primary products of rock decay in place, but that some secondary process of concentration must be taken into account in explaining their origin, will be obvious from a few considerations. First the thickness of the strata removed by solution and erosion from the summit of Iron hill is probably about 800 feet. It cannot, on any reasonable supposition, be more than 1,000 feet. The position of the Niagara escarpment west of the Turkey river, as well as the position of the Niagara outlier at Williams quarry in the northeastern corner of Fayette county, would indicate that the whole region, probably as far as New Albin to the northeast, was originally overlain by the Niagara limestone. Making a liberal estimate of the thickness of the original strata, the beds removed from the top of Iron hill since the sea retreated from Allamakee county would stand as follows:

	FEET.
Niagara limestone	250
Maquoketa shales	100
Galena limestone	250
Trenton limestone	200
Total	800

These estimates are all probably somewhat too large, but allowing them to stand, and allowing, which is quite improbable, that the sea stood over the region until two hundred feet of Devonian strata had been deposited, we would then have a thousand feet of sediments removed in bringing the surface down to the level of the highest divides. Now the amount of iron oxide in a thousand feet of strata is altogether insufficient to account for such a body of hæmatite as occurs on Iron hill, even supposing that none of it had been carried away by the streamlets that have ever been at work removing the clays and all other constituents of the geest. According to analyses made by Whitney, Emory and others, the amount of iron oxide that could possibly be furnished by the Niagara, Maquoketa, Galena and Trenton beds would be less than one per cent of the mass. In one thousand feet of such strata the ferruginous constituent might be sufficient, let us say, to make a layer of hæmatite ten feet in thickness, provided none of it were lost in connection with the processes of erosion during the long ages requisite to bring about the solution and decay of such a volume of sediments. Now in the first place the main body of hæmatite is in places more than three times ten feet in thickness, while in the second place it is highly improbable, indeed it is practically impossible, that the iron oxide alone, of all the residual products, should escape the destructive and translative effects of flowing surface waters. Elsewhere the amount of iron oxide in the geest is but a mere fraction of that which was present in the beds of sediments that have suffered decay. The adjacent portions of the county, with their ferruginous geest, illustrate the ordinary conditions of the residual products, such residua being the normal resultant of the combined action of all the dynamic agents that have been at work on the strata of the region since first it was elevated above the level of the sea. The hæmatite of Iron hill is indicative of some unusual activities and conditions. What these activities and conditions were cannot now be absolutely demonstrated; but in the absence of positive knowledge we are justified in relying on legitimate inference, and there are certain possibilities that may appropriately be considered. By processes well known to the chemist and mineralogist iron oxide is leached out of soils and concentrated in bogs and marshes as a result of chemical reactions taking place between decomposing organic matter—usually vegetable tissues—and the ferric oxide in contact with which decomposition takes place. The processes have been so well set forth by so many writers that the details need not be here repeated.

Ever since the process of rock decay began over Allamakee county the geest has been highly ferruginous and capable of serving, as a source of supply, to agents concerned in the accumulation of iron ore. During the greater part of the time since the Carboniferous period the surface of the county has been covered with a rank growth of vegetation, mostly aboreal, which, falling and decaying in countless successive generations, furnished a second essential for ore concentration. An imperfectly drained area, or marsh, of sufficient extent, constant as to position for a considerable period of time, and receiving the ground water from many square miles of adjacent territory that rises in very gentle slopes, is the only requisite condition remaining. Such a marsh we may assume existed in the latitude and longitude of Iron hill at some time during the long periods required for the removal of the eight hundred feet of sediments that have been stripped off from the whole territory we are discussing above the level of the summit on which the ore now lies. The diagram (Fig. 9), shows the probable succession of conditions which have brought about the present relation of ore to topographic forms. The beds, *d-d*, are the Niagara, Maquoketa, Galena and Trenton strata that have been bodily removed from many hundreds of square miles by the slow processes of solution and mechanical erosion. The line *e-e*, is the profile through the supposed marsh into which the iron was carried after being reduced to the soluble condition through the agency of decomposing vegetable matter. In this marsh the iron was reoxidized and precipitated in the condition in which we now find it. The accumulated ore served to protect the underlying strata, but solution and erosion proceeded to reduce the level of all the surrounding area, until finally the marsh was drained.

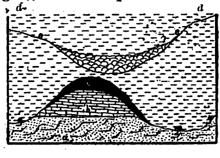


Figure 9. Ideal Section through Iron Hill.

