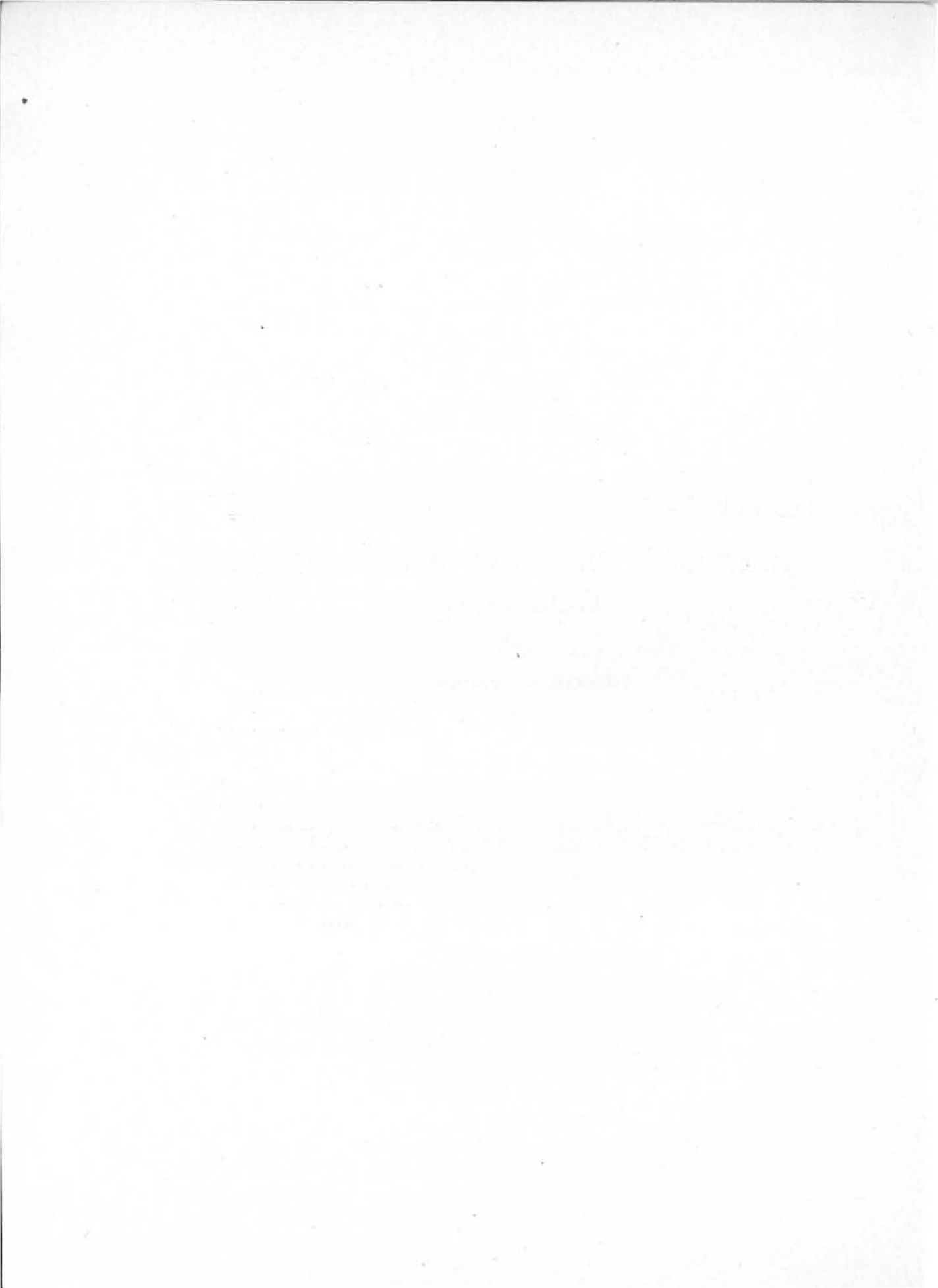

**GEOLOGY OF CLAY AND O'BRIEN
COUNTIES.**

BY

THOMAS H. MACBRIDE.



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INTRODUCTION.

LOCATION.

The two counties which form the theme of our present discussion lie in the extreme northwest portion of Iowa. They

are a part of the great northwest prairie, a region only recently come to the state of complete settlement and cultivation. Osceola and Dickinson bound these counties on the north, and so separate them from the Minnesota line; on the west Sioux county divides them from the western boundary of the state; on the south are Buena Vista and Cherokee counties; on the east lies Palo Alto.

For purposes of study and detailed description, all these counties must be viewed together. No partial treatment such as here attempted can give any very satisfactory idea of the situation, from the standpoint of physical geography, or even topography. The local student must in justice alike to himself and his theme, consult reports of all the counties named, and indeed of the whole state. The natural history of this region, past and present, though seemingly simple, monotonous, and so uniform that the story of a single township might be taken as the type of any or of all, nevertheless in a thousand minor ways shows peculiar differences of an interesting and instructive kind. The student of topography finds his problem ever changing, often within limits singularly narrow, within a mile or two, and the forces which have affected the condition he would describe have acted nowhere in precisely the same way; rather have they inter-acted in such a manner as to produce results the most varied and surprising. Even in these prairie regions, no traveler, however expert, can predict what is to be found in the next township, much less the next county. We have, generally speaking, in these two counties all the diversity of which a prairie is capable, especially in a region destitute of indurated formations, where the only plastic material is the bondless, unstable drift. We have hill-bordered lakes, rush-grown marshes and fens, slow-creeping, tortuous creeks; we have miles of upland perfectly level, at length cut by erosion channels so deep and with walls so precipitous as fitly to receive the name of canons; from the sides of these canons issue springs giving rise to clear perennial streams; we have hill-country, high, irregular,

tossed about with no reference at all to present drainage; we have fine rolling prairie where the drainage is perfect, the slopes long and gentle and every thing contributes to fortunate husbandry.

The native flora likewise is interesting, both in character and distribution, and its study will be of economic importance in our effort to solve the problems of the treeless prairie, the problems of forestation and ornamental planting for the homes of a cultured people.

PREVIOUS STUDY OF THESE COUNTIES.

Some members of the celebrated Lewis and Clark expedition may have reached this part of Iowa, in 1803-6. We have seen that certain of the party had personal knowledge of the Okoboji and Spirit Lake country.* Nicollet reports that he saw both the origin and the debouchment of the Little Sioux river, but he was unable to follow its windings, and his map of its course is hypothetical, chiefly. Owen maps the region† and appears to have visited it. At any rate, his map shows a remarkably accurate knowledge of the course of the river just named, especially in that part of its windings which fall under consideration in this present report. Hall, of course, did not reach our present problem, as his investigations were confined largely to a study of the rock exposures of the eastern portion of the state. Dr. White‡ devotes a page or two to our counties, but, of course, gave less attention to what was then an unoccupied and unsettled prairie.

PHYSIOGRAPHY.

TOPOGRAPHY.

The topography of these counties is, of course, in some ways very similar to that of the adjoining districts already described in these reports. We are still on the western

*See vol. X of the present series, pp. 190-1.

†Geol. Surv. of Wisconsin, Iowa and Minnesota, map.

‡Report on the Geol. Surv. of Iowa, vol. I, pp. 204-5.

margin of the Wisconsin drift, and the same agencies were efficient here that brought about further north the more remarkable topographic features around Okoboji and Spirit Lake. In one sense our present history is but a continuation of the former. We ought to find the same knobby drift here claiming its share of the terrane, the same gravel trains following the course of the streams, the same pebbly drift spread out in level plains, or marked anon by the sculpture of erosion; and, as we may presently discover, we do find all these general features; and yet the whole scene is different and the landscape may fairly and with reason claim a new description.

The morainic hills which in Dickinson county are a feature so conspicuous, cease there rather abruptly just north of the southern boundary of the county. They are succeeded by a high but marshy plain which continues south into Clay county for several miles, drained with increasing efficiency, especially to the westward by Meadow Brook. To the east, however, the marshes presently deepen into lakes, the characteristic morainic topography gradually reappears, so that nearly the whole eastern side of Clay county is given up to typical knobby drift, generally in less pronounced form, but sometimes showing disconnected hills and ridges 150 to 200 feet above the stream valleys. The best display of this topography is seen in Freeman and Logan townships, passing thence east in full strength into Palo Alto county. Some of the more characteristic and notable of these hills may be seen from the railway train as the traveler passes the town of Ruthven. The hills lie to the south, and more than one of them enjoys a local reputation of being "certainly the highest point in the state." If brought to the actual test, however, they would surely one and all disappoint all local ambitions in this respect by perhaps two or three hundred feet.

As we pass south through the eastern townships of Clay county the hills grow lower, gradually fading from the land-

scape to the south and east, though the general level is still high and continues so far around towards the west and into Buena Vista county. At Gilletts Grove the hills meet the Little Sioux river and deflect it almost directly westward, sending it ploughing through great beds of typical Wisconsin drift, as we shall see, until the stream passes beyond our present limits.

There are traces of this same form of morainic material in Waterford township of Clay county, but aside from this all the remaining territory now under consideration may be described as a level plain, not that it is absolutely level; it is a watershed of the prairie type, sending its waters east and west, all indeed into the Missouri river at the last, but strangely and paradoxically enough, starting the great majority of its streams toward the east and south.

