Macbride, Thomas H.
The geology of
Emmet, Palo Alto
and Pocahontas
Counties

GEOLOGY

OF

Emmet, Palo Alto and Pocahontas

COUNTIES

BY THOMAS H. MACBRIDE.

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DES MOINES
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INTRODUCTION TO COUNTY GEOLOGY.

The Iowa Geological Survey is engaged in preparing a geological map of Iowa, upon a scale of half an inch to the mile. That is, a half inch on the map represents a mile upon the surface of the ground. This map is issued in a series of sheets, each covering a county. The sheets are printed as fast as they are prepared. Each is accompanied by a text forming a report upon the area represented by the map, describing its surface features, its geological structure, and its mineral resources. The sheets and accompanying descriptive texts issued in any one year are bound together to form, for that year, the annual report of the Survey. A few hundred copies of each county report are, however, bound separately and issued as pamphlets. Necessarily the text accompanying any one map is concerned with the geology of the particular area to which the map refers, and to that alone.

For the benefit of readers unfamiliar with geology, who may not receive the full set of publications of the Survey, it has been thought desirable to furnish, with each separate county report, a brief resume of the geology of the state as a whole.

Geologists deal almost exclusively with rocks, but rock, in the wide, scientific use of the term, includes all classes of earthy or stony material, whether consolidated or not. Soft chalk, softer clay, or the loose bed of sand or gravel—if produced by natural, physical agents, such as currents of air or water—is to the geologist as much rock as the hard granite bowlder occasionally found on our prairies. In accordance, however, with the somewhat prevalent notion, the rocks of Iowa may be divided into hard and soft, into indurated and non-indurated rocks, into the regularly-bedded deposits that are recognized as rocks by even the non-geological observer and the loose, superficial materials that almost everywhere conceal the beds of the indurated series. The hard or indurated rocks of Iowa are made up mainly of limestones, sandstones, and the various forms of shales, all of which, however, differ among themselves very greatly in the matter of hardness. The indurated series of the state does not include any volcanic rocks, for nowhere, except at a few points now buried beneath some hundreds of feet of later beds, is there any evidence that Iowa ever included volcanic centers.

The hard, regularly-bedded rocks of Iowa were formed almost exclusively under water. They were originally loose, soft sediments spread out where they now lie, in regular sheets or layers, on the bottom of ancient seas. The present sandstones were originally submarine sand banks, the shales were beds of mud, the limestones were the product of coral reefs or marine shells of various kinds, broken and ground into fragments, and the coal seams were first masses of vegetable matter accumulated in swamps or marshes, somewhat as similar matter accumulates in modern peat bogs. The areas in which coal accumulated differed from modern peat bogs, however, in the fact that they were almost exclusively salt-water marshes, limited to what was, at the time of coal formation, the continental borders. That the rocks of the indurated series in Iowa are mainly of marine origin is clearly indicated by a number of lines of evidence; but it may be sufficient to note that the shells, corals, and other organic remains, so generally found imbedded in the various strata, are all of marine types. They are skeletons of creatures that lived in the waters while the rocks were forming, and they are of such types as could live nowhere but in the sea. They tell not only of the presence of an ocean over certain parts of Iowa at the time the sediments in which they are imbedded were laid down, but they reveal the character, condition, and stage of development of the marine life of the globe during the successive far-away periods that collectively make up geologic history. The rocks in question, therefore, so far as relates to Iowa, are nothing more than the consolidated sands and muds of old sea bottoms preserving for our inspection samples of the life that occupied the seas at the time each successive bed was in process of accumulation. Iowa has passed more time under the ocean than as dry land.

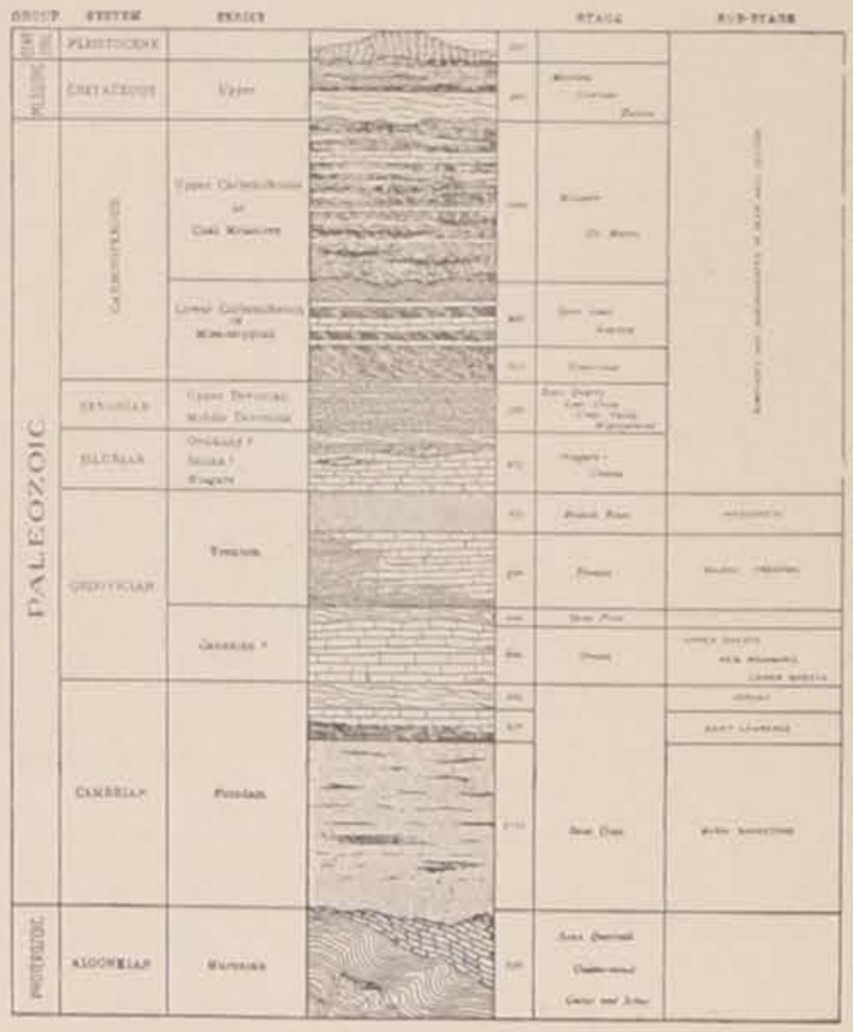
Over the hard or indurated rocks that constitute the foundations of the state, there is spread a covering of unconsolidated materials, varying from a few inches to more than 500 feet in thickness, and forming the soils and subsoils which are so important an element among the many causes of Iowa's prosperity. This non-indurated rock series includes several sorts of material. There is (*a*) the fine sediment—clays, sands, and gravelly loams—laid down by rivers on their bottom lands and called alluvium; (*b*) the red, sticky clay, sometimes mixed with fragments of flint or chert, resulting from the slow decay of limestones where rocks of this kind have been long exposed at the surface. This clay is called residual clay because it is what is left after certain parts of the limestone have been carried away in solution; in some of the publications of the Survey, following the suggestion of a recognized authority on the subject of superficial deposits, it is called *geest*. There is also (*c*) the fine clay, ranging from yellow to buff in color, free from all pebbles but containing little balls of lime, and occasionally shells of land snails, with very rarely a few shells of fresh-water species. This fine pebbleless clay is called *loess*. The origin of the loess is at present somewhat obscure. Lastly, there is (*d*) the blue, black, yellow, or buff bowlder clay, with associated gravels and sands, and not infrequently containing masses of granite or other rock species not native to the state. These materials, constituting by far the greater portion of the non-indurated, or soft rock series of the state, were laid down by great glaciers or ice sheets which, several times in succession, crept down over all or parts of Iowa from the north. The bowlder clays of glacial origin are spoken of in the literature of geology as *drift* or *till*.

The superficial materials, including the drift, loess, geest and alluvium, are the newest or youngest of the rock series of the state. It must be kept in mind that the rocks naturally exposed within the limits of Iowa were not formed simultaneously. Some, as already noted, originated as sediments which were slowly and progressively piled up on the bottom of ancient seas; some were transported and spread out by glaciers; some originated in other ways; but whatever may have been the genetic process, in such a region as Iowa, the order of age among the different beds coincides with the order of superposition.

The very oldest rock in the state is that popularly known as Sioux Falls granite, or Sioux Falls jasper. It happens, however, that the rock is neither granite nor jasper, but is a quartzite. Geologists call it the *Sioux quartzite*. It was originally a loose bed of sand; but in the lapse of time it has been changed, by a very perfect process of cementation, into one of the hardest and most durable of rocks. The Sioux quartzite outcrops at the surface in the northwest corner of Lyon county, but elsewhere in the state it is concealed by newer strata. It is sometimes encountered in wells, and the depths at which it may be reached vary with the location of the well. The same formation appears again at the surface in central Wisconsin, where it is known as the *Baraboo quartzite*.

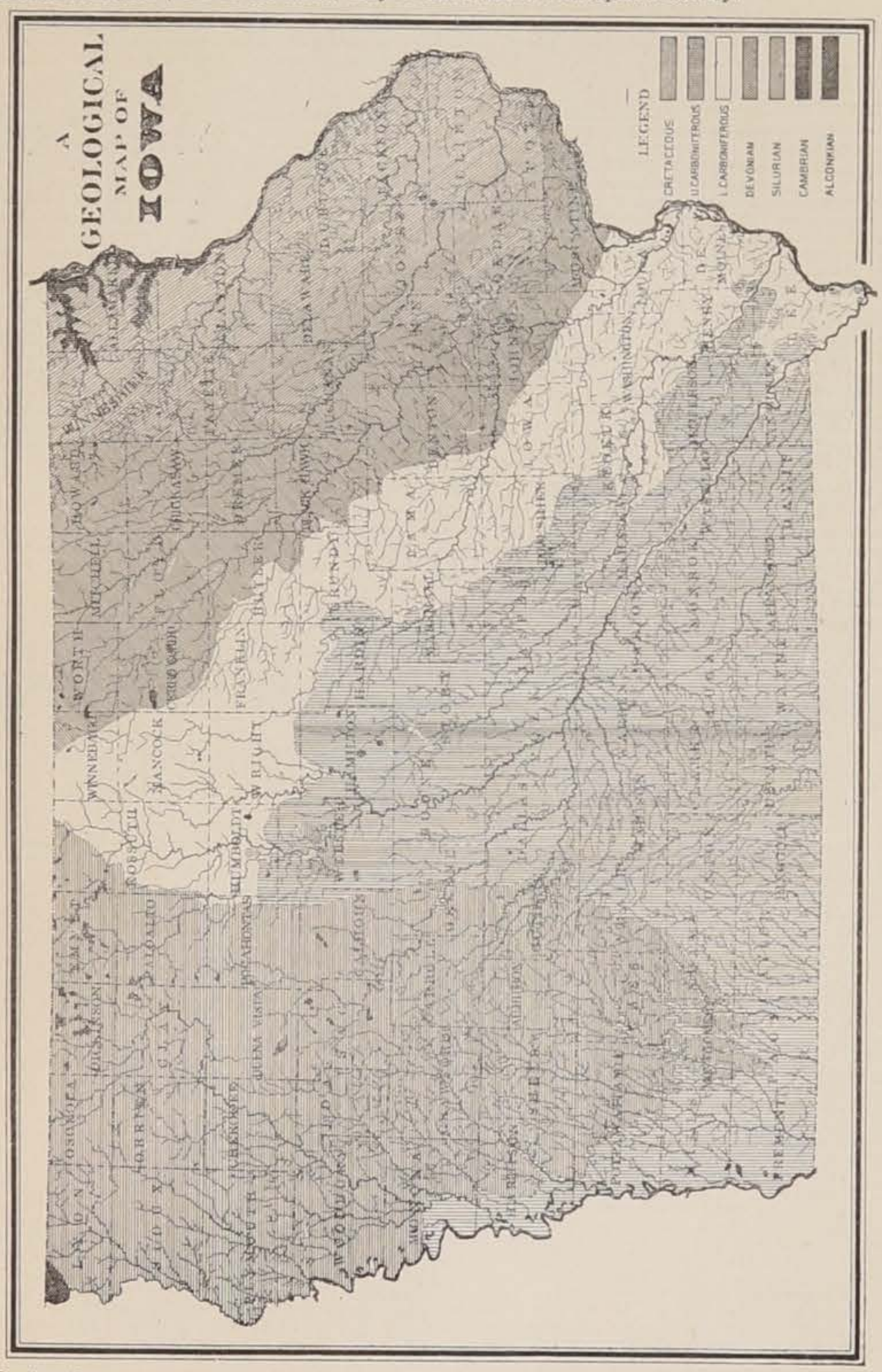
The rock next in age to the Sioux quartzite, as far as relates to Iowa, is found along the Mississippi river, between McGregor and the northeastern corner of the state. This formation is largely sandstone. In the geology of Minnesota and in the reports of the present Iowa Survey it has been called Saint Croix; but in much of the literature relating to the geology of the region, it is known as the Potsdam sandstone. Wells bored in this sandstone at Lansing, Iowa, reached the underlying quartzite at a depth of 700 feet below the water level of the Mississippi river. The same sandstone rises in the bluffs up to a height of 300 feet above the river, thus giving the formation, at Lansing, a total thickness of about 1,000 feet. The Lansing bluffs are capped with 100 feet of Oneota limestone, a formation younger than the Saint Croix; and the road ascending to the highlands, six or seven miles west of the river, leads over the outcropping edges of the upper part of the Oneota, the whole of the Saint Peter and the basal portion of the Trenton. The order

FIG. 1. Geological section from Baraboo, Wis., to Des Moines, Iowa, showing the general stratigrapy of the Iowa artesian area and of the Wisconsin gathering ground. The chief aquifers are the Saint Peter, the Jordan and the Basal sandstone. The line of juncture of the Basal sandstone and the Algonkian is hypothetical. *a* Des Moines; *b* Mississippi; *c* Kinderhook; *d* Devonian; *e* Silurian; *f* Hudson River; *g* Galena-Trenton; *i* Oneota; *j* Saint Croix; including the Jordan, St. Lawrence and Basal sandstone.



