GEOLOGY OF
LYON AND SIOUX COUNTIES.

BY

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CONTENTS.

INTRODUCTION.

SITUATION AND AREA.

Lyon county lies in extreme northwestern Iowa, the state line forming its northern boundary, while the Big Sioux, which here marks the line between Iowa and South Dakota, bounds it on the west. It includes eighteen townships, the northern tier containing thirty square miles each, instead of the normal thirty-six. Its total area is 704 square miles. Sioux county lies directly south of Lyon. It includes twenty-two townships with an area of 768 square miles, those townships along the Big Sioux river being irregular. Both counties are highly favored by nature in soil and climate. Opportunities for agriculture so exceptional have not been overlooked and the entire area is under cultivation. There is no waste land in either county.

PREVIOUS GEOLOGICAL STUDY.

The nature and age of the quartzite in South Dakota, Minnesota, and Iowa have long interested students of geology. The exposures north of Iowa were more generally studied, since they are more conspicuous than the Iowa outcrops. Catlin and Nicollet* were chiefly interested in the quartzite because it was associated with the pipestone of the Indians. In 1865 James Hall made certain deductions in regard to its age from observations in southwestern Minnesota. Hayden examined outcrops in southeastern Dakota and visited the pipestone quarries farther north. In the following year, 1867, White traveled up the Big Sioux from Sioux City and appears to have called attention for the first time to the quartzite exposures in Iowa. Kloos and Winchell, in Minnesota, have each added to our knowledge of the formation, while Upham and Todd have reported valuable observations in South

*For bibliography of Sioux quartzite, see Iowa Acad. Sciences, Vol. 11, p. 218.

Dakota. Keyes, in Iowa, has contributed material to the rapidly-growing literature on the quartzite.

In addition to the quartzite other geological features of the region have received some attention. A general description of the surface features of Lyon county was written by C. A. White for the Iowa Geological Survey, and is found in Vol. II (1870) pp. 77–95. The Hull well has attracted some attention and the records of the strata passed through have been studied by Keyes, Beyer, and Norton. Exposures near Hawarden have been studied by Bain and were reported by him in connection with Cretaceous deposits of Plymouth county.* Todd has examined and reported on certain cuttings east of Canton, while his work in the adjacent territory of South Dakota throws light on many problems across the river in Iowa.†

PHYSIOGRAPHY.

TOPOGRAPHY.

The surface of Lyon and Sioux counties presents a plain broken by the erosion of streams, with a slight slope to the southwest. The following table illustrates fairly the surface inequalities of the region. It hardly gives an idea of the slope that would prevail if the river valleys were eliminated, since many of the elevations cited are those of towns located on the larger streams. The towns mentioned in the table are arranged in four series representing approximately east and west lines, the distance between the first, second, and third averaging fifteen miles, while the fourth is within six miles of the third. All of the towns mentioned lie within the counties under consideration except Ellsworth, which is north of the Iowa line one mile, and Struble and Sheldon, which are an equal distance south and east respectively of the Sioux county line:

The towns in italics are valley towns and their elevation is affected to a greater or less extent by this fact. Lester is in the valley of Mud creek; Rock Rapids, Doon, Little Rock and Rock Valley are in the proximity of Rock river; the elevations of Sheldon, Alton, Hosper, and Carnes are affected by their

* Iowa Geol. Survey, Vol. VIII, p. 332.

† Iowa Acad. Sciences, Vol. VI, p 122.

nearness to the East Floyd, while those of Maurice and Struble

NORTH.

WEST. EAST.

Granite 1310	Larchwood 1465	*Lester* 1377	*Rock Rapids* 1345	Ellsworth 1445	*Little Rock* 1475
Beloit 1240	Inwood 1471	*Doon* 1285 *Rock Valley* 1253	Hull 1433	Boyden 1423	*Sheldon* 1415
Hawarden 1188	Ireton 1377	*Maurice* 1314	Orange City 1421	*Alton* 1308	*Hosper* 1341
Chatsworth 1152		*Struble* 1271		*Carnes* 1261	

SOUTH.

are influenced by the West Floyd. All of the towns in the western tier are near the Big Sioux:

NORTH.

WEST. EAST.

1 mile S of Granite 1440	Larchwood 1465		2 miles E of Rock R'pids 1415	Ellsworth 1445	1 mile W of Little Rock 1505
	Inwood 1471	3 miles E of Rock Valley 1323	Hull 1433	Boyden 1423	1 mile W of Sheldon 1475
2 m N E of Chatsworth 1252	Ireton 1377	3 miles E of Maurice 1395	Orange City 1421		

SOUTH.

The second table gives upland elevations only and bears out the statement that the normal slope is from northeast to southwest, and slight.

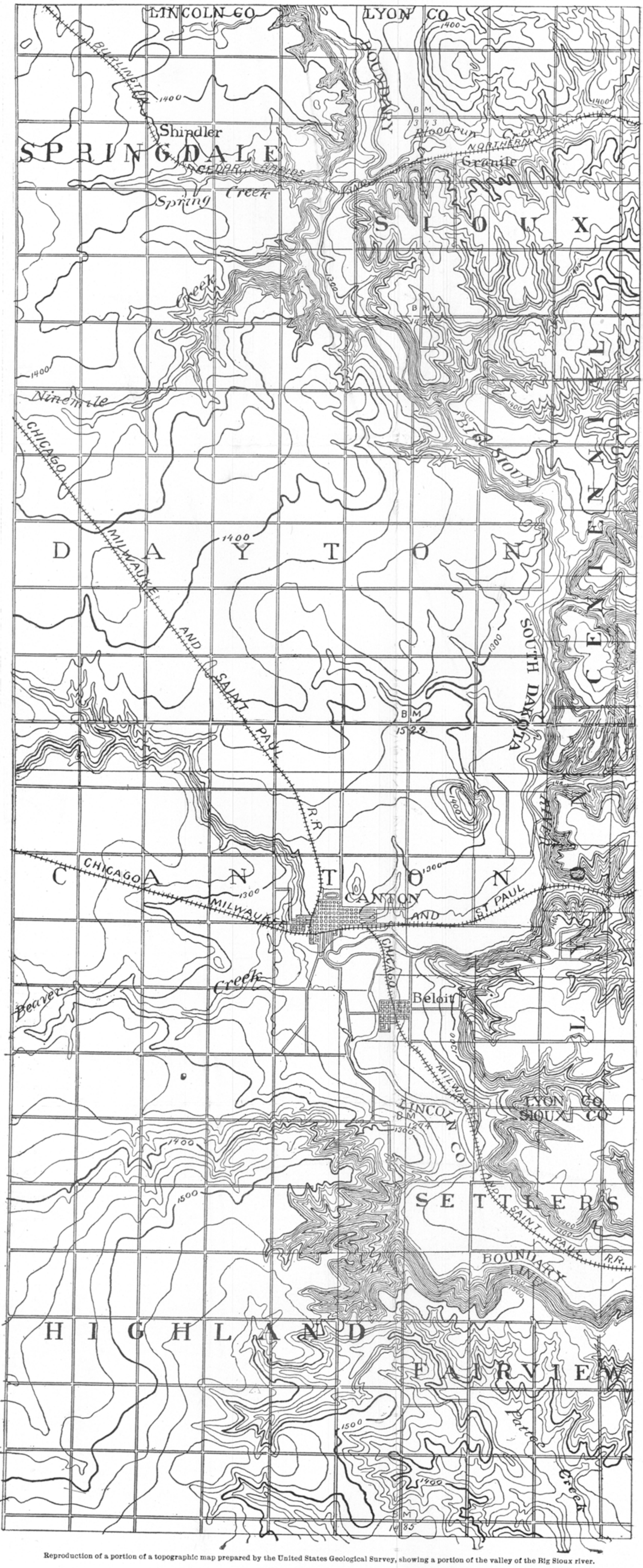
Topography of older drift.—The surface of this slightly sloping plain has been sufficiently diversified by stream erosion to afford perfect drainage, which with the nature of the soil results in an ideal farming region. The slopes are gradual, indicating for the streams a considerable age, and the bottom lands are broad, seldom deeply cut by recent stream beds, making it possible in most cases to cultivate the soil to the water's edge. From fifteen to twenty feet above the flood plain in the valleys of the Big Sioux and Rock rivers there is a conspicuous terrace, generally much broader than the flood plain. The soft nature of the material through which the streams have cut favors the formation of broad shallow valleys. The major stream of the region, the Big Sioux, forms the western boundary of the two counties under consideration. During this short course of forty-two miles its valley changes materially in nature and size. From the state line at the north to Elm Springs, the valley is admirably set forth by the portion of the United States topographic map for the Canton district that accompanies this report. On the Dakota side for four miles south of the state line high bluffs face the river. Continuing south on the same side for ten miles, till a point three miles south of Canton is reached, there are no bluffs, and the gravel terrace is but a few feet below the average level of the region. At this point very prominent bluffs again appear and continue nearly to Hudson. The bluff topography continues to the south, but after passing Hudson they recede from the river, forming bold headlands only here and there where the river has very recently been cutting at their base. On the Iowa side these pronounced bluffs, averaging 150 feet above the river, do not appear north of Blood Run creek, which empties into the Big Sioux three miles below the state line. Beginning at this point they continue without a break as far south as Hudson, where the topographic features become uniform for both sides of the river. For seven miles north of Canton, therefore, the Iowa bluffs overlook the Dakota plain which lies 150 feet below.

The width of the valley varies in the same way. At the state line it is two miles across, and so continues to the mouth of Blood Run creek. Thence to Canton it is often not more than half a mile wide, its upper course appearing narrower on account of the bluffs. From Canton to Beloit it is again two miles wide. A mile below Beloit it narrows sharply to half a mile and this width persists to the mouth of the Rock river above Hudson. From Hudson to Chatsworth its average width is two miles.