Even after the draining of the marsh the degradation of the adjacent territory proceeded without interruption, while the protective deposit of iron ore effectually preserved the small area it covered. In time the profile was changed to that represented by *g-g*. The bed *a*, represents Saint Peter sandstone, *b* the unremoved portion of the Trenton, and *c* the body of ore that accumulated in the long vanished marsh. At *f* is the channel and valley of Village creek, cut down into the Saint Peter sandstone. The fact that the ore is more abundant on the southern than on the northern sides of the hills is doubtless due to the fact that southward facing slopes recede more rapidly than others, being more exposed to attacks by agents of erosion. At present the southern exposures are destitute of forest growth, while slopes facing to the north are clothed with trees and other protective vegetation. Thawing and freezing and other alternations of temperature affect the hill sides that look southward more seriously than the others, and so the destructive forces are eating under the protective cap of iron ore more rapidly on the southern than on the northern side, with the effect that the ore body is no longer symmetrical with reference to the hill.

Professor G. E. Patrick, chemist of the Survey, reports upon three fairly average samples of Allamakee county ores as follows:

"Sample No. 275—Iron ore from Iron Hill, Allamakee county.

Iron, 54.32 per cent.
Sulphur, none.
Phosphorus, 1.30.

The phosphorous is in the form of phosphate: $P_2\ O_5$=2.97 per cent.
The ore is Limonite or Brown Hæmatite (hydrated sesqui-oxide of iron.)"

"Sample No. 278—Iron ore from near Waukon. (Iron hill.)

Iron, 66.920 per cent.
Sulphur, .047.
Phosphorous, .503.

The phosphorous is in the form of phosphate: $P_2\ O_5$=1.15 per cent.
The ore is Hæmatite (anhydrons sesqui-oxide of iron)."

"Sample No. 279—Iron ore from southeast of Waukon. (From section 6 of Paint Creek township.)

Iron, 58.680 per cent.
Sulphur, none.
Phosphorous, 1.15.

The phosphorous is in the form of phosphate: $P_2\ O_5$=.262 per cent.
The ore is Limonite or Brown Hæmatite (hydrated sesqui-oxide of iron)."

At present the nearest shipping point to Iron Hill is Waukon, which would necessitate a wagon haul of three miles. This fact, coupled with conditions that render iron properties of the highest grade practically valueless, makes it now impossible to handle these ores with any profit.

MINERAL PAINT.

The residual product, or geest, resulting from the decay of the Trenton and Oneota limestone is everywhere highly charged with oxide of iron. The rich color which the iron imparts to the clay has led in some places to the popular belief that the whole body of local geest is practically a deposit of mineral paint. While in general the geest contains too much clay to justify the belief referred to, it is yet true that many somewhat limited portions of it are sufficiently ocherous to make it suitable for use in painting barns and other structures where efficiency and durability are the chief qualities desired. Paint creek receives its name from the paint-like character of the red ocherous geest that abounds at different points along its valley, notably near Waterville and Waukon. The chief source of material for paint in the county and the one that may be worked for this purpose with reasonable prospects of profit, is the red, powdery, interstitial filling between the concretions of hæmatite on Iron hill. At all events this source might be operated with profit if there was any paying market for the iron ore.

LEAD.

Galena or Galenite.—Ever since the settlement of the county there has been a prevalent impression that large bodies of lead ore exist in the Oneota limestone and only await discovery to confer undertermined wealth on the fortunate prospector. There is also a tradition that the Indians were familiar with the location of some of these ore bodies, and were in the habit of resorting to them periodically to supply themselves with lead. While is is true that the Oneota, like other great beds of dolomite, is a lead-bearing rock, it may be said at once that it can not be counted among the important sources of supply for this mineral.

More or less of galena of very excellent quality may be found in all the valleys cut in the Oneota limestone. In eroding the valleys the mineral was weathered out of pockets in the dolomite. Pockets and crevices containing galena are often met with in working quarries in the formation. Some of these have been brought to light by systematic prospecting, but with one exception the mineral has not been found in sufficient quantities to pay the expense of mining it. With the single known exception referred to the galena of the Oneota occurs in small pockets or fissures, a few inches wide, and at most from a few feet to a yard or two in length. There are no regular crevices, and the prospector finds after penetrating a short distance from the face of the bluff that the rock around the mineral bearing cavities is solid and not decomposed by weathering. The work of mining, therefore, is difficult and the reward meager and uncertain.

In the valley of Mineral creek, a small stream that enters the Oneota nearly opposite the mouth of Bear creek (Figure 10),

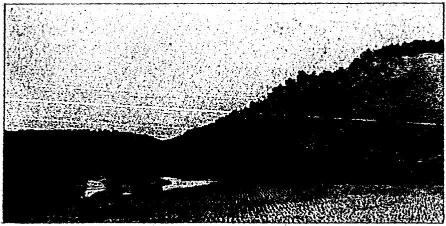


Figure 10. Canyon and bluffs of the Oneota river at the mouth of Mineral creek.

mining was prosecuted with a great deal of vigor a number of years ago. About a hundred thousand pounds of mineral, it is claimed, were taken out, the town of New Galena was built, and there were hopes that an important mining center was about to be developed. But the absence of true crevices that could be followed with ease and certainity, the hardness of the undecayed rock and consequent difficulty of mining, and the small size of the mineral bodies when they were discovered, led to discouragement and general abandonment of the enterprise. The town of New Galena has disappeared and with it have gone most of the miners that came into the picturesque little valley in search of fortune; but a few hopeful prospectors remain, and, undeterred by the results of past efforts, continue to burrow in the hillsides in the hope always that to-day will certainly bring better luck than any of the days that have thus far come and gone. There is enough mineral to make the prospect seem good and to keep hope fully alive, but never enough adequately to pay for the labor and expense involved in finding it. In the aggregate the Oneota limestone doubtless holds a large amount of lead ore, but past experience offers little encouragement to men to abandon other industries and spend time and money in the search for paying bodies of such ore in this particular formation.