General section of the rocks of Iowa, by W. H. Norton.

of superposition, and consequently the order of age, is here definitely determined for the five formations named. By studies pursued in other portions of the state, the relations of all the remaining formations, one to the other, may be ascertained with equal accuracy.



During the progress of deposition of the sedimentary, or indurated, rocks of Iowa that are younger than the Saint Croix sandstone, the northeastern corner of the state, together with a large adjacent area, was gradually elevated or tilted up, hence the shore line of the sea in which

the strata were successfully laid down, retreated step by step, towards the southeast. Accordingly the successively younger rocks are found at the surface in crescentic belts as one travels from the northeast to the southwest. Each formation dips to the southwest, and so passes under the next younger as shown in the accompanying diagram, except that in the figure the inclination of the beds is necessarily very much exaggerated. By drilling a well at Des Moines, for example, the sandstone that crops out in the hills near Lansing is found at a depth of 2,000 feet beneath the surface; and, at Des Moines, we can pump out water which has filtered through the porous layers of the formation, all the way from outcrops of the sandstone in Wisconsin and northeastern Iowa.

Rocks have their individual characteristics. Those laid down during any one period of geological history have certain peculiarities whereby they may usually be distinguished from the rocks of any other period. The rocks which represent a single period of geological time constitute a system. Systems are assembled into groups, and each system may be divided and subdivided into series and stages. All divisions of whatever rank, from groups to stages, and even to substages, are severally known to geologists by definite names. The table on the opposite page, in which the rocks of Iowa are represented diagrammatically in the order of age or superposition, shows (1) the manner in which the indurated rocks are subdivided, (2) the relations of the several members of the geological column, one to the other, and (3) the names used to designate the several geological units, or natural groups of units, as they are recognized in the publications of the Survey. The table shows the strata that would be penetrated in boring a well, provided it were possible to locate a well so that it would pass through each formation, and pass through it at its maximum thickness. In this table, and in all the other figures published by the Survey, sandstone is represented by dotted patterns, shale by lines, limestone by blocks, and drift by lines broken by small circles. Irregular lines between two formations indicate unconformity. For illustration, there is an unconformity between the Saint Louis limestone of the Lower Carboniferous series of the Des Moines stage of the Upper Carboniferous. This means that at the close of the Saint Louis stage, the sea bottom on which the sediments making up this formation had accumulated, was elevated and became dry land. Streams and atmospheric agents carved this land surface into hills and valleys, producing such irregularities as these same agents have wrought over the present surface of southern Iowa. Eventually, however, the region subsided, and what had been dry land became covered with sea. New sediments—those making up our Iowa Coal Measures—were spread out unconformably, the geologist would say, over the carved and uneven surface. Unconformity quite generally records, for the region in which it is seen, the following succession of events: (1) Elevation of sea bottom above sea level, (2) erosion and trenching of the exposed surface, (3) subsidence, and encroachment of the sea, (4) deposition of new sediments over the carved and irregular surface. There is a marked unconformity between the Cretaceous and the Upper Carboniferous, and there is another, equally as marked, between the Pleistocene deposits and nearly the whole series of indurated rocks. While the drift and other superficial materials were not laid down in the sea, they yet rest on an eroded and irregularly carved surface.

Rocks, like our sandstones, shales and limestones, that originate as sediments accumulated on a sea bottom, are, as a rule, spread out in even, regular, continuous, and practically horizontal sheets. Various causes tend to interfere with the regularity of the original deposition. By reason of strains in the earth's crust the beds may be folded or tilted, or the continuity may be interfered with by fractures and displacements. Marked departures from the original continuity and horizontal position of the beds are known as *deformations*.

It will be noted that many of the formations bear geographic names. These names are derived from localities where the beds are well exposed or typically developed. Thus the Des Moines stage is named from the river along which the beds of this age are found as surface rocks; the Saint Louis from the city where the formation was first studied; the other geographic names have similar reasons for their application.

Iowa lies within the Mississippi valley and forms a part of the great prairie plain of the interior. In general its surface shows but slight relief, the local variations in elevation being comparatively insignificant. The northeastern corner of the state embraces a portion of the famous driftless area, a region which glaciers did not invade. Accordingly the surface here has not been modified by the deposition of drift. The hills, in places, rise abrubtly 300 feet above the bottom of the river valleys, and the country, back from the rivers, slopes up to divides that are 300 feet higher than the marginal bluffs. Fringing this area on the west, and covering almost the whole of southern Iowa, is the region of what is known as the Kansan drift. While the surface here is quite uneven, the hills are rounded and less abrupt than in the driftless area, and the valleys, though wide, are comparatively shallow. As in the driftless area, however, the surface irregularities are due to the fact that streams have cut trenches in a once continuous plain. In an area in northeastern Iowa, having Bremer and Buchanan counties as its center, the valleys are broad sags in the surface; they have not been produced by erosion; the streams wander hit and miss among irregular hills; and there are gravel knolls and erratic land forms not due to stream cutting, but to the heaping up of material by glaciers. In north central Iowa, west of Cerro Gordo, Franklin and Hardin counties, there is an area of still younger drift, an area from which the glaciers retreated so recently—perhaps 6,000 to 10,000 years ago—that the majority of the streams have not yet established definite channels. There are numerous undrained areas—sloughs, ponds, kettle holes and lakes. This is the lake region of Iowa, the characteristics of which become more pronounced in its northward extension into Minnesota. The drift covering the region is called the Wisconsin; that of the area represented by Bremer and Buchanan counties is the Iowan, and a drift occupying a small area in southeastern Iowa is called the Illinoian. In nearly all the area not occupied by Iowan and Wisconsin drift, the surface materials is the loess already referred to. With the exception of the driftless area in the northeast, and the small Illinoian area in the southeast, the loess, in general, rests on Kansan drift. The incursion and retreat of the ice sheets that spread out the various drifts mentioned, coming as they did at widely separated times, have had much to do with the rivers of Iowa. The streams have been pushed around, blotted out, made to reverse their course, and changed so many times that the present stream channels often bear little relation to preglacial, or even interglacial lines of drainage. Some of our main river valleys are a patchwork of bits of a number of old, independent valleys pieced together.

THE GEOLOGY

OF

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CONTENTS.

INTRODUCTION.

LOCATION AND AREA.

Geology is withal a most comprehensive, all embracing science. Its problems are wide as the world, far-reaching as time, coëxtensive with the universe entire. The geology of a locality, a single county, or even of two or three counties, might seem, therefore, at first glance impossible. Here is room for suggestion only; no adequate field for the display of any such wide-extended problem; no scope for adequate study much less for the solution of any of the vast and intricate questions which our most superficial inspection is sure to raise, and which, in fact, immediately confront the student on every side. Especially do such limitations appear when one attempts the study of one or more of the counties of northwestern Iowa. Here the usual factors of geologic study are almost entirely removed from human ken, all alike buried, often hundreds of feet deep, by confused and mingled drift; the very drift itself less accessible owing to the minimum effects of ordinary erosion. Only surface indications and features are at the disposal of the man of science, and these, many times, precisely of the sort requiring wide comparison for full or even helpful explanation. Surely the problem of the geology of a northwestern Iowa county promises but small returns even for the most enthusiastic industry. Nevertheless, such is the wide extent of present investigation about the world, that where the experience of the individual student fails him in his narrow field, the labors of others come to his relief, and thus even the problems of a single county, a single township, may, and do become intelligible as forming at least a part of some wider, vaster whole.

Thus we approach our present study. The three counties named in the title form part and parcel of our great northwestern prairie; apparently all alike, to the extent even of wearisome sameness or monotony, and suggesting very little at

first sight of what might go to elucidate the history of the world; and yet, after all, in itself a part of the outcome of all that history, and in itself, therefore, a fact, whose explanation, here as elsewhere, lies largely in the fact concealed, or even revealed; much as the peculiar names of the counties carry with them, for him who can understand, a curious revelation of the history of our composite people.

Emmet. Palo Alto, Pocahontas, these three counties constitute a strip of prairie, in width exactly twenty-four miles; in length, some sixty-six; since from Emmet the northern tier of townships is missing, along the Minnesota line. On the east lie Kossuth, Humboldt, and a part of Webster county; on the south is Calhoun county; while to the west are Dickinson, Clay and Buena Vista. Nearly all of these surrounding counties have been described in these reports; as to the three immediately in hand, their place in the history of civilization dates back only a few decades, forty or fifty years, at most, and in the books of science they have hitherto had scarcely mention.

PREVIOUS GEOLOGICAL WORK.

Dr. White, in his sketch of northwestern Iowa, includes these counties with a brief description.* He was apparently especially impressed by their altitude, their relationship to the general watershed of the state, and to the drainage system of the Des Moines valley. He admired the abundant lakes and pools that gave a certain variety to the otherwise monotonous prairie landscape, and referred these correctly for their origin to the deposition of the all-embracing drift. The same distinguished author realized to some extent, at least, the depth of this same drift, and, knowing the geologic structure of the eastern half of the state, he announced the improbability of mineral wealth beneath these wide deposits, warning the people of the state that shafts sunk in search of coal were almost sure to result in disappointment. He saw, however, the native species of forest trees, here and there wide-scattered, struggling, and even flourishing, wherever they had covert from the

*Rep. of the Geol. Survey of the State of Iowa, by Charles A. White, M. D., Vol. II, pp. 215-219, 1870.

annual fires, and predicted that a few years would suffice "to convert the whole of this treeless space into a well cultivated region with a sufficient amount of artificially planted woodland from which to supply the wants of the inhabitants."* It would be a satisfaction to this pioneer student, geologist and long honored author, could he today personally realize how completely his predictions in this regard have come to their fulfillment.

Aside from the work of Dr. White the counties we now consider have had no attention from student, geologist or geographer. Of no remotest interest to the miner, their fertile, peaceful acres have fallen under the plough and have been forgotten or remembered only as political bits of Iowa's vast farm.

Nevertheless these counties are not without their own scientific interest, and afford within narrow limits much to occupy the intelligent farmer or student, much to tax the ingenuity of the wisest who seek to offer satisfactory explanation of the diverse local phenomena everywhere displayed. Topographic problems are offered by every township, almost by every square mile, and, as for structure, our limited knowledge finds opportunity for enlargement after each erosive freshet, might gain new pages at the sinking of each new country well or the digging of each county-ditch, almost each cave or cellar. There are hills and plains and valleys, mostly hindrances rather than aids to the farmer's plans and industry, there are rivers and creeks and lakes, but often owing to each other only remotest, most indefinite allegiance; there lie beneath our feet, rocks and gravels, sands and clays, but all in confusion mingled. We have but begun to classify these strata as they lie, to interpret their far-reaching history. Even the boundaries of the more general divisions into which the soil elements of northwestern Iowa naturally fall are often difficult of discovery, and an accurate mapping will require months and years of patient research in the field.

The present account is, therefore, but a sketch, a preliminary study, as have been its predecessors dealing with the neighboring counties. To assemble all these partial pictures, correct

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*Rep. Geol. Surv. of Iowa, by Chas, A. White, M. D., Vol. II, p. 215.

them, and at length unite them in some more perfect and general composite view or portrait of this unique and wonderful section of our prairie state remains the much-needed labor of some future day.

PHYSIOGRAPHY.

TOPOGRAPHY.

The topography of the counties before us, at closer view, is sufficiently varied. Although to the eye of the passing traveler often apparently perfectly level, yet the entire country slopes gently to the south and is likewise higher at the western side, for reasons presently to appear. The variation in level is, however, often surprisingly small. On a later page appear the altitudes of several towns as given by the respective railways in each case. These railway levels may with interest and profit be compared. Ruthven, on the western edge of Palo Alto county, is the highest town in the territory mapped, and Rolfe is the lowest; the difference between them is two hundred and seventy-five feet. This, however, gives an exaggerated view of the matter on account of the unusual altitude of Ruthven, perched high on the morainic hills. If we compare Estherville in the north with Fonda of the extreme south, we have a difference of only fifty-two feet. These points are almost exactly on the same meridian. If, however, we draw a line from northeast to southwest, as from Armstrong to Fonda, the variation falls within five feet; Cylinder, Rodman and West Bend are within two feet of the same level; and so, many such comparisons may be made.

Nevertheless, with all this apparently common altitude, the variation in topography in the three counties is by no means inconsiderable. There are hills and valleys and plains here as elsewhere, but their succession is different; they stand in peculiar relation to each other. The hills are some of them high and precipitous, as in Walnut township of Palo Alto county, or Emmet township of Emmet county; sometimes they are simply low swells or mounds, as about Maple Hill or Em-

metsburg. All these are altogether independent of erosion. No streams run among the high hills about Ruthven or Graettinger; nor more among the mounds, of Armstrong or Curlew. These are hills of construction, i.e. they were piled up and abandoned here by an agency of which they are at once result and evidence, an agency in the ages past efficient over wide areas, determining the shape and features of the land surface of a considerable portion of the northern world—the agency of glacial ice. Erosion affects these hills, no doubt, today, as it has for centuries, but it did not make them. This is evident to anyone who will give the subject the slightest study or examination. There are hills of erosion also here although often, generally, insignificant. These may be noted along all streams; along the Des Moines, although here rarely in this region. The Lizard in its winding branches shows now and then an eroded slope; even the upper channels of Cylinder creek show gently sloping, eroded fields. Beaver creek, near Rolfe, shows perhaps more of erosion topography than appears elsewhere in the three counties. This stream seems to have cut down pretty rapidly to the level of the Des Moines flood plain and so shows steep inclines, not a few in the neighborhood of Rolfe and northward. Beaver View farm is a fine illustration. You may find erosional hills in this, our present territory, but by search. The hills we easily study are morainic hills, constructional, as said, owing their existence to forces acting long ago. Consequent here may be noticed the peculiar distribution of these hills. They occur chiefly on the west side of the Des Moines river. Beginning at Estherville and thence south, the hill-country is nearly all on the right bank of the river. There are swells and mounds here and there, everywhere, but for hills, everybody sends the traveller west. And there he finds them sufficient in numbers to raise the general average level, as we have seen, of all the west side of our territory; sometimes grouped together, like miniature mountain chains, a hundred feet high, as about Ruthven and west of Graettinger. In fact this country is so rough and uninviting as to have been only recently occupied. A big church crowning the hilltop here and there tells of some Swedish or Norwegian

colony, newcomers with old time Norseman courage, daring what others have neglected. Between the hills watercourses are most imperfect, but aided now by ditches give to the agriculturist some advantageous variety, lowland meadow and upland slope.