The bottom lands of the Rock river near its mouth are half a mile wide and so continue as far as Doon. The river here divides into the East and West Rock, and the valley of each is proportionately less than that of the stream after their junction. Six Mile creek, on some maps called Ford creek, flows through a valley of some maturity. Ten miles from the mouth of the stream the bottom lands are 200 feet across and lie seventy feet below the upland plain, from which the slope is very gradual. Mud creek is a tributary of the East Rock, into which it empties near Doon. It barely reaches across Lyon county into Minnesota, and drains in its course the greater part of three townships. Its valley is broad, however, broader than the present size of the stream would justify apparently, and an explanation is suggested in connection with other problems of the Pleistocene. The valley of the West Floyd in Sioux county, also, is out of proportion to the present size of the stream. This opinion is reached by comparing it with other valleys in these counties that seem to be of the same age in other respects. Although it rises two miles north of Boyden, in Tp. 96 N., R. XLIV W., Secs. 4 and 8, in Sioux county its valley is two miles wide and sixty feet deep. This extensive valley in the vicinity of Middleburg is indicated on the railroad commissioners' map as a slough. In the neighborhood it is known as Belle lake, though the term lake seems never to have been applicable. In former years the river overflowed this broad bottom land during the spring, but of late the land has been under cultivation. No artificial drainage has brought about the change but the washing down of the slopes has filled in the lowlands. These slopes have been under cultivation for thirty years and the loess surface under these conditions readily washes into the hollows. There are no sloughs or lakes in either county and a topographic map of the region would make clear the fact that the entire area is reached by the streams and none left undrained. The minor feeders are not conspicuous enough to be placed on an ordinary map, and only during the rainy seasons do they appear as water courses. In the spring, however, great quantities of water pour down the broad valleys that everywhere open into the main creek and river beds, testing and sometimes overstraining the capacity of the culverts which, as a rule, are unusually large. The surface of the region, therefore, is decidedly undulatory. Except along the Big Sioux there are no sharp ravines with steep sides, but instead there are gradual slopes from a broad crest leading to a broad valley. To gain one crest, however, is simply to discover another hollow. The grades are not steep, they may usually be climbed with a bicycle, and the long even declines make it possible to coast to the bottom of the depression and part way up the next slope.

The topographic map of the Canton quadrangle takes in enough of western Lyon county to bring out the contrast between this surface and the Wisconsin drift of Dakota. At a glance it reveals the fact that the Lyon county surface is older and its drainage more perfectly developed. This difference would be more marked had a section of Lyon, or Sioux county away from the Big Sioux been taken for comparison, for certain factors to be considered later have made the region along the Big Sioux somewhat abnormal. Notably so is the strip from Canton to the mouth of Rock river. Attention has already been called to the bluffs along the river at this point. The streams flowing into the Big Sioux here are insignificant in length, and instead of valleys they flow through narrow sharp angled ravines commonly termed draws. Their sides are precipitous and wagon roads are made with difficulty.

Topography of Wisconsin moraine and outwash.—Another region with abnormal topography includes certain parts of four townships in northeastern Lyon county. In following the road on the state line toward the east, at Tp. 100 N., R. XLIV W., Sec. 10 center, the undulations that characterize the country to the west will be found to cease and for four



Reproduction of a portion of a topographic map prepared by the United States Geological Survey, showing a portion of the valley of the Big Sioux river.

miles a conspicuously level surface prevails. The western edge of this level area is not clearly defined, yet the changes in conditions will be noticed within half a mile. The inner or eastern edge is bounded by a distinct ridge having an elevation of fifty feet. This ridge trends from southeast to northwest, crossing the state line at Tp. 100 N., R. XLIII W., Sec. 8, eastern edge. Four miles southeast, at Little Rock, it loses its distinctness on account of the erosive action of the East Rock river. Within this ridge, that is, to the north and east, the country is rolling, the ridges in general having the same direction as the outer one. They are more persistent than the ridges formed by erosion found elsewhere in the county, and cutting into them there are no secondary ravines. The East Rock river north of the town of Little Rock flows between two of these ridges in a trough that might readily be mistaken for a valley that the stream has created. The size of the trough, however, is out of proportion to the valley of the stream a little farther south. Here and there within this region of ridges are hummocks of sand and gravel reaching an elevation of sixty feet. These are most conspicuous in Tp. 100 N., R. XLIII W., Secs. 15 and 23. These conditions, namely, a broad level belt fringing a ridge on the inside of which are other ridges having a similar trend, persist to the north and were easily traced as far as Adrian, Minn., and to the southeast into Osceola county.

DRAINAGE.

The rivers of Lyon and Sioux counties are tributaries of the Missouri. The Big Sioux forms the western boundary of these counties and with its branches drains all of Lyon county and the western half of Sioux. Its source is in Dakota some forty miles north of the boundary of Iowa. Between the mouth of Rock river and the Dakota line the Sioux receives few tributaries, Blood Run and Plum creeks being the largest. The elevation of low water at Brandon, South Dakota, which is below the falls and near the state line, is 1281 feet, while at Chatsworth, near the southern Sioux county line, it is 1132 feet; giving a total fall of 149 feet and an average fall of 3.2 feet per mile. This fact makes the stream valuable for water power. At Hawarden and Hudson dams which give a head of seven feet cause the water to set back only two miles.

Rock river is the largest tributary of the Big Sioux and, with its branches, drains northeastern Sioux county and central and eastern Lyon county. Three miles south of Hudson it unites with the Big Sioux. Its elevation here is 1195 feet, while at Rock Rapids its low water level is 1450 feet above the sea, making for the intervening distance a descent of 265 feet, or 5.3 feet per mile. Near Doon it receives as tributaries Mud creek and East Rock river. Kanaranzi and Tom creeks unite with it near Rock Rapids.

Six mile creek empties into the Big Sioux at Chatsworth. It is twenty miles long and drains fifty square miles in southwestern Sioux county. Dry creek, which flows into the Big Sioux at Hawarden, drains an equal area. Both of these streams are insignificant and often quite without water in summer, but during periods of rain, on account of the slope and their elaborate system of feeders, they suddenly assume considerable proportions. Western and central Sioux county is drained by the East and West Floyd. In Sioux county the characteristics of these streams are those of Six Mile creek just described. They have a fall of about five feet per mile.

Of these streams the Big Sioux is the only one that has a valley in which are exposed the indurated rocks that underlie the drift. The age of the stream, therefore, is best considered in connection with the age of the drift and other phenomena of the Pleistocene.

STRATIGRAPHY.

GENERAL RELATIONS OF STRATA.

The formations of Lyon and Sioux counties may be grouped in two classes primarily; those in which the component substances are heterogeneous, and those which are practically uniform in nature. Under the first may be included the glacial drifts and associated deposits. In the drift the rock fragments vary greatly in composition and origin, having been picked up by the ice sheets from the various regions over which they passed. The only deposits related to the drift that approach homogeneity are certain outwash beds of sand, and the loess, though the glacial origin of the latter may be fairly questioned.

Beneath these glacial deposits are formations that in structure and composition are nearly uniform. Between these homogeneous formations and those which vary greatly in composition and structure are certain sands and clays that are not readily classified. The difficulty arises from the fact that these sands and gravels are quite uniform in the few places where found, but exposures are so rare that they may possibly belong to the upper heterogeneous series which, for a very limited area, fails to present its normally diversified characteristics.

Aside from the Sioux quartzite in northwestern Lyon county the only opportunity for directly observing the indurated rocks that everywhere underlie the drift is given by exposures along the Big Sioux river. A limited amount of information may be gained from records of well borings. The Sioux quartzite, which is generally regarded as Huronian, is the oldest rock formation in these counties. Other strata beneath the drift belong to the Cretaceous, except certain sands and clays which are probably to be referred to the Pliocene. The classification of known strata is shown in the following table:

In western Iowa, eastern Nebraska, and eastern Kansas the Cretaceous strata rest directly on the Carboniferous.* Farther west, in the Rocky mountains, the whole Jura-Trias series intervenes. The conclusion follows that at the end of the Carboniferous age the shore line was far to the west of Iowa and that the Carboniferous rocks in the western part of the state were subject to erosion for a very long period of time.

*U. S. Geol. Survey, bulletins, Vol. IV, p. 870.

At the end of this period there was a subsidence that brought the shore line again eastward as far as central Iowa. While this subsidence was going on the Cretaceous deposits were formed. During the first stages of the subsidence, along the gradually retreating shore line, sands were deposited which now appear as the Dakota sandstone, the lowest member of the Cretaceous in northern Iowa. Later, when the depth of the water had increased, the Colorado shales and limestones were laid down above these sands. At the close of the Colorado stage the region was again raised above water, with the possible exception of certain limited areas that were lake beds during Tertiary times.

GROUP.	SYSTEM.	SERIES.	STAGE.	SUB-STAGE.	FORMATION.
Cenozoic.	Pleistocene	Recent.			Alluvium.
		Glacial.	Wisconsin.		Moraines Gravel trains.
			Iowan?		Loess.
			Kansan.		Drift.
	Pliocene?				Sands and clays
Mesozoic.	Cretaceous	Upper.	Colorado.	Benton.	Shales.
			Dakota.		
Eozoic.	Algonkian.				Quartzite.

ALGONKIAN.

THE QUARTZITE.

The Sioux quartzite or "granite," as it is commonly called, appears on the surface in a single township in Lyon county. The area in Minnesota and Dakota, however, within which exposures of this rock are common, is considerable. As stated by Beyer* its extreme eastern limit of outcrop is found at Redstone, and its most westerly exposure is near Mitchell on the James river. Its greatest width is about sixty miles, extending from Flandreau on the north, to Canton, which is on its southern border, giving a total area of more than 6,000 miles. Its thickness has been variously estimated, but on this point there is little on which to base a positive assertion. Well drillings have not passed through it, though they have entered it to a considerable depth, and there are no great folds or flexures. It is thought by Todd of the South Dakota survey† and by Beyer that its thickness does not exceed 1,500 feet.

Instead of quartzite, originally the formation was water-laid sand. Proofs are still present in the ripple marks and lines of lamination and stratification. The layers varied in thickness from two feet to half an inch. Cross bedding was not uncommon, indicating that, in places at least, the sand was deposited by rapidly running water. These characteristics are still preserved in the quartzite. Subsequently the sand was permeated by water holding in solution silica which crystallized around the sand grains and cemeted them together, producing a solid quartz mass. Microscopic study of the quartzite by Irving and Van Hise has made clear the fact that the silica which forms the matrix has been deposited along lines that correspond with the crystalline axes of the several grains. The interstitial deposit of silica explains the unusual firmness of the rock. The same observers made clear that while silica was deposited about all of the sand particles, frequently the quantity was not sufficient to fill all of the spaces between the grains. As a result a sandstone easily crumbled was produced. Throughout the quartzite this condition exists. In close proximity to quartzite and in the same beds the rock shades off into friable sandstone and even into uncemented sand. These softer layers are generally thin and quickly give place to the normal quartzite

*Iowa Geological Survey, Vol. VI, p. 71.
†Preliminary Report on Geol., S. Dak., 1894, p. 35.