Constructional Valleys. In the whole region now under consideration, nearly every important valley is at first wholly constructional. Some of these valleys are mere depressions in the general surface; some are the beds of lakes; some have been lakes and are now largely filled up or have found a more recent outlet and are more or less perfectly drained; others accommodate the waters of some slender, tortuous, but perennial stream, by courtesy called a river. Of course, where streams now occupy these valleys erosion must be taken into account, but in these cases even the amount of erosional excavation is generally insignificant by comparison. In order rightly to understand what lies before us in our discussion, we must keep ever in mind the difference between a valley of erosion and a valley of construction; the former is a ditch, a drainage channel shaped by the descending waters; the latter, the constructional valley, may have almost any form or contour. In the more strictly morainic part of our present territory the valleys of construction are basin-like and form the beds of marshes or lakes; westward they are generally long, more trough-like, arcuate, parallel to each other and to the

local margin of the drift. Of the first type we have illustrations through all the eastern part of Clay county, Swan lake, Trumbull lake, Lost Island lake, Elk lake, Mud lake, not to speak of dozens of unnamed swamps and marshes occupying basins which have no reference to drainage either past or present, and owe to present erosion only diminished depth, income and not out-go. Some of these lakes are of sufficient size and permanence to merit special description. Mud lake, in Garfield township, is rather shallow, a marsh in very dry seasons, but described as showing ordinarily a handsome expanse of water, covering nearly an entire section. Elk lake, in Logan township, is a thing of beauty, a little gem, begirt with native trees and surrounded by precipitous hills; said to be fifteen or twenty feet deep, not at all marshy, overflowing to the east where it joins certain wide marshy fens of Palo Alto county; certainly worthy of preservation if for no other reason than for its attractiveness. Elk lake is a typical morainic pool and owes its existence to precisely the same conditions which gave us Spirit Lake and Okoboji.

Much larger than Elk lake are Trumbull and Swan in Lake township. Taken together they are four or five miles long, of varying width, never exceeding a mile, and cover in all probably three square miles. These are permanent bodies of water, though with marshy borders and consequent variable expanse. Trumbull lake seems to overflow in two directions. The ordinary outlet is westward to join a great slough that stretches through the northwestern part of Lake township, but on occasion also, at least until very recently, the waters of Trumbull lake have had escape to the east, through a marsh here known as Mud lake again, to join at length Lost Island lake and so find exit through the outlet of the latter body.

Lost Island lake is a real lake, worthy to be ranked with those of Dickinson county to the north. The greater part of its expanse is in Palo Alto county, but its outlet is in Clay county, it forms part of the Trumbull series and therefore

may properly be here considered. It covers altogether some four square miles. Its extreme length is perhaps six miles; its greatest breadth, two miles; and it is reported twenty or thirty feet in greatest depth. It is furthermore said to be fed by perennial springs that boil up from the sandy bottom. Its shores are beautifully indented, winding, often forming sandy beaches; to the north and east are low gravelly hills that serve to break the horizon; to the south and southeast, lie wide undrained flats and marshes, extending half way across Freeman township. Where marsh and lake are at their narrowest, the public highway crosses by a long wood-bridge, supported on piles driven into the muddy bottom. From this bridge the view northward and eastward across the lake is one of the finest. Several handsome farmhouses stand along the shores and provision is here made to entertain the summer tourist. From spring till late in fall these lakes less disturbed by boatmen, seem to be the abode of innumerable wild fowl. Ducks sail in flocks above the surface or plash all day long in the sunlight; killdeer, snipe, and tilting sandpipers run along the muddy flats and sandy beaches; amid the dark bulrushes the startled bittern croaks and rises; in the more sombre autumn days the sedgy swamps rustle and sway with the gathering clans of strident blackbirds, when yellowheads, redwings, cowbirds, actually becloud the bulrush-darkened landscape.

All these lakes lie in valleys of constructional type. They differ from similarly formed depressions to the west of them in that they are shorter; they form lakes and not river channels. They go with the moraine and are not found outside of it. However, in Clay county are to be seen some remarkable intermediate types. For instance, in Meadow township, extending through sections 9, 17, and 19, in Lake, and sections 25 and 36, in Meadow, is a long, narrow marsh. It is really a valley with tolerably steep banks in many places, formed by low, approaching hills. In wet seasons a lake, at other times nearly dry, its outlet stretches off toward the east and unites

with that of Trumbull, and so establishes relationship with the general series.

But a more remarkable valley of the constructional type may be seen in Logan township. As one drives south from Elk lake, he suddenly comes in view of an immense valley, sweeping in a broad curve from east to west entirely across the township. The depression lies from 100 to 120 feet below the general level, and is broad enough in its greatest expanse to receive the waters of the Mississippi. But in some places we look in vain even for a stream. We find but a marsh with no discoverable current. In other places a small rivulet may be discovered winding back and forth across the level bottom land. The rivulet receives small affluents from the north, some from the south, but, strangely enough, the valley narrows as we approach the mouth, until near where it debouches into the valley of the Little Sioux, it becomes simply an erosion channel, hemmed in on both sides by precipitous hills. This valley with the little stream that wanders through it is called Elk creek; its general course is westward, it receives the overflow of Elk lake, not directly as it appears, but by the way of the chain of fens and marshes mentioned above, lying in Palo Alto county, away to the east of the point of origin. West of section 15 the banks of the valley are very precipitous, remarkably so when we consider that their material is nothing more resistant than the common pebbly Wisconsin clay. The sides of the valley, the banks, for such they really are, are broken everywhere by short, little, narrow gutters and secondary ravines seaming the grassy sides, affording the general impression of very recent erosion. In fact, everything indicates that rapid erosion is going on now. The land is shaping itself almost before our eyes. Give us a little time and these beetling banks will lose their minatory character; long, gentle slopes will take the place of bluffs, now so steep and so forbidding; even the table-land will vanish and long, low valleys will lead its waters down to the then persistent channel of Elk creek.

Such constructional valleys occur all over the area we here describe. Some of these will be further discussed under the general topic drainage. It remains only to repeat that they are especially characteristic of a morainic region. As has been said, kames and lakes, ridges and trough-like valleys make up especially the eastern and northern parts of Clay county. These features diminish somewhat southward; the southeastern part of Garfield township is a high but marshy table-land; but in the northwestern part of the township the kames and ridges are high enough and strong enough to change the course of the river, as already noted, soon to be particularly described. In Buena Vista county to the south they will doubtless reappear to furnish forth for Storm lake a setting at once adequate and appropriate.

These hills are not anywhere continuous but occur in groups, marking, as it appears, local halts and recessions of the disappearing ice. However, these hills, the high plains between the streams and the level plains which lie in some places by the streams themselves, form three distinct types of topography discoverable within the limits of our present discussion. These are all associated under the general topic, "drainage," and may be conveniently discussed under such heading.

DRAINAGE.

The streams of the region before us flow generally south, southeast or southwest at length, but the country as a whole has a southeastward slope. Thus, a profile of the recently constructed line of the Chicago, Rock Island & Pacific railway shows a rather uniform declivity from section 32, Tp. 98 N., R. XL W. to section 33, Tp. 94 N., R. XXXV W. Nevertheless, points on the open prairie, north and south in Clay county, show the same elevation. The country throughout is rather better drained than are some of the adjoining counties. This is owing in large part to the fact that the constructional valleys referred to inaugurated a system of watercourses to which

subsequent erosion on all sides has more or less extensively contributed. However, the streams of Clay county especially, those tributary to the Little Sioux in particular, are creeping, sluggish currents, winding about, as Meadow Brook, from slough to slough. Even the larger streams, the so-called rivers, are exceedingly dilatory currents having the slightest fall, even long after their union with each other. The Little Sioux passes entirely across Clay county from north to south and forms its only drainage channel; in O'Brien, a branch of the Little Floyd, Mill creek and Waterman creek are similarly beneficent and efficient. Each of these streams is here worthy of special study and description.

The Little Sioux river enters Clay county near the northwest corner of Summit township and follows a broad constructional valley to the southeastern corner of the same township. By this time the valley has widened southward into a broad, sandy plain, the common basin here of the Sioux and the Ocheyedan. Meeting the Ocheyedan the united waters of the two streams flow sluggishly athwart the same sandy plain eastward until they encounter the westward slopes of the morainic hills already described as occupying the entire eastern side of the county. By these slopes turned southward the stream passes out of Sioux township into an erosion valley continually narrowing, the course nearly south but very tortuous, between high banks of Wisconsin drift, to Gilletts Grove; here the gravel mounds of the moraine approach again from the south and send the river westward and southwestward five or six miles until, reinforced by the waters of Willow creek, it starts south again and goes winding through great beds of drift as before, now south, then east, north, south, then west, then south again beyond the limits of the county, only to emerge again at a point about four miles further west to cut for less than half a mile the south line of Douglass township, then out again and on westward some five miles further when it reappears in Peterson township, traverses most

of its southern sections and finally cuts the O'Brien county line at an angle of forty-five degrees, flowing straight to the northwest. In O'Brien county the course, though tortuous, is westward but for a short distance, a mile or two, when the stream suddenly bends southward and so passes beyond our limits for good.

That a prairie stream, draining a country destitute of rocky ledges or denser strata, should pick out a course so crooked

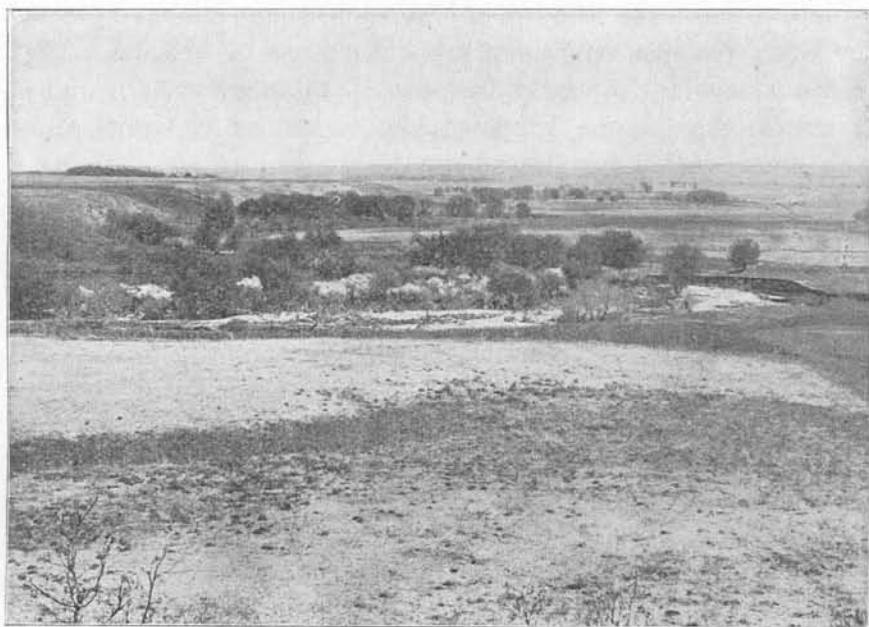


FIG. 38. Where Willow creek debouches into the valley of the Little Sioux.