The mines of the Lansing Mining and Smelting Company constitute the exception already noted. These are located about six miles northwest of Lansing (Tp. 99 N., R. IV W., sec. 10, Nw. qr., E. ½). They were discovered by Captain J. M. Turner who is now serving as superintendent of the mining company. The ore occurs in a north and south crevice that has been prospected and found to contain mineral in paying quantities for a distance of 1,200 feet. The vertical dimensions of the crevice are not known, but are not less than seventy-five feet. The sheet of mineral is about three inches in thickness, but the crevice, since the lead ore was deposited, has been widened by the decay of the wall rock, and the space thus added is filled with a residual product that is practically the same as geest, namely, ferruginous clay with partly decomposed nodules of chert. The ore, when first deposited, was evidently the lead sulphide, but the ground waters carrying carbon dioxide and organic acids have largely decomposed the sulphide and changed it superficially to lead carbonate. It is probable that the lead was deposited in the crevice early in geological time, certainly not later than the earlier Cenozoic, for everything about the wall rock, the ore body itself, and the residual material filling the space that has been added through the effects of agents of decomposition and decay, all indicate the lapse of long periods of time since the galena was collected from the surrounding mass of dolomite and deposited in what was at the time a very narrow crevice.

Captain Turner is confident that the Oneota limestone contains other crevices as productive as the one on which his company is now operating; and there is no reason to doubt the correctness of his position except the fact that this is the only true lead-bearing crevice thus far found in this formation. Others probably will be found in time, but thus far the region adjacent to the mine under consideration has not been very thoroughly prospected.

The decomposition of the wall rock and widening of the crevice makes it possible to follow and remove the sheet of ore with little necessity for blasting. The vertical position of the crevice renders little timbering necessary, and whatever timbers are needed are readily supplied by forests on adjacent portions of the company's property. No pumping is required in operating the mine, for the Oneota limestone is singularly free from underground channels; the nearest water-bearing horizon is that which lies about a hundred feet below the upper limit of the Saint Croix sandstone. The mine, therefore, is dry, the work being in no way impeded by the presence of water. In June, 1893, a hundred tons of ore had been taken out and were lying on the dumps ready for shipment. A letter from Hon. James H. Trewin, president of the mining company, states that during the winter of 1893-4 the mines were worked constantly, employing ten men, and that about 250,000 pounds of ore were raised. The machinery for raising the ore is the simple windlass operated by hand power. The total amount of ore mined and prepared for market up to December, 1894, was 500,000 pounds, and the value of the output at present market rates is about $10,000.

While the Oneota limestone is the lead-producing, and, in general, the lead-bearing rock of Allamakee county, some ore bodies are occasionally found in the underlying Saint Croix sandstone. The Saint Croix lead ore was doubtless deposited by descending waters that became charged with salts of lead while passing through the Oneota limestone and reached the Saint Croix before the sulphide was precipitated. Concerning one of these deposits very recently worked on the Lansing company's property, Mr. Trewin writes: "We took several thousand pounds from the Potsdam (Saint Croix) sandstone, but there does not seem to be much yield in that formation." The ore body of the Saint Croix, referred to by Mr. Trewin, lay in a fissure in the sandstone immediately beneath the lead-bearing crevice of the Oneota from which the Lansing Mining and Smelting Company have taken practically all the ore thus far produced. It occurred at the north end of the mine, where a ravine cuts transversely to the crevice, and all the ore contained in the sandstone was found within a hundred feet of the face of the bluff.

Analyses made by Professor G. E. Patrick show that the lead ores of Allamakee county, like those generally of the Upper Mississippi Lead Region, contain little or no silver. A sample from the Lansing company's mine, quite thoroughly coated externally with carbonate, contained 77.58 per cent of lead, while a specimen of pure sulphide from the site of the old mines near New Galena, analyzed 86.6 per cent.

ZINC.

Zinc carbonate (smithsonite) occurs occasionally in the residual detritus at the foot of cliffs of Oneota limestone. No bodies of this ore were seen in place, but there is no doubt that like the lead ore, it was derived by weathering from pockets and openings in the dolomite. A sample from Mineral creek analyzed by Professor Patrick, showed 46.08 per cent of metalic zinc.

WATER POWERS.