Well drillings that have penetrated the quartzite show that in the midst of the harder rock there are at times several feet of sand. An example of this sort is found in the well of the B., C. R. & N. railroad at Ellsworth, Minn., one mile north of the Lyon county line, where the quartzite was encountered under 180 feet of drift and fifty feet of shale. It was penetrated to a depth of 315 feet, and frequently sand layers of considerable thickness were found. The color of the rock varies from pink to purple, red being most prevalent. The coloring matter is oxide of iron, which forms a thin coating around the quartz grains. Near the upper surface and along joints leaching has evidently taken place, for the colors are dull. As determined by the Minnesota survey the rock is composed almost wholly of quartz, 85.52 per cent consisting of that mineral.*

The Sioux quartzite is extremely hard, breaks with a conchoidal fracture, and takes a high polish. Catlin wrote of it as follows: "The quartz is of a close grain and exceedingly hard, eliciting the most brilliant sparks from steel, and in most places where its surface is exposed to the sun and air it is highly polished beyond any results that could have been produced by diluvial action, being perfectly glazed as if by ignition."† This polishing is without doubt due to the action of the wind. Excellent examples of this wind polishing are found on "the mound" at Luverne, Minn., and some are found on the Lyon county exposures. The polishing is most marked on vertical surfaces and follows the inequalities of the rock, smoothing out the sharp angles, but not wholly removing the unevenness due to the roughness of the original fracture. It differs, therefore, clearly, from glacial polishing. In the same way quartzite blocks carried by the ice far to the south, when exposed on the surface of the drift, readily become polished. The luster is not unlike that seen on large lumps of rock salt that are constantly licked by cattle. The position of wind polished portions of rock, often

* Geol. and Nat. Hist. Survey of Minn., Vol. I, p. 149.
† Am. Journal of Science, Vol. XXXVIII, p. 145, 1840.

within a few inches of the ground and on vertical surfaces that are protected by projections above, preclude the possibility that the polishing could have been done by animals rubbing against the rock. Winchell, in describing this phenomenon in his discussion of the Quartzite of Rock and Pipestone Counties, Minn.,* says: "The edges of the layers exposed toward the northwest are polished, doubtless by the dust particles swept by winds. The surface in some cases is as smoothly polished as can be done artificially with the utmost skill and patience." Gilbert, in a paper on The Natural Erosion of Sand in the Western Territories,† says that "sand when moved by air in regions where there is no moisture, humus, or vegetation to entangle it, is a denuding agent worthy to be mentioned with frost, wave, and flood." Not only are bold cliffs and the walls of mountain passes eroded by this agency, but pebbles lying in the open plain are carved till their surfaces are ridged and grooved and they are finally reduced to dust. Endlich,‡ considering erosion phenomena in Colorado, comes to the same conclusion. To the writer special interest in this subject of wind polishing was given by the fact that lying on the surface of the drift, but buried by the loess, in Lyon and Sioux counties bowlders were found which appear to have been polished in the same manner as the surface quartzite. They will be considered in connection with the drift and the discussion in regard to the origin of the loess. In the Lyon county quartzite exposures it was observed that polishing does not occur at an elevation above the ground greater than five feet, and that it is most common on vertical surfaces not more than eighteen inches above the level of the soil. This would indicate that small particles carried by the wind, but lifted only a little above the ground, are really the polishing agents.

The dip of the quartzite is variable, so that no series of folds can be made out. It is seldom more than ten degrees. At

* Geol. and Nat. Hist. Survey of Minn., Vol. I, p. 541.
† Proceeding of American Soc. for Adv. Science, Vol. XXIII.
‡ U. S. Geog. Survey of Territories, bulletins, Vol. IV, p. 833.

the mound near Luverne the dip is eight to twelve degrees to the northwest, at Jasper pool in Lyon county it is six degrees north, and at Sioux Falls it is eight degrees south. Todd considers this dip to be that of the original deposition rather than of flexures in the earth's crust.* There are two sets of vertical joint planes, nearly at right angles to each other. They vary in distance from one another from an inch to two feet. These, with the distinct layers, render the rock easy to quarry and at the same time expose it to the agencies that cause disintegration. While it makes the most durable of building materials, as exposed in the beds the action of frosts tends to break the rock into fragments varying in size with the distance between layers and joints. For economic purposes, however, the joints are useful rather than otherwise, since they aid in quarrying, and the distance between them is so variable that solid blocks of any size to suit ordinary purposes are readily obtained.

Age of the quartzite.—Beyer, in the report already referred to,† gives the results of special study in regard to the age of the quartzite and associated formations, and from its lithological character and structural relationships refers it to the Huronian. It has been referred to the Cretaceous by Hayden and to the Potsdam by the geologists of the Minnesota survey. Hall, White, Irving, Van Hise, and Todd favor the Huronian. Keyes,‡ after reviewing the opinions of other authorities, is inclined to think that the great age of these rocks is not to be positively affirmed. Heis led to this opinion by certain fossil forms resembling lamel-libranchs of the Cardium and Cytherea types that he has found in the quartzite, and recalls Hayden's reference to abundant casts in another part of the region. Still, until more light is thrown on the subject, he would regard the quartzite as pre-Cambrian.

The quartz porphyries.—During 1892 a well was sunk at Hull, in Sioux county, for artesian water. At a depth of 755 feet a

* Prelim. Report on Geol., S. Dak., 1894, p. 35.

† Iowa Geol. Survey, Vol. VI.

‡ Proceedings Iowa Acad. Sciences, Vol. II, p. 222.

compact olive-green rock was encountered which was mistaken for the Sioux quartzite. More careful study made plain the fact that the drill chips were typical quartz porphyry.* Quoting from Dr. Beyer's report on this well: "After drilling about forty-five feet in quartz-porphyry, a stratum about two feet in thickness of soft fine-grained sandy material was struck. This was immediately followed by another stratum of quartz-porphyry and these in turn gave place to sand-rock. These alternations of quartz-porphyries and sandstones continued to the end of the drilling, a depth of over 1,200 feet. The whole series of quartz-porphyries seem to be identical in structure and composition."

The following is an approximate record of the well below 755 feet:

		FEET.
18.	Compact olive-green quartz-porphyry	755- 800
17.	Fine-grained sandstone	800- 802
16.	Quartz-porphyry	802
15.	Coarse-grained sandstone	825
14.	Quartz-porphyry	832- 840
13.	Fine-grained sandstone	840- 860
12.	Conglomerate	866
11.	Fine-grained sandstone	880- 900
10.	Quartz porphyry	900- 930
9.	Fine-grained sandstone	930
8.	Pebbles and sand	930- 935
7.	Decomposing quartz-porphyry	935- 940
6.	Fresh quartz-porphyry	944
5.	Decomposing quartz-porphyry	949
4.	Quartz-porphyry	975- 990
3.	Sandstone	990
2.	Quartz-porphyry	1,194-1,220
1.	Fine-grained sandstone	1,228

The quartz-porphyries are recognized as of igneous origin, and in this case must represent lava flows of some sort, either overflow beds or intrusive sheets. Beyer's later study of the quartzite and its associated beds led him to interpret the Hull well record as additional evidence of the Huronian age of the quartzite, because the quartz-porphyry "is strikingly similar to the intrusives that are peculiar to the Huronian in the Lake Superior region."

*Iowa Geol. Survey, Vol. I, p. 165.

The quartzite presents many glaciated surfaces. Those on the Lyon county exposures are exceedingly clear and well preserved. Edges that would otherwise be abrupt, are rounded, and surfaces are planed, striated, and in some cases grooved. Chatter marks are common. They are well described by Winchell in his account of the quartzite of Rock county, Minn.*

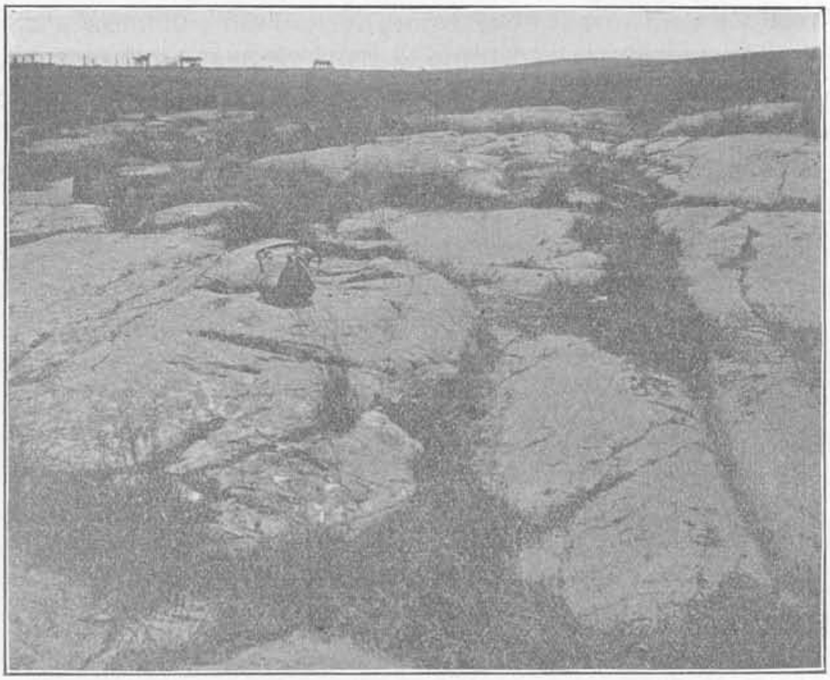


Fig. 1. Glacial groove on quartzite in Lyon county.