is certainly a matter of curious interest. The contrasts shown when one compares different parts of the river valley are also very strange. The upper part of the valley from Summit township to Spencer and beyond, is wide and shallow, flanked generally on both sides by beds of gravel. At Spencer the valley has widened to a broad sandy plain, some two miles wide and seven or eight miles long. Here the river even after it has received the additional waters of several tributaries

still occupies but a narrow channel, shall we say ditch, in the midst of the plain, its banks are of black alluvial soil, and its flood plain is perfectly evident, nowhere wide, but about ten feet lower than the gravel and marked generally, as in the neighborhood of Spencer, by a distinct terrace. As we proceed southward all this changes. The gravel follows us of course, and is to be seen at intervals for the entire course of the stream, but the valley itself suddenly becomes narrower and deeper, the stream winds between high banks that are steep, precipitous, though of clay, cut on each side and gashed by sharp ravines, canons of present or recent erosion. This feature becomes so marked that in Herdland township and in Lee township (Buena Vista county) immediately south of it, the river valley has long been designated as the "straits," often no more than half a mile wide and at the railway bridge above Sioux Rapids even much less. The exact distance here as quoted by the railway engineers is nineteen hundred and ninety feet. The same thing is seen at Peterson, ten or twelve miles by rail farther down the stream, and indeed throughout the whole course of the river from Gilletts Grove south and west. The bluffs of clay are in some places two hundred feet high, and the effect is picturesque in the extreme. The railways have laid their tracks across the valley by bridges, eighty feet above the water, and the trains go swinging and creaking and winding about the sharp turns of the precipitous face of the clay bluffs and through channel-like cuts as if we were indeed in a land of mountains and rocks.

Between Sioux Rapids and Peterson the valley widens out, especially in the vicinity of Linn Grove and west, where a tributary comes in from the south. Here the course of the stream was doubtless determined in large part by some constructional depression which possibly remained for some time a lake or marsh before the stream affected the present deep channel from Peterson northwest. The yet remaining marshy plain west of Linn Grove and the accumulated sands about

the town of Peterson, which overlies the Wisconsin drift, may be explained by some such supposition.

Waterman creek, which drains the eastern tier of townships in O'Brien county, shows an exact parallel, only on a much smaller scale. Its valley also is notable for inequalities of width; the average of the flood plain is perhaps half a mile. The stream rises northwest of Hartley and for eight or ten miles is simply a prairie creek wending along through an almost level country, with slow current, as if from slough to slough. Just before it reaches Grant township it receives an important tributary, Little Waterman, from the west, and forthwith begins to cut into the body of the Wisconsin clays, and so breaks down to the level of the Little Sioux through a series of chasm-like valleys, the walls almost perpendicular banks of clay, sometimes one hundred and fifty feet high. Barry creek, which comes in from the west, and Henry creek, which runs parallel to Waterman on the east, and is tributary to the Little Sioux, offer on smaller scale exactly the same topography. Indeed, the freaks of erosion as displayed by these streams in the southwest corner of O'Brien county are unmatched so far in a prairie country. No photography can do justice to the subject. One is reminded of the Bad Lands and the Mesas of the distant west. The proverbial section-line road which elsewhere follows like a path of destiny the laws of the surveyor, here, for once, falls baffled, toils painfully up the channel of some lateral stream or ceases altogether, leaving the traveler by wide detours to find, if he may, some easier thoroughfare, some gentler gradient.

The comparative newness of the landscape is shown by the peculiar instability of the banks where erosion and change is still, with rapidity, going on. Little narrow gutters run down the face of the bluff sometimes at intervals to be measured in rods. These in winter are choked by snow; in summer they form conductors for rain water of higher grounds and deepen rapidly where not protected as they sometimes are by a curious growth of little burr oak trees. The face of the bluff is every

where so steep that landslides are a common feature. Every spring patches of grass-covered slope slip down, sometimes acres of it in a place. This was especially noticed in the valley of Waterman. The marvel of it all is that no sooner one ascends the bluffs than he finds himself upon a plain often almost perfectly level. Section 31, in Peterson township, for instance, is only partially drained, shows lakes and kettle-holes, though only a mile from the river and one hundred and sixty-five feet above it. Driving along the plain from the west, for example, the explorer approaches without the slightest fore-warning these wonderful ravines. Beautiful farms are thrust out like promontories into the valley of the river commanding, as the channel bends and winds, prospects romantic in the extreme, shining meadows, glittering waters, wooded slopes, sunny fields, and shadowed chasms.

Such is the topography of the Little Sioux valley as it skirts our southern limits, a distance of twenty or thirty miles as the river flows. It is simply a successful effort on the part of the Little Sioux river to cut through the broad morainic ridge of Wisconsin drift which, through all the upper course of the stream, as far south as Spencer, has been able to restrain its waters, sending them to the south and east, parallel to the course of the Des Moines. This ridge occupies all the central portion of Osceola county, the northern half, roughly speaking, of O'Brien county, and continues in a southeastern course diagonally across Clay. It represents, so far as reported, the farthest great out-push of Wisconsin clay in this direction; the outer southwestern boundary of the formation is not yet clearly delimited. The belt of morainic hills already referred to as occupying so large a part of Dickinson county, and all eastern Clay, is recessional, marks the margin of the retreating glacier, the point at which it ceased to be aggressive, halted and laid its far transported, mingled burdens down. When the final retreat began the ice over the ridge in question appears to have been comparatively thin. At first all drainage went over the western slope, spreading

a burden of sand and gravel over all the country to the west and south, filling all low places, as at Sibley and Sheldon, flooding the water courses which we name the Rock and Floyd, with their minor tributary streams. Mill creek also received its share and Waterman was likewise a channel for a lessening drainage from the margins of the melting ice. As thawing went on and the retreat proceeded toward the north and east, the margin of the ice rested at length in the constructional valley that now accommodates the Ocheyedan river. Waterman and Mill creeks were now shut off. The course of the principal drainage went south and east, possibly by way of the Coon river and the Des Moines. At any rate the drainage from the melting ice found a wide lake bed where to-day stands the town of Spencer, and proceeded to fill it up with sand. Here, it would appear, was in those days a lake far wider than any now existent in northern Iowa. We may read its limits by traversing a plain of sand; we may follow its low shores north of Spencer, and especially on the east and south, with ease. Lake Spencer, if so we may call this prehistoric water, included perhaps all of Lost Island lake and the whole system round about it. To the east its waters may have filled in part the Logan township slough. However we may attempt to explain it, the fact is evident that for some time Spencer lake received all the drainage from melting ice in this part of Iowa, and its whole area, as well as the broad areas now occupied by the Ocheyedan and the upper Little Sioux, was in this way filled with sand and gravel. Lost Island lake was out of the course of drainage and remained deep. The case is parallel to that of Spirit Lake and that of Okoboji in Dickinson county.* The deposition seems to have gone on steadily until the gravel had filled up not only Spencer lake from east of Dickens almost to Everly, but had choked up all the affluent streams as well, at least as far back as Milford. All this time erosion had been working northward from a pre-Wisconsin channel

* See vol. X of this series, pp. 210-11.

south of Cherokee and eastward by what, as we have seen, was a constructional valley entering from the southeast the valley of Waterman creek, working back in fact along the present valley of the Little Sioux until it cut through at Peterson, forming the rapids there (a mill-seat, by the way, so narrow is the valley), and drained first the constructional marsh or lake that lay in the vicinity of what is now Linn Grove. This out of the way, erosion began at what we now call Sioux Rapids, cut through the divide of Wisconsin clay that limited our Spencer lake waters to the south, possibly near Gilletts Grove, the "straits" were excavated, and Lake Spencer drained. The erosion of subsequent time has sufficed only to cut down the narrow channel which in the gravel plain or old lake bottom the rivers with their flood plains occupy today. The bridge at Spencer crosses this channel entire, flood plain and all. This also accounts for the gravel banks which form a topographic feature so conspicuous in many places, as in Sec. 20, Tp. 97 N., R. XXXVII W. The newness of the whole situation as it now presents itself becomes more evident the more we study it. The narrowness of the river channel from Gilletts Grove to Sioux Rapids, the very fact of the rapids, used by the pioneer for milling purposes, the peculiar erosion features at the mouths of all tributary streams, of Willow creek and Waterman, the erosion now in progress, every bank gashed with narrow gullies, steep and trough-like, as the valleys of a roof, eroded with every summer shower—all these things seem easily explainable only on the theory that the Little Sioux river has only recently, as things geologic go, made its way across the divide and found an outlet by way of Waterman valley down the Missouri drainage slope. The Little Sioux would thus seem to be a tributary to Waterman creek rather than the reverse. The possibility of this appears when we reflect that the body of drift with which we are concerned is known to cover an earlier land surface already long the subject of erosion and amply supplied with drainage channels. South of the known limits of this later

drift these channels are still in service, the creek and river valleys of the country; the ultimate drainage system of today is just the same as before the later drift came on. The Wisconsin simply obliterated all the sources of the streams and we have but to consult a map and in imagination carry back the older channels as they now appear, to form at least an approximate conception of their former direction and position. The northwest corner of Iowa has always been a highland and the drainage has for ages been toward the south. During the reign of the glacier the pre-Wisconsin channels beyond the ice margin were constantly in use as their far-spread gravel trains now abundantly approve. As the ice retreated the waters would no doubt tend to cut back into their earlier channels, and this certainly sometimes happened; but in many places constructional depressions on the surface of the newly uncovered drift seem to have started streams in new channels, only here and there or at the last to become coincident with those preglacial. Thus Waterman creek, probably Mill creek too, represents an older valley; possibly the original course of the Little Sioux. Compare, for instance, the present course of that stream south of Cherokee, the course of Waterman creek and the upper course of the Ocheyedan. The vast pile of drift extending diagonally across Osceola county, as already described, acted as a dam when once the ice retreated, while a great constructional valley carried the waters far to the east, again to be sent westward by the morainic hills about Sioux Rapids and northward, hills perhaps still encased in ice. The course of the Coon river suggests still another pre-Wisconsin drainage channel which might once have carried the waters of the Little Sioux. This channel would have extended from a point in the present valley of the Little Sioux, west of Linn Grove, south through a range of now existing swamps to Storm lake. This is but a suggestion, and may not be further discussed until the topography of Buena Vista county is better known.