Allamakee county is generously supplied with cascades and with streams having channels descending at a comparatively high angle, so that water powers in large numbers, with head ranging from ten to ninety feet, might easily be obtained. Along the head waters of the streams that are tributary to the main drainage courses, the channels are yet far from being cut down to base level, and it is upon such streams that water powers might be obtained with very little labor. Springs with sufficient volume of water to make them important as a source of power, issue at many points from the sides of bluffs, and the resulting streams fall in a series of cascadessometimes as much as a hundred feet in a comparatively short distance. The cascades at Devil's Den (figure 11) and at Pinney's spring (figure 12)

Figure 11. The waterfall at "Devil's Den."

have already been described, and are typical of what occurs at scores of localities within the county. But little has yet been done in utilizing the numberless sources of energy with which the county is so bountifully provided, but the time is certainly coming when a wider application of electricity to domestic and commercial uses will make all the possible water powers more valuable to the county than beds of coal.

Mr. J. G. Ratcliffe has compiled the following table showing the water power in use in Allamakee county in 1893.

NAME OF MILL.	STREAM ON WHICH LOCATED.	NAME OF OWNER.	POST-OFFICE.	KIND OF MILL.	APPROXIMATE FALL IN FEET.	APPROXIMATE HORSE POWER.	LOCATION.
Myron	Yellow river	Abram Hart	Postville	Grist	14	15	Sec. 3, Post Tp.
Manchester	Yellow river			Grist	10	12	Sec. 6, Franklin Tp.
Forest	Yellow river	Wm. Werham	Forest Mills	Grist and saw	12	18	Sec. 5, Franklin Tp.
Volney	Yellow river	Aug'st Tangaman	Volney	Grist and saw	10	20	Sec. 13, Franklin Tp.
Buckland	Yellow river	E. L. Cahoon	Buckland	Grist and saw	10	15	Sec. 16, Linton Tp.
Ion	Yellow river	Doehler & Kean	Ion	Grist	8	16	Sec. 24, Fairview Tp.
Waterville	Paint creek	V. H. Stevens	Waterville	Grist and saw	14	15	Sec. 22, Paint C. Tp.
Bluff Springs	Paint creek	Michael Haas	Waterville	Grist and saw	10	10	Sec. 31, Taylor Tp.
Eagle	Village creek	Alex. Deramore	Village Creek	Grist	15	15	Sec. 14, Center Tp.
Union	Village creek	August Doehler	Village Creek	Grist	16	20	Sec. 13, Center Tp.
Capoli	Village creek	Joseph Doehler	Village Creek	Grist	4	8	Sec. 18, LaFayette Tp.
Woolen	Village creek	C. O. Howard	Waukon	Woolen fact'y	17	25	Sec. 18, LaFayette Tp.
Centennial	Village creek	Fred Doehler	Village Creek	Grist	7	15	Sec. 7, LaFayette Tp.
Kepler's	Lansing creek	——— Kepler	Lansing	Grist	14	15	Sec. 30, Lansing Tp.
Haney's	Lansing creek	Peter Larson	Lansing	Grist	18	15	Sec. 30, Lansing Tp.
Harper's Fe'y	Bulger's creek		Harper's Fe'y	Grist	15	8	Sec. 23, Lansing Tp.
Hirt's	French creek	Hirt estate	French Creek	Grist	12	12	Sec. 11, French C. Tp.
MacMillan's	French creek	C. MacMillan	French Creek	Grist	15	16	Sec. 2, French C. Tp.
Dorchester	Waterloo creek	J. Langenbach	Dorchester	Grist	15	15	Sec. 24, Waterloo Tp.
Quandahl	Bear creek	Peter Quandahl	Quandahl	Grist and saw	15	15	Sec. 30, Waterloo Tp.

Mr. Ratcliffe adds that, on account of the decadence of milling interests and the change from wheat raising to dairying, many water powers that were formerly in use have been abandoned. In addition to the foregoing list there are at least twenty-four abandoned mill powers that might be enumerated. With the coming demand for energy for other purposes than

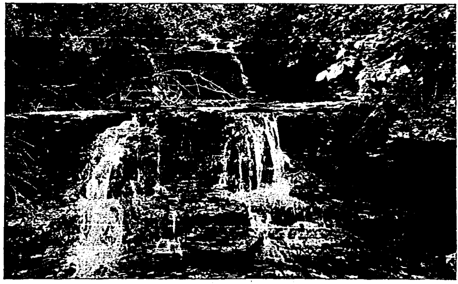


Figure 12. Cascades in gorge of Trenton limestone at Pinney's Spring.

milling, all the old mill properties will once more become valuable, and all the possible properties of the kind that have never been improved will be harnessed to useful work, and made to furnish employment to labor, while supplying comforts and conveniences to homes of intelligence and refinement.

GEOLOGICAL MAP.