He says: "It cannot be doubted that this marking was done by a force that exerted a great pressure at the same time that the marks were made. This pressure is evinced not only in the marking itself, which is on the hardest formaticn in the state, but in the minute cross fractures that cover the surface where the rasping has taken place, and yet leave it in the main a smooth and moutoneed surface. These cross fractures run curvingly downward and at varying angles with the surface, and to all depths less than an inch, but usually less than

*Geol. and Nat. Hist. Survey, Minn., Vol. I, p. 548.

one-sixteenth of an inch, and indicate an incipient crushing to the depth of at least an inch. They show in what manner the rasping reduced the original projecting knobs. Where the natural seams or planes of jointage cross the rock, causing the quartzite to chip off sooner and deeper with a curving and conchoidal fracture, these little checks are larger. Their prevailing direction is transverse to the rasping force, so that the rock along some grooves has a short, conchoidally fractured structure transverse to the grooves, penetrating it to the depth of a quarter of an inch, exhibited in a series of little curving furrows where the laminae broke off successively, the convexities of the laminae being toward the north." Knowing the crushing resistance of the quartzite, he has computed that the pressure that caused these marks must have come from an ice sheet several miles in thickness.

THE QUARTZITE IN LYON COUNTY.

On the surface the quartzite is found in but two sections of a single township in Lyon county, and is nowhere exposed in Sioux county. These sections are 7 in Tp. 100, N., R. XLVIII, W. and 11 in Tp. 100, N., R. XLIX W. The first named exposure is found in the north central part of the section and may be seen from the road on the state line. The outcrop is in the bottom of a small valley and is perhaps fifty feet wide with a total length of half a mile. Erosion has removed the drift over this limited area exposing the quartzite which, doubtless, underlies it throughout this corner of the county. Thirty miles to the east it is known that the Benton shale intervenes. Section 11 of range XLIX is in the bottom lands of the Big Sioux. The quartzite here exposed is in the form of a ridge 100 yards wide and 400 yards long, rising to a height of twenty feet. In the bluffs just across the river an exposure of quartzite, evidently a part of this same ridge, rises to a height of fifty feet.

The dip of the rock at both of the Iowa exposures is six degrees north. Its characteristics are those common to the quartzite in other localities. The metamorphism is general but not universal. Occasionally the rock is soft enough to crumble between the fingers. The joint planes are in two sets

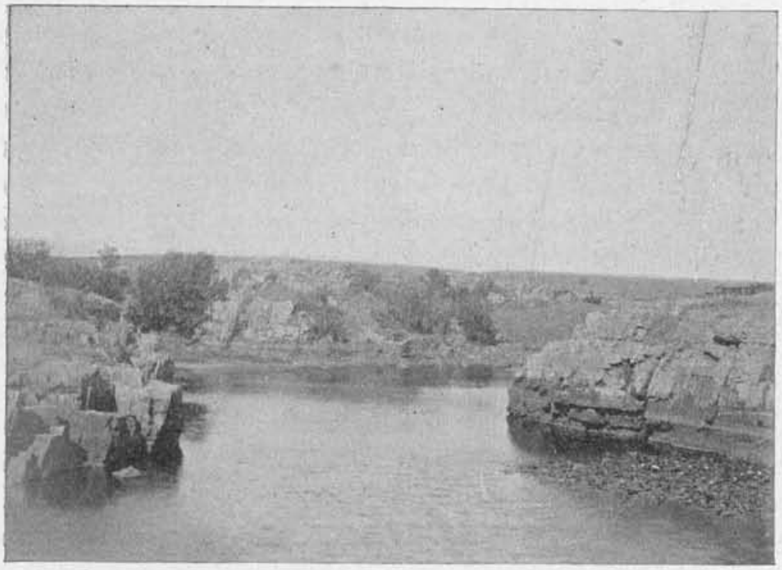


FIG. 2. Jasper Pool. Quartzite exposure in Lyon county.

at right angles to each other and from two to ten inches apart. In section 7 there is a beautiful example of oblique lamination. On the same exposure are remarable glacial striae and grooves. Apparently the drift has but lately been removed from the surface. The maximum depth of the grooves is eight inches, which is considerable when the hardness of the rock is taken into account. There are two distinct sets of striae, one evidently more recent than the other, since in places one is erased by the other. The corrected readings for these striae are S. 30° E. and S. 5° W.* It is not necessary to suppose that they represent two ice sheets. The second set was probably formed by the same ice sheet that was responsible for the first, the change in direction indicating the direction of the ice movement during its recession.

*Allowing 10° for deflection of magnetic needle to the east.

The quartzite, doubtless, underlies both counties, though buried deep by drift and Cretaceous deposits. On Lu Peter's farm near Little Rock, on the eastern boundary of Lyon county, it was encountered beneath shale and drift at a depth of 360 feet. At Ellsworth, Minn., near the northeast corner of Lyon county, it was found beneath similar material at a depth of 281 feet.

FIG. 3. Oblique Lamination in quartzite of Lyon county.

The chief value of the quartzite lies in the fact that it is easily shaped into paving blocks, which, on account of hardness, are practically indestructible. Quarrying for this purpose is extensively carried on at East Sioux Falls, S. Dak. The fragments chipped off in making the blocks can be advantageously crushed for macadamizing. Such a crusher was operated a few years ago at Rowena, S. Dak. Handsome structures for many purposes have been built from the quartzite in the vicinity where it is found, and a considerable quantity has been shipped for building purposes to fairly remote points. There promises to be a steady and gradually increasing demand for quartzite for all of the purposes mentioned, as its qualities become better known.

CRETACEOUS.

For knowledge of all deposits except the quartzite and drift we are dependent on certain exposures along the Big Sioux and upon well data. Inferences may also be made from exposures in neighboring counties. The Big Sioux has cut through the drift and into the indurated rocks to a total depth of 250 feet, while the deep wells of both counties give data that can be interpreted for 300 feet farther. The following records are those of wells drilled by Mr. M. E. Layne, of Rock Rapids, and are selected from many as typical for the locality in which they occur.

Ellsworth, Minn., railroad well, one mile north Lyon county line:

		FEET.
10.	Soil	2
9.	Yellow clay with gravel	3
8.	Gravel	6
7.	Yellow clay with gravel	80
6.	Sand and gravel (little water)	4
5.	Blue clay with gravel and bowlders	95
4.	Soapstone (shale), blue, no gravel	50
3.	Clean, water-bearing sand	30
2.	Sand, with clay	20
1.	Quartzite at depth of 281 feet	

The flow of water from the sand just above the quartzite in this well is said to be 100,000 gallons in twenty-four hours. An effort was made to pass through the quartzite at this point by other well drillers, and the rock was penetrated 300 feet, when the effort was abandoned.

Well of John Vanderberg, near Sioux Center, in Sioux county, Tp. 96, N. R. XLV W., Sec. 27, south ½:

		FEET.
12	Soil	2
11.	Yellow clay with gravel	130
10.	Loose sand (no water)	4
9.	Blue and yellow clay with bowlders	100
8.	Sand and clay	66
7.	Soapstone (shale), no bowlders or gravel	80
6.	Fine sand (much water), entered to a depth of	13

Well at Hudson, in valley of Big Sioux:

5.	Soil	2
4	Yellow clay with gravel	15
3.	Blue clay with gravel	100
2.	Soapstone (shale), no gravel	145
1.	Sand (much water) stopped in this	

New town well at Hudson, nearer the river than the one just described, on gravel terrace:

		FEET.
6.	Gravel	30
5.	Blue clay with gravel	15
4.	"Soapstone" (shale)	70
3.	Gravel (little water)	3
2.	Shale with pyrites	65
1.	Sand rock with pyrites entered only (much water)	5

Railroad well at Sibley:

		FEET.
7.	Soil	3
6.	Yellow clay with gravel	60
5.	Blue clay with gravel	60
4.	Sand and clay (some water)	6
3.	Blue clay, sand with bowlders	180
2.	"Soapstone" (shale) no gravel	80
1.	Sand with much water, entered only (much water)	20

The capacity of this well is given as 117,000 gallons in twenty-four hours.

Mr. Layne reports that the so-called soapstone is a definite formation and that after reaching it he feels certain of his position and can predict quite accurately the distance beneath it at which he will find the water-bearing sands. He reports the "soapstone" everywhere free from gravel and bowlders. Samples of this rock brought to the surface from his wells show that it agrees in color and texture with certain shales exposed along the Big Sioux. These shales will be carefully considered later. The water-bearing sand in which these wells stop is generally coarse, that brought to the surface from a number of wells resembling that which makes up the Dakota sandstone. The abundance of water that the sand yields favors the belief that they are to be associated with this formation.

DAKOTA SANDSTONE.

In Plymouth county, just south of Sioux, the Dakota sandstone is exposed in cuttings and has been identified not only by its stratigraphical relations but by its fossils as well. There it underlies the Benton shale. It is found in the same position in South Dakota. The shale or "soapstone" of the well records is exposed along the Big Sioux and the fossils that it contains readily show that it is the Benton. Without doubt, then, the sands yielding water in the deep wells cited belong to the Dakota formation.

The Dakota sandstone in South Dakota furnishes the water for the wonderful artesian wells that have added so materially to the wealth of that state. In 1896 the outflow of these wells, as estimated by N. H. Darton, of the U. S. Geological Survey,* was 104,000 gallons per minute. A small fraction of the water is derived from sources other than the Dakota sandstone. The pressure at the surface of these wells is often 100 pounds, and in a few cases amounts to 150 pounds. They supply power for large flouring mills, electric light plants and similar industries. The artesian area lies in the main between the James and Missouri rivers. The increase in elevation west of the Missouri renders artesian wells in this region extremely doubtful, for although the Dakota sandstone with its abundant water underlies it the wells already flowing indicate that the head would not be sufficient to raise the water to the surface. The counties along the Big Sioux in South Dakota and Iowa, however, are very low, 200 feet lower than the artesian district. Regardless of this fact there are no flowing wells in the vicinity of the Big Sioux. The water in the Lyon and Sioux county wells that penetrate the Dakota sandstone rises only to within 100—150 feet of the surface. This lack of pressure necessary to produce a flowing well is accounted for in two ways. First, the Dakota sandstone is exposed along the Big Sioux and the Missouri rivers, and there is opportunity for abundant leakage. A more efficient reason is found in the distance

*U. S. Geol. Survey, 7th An. Rep, p 609.

from the source of supply. The Dakota sandstone outcrops in the Rocky mountains and Black hills, and from these regions the water makes its way eastward through the pervious rock to Iowa. In accordance with the well known law of physics the pressure diminishes regularly as the distance from the source increases. Although the source of the water in the Rocky mountains is 8,000 feet above the Dakota formation in Iowa, the distance readily accounts for the diminished pressure eastward. In considering the underground waters

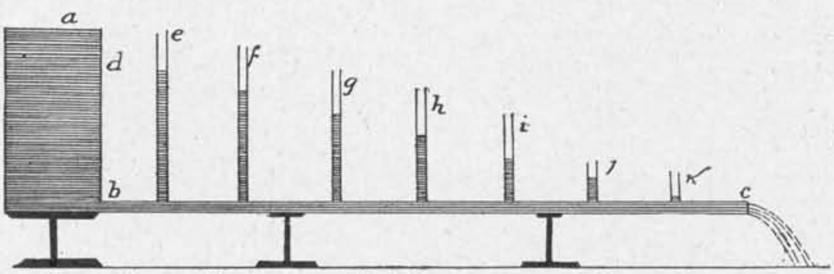


FIG. 4. Diagram illustrating relation of water pressure to distance from source.

of southwestern Nebraska, where the Dakota sandstone furnishes wells like those in Lyon and Sioux counties, Darton† suggests as an additional reason for the limited water pressure, that immediately west the formation may be finer grained and so choke out the water.