However this may all be, the deep, narrow channel of the Little Sioux results from a comparatively late draining of what we have been calling Spencer lake, for the most part a wide marsh, when the ultimate drainage came on. Once the Little Sioux had cut its deep channel, the Waterman, too, found opportunity to cut back and down to the level of the larger stream and has since then effected, in larger part, what we see in Grant and Waterman townships, cutting what was once almost a level plateau into the holes and chasms we have already described. The same thing occurred at the mouth of Willow creek, in Clay county. Willow creek comes out into the channel of the Little Sioux, in Herdland township, nearly a hundred feet deep; empties into the "straits" in fact.

The whole eastern part of Gillett's Grove township is remarkable as typical Wisconsin prairie on the upland, and yet characterized by drainage which narrows the channel at its debouchment. South of Spencer is a wide plain, thousands of acres as level as a floor; a Wisconsin plain with no evident kettle-holes, and no perceptible or evident drainage, save here and there a few shallow, far-reaching creek bottoms; no sculpture, except in the immediate neighborhood of the river. Here, however, the carving is always notable, emphatic, in deep relief, the sides of the channels steep, precipitous, the valleys narrow as in a land where limestone and not simple drift had formed the subject matter on which the sculptor had plied his art.

In all these cases it is to be noted that, as a rule, the east and northeast sides of the streams slope down more gently; the steeper banks are on the west and southwest. Erosion is manifestly greater on slopes warmed by the western sun. There are, of course, many exceptions, due to various local causes. In the vicinity of Sioux Rapids, and all along the narrow course of the river here, the north banks, also, are generally precipitous. The north bank of the river near Sioux Rapids, seamed with line-like erosion channels, is shown in figure 39.

The Ocheyedan river scarcely merits further attention here. Entering Clay county at the extreme northwest corner, it lies in a valley of construction all the way until its union with the Little Sioux. On the west it is controlled by a high plateau of Wisconsin drift, but on the east, especially between Ocheyedan and Stony creek, there are not infrequent traces of morainic deposits of kame and sand hill type, although, for the most part, low and inconspicuous, most notable in the southwest part of Waterford township.

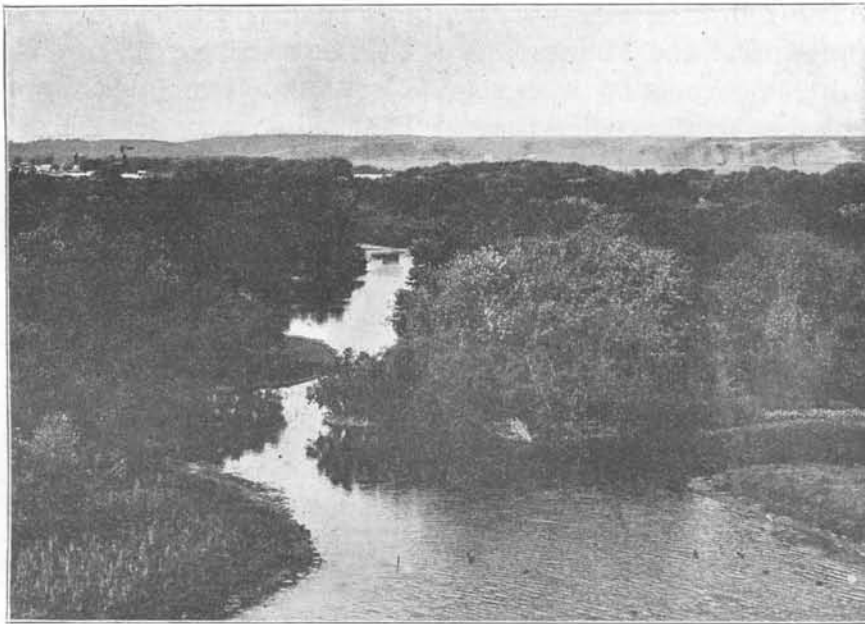


FIG. 39 View of the north bank of the Little Sioux river north of Sioux Rapids.

Concerning the drainage of O'Brien county there is little further to be said. Waterman creek has already received sufficient attention. Mill creek and Little Floyd are interesting because, as seems from present knowledge, their topography is much older. No one can visit these valleys and not notice the contrast between the Foyd, for instance, and the Waterman. In the Floyd valley there is an easy gradient, a rather

wide flood plain with immense deposits of gravel. Mill creek shows the same features; in the neighborhood of Primghar and Paulina the secondary streams are even well developed and the drainage is perfected. One might be disposed at first sight to call the landscape Kansan, but all southwestern O'Brien county is certainly a Wisconsin plain. Mill and Little Floyd probably occupy pre-Wisconsin channels or have been longer subject to erosion. This whole problem must remain indetermined until the southwest margin of the Wisconsin drift is at last definitely known and traced.

The following table of elevations kindly furnished by the engineers of the Minneapolis & St. Louis railway are interesting in connection with the subject of topography, as presented on the preceding pages. The points named are almost in a north and south line across Clay county.

	FEET ABOVE TIDE.
Langdon	1066.
Spencer.....	1010.
Greenville.....	1091.
Bed of Willow creek.....	966.
Cornell	1089.
Sioux Rapids.....	1005.

Langdon is in the "knobby drift" region; Spencer, as we have seen, in the plain of an ancient lake or marsh; Greenville, on a perfectly level prairie, has the same altitude as Cornell, on the other (south) side of Willow creek; Sioux Rapids (station) is about fifty or sixty feet above the flood plain of the river.

STRATIGRAPHY.

The number of geological formations to be described in these two counties is small indeed. The whole surface deposit from side to side is referable to the glacial series and to the Wisconsin stage. We are not without traces and intimations of older deposits, but these are rare and casual. The fine prairies, the broad marshes, the steep bluffs, the alluvial

plains, are all assignable to the familiar Wisconsin drift. The following synoptical table may be tentatively constructed:

SYNOPTICAL TABLE.

GROUP.	SYSTEM.	SERIES.	STAGE.
Cenozoic.	Pleistocene or Quaternary.	Recent.	Alluvium. Wisconsin loess.
		Glacial.	Wisconsin gravel. Wisconsin clay. Pre-Wisconsin sands; al- luvial. Kansan. Pre-Kansan sands and gravels.
Mesozoic?	Cretaceous?	Upper Cretaceous?	Dakota sandstone?

The first *alluvium* in the above table is made up of recent deposit near all the principal streams. It is a fine silt, comparatively free from gravel or sand, black with organic matter. It is well exposed in many places along the Little Sioux, forms the existing river banks, as at Spencer, and in the neighborhood of Peterson. A similar deposit at Sioux Rapids and at Linn Grove forms the material used in the manufacture of tile and a fair quality of brick. The storm-waters have sifted out the pebbles characteristic of the ordinary drift and have deposited along the stream beds the finer material of typical Wisconsin clay, mixed with abundant organic matter.

The Wisconsin Loess.—The second member of the present series is so named here to provide for a curious loess-like deposit found capping the typical Wisconsin gravel, as at Sheldon, and in several places in the northwestern part of O'Brien county. Similar loess-like deposits in the southwestern townships of Osceola county, taken with the peculiar topography of that region, led the present author to map southwestern Osceola as possibly pre-Wisconsin.* The topography is probably referable to pre-Wisconsin erosion, but the loess deposits

*See vol. X of this series, pp. 219, 240, and map.

are no doubt more recent than the Wisconsin gravels, that is, than the Wisconsin ice. This Wisconsin loess is very uneven in deposition, sometimes only a few inches, sometimes several feet in thickness, not especially pure, and may possibly, in some places, after all, be an aqueous deposit of the same age as the underlying gravel. The material, however, shows often the peculiar angular fracture of true loess. In such localities loess-kindchen are not infrequent. Professor B. Shimek of the State University of Iowa, a well known student of the loess and its fossils, has visited some of the localities of best exposure and regards the deposit as consisting of true loess, whatever may be its source or origin. Similar deposits have been commonly observed only a little farther west,* and are discoverable north as far as Ashton, and east as far as Hartley.

The Wisconsin Gravels constitute the third member of our series. These are widely distributed. They are in the main of two distinct sorts, occupying two distinct sorts of location. The first are morainic, or, at least, are deposited in localities not in the pathway of recent drainage; the second occupy the existing drainage channels and are the so-called gravel-trains. Of the first type the gravel pit at Sheldon may be cited as an illustration. Here, high above the valley of the nearest stream, is a vast pile of clean gravel, containing boulders not a few, some of them rotten and coarse, others hard and all unchanged, the whole pile more or less evidently stratified and water laid from top to bottom. The mass is, however, pure, almost free from any trace of organic matter. It seems to have contained at one time lime in considerable amounts. This, with other soluble mineral matter, has been very largely leached out by water, doubtless from the surface, and has effected to cement in layers several inches thick all the lowest strata. The pit has been long worked by the railway engineers and these indurated masses when broken up, make, it is said, excellent ballast. Large masses were observed so well cemented as to be with difficulty broken by

*See vol. X of this series, pp. 118-9, and pp. 147-9.

use of the sledge hammer. Under these indurated layers occurs the usual Wisconsin clay, if the reports of the workmen are to be taken in evidence; the clay is not ordinarily exposed. A similar gravel pit is worked to similar purpose just north of Cornell, in Clay county. This pit is already exhausted. Its floor is blue clay, but there is not lacking true Wisconsin drift here and there above the Kansan. A small but interesting bed of similar make-up is to be seen in the railway cut immediately north of Sioux Rapids; others are on the morainic knobs south of Ruthven, and others in various places in the northern part of Clay county, often worked by the farmers for the excellent road material. The isolated knobs of the Ruthven moraine seem to be in many cases entirely made up of gravel. A beautiful mound of this character, boulder-strewn, lies just south of Elk lake.