The geological map accompanying this report shows approximately the distribution of the various formations of indurated rocks in Allamakee county. A separate map would be necessary to show the superficial deposits. Of the several indurated beds there are many narrow tongues and outlying areas that could not well be represented without confusion on a map of this scale. Only one lead mine is represented, for though lead has been mined at many points within the county, the amounts taken out have been too small to justify the recognition of mines except at the one point indicated. Clays are everywhere abundant, but only at Waukon have sustained efforts been made to utilize them. Stone quarries have been opened at hundreds of points within the county and have been worked to a greater or less extent. In every township, in almost every section, there are many rock exposures capable of affording useful material for many purposes. It is obviously impossible to indicate all of these points without covering the map with quarry symbols. It is to be understood, therefore, that the points symbolized as stone quarries are only a few of the more important localities where stone has been taken out. Lime has been made in small quantities in almost every neighborhood, but the lime kilns indicated at Waterville are the only ones that have been persistently operated on a commercial scale.

ACKNOWLEDGMENTS.

The Survey is under obligation to many citizens of the county, indeed to all with whom its representatives came in contact, for intelligent interest and substantial assistance. Especial acknowledgments are due to Mr. Ellison Orr, of Postville; Mr. Charles Barnard, Judge M. B. Hendrick, Mr. A. M. May, Engineer J. G. Ratcliffe, and Mr. Langford May, of Waukon, and to Captain J. M. Turner, and Hon. James H. Trewin, of Lansing.

These men all possessed knowledge of local phenomena of geological interest, and all freely gave their time in contributing important facts, or in conducting the representative of the Survey from point to point, with the result that the data he might require for the solution of the geological problems which this most interesting division of the state presents were collected and noted in much less time than would otherwise have been possible.

Mr. J. G. Ratcliffe collected and mapped the topographic data without which the mapping of the geological formations would have been practically impossible; and the Survey is indebted to Prof. T. H. Macbride for the interesting subjoined paper on the forests of Allamakee county.

FOREST TREES OF ALLAMAKEE COUNTY, IOWA.

BY PROF. T. H. MACBRIDE.

The forests of Iowa have never been adequately studied. Indeed, so far as known, no systematic attempts have ever been made to render proper account of this most important section of our native flora. We have been so engrossed by the unmatched wealth and fertility of our prairies that our woodlands have been largely ignored, or thought of only as obstacles to be gotten rid of as rapidly as possible. This has ever been the American view of the subject. The older nations of the world, struggling by great expenditure of labor and money to maintain forest conditions in their own crowded communities, look aghast at the wasteful recklessness prevalent in the United States, where by nature we possess, but thoughtlessly turn over to destruction, that which they toil so earnestly to secure. Fortunately for us our people are at last awaking to some appreciation of the situation. The increasing rigor of our inland climate, increasing intensity of cold in winter and heat and drought in summer, with ever swifter and more sudden alterations of extremes of heat and cold, the increased erosion of our lands, accompanied by increased irregularity in the volume of all our streams, the alternate flooding, and the choking of even great rivers like the Des Moines and the Mississippi—all these facts are at last beginning to attract the attention of people generally, and to enable them to see that by the wide occupation of our country we have in some serious way disturbed the orderly operations of Nature. We have accelerated the operation of forces which bring to us, as civilized men, evil and only evil, and that continually. Among the causes which are bringing about these deplorable results are some which are incident to the very fact of the presence of civilized man. Civilized men are agriculturists. They continually loosen the surface of the ground for the cultivation of crops and so incidentally contribute very largely to the erosion which chokes our streams. A more careful husbandry will eventually, in large measure, remedy this by such use of the land as will prevent, to a very large extent, the removal of the soil.

Individual self-interest will look out for this. But there are other factors in our problem much more far-reaching and difficult to manage. Of these, perhaps, the principal is that which pertains to the question of forestry. It is a fact long undisputed that the presence of a certain amount of forest is absolutely essential in those lands which are to remain the habitation of enlightened humanity. This does not mean that there shall everywhere be found trees planted about the homes of men. What is here intended is that in all parts of the country there shall be found regions where the land is given up to trees, where true forest conditions prevail. This was the condition of affairs when civilization first came into the Mississippi valley. In Iowa, for instance, every stream was bordered by natural woods which extended more or less widely over river bottoms and fertile flats, filled up as well every narrow ravine and covered every precipitous hillside, while Wisconsin and Minnesota, as we all know, were largely clothed with dense forests of coniferous trees. Now it is undisputed by all men competent to judge, that such forests greatly modify climate. They form efficient obstacles in the pathway of sweeping winds; also, a yet more important particular, they constitute vast reservoirs of moisture, prevent its rapid dissipation, render more humid the atmosphere and more regular the rainfall over vast areas in regions where such forests are found. Now what is the present situation? We have ruthlessly destroyed the forests of the two great states mentioned; by our methods have almost utterly obliterated the natural woods, leaving a desert in their place. The results are now felt in the whole Mississippi valley. The year 1894 shows a drought such as was never heard of before. In Iowa, too, the same destructive agencies are at work. In the greater part of the state lumber trees, old trees, have long since been nearly all cut away, while the "second growth," which might be efficient, which might stand in place and maintain for us the little forest-conditions that the state at first enjoyed, is rapidly disappearing before the axe of those whose effort is to convert even our steep clay hillsides to purposes of pasture and tillage. We have had so little woodland from the outset that the effect of our clearing is sure to be the more speedily felt. This effect will be manifest in Iowa, rather in the consequent irregular flow of our streams. We shall have, instead of clear rivers and springs and creeks, such as the older residents of the state well remember, flowing the year through, nothing but waterways, now flooded by destructive muddy torrents confined by no legitimate channel, now dry runs, now wide reaches of sand; with dearth of water in all fields and pastures.