THE BENTON SHALES.

Four miles south of Hawarden the Big Sioux river has swung over against its east bank and after cutting through the gravel terrace and drift has made an extensive excavation in the underlying deposits. The Chicago, Milwaukee & St. Paul railroad in laying the bed for its track at this point, has aided geological study by similar excavations. The section thus jointly revealed at one point is as follows:

	FEET.
4. Loess	5
3. Drift	2
2. Shale with selenite	20
1. Limestone	20

†Irrigation Papers U. S. Geol. Survey, No. 12, p. 47.

Three hundred yards down the river the following series is exposed:

		FEET.
5.	Loess	20
4.	Drift	25
3.	Sand	15
2.	Limestone	20
1.	Shale	10

The exact location of these exposures is in Sioux county, Tp. 94 N., R. XLVIIIW., Sec. 22, west center.

The loess and drift have the characteristics common to these deposits elsewhere in the county. The limestone in both exposures is the same stratum. The lower exposure is on a point of land that projects farther into the valley of the Big Sioux than the upper, and it is evident that the shale which in the upper exposure overlies the limestone, has been removed by erosion and in its place sand deposited. The shale beneath the limestone is probably present at both points but is exposed at only one. The section plainly indicated by these exposures is, then, loess, drift, shale, limestone and shale.

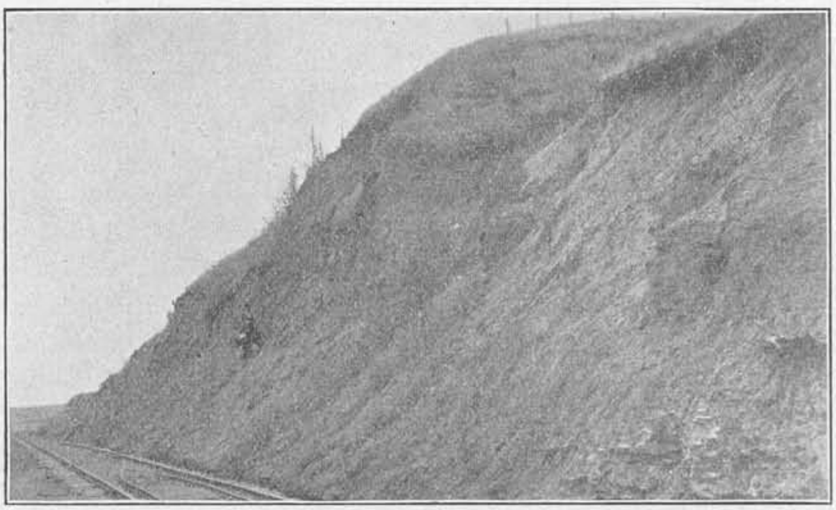


FIG. 5. Benton shale exposed three miles south of Hawarden.

The upper shale is everywhere extremely fissile, the laminae averaging ten to the inch, each quite distinct. It is practically free from lime. The predominating color is drab or slate, though it passes through all shades between red and black. It is everywhere uniformly soft, though it is never reduced to clay. Joints are common, seldom vertical, generally making an angle of 45 degrees with the horizontal laminae. The shale on either side of the joints is oxidized to a rusty red.

In this shale but one fossil form was found. It consists of circular prints about an inch in diameter on the thin slabs of shale. They are the impressions of spiral shells, disc-shaped, the outer volution much larger than those in the center, the volutions ridged.* Three specimens were sent to Professor Calvin, who pronounced them *Prionocyclus wyomingensis*, a member of the Ammonite family.

This shale abounds in selenite. Tabular crystals varying in size from a fraction of an inch to three inches are very common. Generally smaller crystals project from the prismatic faces of the larger ones. Twin crystals are not uncommon. Rosettes often occur, while between the laminae there is a frost work of minute gypsum scales. The larger crystals are seldom clear, all of them apparently containing some impurities.

The limestone that appears in both the upper and lower exposures is in very thin layers, averaging perhaps half an inch. It is clearly distinguished from the upper shale but shades gradually into the lower. It is generally hard and brittle, though at points it is made up of coarse layers and is softer, more nearly resembling chalk rock. At one point there are cracks in the rock sometimes half an inch wide filled with white powder. It effervesces slightly with acid, showing the presence of some lime. When heated it gives off water abundantly. Under the microscope it appears to be made up of very many minute crystals of selenite. The limestone is filled with the large and well preserved shells of *Inoceramus labiatus*.

The shale beneath the limestone is darker, harder and less fissile than that above it. It contains a larger percentage of

*For full description of this ammonite see U. S. Geol. Survey bulletin 106, p. 171.

lime and shades gradually into the limestone. At times the perfectly hard rock gives place to soft clay, which is extremely plastic and in structure and color resembles the fire clay of the coal measures. It is impossible to determine the thickness of this shale here for it extends downward nearly to the water's edge where it is covered with alluvium. From this lower shale rather fragile shells were taken, varying from half an inch to an inch in length, somewhat like clam shells. As identified by Professor Calvin, they belong to the genus Anomia. One specimen of *Ostrea congesta* was found in the same horizon.

The Prianocyclus impressions in the upper shale Professor Calvin regards as sufficient proof that these shales belong to the Benton, for *Prianocyclus wyomingenis* is a characteristic fossil of this group. This precludes the possibility of the underlying Inoceramus limestone stratum being Niobrara. The whole series, namely, upper shale, limestone and lower shale must be regarded as Benton. Professor Calvin reports that just such a series is characteristic of the Benton in the Black hills, where to the limestone stratum the title, "Oyster Shell Rim" is given. Inoceramus specimens from this exposure are of the same type as those of the oyster shell rim in the Black hills, whereas, in the Prianocyclus beds above the rim there is an *Inoceramus labiatus* that has a very different expression, so different that Professor Calvin has

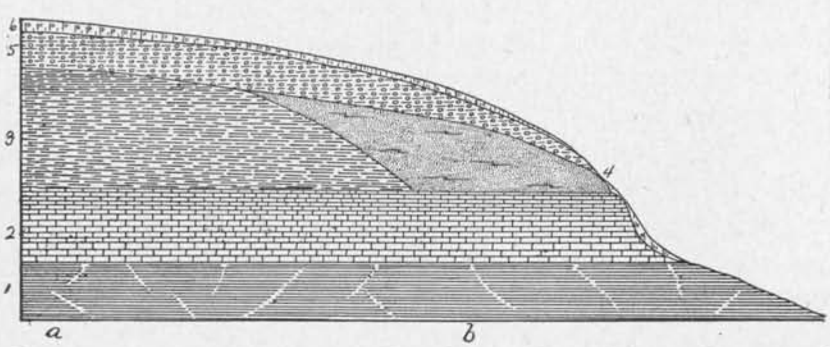


FIG. 6. Section on Big Sioux south of Hawarden. 1. Lower shale. 2. Limestone with *Inoceramus labiatus*. 3. Upper shale. 4. Sand. 5. Drift. 6. Loess.

difficulty in agreeing with writers who do not make it a distinct species.

At the foot of the limestone and in the upper part of the shale which underlies the limestone there are fine springs.

In the lower exposure the sand beneath the drift is evidently older than the drift which it underlies unconformably. This sand in color and texture is like that which generally composes the Dakota sandstone, coarse and red. It is for the most part uniform in texture. In digging down five feet from the surface only one layer a few inches wide was found containing material coarser than sand. Interspersed were occasional layers of clay from one to three inches thick. The upper surface of the sand was cemented by iron into a solid sheet two inches thick. It seems that these sands were deposited by the river before the older drift of the region was laid down. The limestone that underlies the sand was doubtless the stream bed, while the shale, which a little farther back overlies the limestone, was the ancient bank. The Dakota sandstone was exposed to the north and contributed the material.

In the pit of the brick yard at the edge of the town of Hawarden, in Tp. 95 N., R. XLVIII W., Sec. 35, Ne. ¼, there is a good exposure of the upper shale. Its characteristics as here shown are the same as those already noted. The selenite is very abundant and is equally distributed throughout the exposure.

Going north along the river no other exposures are found till a point four miles south of Hudson is reached. Here, as in those exposures south of Hawarden, the river has recently been cutting into the east bank. This point is in Tp. 95 N., R. XLVIII W., Sec. 12, center. Eighty feet of the upper shale are disclosed, extending from the water's edge to the drift that caps the bank. Here, as elsewhere, selenite is abundant. Septarian nodules were found which have not been noted in the exposures farther south.

Six miles north of Hudson, at Fairview, on the Dakota side of the Big Sioux, Todd has found the following section:*

		FEET.
8.	Slope covered with bowlders and clay	50–100
7.	Drab pebbleless clay	14
6.	Unexposed	4
5.	Drab clay thinly laminated without fossils and pebbles	17
4.	Fine gray sand horizontally stratified	13
3.	Slope	40
2.	Lead-colored clay and shell fragments	5
1.	Shale with calcareous concretions, level of stream.	2

On account of the layer of unconsolidated sand separating the upper clays in this exposure from the lower, which he regards as clearly Cretaceous, Todd is inclined to think that sections 5 and 7 in the series above belong either to the Pliocene or the very earliest Pleistocene. Allowing three feet per mile for the fall of the stream the water level here is twenty feet above that of the Hudson exposure, where eighty feet of undoubted Benton shale rise above the river. The surfaces of the two exposures, then, are about on the same level. The surface of the shale, however, before the drift was deposited would probably vary a few feet at the two points. The absence of selenite in five and seven of the Fairview series is perhaps the strongest reason for thinking that they do not belong to the Benton, and leads to the belief that they are to be classed with certain clays that are found farther north.