Gravel deposits of the second type are found in nearly all the stream valleys. Those along the Ochevedan, the Little Sioux, Mill and Floyd creeks, are particularly noteworthy. From Willow creek and Waterman these deposits are conspicuously lacking. This accords with what has been already surmised as to the probable history of these streams. Their principal erosion has occurred since the ice finally retreated. But the amount of gravel laid down in the valleys of the other streams named is something surprising. From the time the Little Sioux enters Clay county until it reaches the "straits" its banks are bordered on this side, now on that, anon on both, by vast beds of gravel. From Everly east to Dickens there is practically nothing but gravel. Its thickness as a deposit is reported at from twenty-five to thirty feet, resting on blue clay, full of water. Drive-wells are in common use over the whole plain. In fact the deposit is continuous, or practically so, from Milford south. Those interested may compare the west bank of the Little Sioux in Sec. 20, Tp. 97 N., R. XXXVII W., with the terraces in Milford township in Dickinson county. At Spencer the city well is nothing else than a

great pit some thirty feet in depth and of nearly as great diameter sunk in the Wisconsin gravels. Similar deposits mark the course of Mill creek, especially south of Paulina; along the margins of the Little Floyd are found the same conditions. All this represents the movement of large quantities of water in a general southward direction, but in a measure independent of the present drainage system of the country and apparently prior to its establishment.

The Wisconsin Clays.—These, commonly called "pebble dirt," constitute nearly everywhere the ordinary subsoil of the country. All the rich upland prairies have for their basis the pale, buff-colored, pebbly drift. It is exposed on every highway where the least cutting has been judged needful to improve the road; it shows at every well mouth, whitens the top of every storm cave and slips and slides in masses great or small down the faces of the bluffs of Waterman and the Little Sioux. Its thickness appears to be variable in the extreme, but cannot be very accurately stated from the data at present available. The reports of well diggers are our best sources of information for the country at large. Occasionally an erosion cut or a railway excavation goes through and reveals the underlying formations. Thus, in the neighborhood of Sioux Rapids, on the west side of the "straits," the railway cutting reaches blue clay at a depth of some forty-five or fifty feet. This does not, however, reveal the total thickness of the Wisconsin at this point, as the cutting is on the face of the bluff considerably below the level of the prairie of the immediate neighborhood. Along the southern margin of the territory here described the Wisconsin clays are, at a maximum, perhaps 150 feet in thickness. The deposit thins out to the west and northwest. West of Hartley and Sutherland the deposit, if well records may be believed, is very thin indeed, nowhere more than twenty-five feet, generally not more than five or six, sometimes no more than two or three; sometimes none; "only black dirt and then blue clay." Thus the well at the county farm east of Primghar is said to be 700

feet deep, "with a foot or two of yellow clay." The deposit seems to be thinner in the vicinity of Mill creek, thicker again in Caledonia township, where well records indicate a depth of at least fifty feet. West of Hartley and north of Primghar, the highland of O'Brien county, 150 feet above the streets of Hartley, the thickness is "only five or six feet, then blue clay."

Pre-Wisconsin Sands.—Well diggers report that just beneath the "pebble dirt," as the Wisconsin is commonly called, a layer of sand and gravel not infrequently occurs. Just how general this may be is a question. At the south end of the highway bridge in section 28, Waterman township, there is a curious exposure of pre-Wisconsin sands. The usual Wisconsin clay, here rather abundantly surcharged with bowlders, makes up the upper part of the exposure, plainly capping a deposit of fifteen or twenty feet of stratified, water laid sand. The Little Sioux river has cut into the base of the deposit and so brought about the exposure. The arrangement of the sand in layers lends color, so far as may be, to the idea expressed above that Waterman creek possibly lies in the line of a pre-Wisconsin stream. It is further to be noted here that there are springs along the Waterman at various points in Waterman township. Some of these springs issue from sand. They doubtless owe their emergence to a somewhat extended sand-couche resting upon a layer of impervious clay.

Kansan Drift.—Under the ordinary surface deposits, whatever their character, everywhere over the whole region we here discuss, the notorious "blue clay" is a matter of unanimous report. It is exposed, as already stated, in the railway cutting near Sioux Rapids, in the gravel pit south of Greenville; it is reached by well diggers in every part of the country, sometimes even in cellars. This clay is regarded as forming part of the widespread Kansan drift, representing an old ice-invasion long preceding that which deposited the Wisconsin clays. It is, where freshly exposed, generally dark blue or gray in color, sometimes fine and pure, sometimes sandy or

mixed with gravel; everywhere charged with bowlders, "nigger-heads," usually exceedingly hard, not very large, varying in abundance in various localities.

The thickness of the blue clay varies in a striking way within limits comparatively narrow; thus in Clay county it is reported at from thirty to sixty feet. In O'Brien county wells 200 and 300 feet "through the blue clay," are not uncommon. The well at the county farm, east of Primghar, is reported 700 feet, nearly all blue clay; on the Boyd farm in Caledonia township is a well said to be 1,000 feet deep, through the blue clay "nearly" all the way! In every case it is essential to go through the blue clay to make sure of a constant and abundant water supply; hence if we had an exact record of the wells of this prairie region we should be in position presently to understand this most important deposit very much better than now. Well diggers have here an opportunity to serve in a peculiarly effective way at once the cause of science and the interests of the community in which they may be employed. It is not very difficult to keep a log of the various wells sunk, and every such record, aside from its scientific interest, would be at once somewhat of a guide as to the probabilities in attempting other wells in the same neighborhood. The cases cited in this report are all from the memoranda of well diggers. If these had been made for our purpose they had been of the highest advantage. As it is they are only suggestive because only approximately accurate. They instruct us in a general way. For instance, beneath the blue clay in our locality occurs either sand or sand rock or both. It is impossible from the reports we have to say what it is in any particular case. It is probably in some cases pre-Kansan sand and gravel; in others, the top of the Cretaceous series as here laid down. There seems to be everywhere a uniformly aquiferous layer just below the blue clay.

It is instructive to reflect that of all the deep wells bored within our present territory, and they are many, not one reveals any evidence of coal. Of course not one was bored

in premeditated search for coal or mineral wealth, but the evidence is certainly just as decisive for all that. There is no coal in the drift at any rate, and the drift in these counties is often of great depth. The well at Peterson, for example, is reported as follows:

	FEET.
Sand and gravel.....	20
Blue clay.....	80
Sand.....	20

In the lower sand is found abundance of fine water. This well is not far from the river and is probably a hundred feet or more below the general level of the surrounding country, that is, of the drift, so that the drift in the neighborhood of Peterson is not less than 200 feet deep, and is probably much deeper.

Pre-Kansan Sands.—Everywhere in both counties a successful well is described as going through the blue clay and striking sand. In this sand, as just remarked, there is always abundant water. This experience is so uniform over a wide portion of the state that even without other evidence we should be warranted in naming as a distinct member of our Iowa drift series the pre-Kansan sands. But there is other evidence, not to be cited here, which leads us everywhere to expect just what the well diggers report. The depth of the formation is not known; it is somewhat variable, certainly nowhere very thick. If reports are to be credited, the formation is sometimes lacking and the blue clay rests directly upon sandstone. This is by no means improbable.

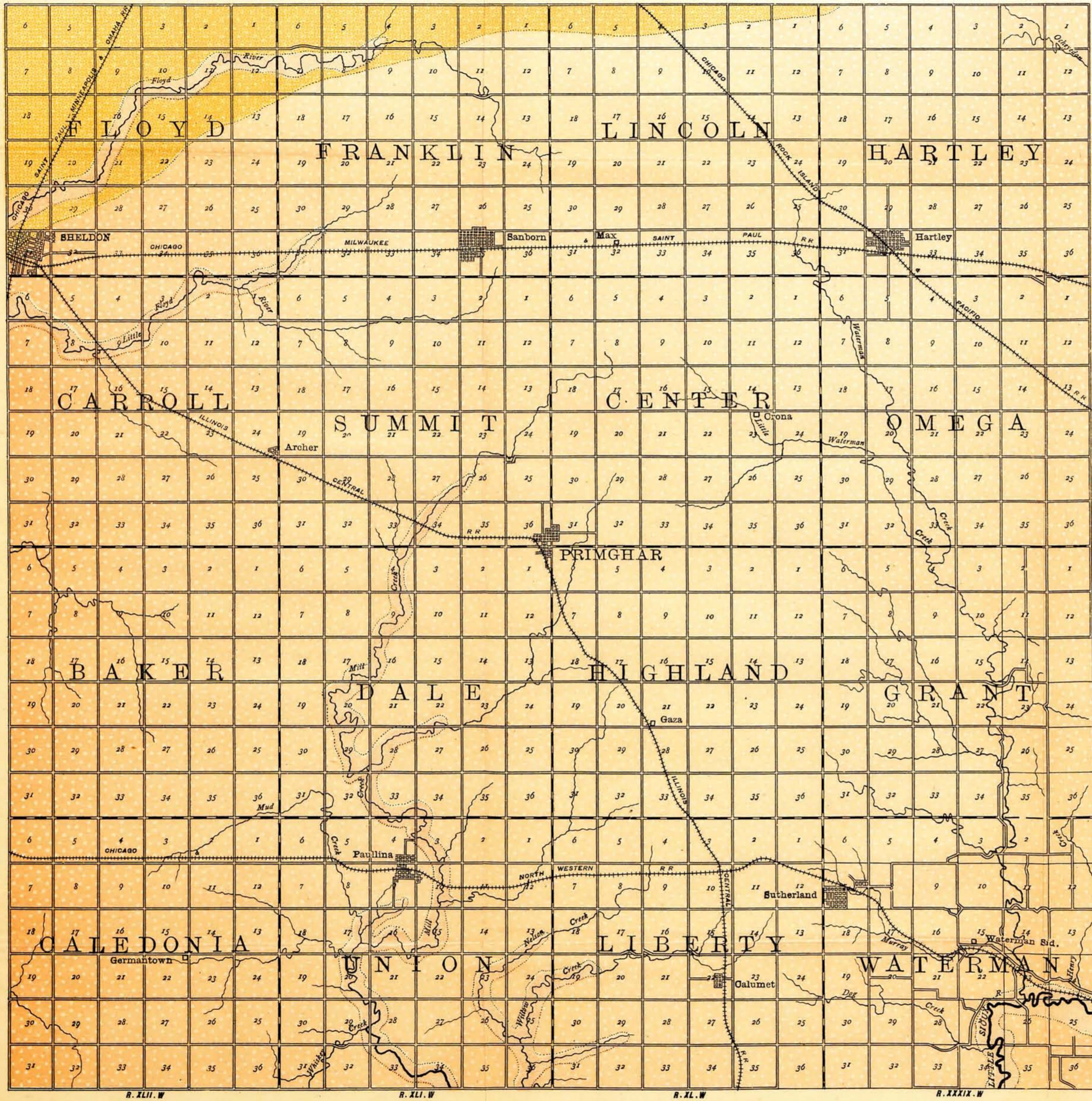
Cretaceous Sandstone.—This is listed here simply to provide for the deposit referred to in the preceding sentence. Sandstone is not infrequently reported, sometimes below the clay, sometimes below clay and a bed of sand. This is not inconsistent with the evidence given by the record of the deep wells on either side of our region, as at Emmetsburg and Sanborn.