While, as stated, these peculiar hills are characteristic and best displayed west of the Des Moines, yet they are by no means lacking in other places. They are prominent north of Estherville, about Dolliver, and extending in broken series in a southeasterly direction past Armstrong. There are low ranges of them in the vicinity of Emmetsburg, especially about two or three miles east of the city; they occur northeast of Rodman and about West Bend. A very interesting specimen, because of location, is found directly athwart the highway east of the town of Rolfe, precipitous all around and forty or fifty feet above the surrounding level.

Associated with morainic hills are always lakes of greater or less dimensions, these in the present instance are neither few nor insignificant. There are lakes in each of the three counties; in Emmet county they are especially numerous. Some of these may claim special description.

Iowa lake, which names for us the northeastern township of Emmet county, lies mostly in Minnesota. In Iowa it covers not more than one square mile, but is withal an attractive and permanent body of water, bordered, especially to the north, by native groves of all the commoner species of our native trees. The lake has no Iowa affluents, but in this year (1903) the outlet, tributary to the Des Moines (?), is a rushing torrent.

Turtle lake, or as the people of the county now prefer lake Okamanpadu, is very much larger than Iowa lake but similar to this lies much of it north of the state boundary. Altogether it covers some four square miles. This lake too is bordered by native woods, once much more extensive than now. The Iowa shores are today nearly destitute. Still the lake is picturesque and beautiful, apparently one of the abiding attractions of a beautiful rural landscape. This lake is also one of the sources of the Des Moines river. It seems to have two outlets one to the east, the larger, to the East Des Moines; the

other flows west to Soldier creek which is itself, however, farther on a tributary of the same stream. Immediately south of Okamanpadu is Swan lake, by far the finest body of water in Emmet county. Lake and swamps together, Swan lake affects half a dozen sections and extends more than six miles from east to west. However, the east end is but a wide marsh full of rushes and all aquatic vegetation. Swan lake proper is at all seasons a fine sheet of water surrounded by good banks, some of them high and generally covered with native woods; trees of the finest varieties; beautiful primeval walnuts still standing. The depth this year is reported fifteen to twenty feet. Singularly enough, the locality is comparatively high. From the west end of the lake the view extends for miles in every direction; the wooded, high, western banks of the West Des Moines river stand like a wall of green; the village of Raleigh appears beyond, while on this side Graettinger, Wallingford, Gruver, Dolliver, and even the groves of Estherville are plainly visible. Yet here is no highland, as such, visible to the eye; this is a lake-shore and the flatness of the far-reaching plain alone surprises the beholder. On the west side of Emmet county are several small lakes, as Four-mile lake, Chester lake and Twelve-mile lake. The last named is possibly the largest and most permanent of these, but all are shallow and likely to be drained and made over into cornfields once the county surveyor with his ditch arrives.

Palo Alto county likewise boasts of several lakes. Lost Island lake, lying partly in Clay county, is a beautiful and permanent body of water, to be classed with Spirit lake and Okoboji. While not quite so large as the former, nor so deep as the latter, it is none the less attractive and has about it the same picturesque hills and winding beaches. Lost Island lake has an expanse of some three or four square miles and is said to be twenty feet in depth. The southern shore has been laid out as a park and affords place for summer cottages. North of Lost Island lake, in Palo Alto county, is a wide marsh as large almost as the lake itself, but distinct, once known as Pelican lake. These lakes are both situated in the very margin of the Altamont moraine and are drained to the west into the Little

Sioux river. There are to the west of them no high protecting mounds, but, on the other hand, their marginal position subjected them to what is called overwash, deposits of sand and gravel from the edge of the retreating ice. This will account for the shallowness of Pelican lake and for the series of swamps and marshes by which in Clay county these lakes find outlet through Outlet creek to the Little Sioux river.

There are in Palo Alto county several other lakes of more or less interest. Elbow lake south of Ruthven is a little better than a marsh; Medium lake at Emmetsburg is permanent, and affords opportunity for boating and pleasure-seeking. Virgin lake and Silver lake, both on the west side of the county, are deeper, though not large, and are beautiful permanent features of the landscape. Rush lake, farther south, is of interest as the source of Lizard creek, to be presently described.

In Pocahontas county are no lakes of interest. Swan lake near Laurens, with native woods about its shores, once adorned with launches, a steamboat and all other minor craft, is waterless now even in this year of floods. Clear lake and Lizard lake also exist but in name.

Having thus disposed of the hill country and the lakes of our present territory we may now consider the simpler topography of the plains and meadows. These are conspicuously two-fold in their origin and position. We have, in the first place, the level of the general prairie. Of this nearly all Pocahontas county affords an illustration, nor less, large areas in Emmet and Palo Alto. About the town of Pocahontas, for instance, is a grass-grown level, unbroken for miles, and almost without drainage or slope in any direction. Where the lands are better drained the fields are yet flat, the streams long, crooked and shallow, sluggish and easily overflowed. In a general way the whole valley of the Des Moines river from Emmetsburg south is of this character. Compare again the table of levels, Emmetsburg 1234, Curlew 1222, Cylinder 1195, Rodman 1193, Whittemore 1207, West Bend 1197, Mallard 1198, Plover 1190, Rubens 1193, Gilmore 1207, etc. Here we have the indices of an almost absolute plain some fifteen or twenty miles wide and more than thirty long. Of course this plain is

not absolutely even; it is interrupted, in Palo Alto county especially, by scattered low knobs or ridges; in Pocahontas, less by such features and more by broader inequalities determining the far-reaching though all-imperfect drainage system. Such a level as this is known everywhere in these reports as a Wisconsin drift plain. In fact, our whole three counties may be regarded simply as such a plain sloping a little to the east, rather more to the south, cut diagonally into two almost equal parts by the Des Moines river, and encumbered to the west more or less extensively with irregular tumbled piles of the same constructive material, the groups and series of morainic hills. The lakes, for the most part, are simply undrained depressions amongst these hills.

But the river valley proper shows us a plain topography of yet a different character. On either side of the river, now chiefly on this side, now on that, is a peculiar gravel plain, abutting plump against the hills where these approach; below the level of the general plain and sharply divided even from this, where they mutually approach; distinct at once in structure as in position. This is no alluvial plain in the ordinary acceptance of the word, as might be at first surmised. Indeed, here is no alluvium at all resultant from the action of the present stream. Here is a plain, generally more than a mile in width, sometimes two or three, composed entirely, except a little organic matter at the top, of coarse water-laid sand, bowlders and gravels fifteen or twenty feet in depth, resting often on blue clay. If we study the course of the present stream we shall discover that it has indeed its own alluvium, its own alluvial plain, its flood-plain covered at high water, enriched by gifts of falling silt, but this is entirely a different matter. Over the gravel plain the river never, in its highest waters, sweeps at all; it never reaches to that lofty level. Yet, as just stated here are water-laid sands and gravels of wide extent. These valley plains are not the alluvium of our present stream; they are hardly to be reckoned the alluvium of any stream; they are rather the bottom of an ancient river that came down the valley occupying its total width in its sweeping flood, when the whole country, new-born, was taking shape

as we see it now. On this old river bottom, this gravel plain, stand Estherville, Graettinger, Wallingford, Osgood, part of Emmetsburg, Cylinder; the latter on an identical plain, though remote from the river. A fine view of this river-plain is obtained from the car-windows by those passing up and down the valley on the Rock Island railway. It is well seen from the morainic heights west of Estherville; it lies fair before the observer seen from the brow of the hill west of Osgood bridge; and, strangely enough, we traverse the same sort of a gravel, sandy plain, extending for some four miles north of the town of Cylinder, two or three miles in width. This plain has also the same origin as those by the Des Moines and represents an out-wash from the plateau of Fairfield and Independence townships. This plateau is a continuation of that seen in Kossuth county, its abrupt margin extending from the Crystal lake moraine in Hancock county around by Saint Benedict, Irvington, north of Whittemore and so into Palo Alto. This plateau lies thus between the Des Moines and Iowa rivers near their origins, and rises to a height of something like one hundred feet above the general level, the highest point between Algona and Whittemore.

Following is given the elevation of several towns in the area under discussion. The data were obtained from Gannett's dictionary of altitudes in the United States:

TABLE OF ALTITUDES.

Estherville	1,298	Rodman	1,193
Armstrong	1,237	West Bend	1,197
Emmetsburg	1,234	Plover	1,190
Crippen	1,166	Rolfe	1,160
Ruthven	1,435	Gilmore City	1,207
Cylinder	1,195	Rubens	1,193
Ayrshire	1,293	Havelock	1,227
Curlew	1,222	Laurens	1,307
Mallard	1,198	Fonda	1,232

The margin of the above mentioned plateau in Palo Alto as in Kossuth has been generally well drained so that the topography is unusually broken as the plateau breaks off to the plain.

Thus the north part of Fairfield township is well drained, although representing the Wisconsin plain. Considerations such as these lead us easily and naturally to our next topic.

DRAINAGE.

Des Moines river.—The valley of the Des Moines river in two branches constitutes the principal drainage channel of the territory we study. That drainage is determined by topography is proverbial in northwest Iowa. And so the Des Moines, especially its western branch, occupies, in large measure, a rather wide, constructional depression, first formed and excavated by glacial drainage, then partially filled again, as we have seen. This West Des Moines is, at the ordinary stage, a fine clear stream, of great service, both as a drain and for water supply, and its course southward is very interesting to one who will study determining causes. Taking rise in Minnesota it enters Iowa almost exactly at the northwest corner of Emmet county, making its way amid morainic hills, cutting through their opposing ridges it reaches the Wisconsin plain in the neighborhood of Estherville. Here, however, its course is still controlled by the moraine; the high, abundant, hills of western Emmet county guide the river to the east, nor less those of western Palo Alto, until immediately south of Emmetsburg morainic ridges of rather low degree divert its course and send the stream eastward, finally in Nevada township directly east, only to encounter south of Rodman the West Bend series of hills through which the stream makes its tortuous way to enter Humboldt and Pocahontas counties almost simultaneously, following in zigzag fashion the line between the two; joins Beaver creek, which may represent an old-time channel, and finally enters at Bradgate, about one mile east of Pocahontas county line, the rock-walled conduit of some preglacial water. It is even possible that Beaver creek may represent part of the same preglacial, i. e., pre-Wisconsin, stream, and this may be a remnant of what is now the Little Sioux, whose course has been so strangely shunted by the Altamont in Clay and Buena Vista counties.* At any rate, we are beginning to see

*See of this series Vol. XII, p. 334, *et seq.*

that the pre-Wisconsin drainage of all this part of Iowa was not very different in direction, at least, from that which obtains today. Great ridges of older drift are still in evidence, which have for ages been watersheds; the Wisconsin simply threw these less forceful streams into confusion. The uncertain course of the Des Moines across these prairies is apparent when one notes the often slight character of the obstacle by which the stream has been deflected; some low swell of drift, of sand and gravel, as in section 33 of Nevada township, Palo Alto county, or in section 32 of Fern Valley township in the same county. Indeed, the course of the river is scarcely yet determined. In time of flood the river, south of Emmetsburg, leaves in part its channel in section 2 of Great Oak township, passes directly south around an island of morainic knobs in sections 12 and 13, and finally joins the main current again in section 20 of Nevada township. In fact, the whole of Ellington township and part of West Bend is simply a confused field of low, irregular hills and swamps where it would seem that a river might cut through at any time in one place as well as another. West Bend, so named because the valley of the river was settled by immigration from the south, and for men coming from the south the river here turned west, West Bend is, after all, truly historic in its naming. We must remember that our assumed ice sheet retreated northward; the excavation of all stream-channels now in service proceeded pari-passu, with equal pace. Beginning, for instance, with the stony channel in Humboldt county, the conduit of the Des Moines was determined northward a little at a time; and any slight obstacle, no doubt, was at first sufficient to determine the direction of the current. This will explain the peculiar winding of the river in these townships named. The current returns again and again upon itself; surely no such crooked channel is elsewhere represented on the maps of Iowa. For this reason, although a drainage channel of prime importance, the river is here singularly inefficient, and the problem of those who would cultivate these naturally undrained meadows is difficult indeed.