The next exposure to the north was found on the Chicago, Milwaukee & St. Paul railroad four miles east of Canton, in Tp. 98 N., R. XLVIII, Sec. 11, center. This point is three miles east of the river. It gave the following section:

		FEET.
4.	Drift, somewhat oxidized, with gravel	8
3.	Gravels, rusted, but slightly rotted	5
2.	Sand, very fine, unoxidized	20
1.	Clay, drab, without pebbles	6

The lower clay is homogeneous in texture and uniform in color except along joints where it is stained red. Care was

*Prelim. Rep. on Geol. S. Dak., 1894, Vol. I, p. 111.

taken to determine the presence or absence of pebbles. The surface was stripped to a depth of eight inches to remove material that had fallen from above. In excavating a cubic yard every spadeful of clay was minutely examined and not one pebble was found. The clay lacks the lamellar structure of the upper Benton. The sand is a striking feature of this exposure. It is extremely fine and resists erosion, presenting the vertical faces so characteristic of the loess. To the unaided eye it reveals minute mica scales, while the microscope shows that in the main it is composed of rounded quartz fragments.

In cuttings on either side sands in the same horizon are coarser and are everywhere water-bearing.

The clay probably corresponds to that of the upper members of the Fairview series. Everywhere in Iowa where the upper Benton is exposed it is so definitely characterized by the presence of selenite and its lamellar structure, that the absence of these characteristics here makes reasonable the supposition that the clays are younger than the Cretaceous.

The sand here exposed seems to be more than a local phenomenon. Well drillers report that in the vicinity of Inwood, which is two miles east of the exposure in question, they frequently encounter quicksand at a depth equivalent to that of these sands. At a corresponding level north of Sioux City Mr. Bain has found beds of fine sand overlaid with gray and yellowish clays with a few pebbles which do not seem to be of northern origin. In these sands were found teeth which Professor Cope identifies as *Equus major*. Cope assigned the sands to the Pleistocene.

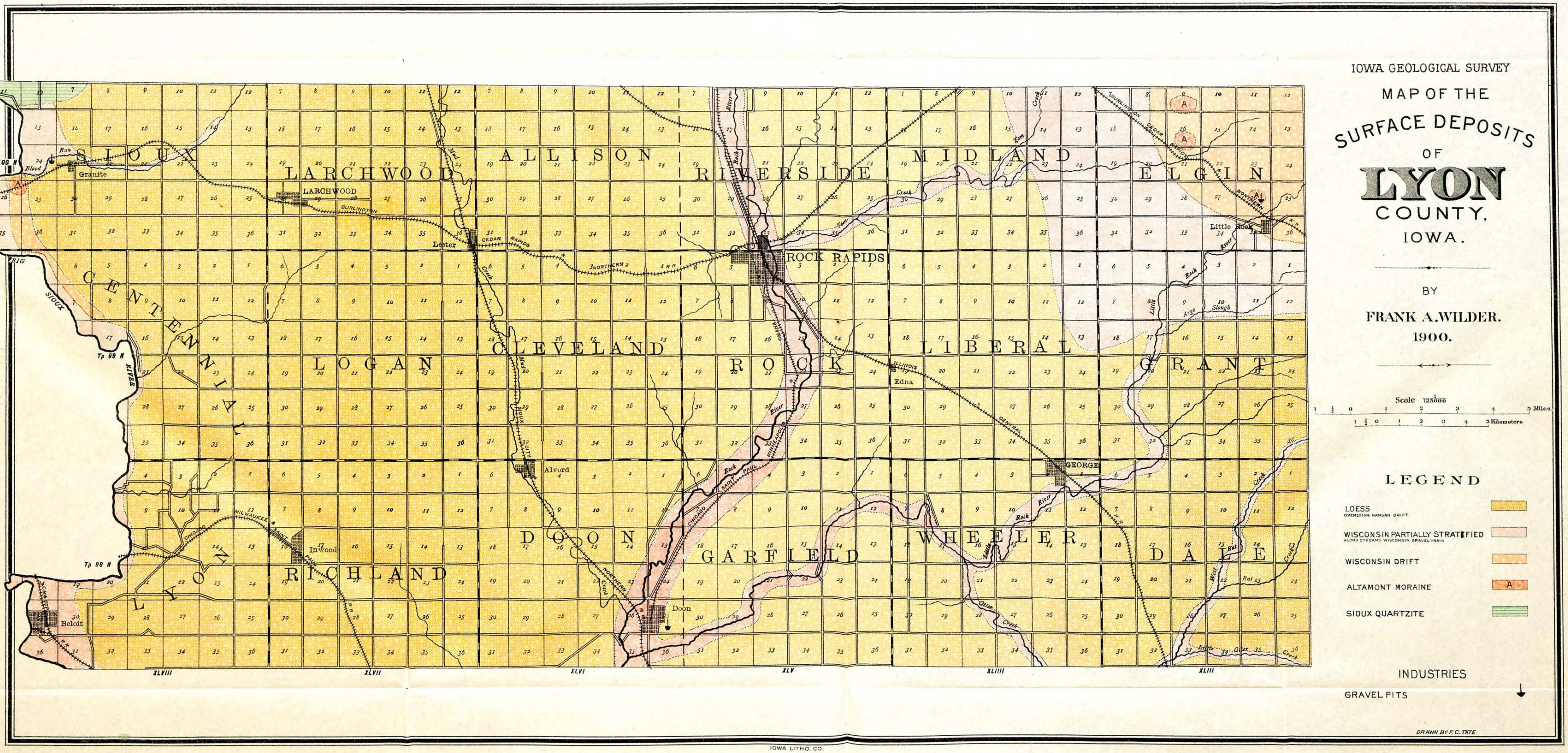
Very recently in the vicinity of Akron, Professor Todd has found elephant bones. These, however, were in the drift. It seems safe to infer that the sand and clay in these exposures is younger than the Cretaceous and older than the drift that is common in the vicinity.

THE PLEISTOCENE.

THE LOESS.

Excepting the areas indicated as having an abnormal topography, namely, the four townships forming a square in northeastern Lyon county and a narrow strip along the Big Sioux, north of Hudson, the entire surface of the region, save the lower valleys of streams, is covered with a deposit known as loess. In popular language it is called clay or loam, though it is generally understood that its description does not fully correspond with either. It is light in color, suggesting putty, fine grained, so that when dry and rubbed it blows like dust, porous as usually found, readily absorbing and holding water. When wet it is plastic, yet adhesive, and readily yields to the brickmaker's art. It resists erosion and when cut through, as in roadmaking, will present a face nearly vertical for years. It shows a tendency to crack along definite vertical planes, which at times gives rise to a structure roughly columnar.

It is free from pebbles and bowlders, and in this region they will be found on the surface only in lowlands or on hillsides where the loess has been washed away. The loess shades upward gradually into soil, which is simply the loess with matter of vegetable origin added. The result is a soil darker than loess, but lighter than that derived from drift or alluvium. The upper loess of Lyon and Sioux counties is generally leached, while the lower shows an abundance of lime. The lime often manifests itself in the form of concretions or lime-balls, which in size vary from that of a pea to lumps half an inch through. When broken open they resemble clay and are hollow, with cracks running from the center. They are formed by water, bearing mineral matter which it has obtained from the loess above. This material forms a coating about a nucleus, and as fresh matter is contributed the concretion grows. In regions where the surface loess is unleached there is often evidence to prove that erosion has removed the upper portion. The loess that abounds in these counties has another characteristic to which attention is called, inasmuch


IOWA GEOLOGICAL SURVEY
MAP OF THE
SURFACE DEPOSITS
OF
LYON
COUNTY,
IOWA.
BY
FRANK A. WILDER.
1900.
Scale 1/125000
Miles
Kilometers
LEGEND
LOESS
OVERLYING KANSAN DRIFT
WISCONSIN PARTIALLY STRATIFIED
ALONG STREAMS WISCONSIN GRAVEL TRAIN
WISCONSIN DRIFT
ALTAMONT MORAINE
SIOUX QUARTZITE
INDUSTRIES
GRAVEL PITS
DRAWN BY F.C. TATE
SIOUX
LARCHWOOD
ALLISON
RIVERSIDE
MIDLAND
ELGIN
CENTENNIAL
LOGAN
CLEVELAND
ROCK
LIBERAL
GRANT
LYON
RICHLAND
DOON
GARFIELD
WHEELER
DALE
Granite
Larchwood
Lester
Rock Rapids
Little Rock
Edna
George
Alvord
Inwood
Doon
Beloit
Tp 100 N
Tp 99 N
Tp 98 N
BIG SIOUX RIVER
Rock River
Little Rock River
XLVIII
XLVII
XLVI
XLV
XLIIII
XLIII
IOWA LITHO. CO.

as it helps to distinguish it from other material which may perhaps be called loess, but which differs from the typical loess of the region. This characteristic is its mottled appearance, which appears only on close examination. The colors present are red and buff, as though in spots more iron were present or oxidation had gone farther. Very often, though not always, there are black spots which seem to be of vegetable origin. At times the loess shows slight lamination, the planes being horizontal. No fossils have been found in the loess of this region, though they are frequently associated with it elsewhere. In thickness it is variable. On the bluffs three miles south of Hawarden it is twenty feet thick. An average thickness is six feet. On the hillsides it is often slightly thicker than on the crestis. The line between the loess and underlying drift is invariably well defined. The drift and

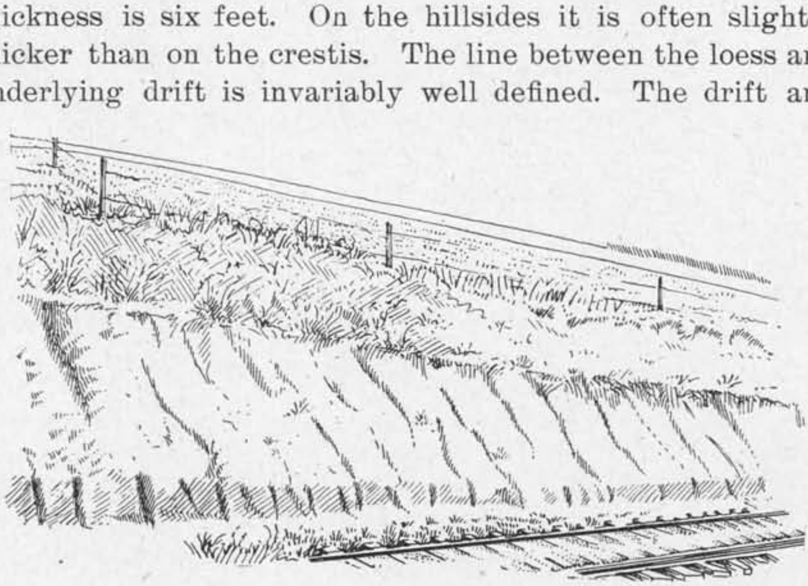


FIG. 7. Section in Tp. 100 W., R. XLIV W., Sec. 18, one mile south of state line, showing sharp line between loess and drift.

stratified material that underlies it always give the contour of the region, and the loess is simply a veneer, never seriously affecting the topography.