ECONOMIC PRODUCTS.

The economic products of this part of Iowa are neither numerous nor varied. This region is not a land of mountains and valleys, of crystalline rocks freighted with gold and silver or other metallic ores; neither is it a region of sandstones or limestones and shales, exposed by long erosion on the banks of every stream; we have rather to do with a simple prairie, where vegetation has for some thousands of years been contributing a wealth of organic matter to the surface soils now of a fertility unmatched, resting upon subsoils of unusual depth, and of a constitution for the support of all our agricultural plants simply unrivalled.

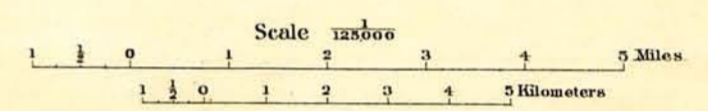
Soils.

The soils of the two counties in question are almost uniformly of one description. We find almost over the whole area the same deep, rick, black, fertile loam, well adapted, as abundant experience has proved, to meet all the requirements of successful agriculture. Configuration of the surface makes tillage a matter of the greatest ease; there are no hills, save the few bluffs along the streams as heretofore described, and these are not given at all to tillage; on the other hand, aside from these few steep slopes, it would seem that every acre might be subjected to the plow. The whole country is one vast, beautiful field, adorned with groves, and mapped in summer with the colors of a varied harvest. In some places, as about Spencer, the soil is warmer, more sandy, but is none the less productive. The subsoil is nearly everywhere calcareous, continually yielding up the very materials needed for the most successful raising of wheat. Even the marshes and swamps that have been thought for so long a detriment to this portion of Iowa, are vanishing, and well directed drainage will soon have left no trace of them in the continuously cultivated field.



IOWA GEOLOGICAL SURVEY
 MAP OF THE
 SURFACE DEPOSITS
 OF
O'BRIEN
 COUNTY,
 IOWA.

BY
 T.H. MACBRIDE
 1901.



LEGEND
 GEOLOGICAL FORMATIONS.

- WISCONSIN DRIFT
- WISCONSIN GRAVEL TRAIN
- LOESS OVERLYING OLDER DRIFT.

R. XLII. W

R. XLI. W

R. XL. W

R. XXXIX. W

DRAWN BY F.C. TATE

Sands and Gravels.

The few exposures of sand and especially of gravel in these counties have been of the highest value in many ways. Wherever accessible they have been extensively worked by the railway companies for ballast. The gravel pit at Sibley has already been referred to, as also that near Cornell. Such deposits are quite as valuable for road making as for ballast, and the principal towns have fine streets made of this simple material. The time is doubtless near when the rural highways will receive as much attention as those of the city have received, and these gravel beds of the northern drift will then be estimated at their true value.

Brick Clay.

Good deposits of brick clay are yet a desideratum in both counties. The common drift contains too much lime. The blue clay seems to contain too much gravel and sand. That, however, exposed in the bottom of the Cornell gravel pit seemed to promise better results in this regard. At Sheldon Mr. A. S. Hurley manufactured last year 700,000 brick. Mr. Hurley uses the loess-like deposit above the gravel in that neighborhood, mixed with a certain proportion of soil taken from near the surface. The brick shown by Mr. Hurley are a fair quality of rather soft brick. Some of his kilns are first rate, but the quality, he reports, is uneven.

At Sioux Rapids, just south of the Clay county line, Mr. J. F. Cooley is making good soft brick at the rate of 500,000 per year, and tile at the rate of 700,000 per year. Mr. Cooley uses an alluvial Wisconsin clay. At Spencer, Mr. Ira Hilliard has for a long time been manufacturing a fair quality of soft brick. He, too, uses a form of alluvial clay mixed with soil taken from near the surface.

Fuel.

The fuel supply of these counties is thus far wood. As will appear in the list of forest trees to be given further on, the

early pioneers found native timber in this part of Iowa in considerable variety and in amount sufficient for their immediate uses. Some of the primeval trees are still standing, showing that the supply was not exhausted when the railways began to bring coal within convenient reach. At present almost every farmer has in his grove a supply of fuel, if not wholly adequate, at least so far productive as to make him, for the greater part of the year, independent of importations.

It is the belief of many that coal may be found in northwestern Iowa, once we put ourselves to the trouble to make the necessary investigation. Coal in Iowa and elsewhere has usually been revealed by erosion. The rivers and streams have cut down through the overlying rocks and uncovered the coal which is supposed to lie spread out everywhere beneath the surface. In northwestern Iowa the streams have nowhere reached the indurated formations at all and it is accordingly thought necessary to make exploration by boring, and it is thought that if the boring be only continued far enough and deep enough coal is sure to be encountered in Clay county, for instance, as surely as in Polk or Mahaska. The first part of this assumption is well founded. The streams have certainly reached no coal, nor anything suggesting it, and if coal exists beneath the surface at all its presence must be revealed by artificial means.

Fortunately or unfortunately, as the case may be, we have at hand a very considerable number of borings, more or less deep, bearing directly upon our problem. These are the deep wells which all over this section of Iowa the industrious farmers have been sinking, are sinking every day, for the purpose, not of finding coal it is true, but of securing a permanent supply of pure water. However, these all answer our purpose just as well. Every one according to its depth answers the question whether there is coal or not in the particular locality where the well goes down. Nearly all the wells in this part of the country, and there are hundreds of them, go through the blue clay. Very rarely are these wells less than one hundred feet

deep; they are generally from 250 to 500 feet deep, and sometimes very much deeper. It will be conceded, then, that if there be coal here beneath the surface it is pretty deep down and lies all below the blue clay. This practically puts any coal there may be out of our reach. We should have not only the great depth to contend with, but, what is worse, the strata below the clay seem saturated with water, water under considerable pressure, that would render difficult, if not wholly impracticable, the operation of a mine at that horizon.

But it is by no means certain that we can find coal even in the strata reached after we pass the blue clay. Indeed the evidence we have is discouraging. Many wells in these two counties have been sunk considerable distances beyond the blue clay without encountering the faintest suggestion of anything like the coveted mineral. A deep well at Emmetsburg goes down more than 600 feet beyond the blue clay without a trace of coal. Directly west, in one of the counties now considered, at Sanborn, is another well whose fountains are more than a thousand feet below the blue clay and no trace of coal yet. The probabilities of finding coal along the line of Chicago, Milwaukee & St. Paul railway in this section are evidently not very great. Nor is this all. If reports are true there is a well in the southwestern corner of O'Brien county 1,000 feet deep with no report of coal; Sioux City a little further southwest, continuing a line from Sanborn in the same direction, has a well more than 2,000 feet deep and no coal. At Holstein, directly south of Sanborn we have another very deep boring with the same report. The chances then of finding coal, not to say of working it, in the counties thus reviewed are evidently not the best, at least until we descend more than a thousand feet below the surface. Now this is all apart from anything a geologist might say about the subject, forming his opinion on what he knows of Iowa and the extent and arrangement of its various rock strata. All the statements made above record facts, reported not by geologists, but by men who dig

wells; men who seek not to establish a theory, but to find water. Their testimony, at least, ought to be convincing.

At Peterson many years ago a well was sunk with the avowed purpose of finding coal. By the report of the man who made the boring coal was found. By the courtesy of Mr. J. A. Kirchner of Peterson the writer was permitted to read the "log" or record of the enterprising, if less scientific, contractor who made the boring. We present the record, not for its accuracy at all, but as a curious illustration of human ingenuity where knowledge fails or is in any way defective. The table is here reproduced from an extra edition of the Peterson Pilot and bears date, August, 1883.

	FEET.
"Sand and boulders.....	10
Blue clay	47
Sand rock.....	15
Reddish brown and pink feruiginous sand, containing large amount of pofery* and carbonaceous matter.....	13
Steatite serpentine.....	10
Arenaceous shales, very hard iron bands;.....	10
Magnetic oxide iron in alternate layers pofery.....	5
Sand pocket black sand.....	1
Feruiginous steatite and oxide of magnesia.....	4
Bituminous shales and slate.....	4
Coal	3½
Good pure fire clay.....	3½
Coal	3½
Fire clay and shale.....	3½
Good coal.....	3
Limestone".....	..

Enticed by such remarkable prospects we are not surprised that the little community enthusiastically supported a movement to proceed at once to develop the natural resources thus revealed and only 120 feet below the surface. A company was formed, a carefully constructed shaft was carried down at cost of many thousand dollars. A log of the shaft seems not to have been preserved, but from the memory of one who watched the excavation it was something like this:

*Original orthography preserved.