The tributaries of the Des Moines in this part of Iowa are School-section creek, draining the western part of Emmet

county, cutting down to the level of the river through a chasm of remarkable depth, of wild abrupt, picturesque beauty, but not yet efficient for the remoter sections of the basin in which it rises; Jack creek, the outlet of Swan lake and ordinarily simply a creeping, crooked prairie stream, draining imperfectly a township of the same name; Cylinder creek, a stream of the same sort, draining pretty well the two northeastern townships of Palo Alto county and receiving as a contribution from the west the waters of the unwilling outlet of Medium lake, a body which seems formerly to have sent its surplus waters southward directly to the Des Moines, across the plat of the present city of Emmetsburg; the outlet of Silver lake, Willow creek, which has effected considerable erosion and affords in ordinary seasons good drainage for the farms of Great Oak township; Beaver creek and Pilot creek, which, rising in Palo Alto county drain some of the finest of farms in the vicinity of Curlew and Mallard and become efficient streams in the northeast township of Pocahontas county. The Lizards which in manifold branches spread over nearly the whole of the county last named, deserve a special sentence. Lizard creek, as a stream of some dignity and recognized importance, enters the Des Moines in Webster county, but in Pocahontas county it consists of three principal branches with many secondary, sometimes inter-communicating marshes and sloughs. These branches in many places lie upon the prairie rather than drain it. Except in the case of the North Lizard, and far down in its course, erosion is almost none. Here and there the county supervisors have taken the matter in hand and have cut a broad ditch for the impotent, channel-less stream. As central Pocahontas county is a typical Wisconsin plain, so the Lizard creeks are typical prairie streams. Fortunately a deep channel of the Des Moines is not very far away, with a fall to the north of the Lizard of something like two hundred feet, so that the art of the engineer will no doubt one day amply supplement nature's unfinished work for Pocahontas county.

Cedar creek with two principal branches is an important stream in the western part of Pocahontas. It rises in the marshy fields north of Laurens and affords to the townships it

passes fair drainage. Cedar township, especially, is well drained.

The East Des Moines, although a fine perennial stream, is of importance in this discussion only as affecting the northeastern townships of Emmet county. Even here, such is the morainic character of the country that artificial drainage is everywhere resorted to.

In ordinary seasons the drainage of all this section of Iowa would seem a matter of no especial difficulty. Within the last ten years thousands of acres of lowland have been brought into cultivation; but in seasons of unusual rain the problem of speedy removal of surplus storm-water becomes more serious.

STRATIGRAPHY.

From the preceding description of these counties it is easily inferred that the stratigraphy, or geologic structure of this part of Iowa, so far as exposed to ordinary view, is extremely simple. The drift is indeed susceptible of some classification, but the student seldom finds it in sections undisturbed. Erosion valleys, by the very nature of the case, are less satisfactory. These looser deposits become mingled; they are always "in place;" i.e., while a transported indurated rock is identifiable as such, the materials of the drift lose their identity no sooner they leave their proper horizon. In other words, while the stratification of the drift when undisturbed is evident enough, yet to identify the elements of the several strata once weathered or eroded requires discrimination of the most discerning sort. The materials from which the successive drift sheets have been built up are much the same; yet there are differences, more striking and more numerous doubtless by far than our science is now prepared to realize. However, even erosion valleys often serve, when the shifting current uncovers a fresh surface or undermines a slipping hillside. Other than this the student of stratigraphy relies upon the glimpses offered by artificial excavations of various sorts, the grading of the highway, the cutting of the railway through a mound or hill, the sinking of farmers' wells.

One outcrop of the older rock also strangely enough comes to light within our present limit so that our synoptical table is more extended than was to be expected:

SYNOPTICAL TABLE.

GROUP.	SYSTEM.	SERIES.	STAGE.
Cenozoic.	Pleistocene.	Recent.	Alluvium.
		Glacial.	Wisconsin Gravels.
			Wisconsin Clay.
			Kansan.
			Pre-Kansan sands and gravels.
Paleozoic.	Carboniferous.	Lower Carboniferous.	St. Louis.

GEOLOGICAL FORMATIONS.

Pleistocene System.

The Pleistocene deposits,here as elsewhere in northern Iowa, consist entirely of sheets of clay, gravel, sand, or of these inextricably mingled together. In fact a pure clay is probably nowhere to be found within our present limits; so that we may say that our Quaternary or Pleistocene deposits here are wholly drift, mingled clay and pebbles or bowlders, or beds of gravelly sand.

ALLUVIUM.

By this term is indicated the fine, usually black, soil ordinarily present along the banks of rivers and streams in prairie regions, which evidently owes its position as well as character to the sorting agencies of water. Ordinarily it is a fine, black silt, sometimes heavy with fine sand; and represents the latest

Tp. 100 N.

Tp. 99 N.

Tp. 98 N.

EMMET

ELLSWORTH

LINCOLN

IOWA LAKE

ESTHERVILLE

CENTER GROVE

SWAN LAKE

ARMSTRONG

TWELVE MILE LAKE

HIGH JACK CREEK

DENMARK

Des Moines

EAGLE LAKE

Huntington

GRASS LAKE

TUTTLE LAKE or OKAMANPADU

TREMONT LAKE

Dolliver

IOWA

LAKE

Soldier Creek

East Branch

Des Moines River

Saint Louis & Minneapolis R.R.

Chicago Rock Island Pacific R.R.

Griffith Spur

Brown Creek

Gruver

Maple Hill

Gridley

FOUR MILE LAKE

CHEEVER LAKE

RYAN LAKE

SWAN LAKE

North Chicago R.R.

Halfa

Raleigh

Wallingford

Bubona

MUD LAKE

HIGH LAKE

CRANE LAKE

Ringsted

TWELVE MILE LAKE

Jack Creek

Black Hoprig

Western R.R.

R. XXXIV W.

R. XXXIII W.

R. XXXII W.

R. XXXI W.

IOWA LITHO. CO.

IOWA GEOLOGICAL SURVEY

MAP OF THE SUPERFICIAL DEPOSITS OF EMMET COUNTY, IOWA.

BY

T. H. MACBRIDE.

1905.

Scale $\frac{1}{125000}$

1 ½ 0 1 2 3 4 5 Miles.

1 ½ 0 1 2 3 4 5 Kilometers

LEGEND

ALLUVIAL DEPOSITS

WISCONSIN DRIFT
AFFECTED BY MORAINIC KNOBS

WISCONSIN PLAIN

INDUSTRIES

GRAVEL PITS

CLAY WORKS ▲

DRAWN BY F. C. TATE

IOWA LITHO. CO.

or farthest deposition from waters laden with the products of erosion. In our newer valleys the amount of such material is inconsiderable; nevertheless there is some of it discernible by all the principal streams, as the branches of the Des Moines, where occasionally a wide, flat meadow is made up of alluvial soils that rest thinly upon beds of river sands and gravel. Sometimes it has accumulated to the depth of several feet and shows black banks in presence of most recent erosion. The amount of this material is, however, in the present case too small to admit of representation on the map.

WISCONSIN STAGE.

Wisconsin gravels.—The deposits so named are the immediate effect of the outpouring of the waters accompanying the melting and retreat of the Wisconsin ice. As the face of the ice cliff moved northward the floods of water seem to have covered the country and the gravel and sand with which the streams were charged were deposited everywhere; especially, of course, in the forming valleys and channels of drainage. Sometimes these channels were no doubt on or in the ice itself so that gravel deposits may, and often do, now appear far out of the way of any present drainage system of any sort whatever; in isolated mounds, on the flanks of hills, in low ridges athwart what were otherwise a level plain. As already indicated in the discussion of topography, the valley-plain of the West Des Moines river is a gravel plain, all gravel of varying depth and width, from the Minnesota line or near it south to Humboldt county. At Estherville and at other points this gravel is worked by the railways for ballast-construction, and from the city named thousands of car-loads have been transported in this way to various parts of the state. The beautiful situation of the town (see plate IV) is due wholly to this unique deposit. The city is built on the gravel plain. One ascends to the typical drift as he passes east out along any of the principal streets. In many places one may see the distinction by merely standing in the street and looking east.

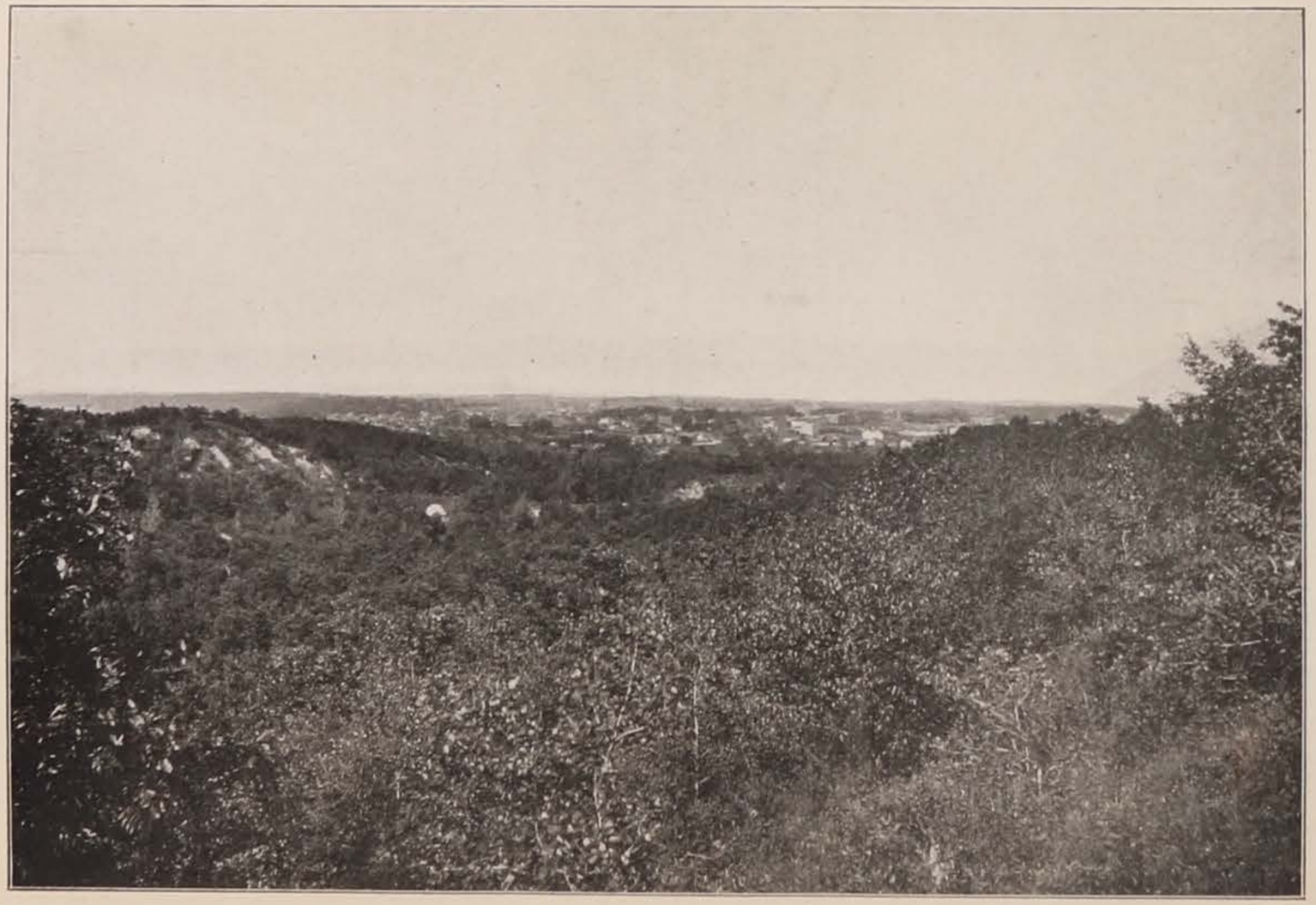

Plate IV. View of the town of Estherville, and the prevailing topography of the Wisconsin drift.

At the bridge across the Des Moines in section 28, township 100 north, range 34 west, the gravel is piled in such a way as to give the observer a fair idea of the immense erosion changes that once went on in what we now term the valley of the river. Here the gravel on either side of the river is discoverable high up above the ordinary plain, fifty or sixty feet; lodged against the banks of drift. Between lies a half mile or more of gravel plain perfectly solid and flat, the bottom of the ancient glacial river that swept this way and eroded the valley as we see it, beginning away up on the level where now occur the highest deposits of these singular water-marks. The present stream is as nothing when compared to that earlier river. The Des Moines river in this year of 1903 is described as high beyond the previous experience of observers, and yet the Des Moines river by no means covers this gravel plain. The present stream has its own flood plain which in times of freshet it may cover or erode, but this old time valley owns no relationship to the present river. One might suppose that the action of the earlier, larger, current continued not very long; but we must reflect that the erosion force in this its upper channel was limited by the work that must be done arther south and east, where the indurated Paleozoic formations were encountered and set bars to the agents of erosion as at this day. The result is that the gravels of that older river lie in these upper stretches largely undisturbed, slow-mouldering with the lapse of centuries.

When we come to investigate the composition of the gravel trains we discover, first of all, the evidence of the mode of their deposition. No better sections need be wished of the entire deposit than those encountered at Estherville. Here one may easily see the sorting cross-bedding resultant from the water currents that once swept the stony debris on and down. But the materials themselves are of every imaginable source; i. e., one may find samples of rock of almost every description of all sizes, from merest pebbles to stones weighing hundreds of pounds. Some of these pebbles are of great age as such; have long been buried, subject to the slow action of waters, filtering, bearing all sorts of solvents in solution. Such pebbles no longer hold together as rock at all, but crumble no sooner exposed to light

and dryness, may be picked from the bank and crushed in the fingers. Through large gray bowlders the steam shovel passes as through sand, and such sections may be commonly observed. These were doubtless, some of them already long constituent parts of the older Buchanan gravels which the Wisconsin ice in these latitudes so generally swept away. Possibly the larger part of these vast recent deposits consist of but a resorting of those older piles and trains laid down by the waters of the Kansan so long ago. Nay; perhaps some of the earlier gravel, even in these river valleys still lies in place here on the blue clay that stretches everywhere beneath all surface deposits in these

FIG. 16. The gravel pit of the Minneapolis & St. Louis railway, Estherville, Iowa. This illustration shows in a marked degree the characteristic cross-bedding of glacial gravels.

regions. Thus if anyone will closely scan the exposed wall of gravel in the excavations south of Estherville he will easily discover that the lower portions of the exposure are different, strikingly different, from the upper, overlying part. The wall

stands up largely because of these differences. Above, the gravel is more loose, fresher and evidently more recent, judging from appearance; below, the material is imperfectly stratified, often stained with iron, deep brown sometimes, the pebbles and bowlders more or less cemented together and associated with concretionary nodules of impure hematite. The line of demarcation is not well defined, but is sometimes quite evident. One is inevitably led to conclude that the lower gravels are here older than the upper.