In view of such facts and conditions what shall be done? We cannot do anything for Minnesota and Wisconsin. Those great commonwealths must act for themselves, as they will presently, the more energetically as the interests involved are vaster. We, however, residents of fruitful Iowa, must do something. We must spare the forests we have. Every man owning forest lands must be taught to prize his possession. He has, by Nature's effort, that which money cannot restore. Not that he shall cut no trees, but simply that he shall not extirpate the woods. He shall preserve the forest conditions and allow the forest, as it will, to continually renew itself. Especially must this be done along steep hill sides and along all the water courses of the state. We are in danger of seeing in Iowa the conditions which obtain in western Nebraska and Kansas. Our only hope lies in the wisdom of our people. The state, therefore, cannot too soon begin to spread information on this subject. It is even now too late to know the whole truth. Our study of Iowa forestry must depend upon knowledge derived from examination of a remnant. A thorough report on the present conditions of the state in this regard is most urgently needed. Such report should be accessible to every citizen, to the end that universal information should create a popular sentiment favorable to forest preservation.

The present paper aims simply to present a few facts observed in a recent somewhat hasty survey of the hills of Allamakee county. This region of the state offers many geological peculiarities. These are reviewed more or less exhaustively elsewhere in this report. To trace the relationship between these topographical conditions and the spread of the native forest would be an interesting endeavor for which we have at present hardly sufficient data. Even under existing conditions we may, however, determine some facts pretty clearly.

Except in special localities the primeval forest in Allamakee county, as elsewhere in Iowa, was, when first seen by white men, not dense as it has since appeared. I have been informed by men who traversed the woods more than sixty years ago, that at that time one could drive a wagon anywhere through the Iowa forest. We may well believe this if we observe simply the old trees, where these yet remain, and remember that all the crowded smaller trees have come up within the last thirty or forty years. Fire is the great check to the extension of the forest, and prior to the occupancy of Iowa by civilized men fires were sufficient to so far retard forest growth that only a few trees found place where now stands the impenetrable so-called "second growth." In that early day a large portion of Allamakee county was covered with such forests, especially the eastern half of the county. Not only the river valleys and the hillsides sloping to them were wooded, but even the flat hilltops, now cultivated, were covered by scattering trees. At present the old trees which constituted the entire forest primeval are mostly gone. Here and there, for one cause or another, a few remain, but throughout the county the best and largest have, even within recent years, found their way to the saw mill.

It is claimed by some people that the second growth occupies really more territory than that occupied by the original timber; that it has actually invaded the prairie. This might have been possible if the prairies had remained long untilled subsequent to the suppression of the fires; but inasmuch as the suppression was that the prairie might be occupied by agriculture, it seems probable that the second growth hardly marks the extent of the original wooded district, much less overreaches it. The number of individual trees may possibly be greater now than before, because the smaller trees are much more closely crowded.

Prairie fires have been mentioned as the probable check to the westward extension of the woodlands of Iowa. This is only one of the factors in the problem and this itself is conditioned upon another, viz: the amount of moisture prevalent in the region, that is the amount of precipitation of rain or snow. If the rainfall of spring is sufficient to make the ground quite wet until the season of spring prairie fires has passed, the seedlings of the forest have a chance to start and grow for some months before they are in peril of fire in the fall again. If in this latter season there is sufficient rainfall, and if during the winter the country is buried in snow, the danger from fire is so far minimized, and the young trees have a chance to attain considerable size before the unequal seasons bring about conditions that shall subject the saplings to the test of fire. It follows from this that, other things being equal, those particular localities will be more favorable to the occupancy by trees where the amount of moisture is greater, and especially where it is more continuous from month to month throughout the year. Now it is a matter of common observation that in a hilly country, in the Mississippi valley at least, the south and west hillsides are dryer than those sloping to the north and east. This, for two reasons. In the first place the afternoon sun dries the first named hill-

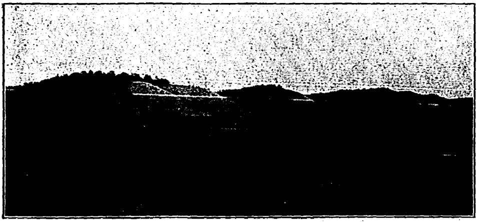


Figure 13. Bluffs showing characteristic distribution of timber.