	FEET.
Sand and gravel.....	20
Blue clay.....	85
Quick sand.....	?
Sand and gravel or sandstone.....	30

At this juncture for reasons unexplained the work was abandoned. The water gave a great deal of trouble and perhaps afforded the principal excuse for suspending operations.

The discrepancy between this log and the former is sufficiently marked. Indeed, the latter record more nearly coincides with that of the town well some rods further to the west. Supposing the shaft to have been begun twenty feet higher up the slope than the point at which the boring began we still have over 100 feet in which the two records may be compared foot for foot. The contrast is all the more surprising when we further reflect that the distance from the mouth of the boring to that of the shaft does not exceed thirty rods, perhaps does not equal twenty. Who may resist the conclusion that the first log is made up of misstatements intended to mislead?

As these lines are written the newspapers of the country are bringing tidings of the discovery of petroleum in the center of Clay county. Judging by what we know of the structure of this part of the country, judging from data gathered as above, the chances for finding coal-oil in Clay county are about equal to those of finding coal. The question of the presence or absence of petroleum will of course be answered in this case also by the sinking of a prospect hole. For the sake of the enterprising people who make the investigation let us hope that the prognosis of science may here fail of justification, and that if oil should refuse to flow, a well of purest water may at least reward their toil.

Water Supply.

From what has been said in the last few pages there can be in the mind of the reader no doubt as to the abundance of the

water supply in this part of the state. An unfailing supply of the best water may be obtained, it would appear, almost anywhere by piercing the blue clay, and this, while thick, is nowhere so thick as to make drilling impracticable. The deep well at Sanborn, however, is a disappointment; it pierces the strata far below the blue clay and derives water from the lowest source only. The earlier water veins reached were shut off, as encountered, by the casing. In a great many places the deep well is not yet a necessity. In some places it probably never will be. In all localities marked by the presence of gravel shallow wells are all-sufficient. Drive wells have been mentioned in connection with the Spencer plain. The public well at Sheldon is not deep, is simply excavated in the gravel described elsewhere in this report.

The streams coursing the counties before us are of the highest importance from the present standpoint. The Little Sioux, the Ocheyedan, the Little Floyd, Waterman, Mill creek and Willow creek are all perennial streams of greatest service to those contiguous to their channels. The mill at Peterson possesses the only water power now in use in either county. The amount of fall at this point is such as to warrant the expectation that the power may still find profitable employment, even if the manufacture of flour should no longer prove desirable.

Acknowledgments.

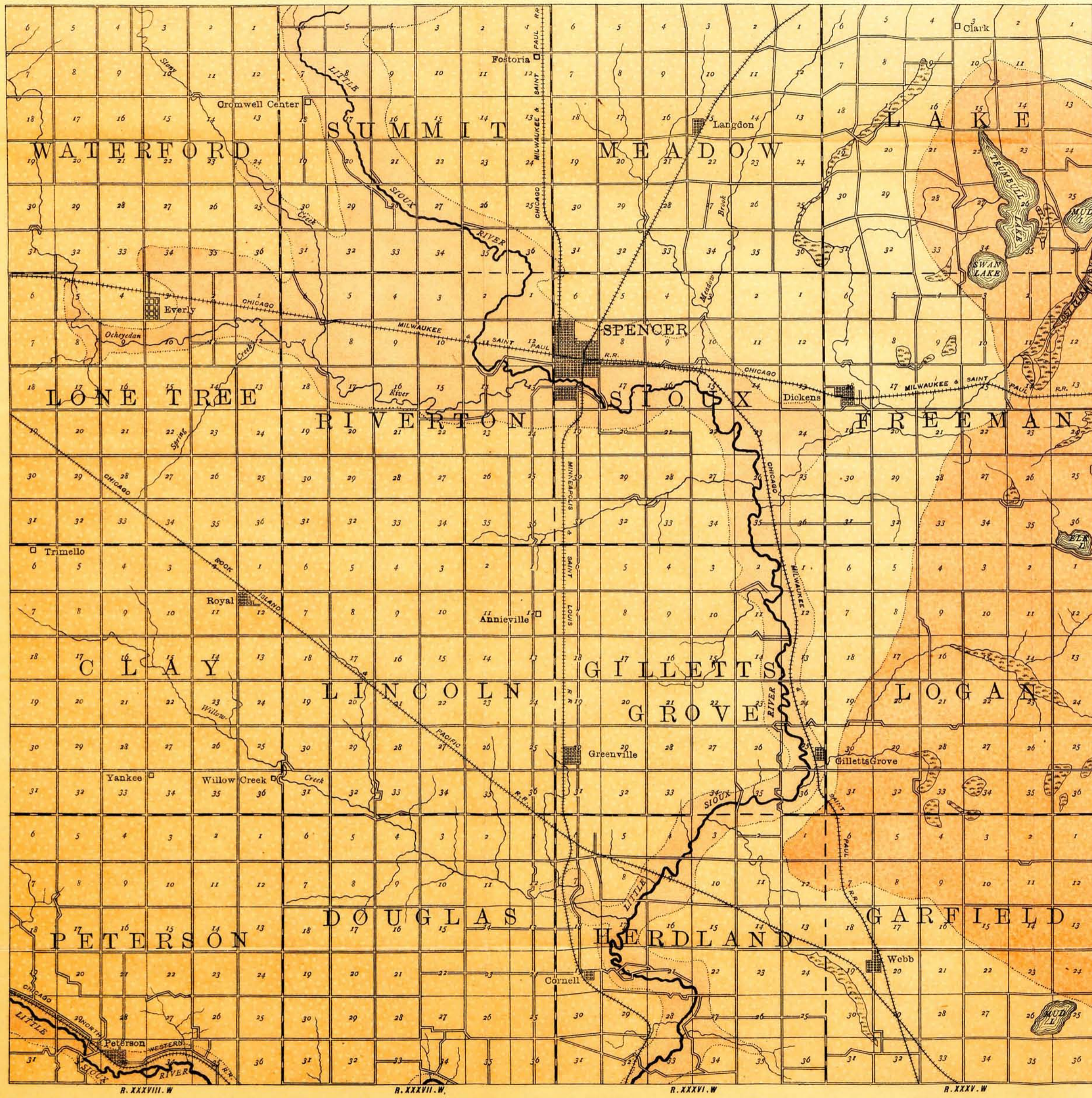
In the prosecution of the work of which the present pages furnish some account, the writer would tender his best thanks and acknowledgments to the many citizens of the two counties who were ever willing to assist in every possible way where the author sought to gather the necessary data. Special thanks are due Mr. J. A. Kirchner, of Peterson, as also Mr. C. W. Fillmore of the same village. Mr. W. H. Bloom aided us in the neighborhood of Sutherland and Mr. C. E. Jacoby in the region about Sioux Rapids.

The writer would also tender grateful acknowledgments to Mr. Marvin Dey, of the Chicago, Rock Island and Pacific rail-

way, for the profile of the two counties studied, and to Mr. H. G. Kelly, of the Minneapolis & St. Louis railway, for similar favors. Throughout the author has also enjoyed the advice and assistance of the director of the Survey, Professor Samuel Calvin, and of the assistant geologist, Mr. A. G. Leonard.



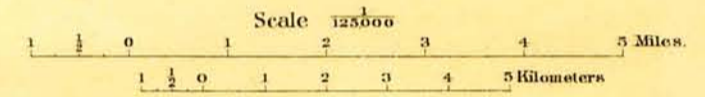
FIG. 40. Primeval oaks by the Little Sioux, near Peterson.



IOWA GEOLOGICAL SURVEY

MAP OF THE
SUPERFICIAL DEPOSITS
 OF
CLAY
 COUNTY,
 IOWA.

BY
T.H. MACBRIDE
 1901.



- LEGEND**
- WISCONSIN DRIFT PLAIN
 - KNOBBY DRIFT
 - WISCONSIN PARTIALLY STRATIFIED
 OUTWASH GRAVEL AND ALLUVIUM

FORESTRY NOTES FOR O'BRIEN AND CLAY COUNTIES.

The traveler through the northwestern counties of Iowa is treated to continual surprise in the number and variety of arboreal species certainly native to these prairie regions. Every river valley, every sequestered or protected nook has its trees. True, these are at present mostly rather small, probably in many cases not more than fifteen or twenty feet in height, probably in most cases not more than fifteen or twenty years of age, but they are vigorous and abundant and show a disposition to form a forest, often exhibit genuine forest conditions, all in such a way as to make certainly successful any well advised attempt to raise forest products on the prairies. In some places the primeval trees still stand. (Fig. 40). All the better specimens of course have long since been cut away to build and warm the homes of the pioneers, but enough remain, in regions less conveniently accessible, to show at least what these ancient trees were like, how they braved, in many an individual case, the perils of their own frontier position and have even lived to see in happier days a generous progeny. (Fig. 41). This figure is especially interesting. The thinly clad branches of an ancient elm may be seen in the illustration, rising above a dense mass of umbrageous trees. This is the "lone tree" of Lone Tree township, Clay county, dying now, chiefly because of recent ill usage, but at one time, as the story goes, the only tree on all the wide prairie west of Spencer. No one now passing and seeing the abundant young forest, not of elms only, but of varied species, extending around the old elm and up and down the Ocheyedan here, would ever think that these trees are all indigenous, and that twenty-five years ago there was not

another tree in the township. Another view here offered shows a bur oak and its descendants. (Fig. 42). Such trees are not infrequent in out of the way places, on the crown of some steep bluff or on an exposed hilltop, as in the neighborhood of Peterson, along the highway leading west. It would seem thoughtless indeed if the owners of such trees should fail to appreciate their significance. The hardiness they



FIG. 41. Lone Tree, surrounded by the new forest.

exhibit, which centuries of fire and storm have not sufficed to overcome, appealed to the sympathetic pioneer and speaks eloquently for the possibilities of future years, when the efforts of nature shall be less disturbed by such unfriendly conditions. The young forests along the Little Sioux are as beautiful in effect as any, and if not destroyed prematurely by their impatient owners, will yet prove a source of abundant profit.