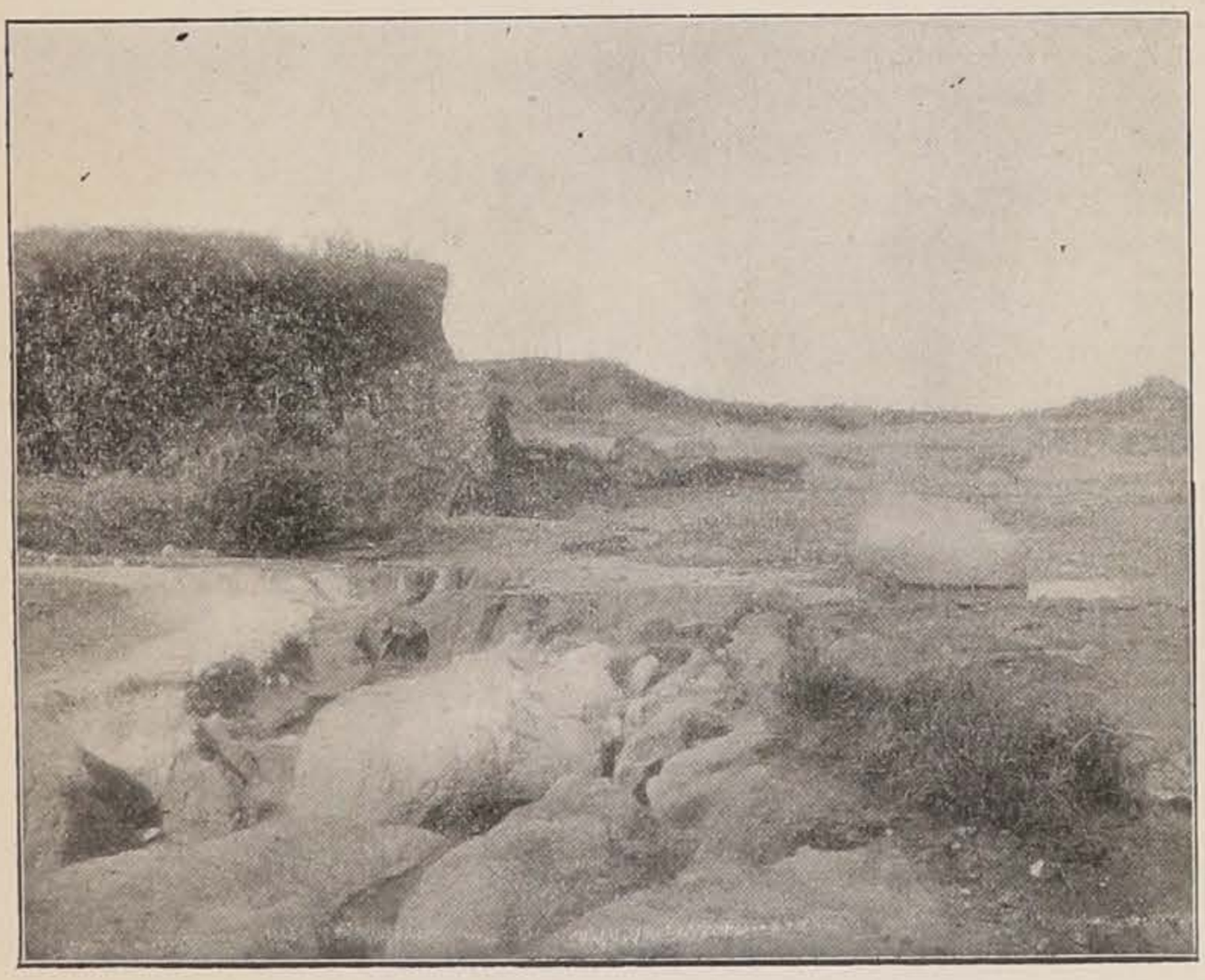

FIG. 17. The blue clay—eroded by the drainage stream issuing from the gravel pit of the Minneapolis & St. Louis railway, near Estherville, Iowa.

But this is not all. In the gravel pits operated by the Minneapolis and St. Louis railway near the same city of Estherville, especially at the extreme south of this artificial exposure, storm-water erosion has supplemented the artificial excavation to the complete uncovering of the old blue clay. A finer display of this was never seen. Resting directly upon this bed of

blue clay is the same more or less indurated, brownish gravel seen in the other excavations, while further north appears the typical sands and gravels of the Wisconsin age.

However we may name these lower gravel strata, the wide distribution of the Wisconsin subwash and overwash is indisputable. Not only by the river, as here, but, as noted, far away from streams now flowing or even the possibility of streams, piles of water-laid sand and gravel surprise the traveler. At Ruthven there is abundance of this material in the lowland west of the city, nor less on the top of the hill in the city itself near the Rock Island station. In many cases these gravel deposits rest unmistakably on the country drift, so that there can be no question as to their relative age.

The Wisconsin drift.—This is the common surface drift or pebble clay of all this northwestern country. It has been often described in these reports and is generally easy of recognition; strongly calcareous, it is usually white or whitish when dry, though sometimes yellowish or buff colored. Ordinarily it is covered deep by rich, black surface soil and visible only where uncovered by erosion or some sort of artificial excavation. However, exposures are sufficiently abundant. Throughout the entire intra-morainic territory as sketched in these reports, the characteristic color, the flat, limestone pebbles and small, angular bowlders, often of the same material, newly planed, mark every hillside road or railway cut. The abundant lime, whether in form of finest dust or as pebbles and bits of limestone rock, forms the most patent characteristic of the deposit. To the west this drift passes over into something older, but in color and appearance often but slightly different. The reader may compare earlier volumes of this series of reports; this may be subject of future discourse. But in our present territory the Wisconsin drift is well defined, remarkable, chiefly, for its thinness as a deposit. In fact, the relation of this deposit to underlying strata in these marginal counties merits closest scrutiny. Over the larger part of our area, over all, if well diggers, almost our only source of information, are to be believed, true Wisconsin drift does not average more than fifteen feet in thickness. Doubtless in western Palo Alto and Emmet counties, on the morainic hills, the depth is often

great; but on the ordinary Wisconsin plain the depth is quoted never to exceed twenty-five feet, and often no more than five or six. In the moraines are great piles of it, as one may often see in sections where, in our rectangular road-making, we must need cut through a hill of greater or less extent, but everywhere else the depth is comparatively small. Such exposures as were noticed showing Wisconsin drift above blue clay were not inconsistent with well-reports. An outcrop of the older formation occurs immediately west of the Osgood bridge over the Des Moines. Here the thickness of the later drift does not exceed twenty-five feet. The question of an earlier and a later Wisconsin for this part of Iowa remains for future decision.

KANSAN STAGE.

Buchanan gravels.—Old gravels of Kansan age, called in Iowa Buchanan gravels, were reported in an earlier sketch by the present author.* The outcrop appears overlying the Saint Louis limestone in the Gilmore quarry. In addition to this, the older gravels already described in the pits south of Estherville may with more or less confidence be here referred. There are other exposures of old material. Indeed, it seems as if it may be looked for almost anywhere as a bottom deposit of what has been here denominated the gravel plain. Something of the older gravel, for instance, appears along Cylinder creek as it emerges from the plateau in Fairfield township of Palo Alto county. It must be admitted that in exposures so far seen the gravels here in question are not well delimited above, but their uniform occurrence in direct contact with the blue clay would seem to justify the present provisional reference.

The Kansan drift.--This widespread formation is in evidence in every part of the territory we now describe. Not a deep well has been successfully opened but "goes through the blue clay." Everywhere the gravel of the valley is reported resting on the blue clay, and, as above noted, the report may be easily confirmed by present exposures. This blue clay is decidedly marked both in constitution, color and general appearance as to be unmistakable, so that we may assume as correct its gen-

*See Vol. XI, p. 138 of the present series.

eral identification. It is exceedingly tough and endures erosion, almost as so much rock. The eroded surface looks like eroded rock. The matrix is a fine-grained, compact clay, but in this is commingled sand, pebbles, bowlders of various sizes and shapes, in the strangest confusion. It is difficult to imagine how such a mass has ever come into place. It has the appearance of a more than half-dried paste, stiffened and compressed during the long centuries by vast superincumbent weight. No other formation on the face of the earth compares with it. There are in the older strata slates and shales and clays, soft masses that have endured enormous pressure and so been modified and changed, but they are not like this; this is a glacial clay, unjointed, unfissured, unwedgable, unblastable, the unyielding foundation of all our surface soils, the unperforate, impervious cap of all our subterranean waters.

The thickness of this deposit is very far from uniform. Reports of well diggers go as low as ten feet; but more frequently from one to three hundred feet is the range of experience. In Emmet county, in Estherville township, the well of Mr. McKay went three hundred feet in blue clay; but this is on a high ridge where some of the pre-Wisconsin topography probably still persists. The older blue clay was no doubt subject to erosion for centuries before the later glaciers came upon it to still further shave away its upper surface. The inequality in thickness is probably thus to be explained. Underneath the blue clay is a widespread couche or bed of gravel and sand, and often more clay below that, so that there is evidently another drift sheet below the famous clay. On the farm of Mr. Lardell of Emmet county is a well two hundred and seventy-five feet deep. The record given by the well-digger is:

To the blue clay	20 feet
Blue clay	130 feet
Gravel, with water	3-4 feet
Blue clay	40 feet
Black muck	2-3 feet
Yellow sand	80 feet

This "yellow sand" is evidently below a former vegetation-bearing surface. The muck represents organic stuff, plant and animal remains in a state of partial oxidation or decomposi-

tion. This decomposing matter sometimes sets free inflammable gases in considerable quantity, and such gases caught under the clay find vent only as the covering is pierced. The Burnett well, near Swan lake, emitted an inflammable gas, and when this was ignited "it burned for three months." More commonly the gases thus set free are not inflammable; they are either ordinary air that has been caught and so imprisoned, or

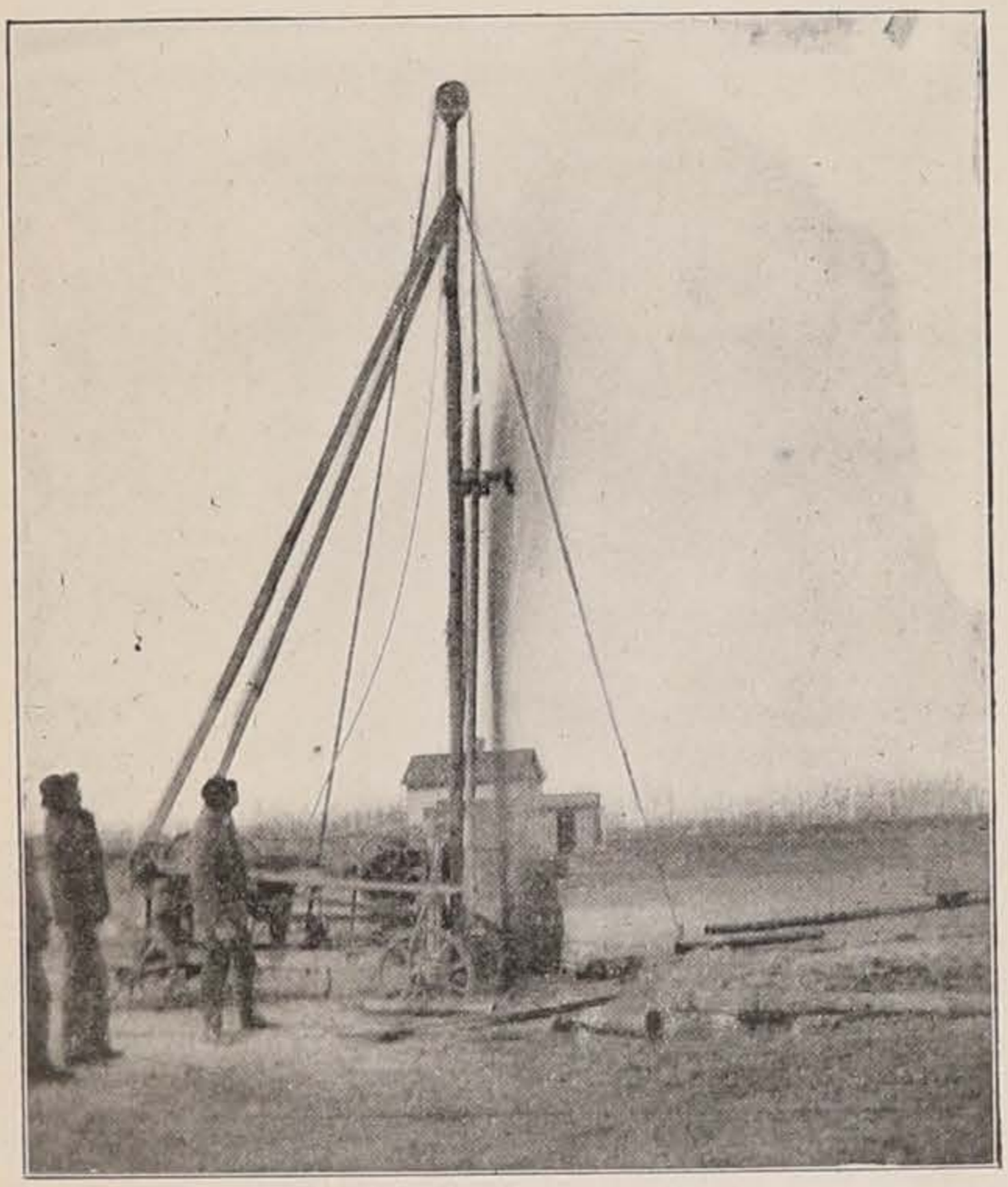

Fig. 18. View of the Wier well showing the escaping gas when a pocket of gas-bearing sand in the drift was penetrated. Emmet township, in Emmet county.

they consist largely of choke damp, carbonic acid gas, another result of the decomposition of organic stuff in places destitute of available oxygen. Thus, Mr. Grems, a well-digger at Swan lake, asserts that all the wells in Center township, from Ryan lake north, are blowing wells when first the blue clay is

pierced. The well on the farm of Mr. George Weir, in Emmet township, blew for days in such a fashion as to stop all proceedings. Pebbles of considerable size, and pieces of wood, were cast high into the air, "more than one hundred feet." By the kindness of Mr. C. C. Stover, of Estherville, we are able to offer here a cut showing the Weir well in action. Figure 18.