sides more competely. North slopes in our latitudes are for only a few months exposed to the sun at all; eastern slopes have the advantage of the dewfall and the coolness of the night before meeting the heat of the morning sun; while the south slopes lie all day long beneath the hottest rays, and the west endures the heat of the afternoon. In the second place, our prevailing winds being from the west, the greatest amount of snow is always lodged on eastern or southeastern slopes. Of all these conclusions Allamakee county shows us a remarkable confirmatory illustration. The observer has but to drive across the county anywhere to discover that the southwestern sides of all the rounded knolls and hills are bare; always have been. This is plainly shown in figure 13 from a photograph taken near the center of section 16 in Union City township. This circumstance is not due to difference in soil, level, pitch or anything of that sort, for these factors around the hill are just the same. The difference comes wholly from unequal amount of moisture received and retained.

A casual examination of the case in Allamakee county illustrates still another fact in reference to Iowa's forest trees, that is that some are much better adapted than others to unequal conditions such as just described.

The bur oak, for instance, comes nearest to being able to occupy the unfavorable sides of an Iowa hill. Let anyone take the road leading south from Silver creek in the direction of Waukon (Tp. 98 N., R. V W., secs. 3 and 4). The road for some distance follows a ridge of Trenton limestone. Here the west side of the road is occupied by bur oaks almost exclusively. Hickories, black oaks, scarlet oaks, etc., abundant to the east, hardly pass the middle of the ridge. This fact is so patent that it is sure to attract the attention of anyone merely driving along the highway. This hardiness of the bur oak is in accordance with what may be observed elsewhere in regard to its general distribution. The species is found entirely across the state and as far west at least as the Black Hills of South Dakota. In many cases it forms a scrubby grove upon the prairie, the only species of arboreous plant for miles and miles.

The following is a list of the larger trees observed growing native in Allamakee county:

Tilia americana L., Basswood. Common.

Acer saccharum Marshall, Sugar Maple. Common, especially along streams.

Acer saccharinum L., Soft Maple. Common. Commonly planted everywhere.

Acer spicatum Law., Mountain Maple. Rare, along the bluffs of the Mississippi.

Negundo negundo (L.) Sudworth, Box Elder. Common everywhere and commonly planted.

Rhus typhina L., Staghorn Sumach. Common in the eastern part of the county, especially along the bluffs overlooking the Mississippi river, where trees eight inches in diameter and forty feet in height may be seen.

Robinia pseudacacia L., Common Locust, Black Locust. Common. Subject to the destructive attack of a species of beetle which a few years since threatened the existence of the species in this part of the world, at least rendered the tree useless for economic purposes. Within the last ten years, however, the beetle seems to have met with some check which greatly diminishes its power for evil, and the Locust is rising to its former importance as a timber tree.

Gymnocladus dioicus (L.) Koch. The Kentucky Coffee-tree. Not common.

Gleditschia triacanthos L., Honey Locust. Not common, but seen in a few places near the Yellow river.

Prunus americana Marshall, Wild Plum. Everywhere common.

Prunus serotina Ehrh. Wild Cherry, Wild Black Cherry. Not uncommon.

Cratægus coccinea L., Common Hawthorn. Not rare.

Cratægus tomentosa L., Scarlet Thorn. Common.

Amelanchier canadensis Torr. and Gray. Service Berry, Shadbush. Not rare along rocky banks.

Fraxinus americana L., White Ash. Common.

Fraxinus expansa Willd., Green Ash. Common.

Ulmus pubescens Walt., Slippery Elm. Common.

Ulmus americana L., American Elm, White Elm. Common.

Ulmus racemosa Thomas, Cork or Rock Elm. Beautiful specimens of this tree occur in all the valleys visited. The species is very distinct, recognizable from afar by anyone who has once compared it with either of the other two common species.

Celtis occidentalis L., Hackberry. Not rare.

Morus rubra L., Mulberry. One tree only noticed near the mouth of Yellow river.

Platanus occidentalis L. Common along streams, especially near the Mississippi river.

Juglans cinerea L., Butternut, White Walnut. Common.

Juglans nigra L., Black Walnut. Common. A few large trees still occur here and there, and no grove of "second growth" on rich land seems to lack its quota of this most valuable species.

Hicoria ovata (Mill.) Britt, Shell-bark Hickory. Common.

Hicoria glabra (Mill.) Britt, Pig Nut, Brown Hickory. Common.

Betula papyrifera Marshall, Paper Birch, Canoe Birch, White Birch. Not uncommon. Certainly confined to the northeastern corner of the State.

Betula nigra L., River Birch, Red Birch. Common along the Mississippi river.

Alnus incana Willd., Speckled Alder, Hoary Alder. Common along Yellow river.

Ostrya virginica Willd., Ironwood, Hop Horn-bean, Leverwood. Common.