THE DRIFT UNDERLYING THE LOESS.

In Lyon and Sioux counties drift is everywhere found underlying the loess. Well drillings already quoted show that its thickness is about 200 feet. In the loess covered region the characteristics of the drift are quite uniform, though this drift varies decidedly from that of northeast Lyon county where loess is absent. The best opportunity for studying the drift is found in the railroad cuttings which are abundant in both counties. A typical cutting is given in the accompanying sketch. It is found in Tp. 95 N., R. XLV W., Sec. 20, Se. ¼, on the Sioux City & Northern railroad, two miles south of

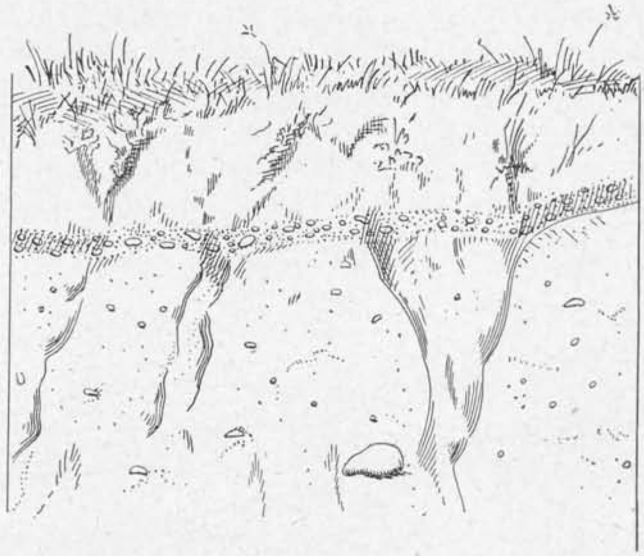


FIG. 8. Typical section through drift and loess in Lyon and Sioux counties, showing position of intervening gravel and sand layer.

Sioux Center. About fifteen feet of drift are found under seven feet of loess. The line between the two is distinct. Directly under the loess here, as in very many other places, there is a layer of gravel varying in thickness from a few inches to two feet. In place of gravel, sand is sometimes found. Where both sand and gravel are lacking there is invariably a line of rock fragments varying in size from pebbles to bowlders two feet through. It may be said without exception that on the surface of the drift, fragments of rock coarse or fine have accumulated in quantities greater than in an equal area of the drift below. In two cases wind-polished bowlders were found resting on the surface of the till and projecting upward into the loess. These were found in cuttings in Tp. 98 N., R. XLVII, Sec. 28, Sw. ¼ and Tp. 100 N., R. XLIV, Sec. 18 Ne. ¼.

In other localities similar bowlders were found in like positions, but their surface characteristics were not definite enough to render at all certain the statement that they show the effects of wind action. The subsequent decay of the surface of many bowlders has obliterated characteristics that were once clear. In the first case cited a granite bowlder eighteen inches in diameter is buried but slightly in the drift and projects into the loess more than a foot. The upper side is beautifully polished and calls to mind at once the wind polishing on the quartzite already referred to. Its surface is covered with indentations

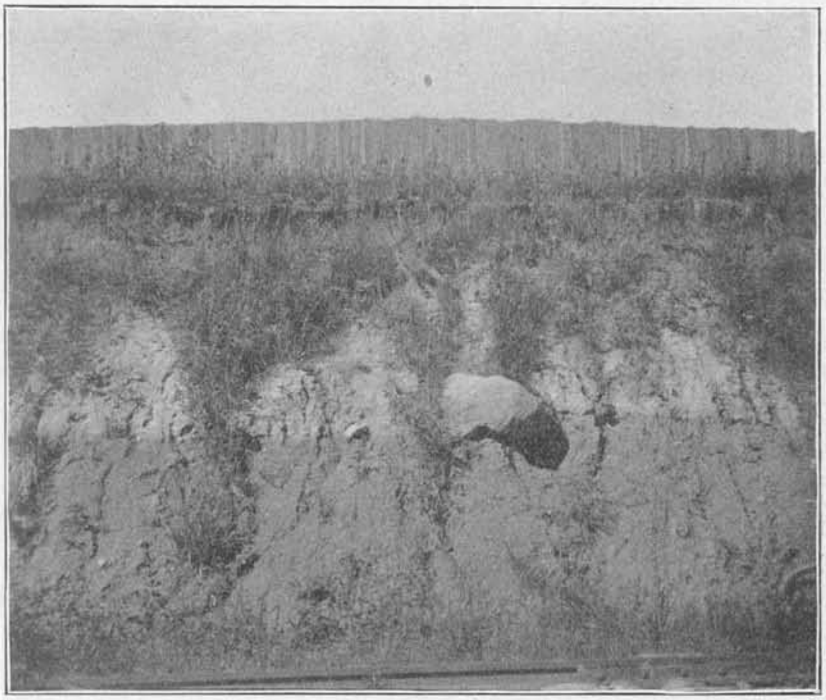


FIG. 9. Wind polished bowlder resting on drift and projecting into loess. The figure shows nicely the sharp line between drift and loess.

and irregularities and there is no suggestion of planing and yet, regardless of the unevenness, it is uniformly polished. It is strikingly different from bowlders planed, striated and polished by ice. The wind with material that it carries are the only agents to which polishing of this sort can be attributed. The fact that the under surface which rests on the drift is unpolished bears out this belief.

The amount of rotten material that rests on the surface of the drift is more abundant proportionately than that scattered through it. In the drift bowlders, granite predominates when the entire area is considered, but in the western half of both counties quartzite is most abundant. In the pebbles there is a greater percentage of limestone, perhaps one-fourth of all the smaller rock fragments being of this material. Next in order of abundance are granites, greenstone and quartzite. The pebbles and sand on the surface of the drift are usually badly rusted and stained.

The upper part of the drift is invariably darker than the lower, the color shading off gradually through six or seven feet. This darker color is due to the oxidizing of the iron in the clay. This dark rusty red follows the joints into the lighter clay below, extending back from the joints about an inch on each side. Away from the joints the lower drift is but slightly oxidized. The upper drift is not dark enough to be called ferretto, and apparently oxidation has not gone as far as in the southern part of the state where the very dark surface band is developed to which this term is applied. The drift is nearly everywhere unleached and responds vigorously to the acid test. Lime concretions like those found in the loess are common near the surface.

In the following railroad cuttings loess and drift like that described are exposed:

On the Illinois Central:

Tp. 99 N., R. XLV W., Sec. 10, Se. ¼.
Tp. 99 N., R. XLV W., Sec. 14, Se. ¼.
Tp. 97 N., R. XLIII W., Sec. 10, Sw. ¼.
Tp. 97 N., R. XLIII W., Sec. 36, Ne. ¼.

On the Chicago, Milwaukee & St. Paul:

Tp. 97 N., R. XLIII W., Sec. 36, Nw. ¼.
Tp. 97 N., R. XLV W., Sec. 29, center.
Tp. 97 N., R XLVI W., Sec. 25, center.
Tp. 97 N., R. XLVI W., Sec. 26, N. ½.
Tp. 98 N., R. XLVII W., Sec. 28, Sw. ¼.
Tp. 98 N., R. XLVIII W., Sec. 11, Se. ¼.

On the Burlington, Cedar Rapids & Northern:

Tp. 100 N., R. XLIX W., Sec. 26, Ne. ¼.
Tp. 100 N., R. XLIV W., Sec. 18, Ne. ¼.

On Sioux City & Northern:

Tp. 95 N., R. XLV W., Sec. 5, Sw. ¼.
Tp. 97 N., R. XLV W., Secs. 8 and 6, a series of cuttings.

On Chicago & North-Western:

Tp. 94 N., R. XLV W., Sec. 17, Ne. ¼.
Tp. 94 N , R. XLV W., Sec. 18, Ne, ¼.
Tp. 94 N., R. XLVIII W., Sec. 1, center.

Well drillers report that large bodies of sand are met with in the drift, and all of the wells in the region more than thirty feet deep and less than a hundred, end in these sand layers. In thickness they vary from six to thirty feet. In some places they are dry, but often they yield a considerable supply of water, showing that they underlie more than a limited area. On the Milwaukee road near the town of Perkins such a layer of sand ten feet thick is exposed. The locality is Tp. 97 N., R. XLVI, Sec. 25, center. Well drillers also state that the yellow bowlder clay persists to a depth of eighty or one hundred feet, and is succeeded by blue clay, which continues until the shale is reached. The alternation of blue and yellow clay is also reported, but so vaguely that it seems impossible to determine what it may signify.