The blue clay, therefore, however discovered, is one of the most interesting formations in Iowa. It deserves thorough and widely extended study, and stands closely related to the water supply of the entire state.

PRE-KANSAN STAGE.

Pre-Kansan sands and gravels—These have been already referred to in the preceding section. Our only knowledge of them in this region comes as a result of well construction. We are indebted to Mr. R. I. Cratty for the following log of a 500-foot well recently drilled at Ringsted:

7.	Surface drift	12 feet
6.	Blue clay	138 feet
5.	Gray or bluish sand	10 feet
4.	Yellow sand	38 feet
3.	Shale, black and white	164 feet
2.	Blue shale	2 feet
1.	Limestone	136 feet

The porous beds form the universal aquifer or water-couche under the blue clay; sometimes directly, sometimes with the intervention of an old time land-surface, with muck, etc., under the blue clay; in case of the McKay well, already mentioned, occurs sixty-five feet of clean white sand"! This is not only of itself remarkable, but recalls an exposure of similar material in the banks of the river a few miles northwest of Humboldt, in Humboldt county. These sands may represent a pre-Pleistocene formation, possibly Cretaceous, and further reports of their distribution may be awaited with interest.

Since the boring of most wells stops no sooner than a water-bearing gravel is reached, we have no means of determining the the amount or depth of the pre-Kansan in our present territory.

Tp. 97 N.

Tp. 96 N.

Tp. 95 N.

Tp. 94 N.

LOST ISLAND

WALNUT

VERNON

INDEPENDE

HIGHLAND

EMMETSBURG

FREEDOM

FAIRFIE

SILVER LAKE

GREAT OAK

NEVADA

VALLE

BOOTH

RUSH LAKE

ELLINGTON

WEST BEND

HERN

Graettinger

Fallow

Osgood

Depew P.O.

Fairville

Lost Island Park

Lost Island Lake

RUTHVEN

Elbow Lake

Virgin Lake

Crippen

EMMETSBURG

Cylinder

Prairie

Ayrshire

Silver Lake

Rodman

Curlew

MALLARD

Beaver

Jack Creek

Willow Creek

Pilot Creek

Cedar Creek

Cylinder Creek

Des Moines River

OLD CHANNEL OF THE RIVER

Fork

McGinnis Lake

CHICAGO MILWAUKEE & ST. PAUL R.R.

CHICAGO ROCK ISLAND & PACIFIC R.R.

R. XXXIV W.

R. XXXIII W.

R. XXXII W.

R. XXXI W.

IOWA LITHO. CO.

IOWA GEOLOGICAL SURVEY

MAP OF THE SUPERFICIAL DEPOSITS OF PALO ALTO COUNTY, IOWA.

BY

T.H.MACBRIDE

1905.

Scale 1/125000

1 ½ 0 1 2 3 4 5 Miles.

1 ½ 0 1 2 3 4 5 Kilometers

LEGEND

GEOLOGICAL FORMATIONS

ALLUVIAL DEPOSITS

WISCONSIN DRIFT

MORAINIC DEPOSITS

BORDER OF GLACIAL ADVANCE NOT CHARACTERIZED BY CONSPICUOUS MORAINIC DEPOSITS.

INDUSTRIES

GRAVEL PITS.

DRAWN BY F.C. TATE

IOWA LITHO. CO.

"Twenty feet in the gravel" is, however, a not infrequent description. In Pocahontas county the drift layers of all ages appear to be thinner; the blue clay is quoted at thirty and forty feet, and the subjacent gravels it would seem, sometimes fail entirely. Wells are sunk in limestone rock.

Carboniferous System.

SAINT LOUIS LIMESTONE.

The only outcropping of indurated rock in the region we study is found in Pocahontas county. This exposure has already been made the subject of comment in these reports and the present review of the case can offer no new facts or detail.* The exposure in question is limited to a very narrow area, one hundred acres or less, and even then is not a natural exposure. Where quarried the rock is covered by soil and drift to a depth of several feet, although a few rods further south rock in place is struck by the passing plough. The quarry occupies the place of a former sink-hole as described in the report cited; the upper strata of the rock are marked by fissures long subject to erosion by descending floods of water, and the quarry shows natural walls of cross-bedded limestone. In these wet seasons, work in the quarry is much hindered by water, which fills the pit in a night, but presently disappears again by subterranean drainage.

Above the limestone, between the limestone and the drift, occurs in limited measure, on the west side of the present opening, a deposit of peculiar, fine-grained, non-calcareous, reddish clay. The stratigraphical relationship of this substance is not known. It is interesting in its position and if in quantity would possess high economic value; it is so very pure and uniform. That such substance has been reached by those who in Pocahontas county sink their wells to the limestone in various places is nowhere reported. This clay may represent a member of the Cretaceous system.

* See of this series Vol. XI, pp. 131-133.

ECONOMIC PRODUCTS.

Clay.

The economic celebrity of these counties will, in the future as in the past, rest rather upon the extreme fertility of the soil and its adaptation to varied agriculture, rather upon this than upon resources of special type such as occur in the regions affording ore and coal. Even the manufacture of tile and brick is much handicapped by the occurrence of a large percentage of calcareous pebbles inextricably mingled with the ordinarily accessible beds of clays. Many efforts are making in various places, if possible to obviate this difficulty. At Armstrong, Messrs. Robinson & Stewart, although their work is yet somewhat in the experimental stage, will manufacture this year some 300,000 brick and about the same number of tile. The clay used is from a peaty slough a short distance north of the works. It is reasonably free from the lime pebbles, but still gives so much trouble as to suggest plans for their elimination. This is the only attempt at present in Emmet county toward the prosecution of the clay industry. In Palo Alto county there is at present, so far as could be learned, no brick or tile kiln at all.

At Fonda in southwestern Pocahontas county the Straight Brothers have been very successful in handling the same pebbly Wisconsin clay. They use a rotating screen and so eliminate from the dry material pebbles of all and every sort. The dump behind the screen-house reveals in a surprising way the nature of the difficulty everywhere encountered in the making of brick in northwestern Iowa.

By the means adopted, however, Straight Brothers are making excellent tile at the rate of about one million per annum. Some shale from Fort Dodge is imported and mixed with the screened clay, and such brick is said to excel that made at Fort Dodge, from shale or Carboniferous clay alone.

At Rolfe, Messrs. Nelson and Dawson have recently undertaken the manufacture of tile. The material used is the same as that sought elsewhere, a Wisconsin clay which has been somewhat sorted by the action of water, that is fine silt; here partial alluvium. The pit shows rather uneven material, but the product is quite good; some of it excellent. It is here proposed to separate the pebbles by a process of washing, and plans are maturing for such an experiment. The present capacity is 700,000 tile per year; no brick. In all these cases coal is the fuel used, and this is brought from Des Moines. But with all the disadvantages, it appears to be far cheaper to import fuel and manufacture on the ground than to import the vast quantity of tile which for this undrained territory is an absolute necessity, and where for years to come the demand will outrun all probable local supply. For farm drainage even large sizes of tile are demanded and pipes fifteen and sixteen inches in diameter are going into the marshes of these counties.

Since the report on Clay county was written a bed of almost pebbleless clay has been discovered a mile or so northeast of Spencer. From this, although its extent is at present unascertained, great results are expected. So far as examined the tile are excellent and the clay promises well. This clay lies in a flat, undrained field, higher than the gravel plain and is no doubt a deposit from water. It is not loess but represents the result of the slow subsidence of fine silt during a long course of years. Such deposits are to be expected everywhere where similar conditions obtain. The gravel plain from Estherville south to Emmetsburg was formed under conditions precisely similar to those which gave rise to the gravel plain at Spencer; so that deposits of similar clay may be hopefully looked for pretty well up toward the general country level, but in the vicinity of the great drainage valleys. Such deposits are likely to be discovered by the ditcher. As this is written there are rumors that some such beds have been discovered not far from Estherville. *

* Investigation shows the material in use at Estherville to be the common blue clay underlying the whole country, and effort is making to free the clay from pebbles and bowlders. June, 1905.

Stone.

The one stone quarry of the three counties, that near Gilmore in Pocahontas county, is in constant use, but the amount of rock taken out is nothing like so great as in former years. The rock is well bedded, comes out in fine blocks for all sorts of range work, but has, after all, only a local demand. The product last year was eight hundred and seventy cords. Quarrying for two years has been hindered much by surface water. The location is low, a former marsh, in fact, and heavy rains fill all the excavations with water. This, however, disappears presently by the marvelous subterranean drainage characteristic of this part of Iowa. The Gilmore rock is very rich in lime. According to reports some samples show 99.64 per cent lime. A large set of lime kilns was once in operation here, but for some reason the lime industry has been abandoned.

Gravels.

Among the several natural economic resources of this region the vast supplies of gravel found, as stated, along all streams and not infrequently remote even from the water-courses, seem deserving of special mention. These gravels are today carried by hundreds of car-loads to be used as ballast along the great railway lines of the Northwest. Nor is such material less serviceable in the localities where found. Gravel makes excellent streets; witness those of Estherville; excellent country highways; excellent causeways across marsh and flat as every traveler along the valley of the Des Moines will gratefully testify. The old glacial gravels of northern Iowa are the sure promise of good public roads.

Water Supply.

Through two of the counties here studied, the West Fork of the Des Moines river passing, affords a perennial water supply. The general drainage system of the country whether natural or

T. 93 N.

T. 92 N.

T. 91 N.

T. 90 N.

SWAN

WASHINGTON

POWHATAN

DESMOINES

SWAN LAKE

RAT LAKE

LAKE

LAURENS

CHICAGO AND NORTH WESTERN R.R.

HAVELOCK

Plover

CHICAGO ROCK ISLAND AND PACIFIC R.R.

Beaver Creek

Pilot Creek

Rubens Siding

ROLFE

Ware

MARSHALL

SHERMAN

CENTER

GARFIELD

Little Cedar Creek

POCAHONTAS

CLEAR LAKE

Big Cedar Creek

Lizard Creek

DOVER

GRANT

LINCOLN

LAKE

Rusk P.O.

Varina

LIZARD LAKE

CEDAR

COLFAX

BELLVILLE

LIZARD

PALMER

Lizard

FONDA

Blanden

CHICAGO MILWAUKEE AND ST PAUL R.R.

ILLINOIS CENTRAL R.R.

R. XXXIV W.

R. XXXIII W.

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1 ½ 0 1 2 3 4 5 Miles.

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LEGEND

WISCONSIN DRIFT

INDUSTRIES

CLAY WORKS ▲

DRAWN BY F. C. TATE

IOWA LITHO. CO.

artificial is also in a measure serviceable. Beaver creek, Lizard creek and Cedar creek in Pocahontas county are said to be perennial streams. But water of excellent quality is everywhere so surely accessible in wells of moderate depth that, for serving the purposes of the people,streams and lakes are hardly regarded. In many places, as on the gravel river-plains, water is obtained by the so-called "drive wells." This is true also of the vicinity of Cylinder and north. Wells of twenty to thirty feet in depth and inexhaustible are reported from Ringsted, Mallard, Curlew and other places. In most cases, however, the wells are deeper, ranging from eighty to four hundred feet. The city water supply at Estherville is from springs coming out on the blue clay near the Des Moines river. Similar water doubtless fills the wells in the gravel at Graettinger and at Emmetsburg. Fonda has a deep well with water of excellent quality.

Fuel Supply.

Residents of these counties rely chiefly for fuel upon outside sources of supply. There is some native wood; every farmer has now a grove; so that wood is comparatively cheap. In some places vast beds of peat occur, as at Ruthven in Palo Alto county, but Iowa peat has only in rarest cases been put to practical use.

ACKNOWLEDGMENTS.

In the preparation of these reports the author has enjoyed the assistance of many people in every part of the counties traversed. Mr. C. C. Stover was especially helpful at Estherville. Mr. Jackson, of the Watson Land Co. at Emmetsburg, gave personal assistance in the work of the survey. To Mr. R. I. Cratty of Armstrong we are indebted both for many courtesies and for the accompanying Forestry notes which are the result of his long study of the flora of the upper Des Moines valley. To Professor Calvin, the Director of the Survey, the author is under constant obligation for counsel and personal assistance.

FORESTRY NOTES FOR EMMET COUNTY.

BY R. I. CRATTY.

General Discussion.

To one who has spent much of his life in a forest region, our treeless western prairies present a picture which, though interesting at first, at length loses much of its attractiveness because of the monotonous landscape. When this portion of Iowa was plowed and furrowed by the ice fields which covered the region during the Glacial epoch, the retreating ice left its load of clay and sand and gravel in low ranges of hills which in our day help somewhat to relieve this monotony, but excepting these morainic hills and the lake beds, the ever varying topography is usually the result of erosion. Though the face of a country vary ever so much in the character of its surface, and in its carpet of green grass, adorned with beautiful flowers, still there is something lacking if the trees, those noblest examples of Nature's handiwork in the vegetable world, are wanting.