The success of tree planting has been everywhere marked. A farm without a grove is anomalous. If along the highway one such does appear, we may be sure the land is rented; the



FIG. 42. An aged burr oak and its progeny.

owner has not sufficient interest in his land to make it beautiful, nor sympathy with his tenant to seek to make him comfortable. The persistence of native species and the abundant success of the planted varieties leaves no doubt that in these

two counties also timber supplies of all sorts adequate for home consumption may easily be produced.

The trees native to O'Brien and Clay counties were all at first confined to narrow areas around the more prominent bodies of water, the lakes and rivers. All along the Little Sioux river, from Spencer southward, trees were not rare. Gilletts Grove by its very name will preserve the history of vegetation in that neighborhood. Trees were not wanting to the valleys of Henry and Waterman creeks, and there were not a few in the neighborhood of Lost Island lake and some about Elk lake. Nearly thirty species of woody plants have been reported from this "treeless" region, and the personal observations of the present writer confirms the report in nearly every case. The woody plants of the region are as follows; native unless otherwise stated.

Tilia americana Linn. Basswood, Linden.

Common in Gilletts Grove, about Peterson and in the valley of Waterman creek. This is a most valuable and hardy tree. It grows rapidly, is a fine shade-tree, its flowers afford the bees material for the finest honey, and its trunk at last makes a valuable kind of soft lumber. The tree does best in rich soils, but is also to be found climbing the clay bluffs of the Wisconsin drift; so that in northwest Iowa it will probably grow wherever planted.

Xanthoxylon americanum Mill. Prickly Ash.

A vigorous shrub, of spicy twigs and foliage, small flowers followed in August by bright red, berry-like fruit which presently breaks open revealing a pair of shiny black seeds. Not rare in the valley of the Little Sioux from Gilletts Grove south. Useful only as an ornamental shrub. The flowers are of two sorts on different bushes and to secure the fruit the two must be found and planted near each other.

Acer saccharinum Linn. *Acer dasycarpum* of Ehreart and of the books. Common Maple, Soft Maple, White Maple.

This is the maple everywhere commonly planted as shade tree and wind-break. Reported indigenous about Peterson.

One of our most valuable prairie trees, very hardy and ready to grow on all sorts of soil, rapidly attaining usefulness as bringing shade in summer, protection in winter. The most valuable friend of the farmer-pioneer. The wood though soft makes excellent fuel and a grade of lumber not to be despised. Unfortunately the barbarous lopping to which, under pretense of pruning, the trees are everywhere subjected, opens the heart of the tree to the weather and to speedy decay and so good logs from cultivated trees are seldom seen.

Acer negundo Linn. Box Elder.

Native to the stream valleys; exceedingly common in the valley of the Little Sioux near Peterson. Doubtless spreading since the fires have been checked. Everywhere a favorite for wind-breaks and commonly planted. This is also a useful tree as a temporary protection or nurse for trees of better quality.

Rhus glabra Linn. Smooth Sumac.

This is the common sumac of all the northern woods east of the Rocky Mountains. In the counties here studied it is small, dwarfed and not common. Well worthy of preservation and cultivation as an ornamental shrub. Nothing lends quite the same rich brilliancy of color to the autumn landscape, nothing to equal the glowing foliage of the sumac. Contrary to popular impression, the shrub is not poisonous. The poison sumac, poison ivy, three-leaved ivy, *Rhus vernix* Linn., was not observed nor is it reported in either county, although it may certainly be expected wherever woody species flourish at all. It may be known by its three-foliolate, three-parted, leaves and loose clusters of whitish, berry-like fruit, hanging on the leafless stems in fall and winter. The plant is of very variable habit, sometimes a vine climbing by rootlets attached to the bark of trees, sometimes a low shrub, one to four feet high, common about fence posts where seeds are dropped by perching birds. Formerly reported from the eastern part of the state only, it is now doubtless distributed over the whole area and will be

found probably, in every county. The fruit is poisonous, and for some people the plant is poisonous, even to the touch, especially when the leaves are vigorous, or when the plant is in flower; in this latter case, however, most people appear to be immune. Thousands of people unconsciously walk over poison ivy, pass by it, even handle it, every year, and yet suffer no ill consequences.

Prunus americana Willd. Wild Plum.

A common tree forming thickets here and there by the roadside, especially on the shores of Lost Island lake, along the Little Sioux, and in similar situations everywhere. A beautiful ornamental tree, nothing finer when in bloom; valuable as a hardy fruit stock and as constituting an element of a northern grove; inured to severest climatic conditions of every sort. This and the Wild Crab are largely held in check by rabbits, which, in winter, girdle the stems of young shoots; otherwise the species would be of almost universal distribution.

Prunus virginiana Linn. Choke Cherry.

Found only in the valley of the Little Sioux. A rather handsome little tree, tending to form thickets, covered in spring by showy clusters of white flowers; later laden with shining black fruit, the delight of the wild birds.

Pyrus iowensis. Crab Apple.

Common in thickets about Lost Island lake and along the Little Sioux. A fine ornamental tree; the bloom beautiful and sweet, the fruit not without value, and the tree, itself, admirable to the formation of a thicket, as a wind-break, or protection against snow drifts and storms.

Crataegus coccinea Linn. Hawthorn. Red Haw.

This species occurs occasionally with the preceding along the river and is commendable in much the same way.

Symphoricarpos occidentalis Link. Wolf Berry.

This is a handsome little shrub characteristic of the borders of the northern woods. Growing in clumps, the stems two or three feet high, with handsome axillary flowers in July

and August, succeeded by beautiful white berries in fall. Deserves a place at the border of every northern lawn.

Sambucus canadensis Linn. Elderberry.

Not common; probably escaped from cultivation here and there. Planted sometimes in gardens by those who esteem the fruit, and like to share it with the birds.

Viburnum lentago Linn. Black Haw.

Mr. Kirchner reports this from near Peterson. It is a small tree popularly known and appreciated for its fruit. Useful chiefly as an ornamental shrub, or as an index of the possibilities of the region where it occurs by nature. The tree loves rich soil and bespeaks forest conditions.

Fraxinus americanus Linn. White Ash.

Native to both counties and everywhere commonly planted. One of the most valuable, if not the most valuable tree in northwestern Iowa. Native to the whole region, along streams and by the lakes; by the farmers everywhere wisely planted in groves and wind-breaks, clean and healthy, this tree makes splendid wood, good timber for all farm purposes, is long-lived, tough and strong. It should now supplant in large measure the less desirable cottonwood and box elder.

Ulmus americana Linn. Common Elm. White Elm.

This is another hardy and common species. The only tree for street planting. Some rather fine specimens are still standing on the county line of Clay county, immediately north of Sioux Rapids.

Ulmus fulva Michx. Slippery Elm.

Mr. Kirchner reports this species as native to the valley of the Little Sioux. Less valuable than the preceding and not common. *Ulmus racemosa* Thomas, should be found in these counties as it occurs about Spirit Lake, but was not observed, nor is it on the list of trees reported.

Juglans nigra Linn. Black Walnut.

This most valuable species is also reported from the groves about Peterson, by Mr. Kirchner. Specimens were also observed in the southeastern part of Clay county. These

trees are easily raised from the seed and they grow at first rapidly on the prairie soils, but the walnut is essentially a forest tree and can flourish under forest conditions only. Growing walnuts must be protected by the presence of other trees. They flourish best in sandy, but not impoverished soil, and in low but well drained grounds. In ash and black walnut the farmers of northern Iowa have at hand two timber trees of highest value. They should be introduced in groves of box elder and soft maple and allowed to slowly, in part at least, supplant these less desirable forms.

Carya amara Nutt. Bitter-nut. Pig-nut.

Not common. Yet to be seen here and there in the valley of the Little Sioux. A tree of comparatively small value. It grows slowly and has few qualities to recommend it in the present case except as the wood may be used for fuel.

Corylus americana Walt. Hazel. Hazelnut.

Common wherever there is native woodland, it is in a measure a nurse for other species. It may often be seen in patches out at some distance from the established forest and by holding leaves and especially snow, has served to check in spring the ravages of fire, which is of old the destructive foe of seedling trees.

Ostrya virginica Willd. Ironwood.

A rather common tree along the Little Sioux and by the banks of Waterman creek, of slow growth it forms wood of remarkable density and is serviceable in making tool handles, in the repair of farm machinery, etc.

Populus deltoidea Marsh. Cottonwood.

Common everywhere and everywhere planted. Mr. Griffin has beautiful rows of this tree near Greenville, in Clay county, and groves of the species are to be seen on every horizon. Fig. 43. Valuable chiefly in single rows or as isolated or scattered trees, border to a grove of some other species; less successful when used to form a plantation. The trees in the middle of a grove of cottonwood are stunted, even die out entirely,

and are in every way a disappointment. When planted along the highway these trees, as in the case cited, make a handsome avenue, but their shade, refreshing to the traveler, is at the same time deleterious to growing crops in the field. For



FIG. 43. A row of noble Cottonwoods shades the highway

this reason the farmer is apt to esteem such decoration of his holding too expensive. Planted on north and south lines they are less objectionable, and on the south side of an east and west highway they are almost without injurious effect.

Juniperus virginiana Linn. Juniper. Red Cedar.

This seems to be the only evergreen native to the region. It is reported to have been at one time common along the steep bluffs of the Waterman. Specimens brought from these localities are now to be seen in many dooryards, but none were observed in their native habitat. A remarkably hardy tree is this, well adapted to the region, enduring shade, making fine borders, hedges, etc. The tree suffers much from snows, where fully exposed, and often becomes crooked and straggling with age.

These are the principal woody plants of the counties we have been studying. The list is not very long but surprisingly long for a treeless region. At any rate, we have here a variety sufficient to guide us in our planting in this part of Iowa, and to make possible very handsome grounds and homesteads, as the experience of the farmer in many places already begins to show. The more common fruit trees are to be seen everywhere planted, and of conifers many introduced species were observed, such as the larch, the Norway spruce, the white pine, and especially the Scotch and the Austrian pine. The last named seems to be by far the better of the imported species.