Carpinus caroliniana Walter, Blue Beech, Water-Beech, Ironwood. Common on rocky banks along streams.

Quercus alba L., White Oak. Common.

Quercus macrocarpa Michx., Bur-Oak. Common.

Quercus muhlenbergii Engelm., Chestnut Oak. Common or, at least, not rare.

Quercus rubra L., Red Oak. Not rare.

Quercus coccinea Wang., Scarlet Oak. Not rare.

Salix nigra Marsh., Black Willow. Common in various parts of the county.

Populus tremuloides Michx., American Aspen, Quaking Asp. Common.

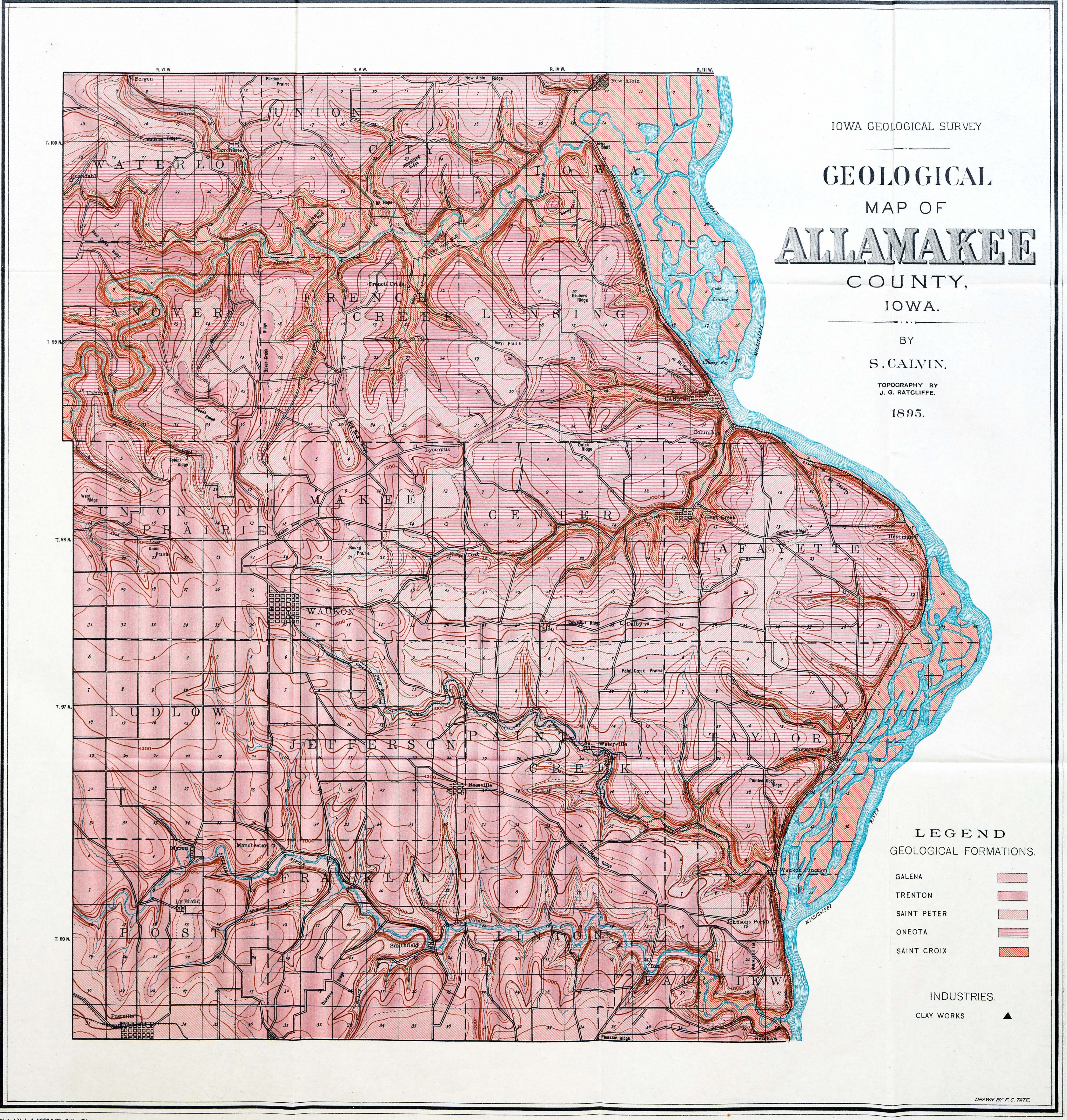
Populus grandidentata Michx., Quaking Asp, Poplar. Common.

Populus monilifera Ash., Cottonwood, Necklace-poplar. Common. Commonly planted in prairie parts of the county.

Pinus strobus L., White Pine. Not uncommon on the higher ridges.

Abies balsamea Miller, Balsam. Not rare. A fine grove on the hill above Yellow river, near Myron.

Juniperus virginiana L., Red Cedar. Not rare on rocky ledges.



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