However well this region may have been covered by an arboreal vegetation previous to the period of the Wisconsin drift, its reforestation after the ice disappeared has been very slow. Among the many causes which have united to produce the result may be enumerated the hot, drying southwest winds of autumn, quite common in western Iowa some years ago; and since man's advent upon the scene, the prairie fires. In this portion of the state land sloping to the southwest is usually devoid of native timber unless protected in that direction by high bluffs, or some considerable body of water, which would modify the effect of the hot, dry winds. A northeast slope, other conditions not being wanting, is an ideal one with us for native timber, as well as for orchards and artificial groves. Until recently the prairies were covered every season with a luxuriant growth of native grasses, and were very often burned over by the Indians, and in later years by the white hunters and settlers. These

fires usually occurred in late autumn or early winter when the prevailing strong winds were from the west or northwest, and this is at least one reason why our native timber is mostly found on the south or east side of lakes and streams. When it does occur on the west or north it is usually a fact that the forest line is protected in that direction by bluffs with a scanty covering of grass, or by deep marshes. It may be observed also that no timber except a few small willows, is found along the smaller streams flowing through our more level regions, which, though capable of furnishing the necessary conditions of soil and moisture, nevertheless could not furnish protection from the prairie fires.

The area of native timber in this county is quite small, much the larger body being found along the West Fork of the Des Moines river, west and north of Estherville. There are also several smaller bodies, the larger of which are along the East Fork of the Des Moines in Armstrong Grove township, and along the shore of Iowa lake. Now that the days of the prairie fires are ended, a young growth of timber, mostly ash, box-elder and willow, is gradually fringing both banks of our rivers, and if man does not interfere, our forest area will surely increase.

A great amount of the best timber in this region was cut down by the early settlers for fuel or for building purposes, some of it being sawed into lumber by sawmills which have long since disappeared.

Since the advent of the railroad, bringing fuel and lumber, this wholesale destruction of our best timber has almost ceased, and a fine young growth, if given sufficient protection, will in time do much to restore the former conditions. The habit of too closely pasturing our native woods can not be too severely condemned, as, where the humus and undergrowth are destroyed by the tramping of cattle, the hot, drying weather of autumn frequently causes the death of many of our native trees. By retaining this leaf mould and undergrowth, thus preventing too rapid evaporation, and a judicious cutting of the older timber for use, there is no reason why our woods should not gradually improve. Fortunately, our best timber is situated on land unsuitable for cultivation, and thus at least

one temptation is lacking to remove it, and it is sincerely hoped that the owners of these tracts will use all reasonable efforts to preserve and improve the present condition of what is left.

The most valuable of our trees are the two species of oak, the bur oak and red oak, the white and the slippery elm, the hard and soft maple, one ash, one hickory, the basswood, the hackberry, the black walnut and the cottonwood. Besides these there are numerous smaller trees and shrubs. There are also several species of trees common in cultivation such as the cottonwood, lombardy poplar, white willow and several kinds of evergreen.

Throughout this prairie region there are numerous artificial groves which add much to the beauty of the landscape, and there is no reason why every country home should not be surrounded with a beautiful grove of trees to furnish a shelter from the severe winds and the snows of winter, and in summer to delight us with cooling shade, and furnish a safe home for our feathered friends, that they may come and dwell among us and sing to us their songs of joy and gladness as they build their nests and rear their young.

List of Trees.

The following list of the trees and shrubby plants of Emmet county, systematically arranged, is also believed to be nearly complete for the bordering counties as well. The number of species is comparatively small, but this may be partially accounted for by the fact that this region was entirely covered by the Wisconsin drift, a much later geological formation than is found in the southern and eastern portions of the state, and one which gives us little variation in the character of surface and soil.

PINACEÆ.

1. *Juniperus virginiana* L. Red Cedar. This is the only evergreen native to this portion of Iowa, and is found sparingly on the bluffs around the lakes. Most of the trees have been cut for fence posts for which purpose they furnish our most

durable timber. This tree flourishes well in our prairie soil and makes a rapid growth. It may be used to advantage as a windbreak as well as for ornamental purposes. The dark green of its foliage contrasts very pleasingly with that of the surrounding deciduous trees. Besides it has economic value for the purpose mentioned and there is no reason why farmers should not raise their own fence posts.

JUGLANDACEÆ.

2. *Juglans nigra* L. Black Walnut. This very valuable tree was once quite common in low woods. It is at present quite scarce in a wild state, having been made into rails and used for fuel by the early settlers; and later the trees of sufficient size have been cut down and sold to be sawed into cabinet lumber. The tree is becoming quite common, however, in cultivation, for which purpose it is very valuable, not only for its timber and shade, but for its fine shape which makes it well adapted for planting along roads and driveways. The delicious nuts which it yields abundantly are great favorites with the young people. It is most successfully raised from the seed planted where the trees are to remain, as its deep taproot makes its transplanting difficult.

3. *Hicoria minima* (Marsh), Britton. (*Carya amara* Nutt). Bitternut. Our only hickory; a small tree with very hard, close-grained wood, useful for many purposes, such as handles for tools. The thick-shelled nuts are of little value. The tree has a wide distribution in this region, but is nowhere very plentiful.

SALICACEÆ.

4. *Populus alba* L. White or Maple-leaved Poplar. This European tree is very frequently planted for shade, but is not to be recommended, as it spreads very badly by its roots. It has escaped from cultivation in many places.

5. *Populus tremuloides* Michx. Poplar. Trembling Aspen. A graceful little tree, quite frequent in woods, and one which formerly was occasionally found in clumps on the prairie. As it spreads by its roots, like its European cousin, and will grow

up again if burned over, it was better fitted than most of our native trees to survive the prairie fires; a great enemy of our native forest development. Its beautifully shaped leaves are so hung on the slender, flattened petioles, so as to rustle in the slightest breeze. With us the tree does not reach a size to make its soft wood of much value except for fuel.

6. *Populus deltoides* Marsh. (*Populus monilifera* Ait.). Cottonwood. This large tree, everywhere common in cultivation, was very rare in this county in early days. Mr. M. Richmond, who settled in Armstrong Grove township in 1868, reports one large tree, then a foot in diameter, south of the East Fork of the Des Moines river, not far from his home, and also a few smaller ones elsewhere along the river. The larger one must have been a native before the coming of the white settlers, as its size would indicate, the first settlement having been made in that section about 1865.

Regarding this species the Hon. Howard Graves, of Estherville, who came to the county only four years after the first settler, writes the author as follows: "When I came to this county, A. D. 1860, there was one large cottonwood tree (evidently native) growing on the west bank of Ryan lake. In this tree eagles nested for many years. The water finally washed around the roots of the old cottonwood, and it toppled over into the lake where it now lies in a state of decay. There were at the time mentioned a few other native trees of the cottonwood species on the south bank of Turtle lake; none on the West Fork of the Des Moines river or in the immediate vicinity of Estherville."

The early settlers planted this species extensively as a shade tree around their dwellings and along roadsides, its very rapid growth making a quick return for the labor used in planting and cultivating. Trees thirty-five years old frequently measure two feet in diameter and seventy feet in height. The wood is soft and perishable, but when seasoned is quite valuable for fuel. The tree does not thrive on the prairie when planted in a grove, only the outside row or two doing fairly well; but when given plenty of room, the rapidity of its growth is all that could be desired. Though once so rare, it is escaping

from cultivation in many places. This tree, like all the willows and poplars, is diœcious, the stamens and pistils being borne on separate trees, and its small seeds, each with its tuft of cotton, is a source of great annoyance to tidy housewives. If cuttings for planting were taken only from the staminate or sterile trees this objectionable feature would be removed.

7. *Salix nigra* Marsh. Black Willow. Frequent along streams and lake-shores. It sometimes attains a very large size, forty to fifty feet in height, with a trunk a foot in diameter. This and the following species usually bend gracefully over the water, their leaves and slender branches reaching down as if to kiss the face of the stream that smiles in the sunshine below. The wood though soft is quite durable and is valuable for fuel and fence posts, for which purposes it was much used by the early settlers.

8. *Salix amygdaloides* Anders. This large tree is similar to the preceding, and grows with it. It may be recognized by its broader leaves, about one inch broad and three to five inches long. It seems to be widely distributed throughout this region.

9. *Salix alba vitellina* (L.) Koch. White Willow. This is the form in universal cultivation throughout this part of the west, and is very valuable for forming a hedge or windbreak where a quick return is especially desirable. When planted in single rows the growth is used for summer wood and for fence posts. For this latter purpose the posts should be four to six inches in diameter, and if well seasoned will last from three to ten years.

A large clump planted on some low corner in the permanent pasture will afford a fine shade, and will be greatly appreciated by our dumb friends on hot summer days. While not a native of this country, this willow has escaped from cultivation and is frequently found along highways and streams.

10. *Salix fluviatilis* Nutt. (*S. longifolia* Muhl.) Sand-bar Willow. This is a much branched shrub, seldom attaining the size of a small tree, which grows in clumps along streams and in marshes. It is of little value, though sometimes used for fuel when nothing better is at hand. This is our most common species.

11. *Salix bebbiana* Sargent. (*S. rostrata* Richards.) Bebb's Willow. Occurring as a shrub in a large marsh, two miles north of Armstrong.

12. *Salix humilis* Marsh. Prairie Willow. This little shrub is very rare in this region. It is seldom more than two or three feet high, and occurs on prairies or borders of woods.

13. *Salix discolor* Muhl. Glaucous Willow. A shrub or small tree which attains a height of ten to twenty feet in this locality. It occurs along streams, but more frequently in marshes or on low prairies. Its leaves when mature, are a bright glossy green above and whitish underneath, hung gracefully on the slender branches, make this a beautiful species.

14. *Salix sericea* Marsh. Silky Willow. A most beautiful shrub. The young leaves are silky-pubescent, but later in the season are a dark, glossy green. Rare in marshes near Armstrong.

15. *Salix cordata* Muhl. Heart-leaved or Pussy Willow. A straggling shrub five to twelve feet high, very common in clumps along streams and on low prairies. Of no economic value. The closely allied *S. missouriensis* Bebb, occurs at Okoboji, Dickinson county.

16. *Salix myrtilloides* L. Bog Willow. This is a beautiful little shrub about two feet high. A large patch of it occurs in a marsh three miles north of Armstrong, the only locality known in the state. It ranges from New Jersey to Iowa and northward into British America, and is also common in northern Europe, being the only Iowa willow native to both the Old and the New World.

BETULACEÆ.

17. *Ostrya virginiana* Walt. Hop Hornbeam. Ironwood. This small tree is easily recognized by its hop-like fruit. Its very hard wood is useful for various purposes, like the hickory. Though very common in woods with us, it never attains much size.

18. *Corylus americana* Walt. Hazelnut. This low shrub is much less common in this region than in the eastern and southern parts of the state. It is found rather sparingly on the

borders of woods or along river bluffs. Its fruit, ripe in August or September, is eagerly sought by the children, as well as by their friends, the squirrels and chipmunks.

FAGACEÆ.

19. *Quercus rubra* L. Red Oak. This oak, which becomes a large forest tree in more favored localities, seldom attains any considerable size in this region. It is frequent in the woods near Estherville. Though a very pretty tree, it does not possess much value except as fuel.

20. *Quercus macrocarpa* Michx. Bur Oak. This is our hardiest tree as well as our commonest hard-wood species. It varies from a large tree in favored localities, to a gnarled and straggling shrub on the river bluffs and the outskirts of the woods. Single trees are occasionally found at long distances from any other timber where they have, sentinal-like, withstood the buffetting storms for centuries.

Like all the oaks it cannot be transplanted successfully, unless at great expense, and for this reason, as well as because of its slow growth, it is not used in cultivation. The wood is hard, strong and close-grained and is very valuable for fence posts and fuel. The white oak does not occur in this county, its nearest station being at Algona twenty miles southeast of our limits.

ULMACEÆ

21. *Ulmus americana* L. White or Water Elm. This large tree is very common along large streams, and is our most valuable native species for a shade tree along streets and around dwellings. It is perfectly hardy, and its tough, wiry branches withstand the wind remarkably well. Its wood, quite valuable for fuel, is difficult to split.

22. *Ulmus fulva* Michx. Slippery Elm, Red Elm. A smaller tree than the preceding, and comparatively rare in this region. The wood is stronger and more durable than that of the white elm. The mucilaginous inner bark is often chewed by children, and is used to some extent in medicine.

Ulmus alata Michx. The Winged Elm has been found in Dickinson county by Prof. T. H. Macbride.

23. *Celtis occidentalis* L. Hackberry. This large tree attains only a medium size with us. It occurs scattered through woods and along river banks, and shores of lakes. The tree has the aspect of the elm. Its small, berry-like fruit, ripe in August, is said to be sweet and edible. The wood is weak and coarse grained.

SAXIFRAGACEÆ.

24. *Ribes cynosbati* L. Gooseberry. This species occurs in the woods west of Estherville, but is much less common than the next. Its fruit is quite large and covered with prickles.

25. *Ribes gracilis* Michx. Gooseberry. This smooth-fruited shrub is very common and is sometimes transplanted to gardens. The fruit, which when ripe is very pleasantly flavored, is occasionally offered for sale in the market.

26. *Ribes floridum* L'Her. Wild Black Currant. This is a very common shrub in low woods and along the banks of streams. The fruit has a flavor similar to the black currant of the gardens, and is liked by some persons. The bush is handsome when in bloom, and should be used for ornamental purposes.

ROSACEÆ.

27. *Spiraea salicifolia* L. Meadow-sweet. This beautiful little shrub, two to four feet high, is very common on low prairies and along streams. Its graceful panicle of white or rose-tinted flowers makes a pretty sight. It is scarcely inferior to some of the cultivated species.

28. *Rubus strigosus* Michx. Wild Red Raspberry. Frequent in woods. The light red fruit is very pleasant to the taste. This species is the original of the Cuthbert raspberry of cultivation.

29. *Rubus occidentalis* L. Wild Black Raspberry. A common species in woods, the original of the "black cap." The artificial groves contain many of these black raspberries which

have grown from seeds dropped by the birds, and it is impossible to distinguish between those derived from the wild and the cultivated stock.

30. *Rubus villosus* Ait. Blackberry. A few plants of this species were found twenty-two years ago in the woods west of Estherville, but they have probably disappeared before this. These three species of bramble are not true shrubs, the stems being biennial.

31. *Rosa blanda* Ait. Wild Rose. This pretty shrub, two to four feet high, is restricted to the woods and river banks. Its stems are only sparingly armed with prickles, the leaflets are usually three to five in number. Those who love our wild flowers as nature left them, will find this a desirable shrub for cultivation.

32. *Rosa arkansana* Porter. Prairie Rose. The small wild rose, so common everywhere on our prairies, is this species. The stems densely covered with prickles are far from pleasant to handle when bound in a bundle of grain. The roots are so deep seated that only very deep plowing and the most thorough cultivation will destroy them. It, however, does little harm in our fields, and one can readily forgive a few scratches for the pleasure of seeing its beautiful flowers at his feet as he labors, showing every shade of color from pure white to the deepest red and crimson.

POMACEÆ.

33. *Malus ioensis* (Wood) Britton. (*Pyrus ioensis* Bailey). Wild Crab Apple. This small tree, now considered distinct from the form occurring in the eastern states, is found but rarely in this region. When in full bloom one could scarcely wish a prettier sight, and for this reason, as well as for its bright foliage, it is a desirable ornamental tree, although it is somewhat difficult to transplant from the woods. The fruit is pleasantly scented, and very acid.

34. *Amelanchier alnifolia* Nutt. Serviceberry. This pretty shrub, four to eight feet tall, is found on bluffs along lakes, and in high woods. The fruit, ripe in June, is very pleasantly flavored, and seems to be liked equally well by birds and people.

35. *Cratægus punctata* Jacq. Hawthorn. This small tree is quite common in the woods around Iowa lake. The large red fruit is not unpleasant to the taste.

36. *Cratægus coccinea* L. Scarlet Thorn. This is our most common hawthorn, or thorn apple. This beautiful small tree or shrub is found in thickets, and occasionally in artificial groves where it has evidently been introduced by birds. It is also sometimes seen in cultivation for which purpose it is well suited.

37. *Cratægus mollis* (T. & G.) Scheele (*C. subvillosa* Schrad). Hawthorn. Thorn Apple. Woods, rather rare. The broad leaves are very soft to the touch, especially when young. The large red fruit is not unpleasant to the taste. This is also a desirable tree in cultivation. In later years so many new species have been segregated from the few formerly recognized that the three given here may include several of the new species, but in the present unsettled condition of the genus it seems best to await further developments before attempting to prolong this list.

DRUPACEÆ.

38. *Prunus americana* Marsh. Wild Plum. This is a shrub or small tree with a profusion of small thorns. Though often cultivated, it does not bear much fruit after a few years. The large yellow or red fruit is very much desired for canning and jelly, and formed an important addition to the few luxuries of the early settlers before the introduction of other fruits. The tree is very common throughout the state, preferring the margins of the woods or the dry banks of lakes and streams.

39. *Prunus virginiana* L. Choke Cherry. This is a shrub six to eight feet high, growing in clumps in open woods, or on bluffs along streams and lakes. It is troublesome in cultivation as it spreads very readily by the roots. The fruit is nearly black and very astringent.

40. *Prunus serotina* Ehrh. Wild Red Cherry. This tree which attains a very large size in the eastern states, occurs sparingly in the woods west of Estherville, where it is quite small, attaining a height of ten to twenty feet. The strong

reddish-brown wood of this species is very valuable in cabinet making. The fruit, which is a dark red, and only slightly astringent, is occasionally used for food.

PAPILIONACEÆ.

41. *Amorpha fruticosa* L. False Indigo. A shrub six to eight feet tall, common in open woods and along streams.

42. *Amorpha nana* Nutt. (*A. microphylla* Pursh.) False Indigo. A very beautiful little shrub growing in clumps and common on the prairies of northwestern Iowa. In its small leaves, their color and surface, and the general appearance of the shrub, it bears a close resemblance to the box. The numerous spikes of flowers appear in May or June and are very showy. The plant would seem to be worthy of cultivation.

43. *Amorpha canescens* Pursh. Lead Plant. Shoe-String. This is a shrubby plant about two feet high, with spikes of bright, indigo-blue flowers, which are very pleasantly scented. The strong roots offer considerable resistance to the breaking plow, whence the popular name shoe-string. It grows very commonly on rather dry prairies and borders of woods.

44. *Robinia pseudacacea* L. Locust Tree. This ornamental tree from the Atlantic states is frequent in cultivation, and has escaped in a few places. Its wood is said to be very durable for posts.

RUTACEÆ.

45. *Xanthoxylum americanum* Mill. Prickly Ash. This pretty shrub or small tree is quite common in thickets and occasionally introduced by birds into artificial groves. Its pinnate leaves and mature capsules, displaying the shining black seeds are very pretty, but the numerous prickles on twigs and petioles are a serious objection.

ANACARDIACEÆ.

46. *Rhus hirta* (L.) Sudw. (*R. typhina* L.) Staghorn Sumac. This is our rarest and handsomest species. Only a few shrubs have been found on the river bluffs southwest of Armstrong, and near Iowa lake. The graceful, fern-like leaves, as well as

the bright crimson foliage and fruit in autumn, make it a desirable plant for cultivation. Its only drawback is its liability to spread by the roots.

47. *Rhus glabra* L. Smooth Sumac. Common everywhere near woods and on the bluffs along lakes and rivers. It is almost as pretty a shrub as the preceding. The showy fruit, ripe in autumn, is covered with short, red, acid hairs.

48. *Rhus radicans* L. Poison Ivy. In this locality this plant only occurs as a low shrub, one to two feet high. The leaflets are in threes, and the clusters of dry, whitish berries are carried on the plant all winter. It is very poisonous to most people, and for this reason should be destroyed, especially if found around dwellings. It should not be confounded with the beautiful virginia creeper, which is also very common. The latter always has the leaflets in fives. The climbing form of the poison ivy probably does not occur in this part of the state.

CELASTRACEÆ.

49. *Euonymus atropurpureus* L. Wahoo. Burning Bush. A shrub or small tree, very rare here, having been found only in the woods near Estherville. When the capsules open in autumn, displaying the dark colored seeds in their red setting, the plant is highly ornamental.

50. *Celastrus scandens* L. Climbing Bittersweet. This beautiful woody vine climbs trees to the height of ten to twenty feet. When the seeds are displayed in autumn in their scarlet arils, they are very attractive, and are much used for house decoration in winter. The vine is more commonly found in thickets and is also occasionally seen in artificial groves where it has probably been introduced by birds. Both this and the preceding species are frequently cultivated.

STAPHYLEACEÆ.

51. *Staphylea trifolia* L. Bladder Nut. A shrub about four to eight feet high with pretty, trifoliate leaves, and seeds enclosed in bladder-like capsules. It was found only in one place in the woods west of Estherville, and is probably very rare in this region.

ACERACEÆ.

52. *Acer saccharinum* L. (*A. dasycarpum* Ehrh). Soft Maple. This tree is native along both the East and West Forks of the Des Moines river, but is much more common in cultivation. It is one of our most useful and rapidly growing shade trees, and worthy of much more attention than it receives. Planted in a hedge for a windbreak it does very good service, growing when planted closely, tall and slender, like the white willow. Planted along the road, or on the lawn, it will assume very fine proportions if properly pruned. When given plenty of room it is a very rapid grower, and its branches are somewhat easily broken by the wind, but, if after the trees have attained a height of ten to twelve feet, a heavy blue-grass sod is allowed to form around them the growth will be sufficiently retarded to render the wood much tougher, and less liable to injury. The tree is remarkably free from insect enemies. The wood is quite valuable for fuel, but is of little value for posts, as it decays rapidly when placed in contact with the soil. The trees are best raised from seed, planted a few inches apart in rows which are at a sufficient distance from each other to allow of thorough cultivation. Young trees are easily transplanted to their permanent location when five or six feet high, which will be in about three years.

53. *Acer nigrum* Michx. Black Sugar Maple. Common on high ground in woods near Iowa lake and Estherville. It is a most beautiful tree, and is valuable for its strong, close-grained wood. As a shade tree for lawns and parks it is very much admired, but seems prone to die in the top when transplanted to our heavy prairie soil. The trees in this region are mostly small in size and have been used very little for the purpose of making maple sugar.

54. *Acer negundo* L. (*Negundo aceroides* Moench.) Box Elder. A small tree, very common along streams, which is destined, now that the days of prairie fires are ended, to play an important part in lining their banks with timber. The tree is not a desirable one for planting on the lawn or along the street because of its low branches and bushy appearance, as well as its liability to be infested by a species of bug marked with red,

known as the Indian bug, which often gather on it in great numbers and enter houses to the great annoyance of tidy housewives. Its wood is of some value for fuel.

RHAMNACEÆ.

55. *Ceanothus americanus* L. New Jersey Tea. Red Root. This beautiful little shrub, one to two feet high, grows in dry soil on prairie hillsides, and on the border of woods. It is easily destroyed by pasturage or cultivation, and is rapidly disappearing.

VITACEÆ.

56. *Vitis vulpina* L. (*V. riparia* Michx.) Wild Grape. This shrubby vine is very common in low woods, especially along streams. The acid fruit, ripe in September, is largely gathered for making wine and jelly. It is becoming very plentiful in the artificial groves where its seeds have been left by the birds. It is extremely hardy and stands the cold of our severest winters without injury.

57. *Parthenocissus quinquefolia* (L.) Planch. (*Ampelopsis quinquefolia* Michx.) Virginian Creeper. This beautiful climbing vine is perfectly hardy and is worthy of extensive cultivation. Its leaflets are in fives which at once distinguishes it from those of the poison ivy which are in threes. The black berries and crimson leaves in autumn add still more to its atttractiveness. By the means of adhering disks at the end of its tendrils, it readily climbs the side of a building without other support. Common everywhere in woods, it is rapidly being introduced into artificial groves by the birds.

TILIACEÆ.

58. *Tilia americana* L. Basswood, American Linden. This handsome tree, native along streams, prefers soil not too low, but where its roots can secure an abundance of moisture. The sweet-scented flowers are great favorites with the bees. It is a desirable tree for the lawn wherever some shelter from heavy winds is afforded. Its soft wood is quite valuable for fuel, and in early days many of the larger trees were sawed into lumber.

CORNACEÆ.

59. *Cornus circinata* L'Her. Round-leaved Dogwood. This pretty shrub, four to ten feet high, grows in clumps on river banks, but is not common. Its broad, thin leaves at once distinguish it from our other species of the genus.

60. *Cornus asperifolia* Michx. Rough-leaved Dogwood. This small shrub occurs in woods near Iowa lake, and Armstrong Grove and is probably frequent in this portion of the state.

61. *Cornus stolonifera* Michx. Dogwood. This pretty little shrub with reddish purple twigs grows in dense clumps along streams. It is not so common as the next species.

62. *Cornus candidissima* Marsh. (*C. paniculata* L'Her.) Dogwood. Our commonest species, everywhere along lake shores and water courses where other timber is found. This shrub has white fruit.

63. *Cornus alternifolia* L. Alternate-leaved dogwood. This is our largest species of the genus, being a tall shrub, or small tree. It occurs sparingly along the south bank of the Des Moines near Armstrong, and in the woods west of Estherville.

OLEACEÆ.

64. *Fraxinus lanceolata* Borck. (*F. viridis* Michx.) Green Ash. This is one of our most valuable native trees; everywhere common along the larger streams and lake shores. Its rapid growth and strong, durable wood make it a valuable tree for planting in grove or lawn. It was very largely used for fuel by the early settlers, as well as for supports for the hay sheds which were the barns of the pioneers. It bears transplanting to the prairie soil remarkably well and is reasonably free from injury by wind-storms and insect enemies. The white ash, a larger and more valuable species, has not been found within our limits.

CAPRIFOLIACEÆ.

65. *Sambucus canadensis* L. Black Elderberry. This pretty shrub, so common in the Eastern states, is occasionally found in our woods where it is undoubtedly native. It is often trans-

planted to gardens for the sake of its graceful shape, and its berries, which are used for pies. The red-berried elder (*S. pubens* Michx.) occurs twelve miles north of our county line, in southern Minnesota.

66. *Viburnum pubescens* (Ait.) Pursh. Arrowwood. This is a low, branching shrub, with nearly black berries. It occurs in the woods west of Estherville.

67. *Viburnum lentago* L. Nanny Berry, Sheep Berry, Black Haw. This pretty shrub is frequent in woods, preferring high banks near water. Its flowers are very attractive in May; its fruit, ripe in October, is edible and much liked for its peculiar shape, and pleasing flavor. It is a near relative of the snow ball of the gardens.

68. *Symphoricarpus occidentalis* Hook. Wolf-berry. A neat little shrub, very common in open woods, and occasionally on gopher knolls on the prairie. The clusters of pretty, whitish flowers are succeeded in August by the white berries which remain long after the leaves have fallen.

69. *Lonicera dioica* L. (*L. glauca* Hill.) Honeysuckle. The only true honeysuckle found in this county. It occurs in open woods, and is worthy of cultivation. If planted alone it is self-supporting, but it usually twines around shrubs or other supports when they are within reach. The plant in the woods commonly called honeysuckle by the children, is a species of columbine (*Aquilegia canadensis* L.)

It thus appears that there is hardly a woody plant in northwestern Iowa but that is worthy not simply of preservation, but of cultivation as well, at the hands of the intelligent farmer. It is hoped that even the preceding list may serve to awaken renewed interest in this part of the natural resources of our country, and that, in consequence, each succeeding year may see increasing numbers of our people surrounding their homesteads with native trees and shrubs, alike to their own enjoyment and comfort and to the advancement of our common prairie home.