Age of the Drift under the Loess.—With hardly an exception the geologists who have studied the drift of Iowa believe that the state has been invaded by more than one ice sheet, and that there were considerable lapses of time between these invasions. One reason for so thinking is the frequent discovery of buried forests and peat beds in the midst of drift. Such discoveries are reported from all parts of the state, one particularly interesting example occurring in Lyon county. In most of these instances logs and peat are encountered in well digging. These discoveries are altogether too numerous and too well authenticated to be disputed, and prove that the ice sheet that deposited the lower drift must have retreated at least for an interval sufficient to permit vegetation to gain a foothold. In the second place buried soils, that is, drift mixed with humus, are frequently encountered. The soil that has formed on the surface of the latest drift is but twelve to fourteen inches thick. Soil lines much thicker buried under many feet of drift are frequently encountered, and the inference is that a longer interval elapsed before the upper drift was deposited over this now buried soil than has passed since the last drift sheet itself was deposited. Thirdly, where old soils are so buried the clay beneath is generally leached. The water percolating through the soil near the surface takes its lime in solution and deposits it elsewhere. Water has little access to deeply buried drift except along sand and gravel horizons through which water is flowing. Leaching, therefore, generally accompanies other signs of old surface lines. The extent of leaching depends not only upon the length of time that the drift was on the surface, but also upon the amount of water percolating through it. Under certain conditions, therefore, it would be possible to have an unleached soil, though it had long been exposed at the surface. A fourth proof that former drift surfaces have been covered by subsequent drift is found in buried zones of oxidized material. Exposed to the air the iron, always abundant in clay, is changed from the blue ferrous oxide to the red ferric, the depth of coloring varying with the degree of exposure. This in turn varies with the nature of exposure and length of time that the drift was subject to atmospheric action. The lower the drift below the soil line the lighter the color, till it passes from the red through yellow to simple blue clay. Again, in connection with other phenomena indicating an old surface line buried by subsequent drift, are proofs that erosion to a greater or less extent has modified the former surface. Such proofs are found in accumulations of pebbles and bowlders, evidently once mixed with the clay, as in drift, but left behind while the lighter material was washed away. It is possible, of course, that such deposits were due to water action contemporaneous with the ice sheet, yet when they occur prevailingly over large areas the former explanation often seems more reasonable.

The occurrence of any one of these phenomena in a given region would hardly prove conclusively that there were at that point two or more drift deposits. When, however, many or all of the phenomena cited occur together as they do throughout the state, the proof seems adequate.* Working along these lines the geologists of the United States Survey and of the states of Iowa and Illinois have determined the following drift sheets.

The Wisconsin, the youngest, overlies the others when they occur in the same vicinity. Its topographic features, likewise, show that its age is not great. In Iowa it extends in a narrow lobe from the northern boundary of the state as far south as Des Moines. Its western border, as will be shown later in this report, barely enters northeastern Lyon county. In northeastern Iowa there is a drift sheet older than the Wisconsin, and in places lying under it, to which the term Iowan has been applied. Earlier than the Iowan ice was the Illinoian which moved from the northeast and entered Iowa for only a few miles beyond its eastern boundary. More general than these and earlier was the Kansan ice invasion, which covered the entire state and extended on to the south. Below the drift that is plainly Kansan, and separated from it by gravel beds, in certain localities is found a drift that is believed to be pre-Kansan.

The drift of northwestern Iowa has never been positively identified with any of these drift sheets, though it has been

*See proceedings Iowa Acad. Science, Vol. V, pp. 64—100.

thought that more careful study would result in associating it with some one of them. One of the reasons for undertaking at this time the geological study of Lyon and Sioux counties was to obtain, if possible, more light on this problem. The same drift is found to the south under the loess in Plymouth and Woodbury counties, while still farther south, in Carroll county, the drift was recognized as Kansan. No break or line separating this Kansan drift from that of the northwest having been found, unless there were other proofs to the contrary it would be natural to regard the drift of the northwest as Kansan. The study of Plymouth, Woodbury, Lyon and Sioux counties has brought out certain difficulties in so associating it. First, in the Kansan of southern Iowa, oxidation has gone farther than in the drift of Lyon and Sioux counties. In Appanoose county, for instance, and in Polk county under the Wisconsin, the Kansan drift has been so thoroughly oxidized that it presents a very dark band four feet thick. To this band the term ferretto has been applied. The oxidized zone in the drift of the northwest is not as well developed though it is sufficient to make a strong contrast with the unoxidized Wisconsin. Secondly, the drift of Lyon and Sioux counties is practically unleached while the known Kansan farther south is almost free from lime for three or four feet below the surface.

Opposed to these objections are the following considerations: First, as already stated, no line of demarkation has as yet been found separating the drift recognized as Kansan from that of northwestern Iowa. In parts of Carroll county drift recognized as Kansan lacks the ferretto zone* and this has been accounted for by supposing that erosion has been unusually rapid at those points. Toward the north the oxidation seems to diminish. There is an interesting cutting on the Illinois Central railroad half a mile east of Sioux Falls, S. Dak., which presents the following section:

*Iowa Geol. Survey, Vol. IX, p. 87.

		FEET.
5.	Sandy loess, in places sand	1-3
4.	Drift, unoxidized, with fresh pebbles	6-10
3.	Silt, slate color with shells	3
2.	Gravel, stained, partially decayed	1-2
1.	Drift with ferretto very distinct	15

The oxidation of the lower drift at this point is as great as in the typical Kansan. The gravel above it is like that above the drift in parts of Lyon and Sioux counties. On the north side of the cutting it is nearly two feet thick, while on the south side only six inches. It is replaced on the south side by silt containing many fresh water shells and bones of turtles. The shells have been identified by Professor Shimek as follows:

1. *Planorbis bicarinatus* Say.
2. *Planorbis parvus* Say.
3. *Physa heterostropha* Say.
4. *Limnea caperata* Say.
5. *Valvata tricarinata* Say.
6. *Sphaerium sulcatum* Prime.
7. *Pisidium compressum* Prime.
8. *Vallonia costata* Ster.

"Of these, one to four are Pulmonates, five is a gill bearer (Prosobranch), six and seven are bivalves, and eight is terrestrial. The set one to seven can be duplicated in most of our northwestern ponds with muddy bottoms. Eight is terrestrial, but grows sometimes near the edges of ponds and is common along streams. There is one specimen of this."*

The overlying drift is light colored, unleached and carries fresh rock fragments. It, in general, resembles the Wisconsin of other localities.

Similar exposures are found in the northern part of the town of Sioux Falls, at several points near the brewery on Main street. The beds are on about the same level as those east of town. The drift below the silt at these points shows no ferretto, and oxidation has gone about as far as in the drift of Lyon and Sioux counties. The extreme oxidation seen east of Sioux Falls seems to be quite local.

*Proceedings Iowa Acad. Sciences, Vol. VI, p. 125.

In other respects the exposures are practically the same. These points were visited by Salisbury, Bain, Leverett and Todd, and the lower drift pronounced Kansan. The question remained whether the upper or lower drift was to be correlated with that of northwest Iowa. The resemblance of the overlying drift to the Wisconsin has impressed all those who

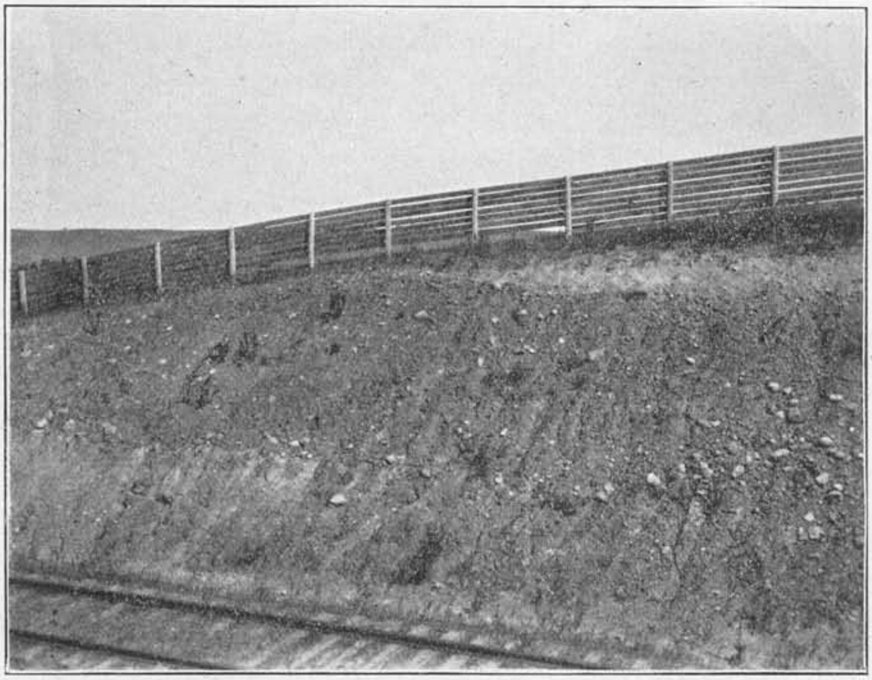


FIG 10. Exposure east of Sioux Falls, S. Dak., showing Kansan drift under Buchanan gravels, and these in turn under Wisconsin drift. (After Todd.)

have seen these exposures. Conspicuous kames of Wisconsin material in the vicinity, two miles south of the falls on the south side of the river, have been noted by a number of observers. The study of the Wisconsin moraine in connection with this report has made plain that the exposure on the Illinois Central east of Sioux Falls is on the edge of the moraine, and that the loam and sand associated with it are to be referred to the Wisconsin. Similar deposits of sandy loess were found associated with the Wisconsin moraine in other localities. There seems to be very good reason, therefore, for associating the lower drift at Sioux Falls, which is regarded as Kansan, with the drift of northwestern Iowa, for the older drift in northwestern Iowa in all probability corresponds to one of the two drifts in the Sioux Falls exposure. It is of course possible that the Lyon county drift is not to be associated with either of the drifts at Sioux Falls, but the distance between the localities is so short that the Lyon county drift can hardly be considered a third deposit. The drift in northwestern Iowa is plainly not Wisconsin, therefore if it coincides with either of the drift sheets exposed at Sioux Falls it must be with the lower or Kansan.

Topographically the Kansan drift of southern Iowa has been regarded as older than that of Lyon and Sioux counties. The high gradients of the streams already cited is indicative of youth. Yet streams of similar size flowing over undoubted Kansan drift have as great a fall. English river in Washington county descends 3.3 feet per mile, while Skunk river, in the same county, falls 2.75 feet in each mile. Iowa river, at Iowa City, Johnson county, has a slope of 3.5 per mile, while its tributary, Old Man creek, has a gradient of 5 feet per mile.

In many places the gravel that so generally lies on the drift just beneath the loess in Lyon and Sioux counties suggests a similar zone found elsewhere above the Kansan. These gravels are so prevalent above the Kansan that they have been given a distinct name from the locality where they were first carefully studied, Buchanan county. Professor Calvin, in describing the Buchanan gravels, calls attention to the following characteristics. The material has been derived chiefly from northern sources, though fragments of fossiliferous limestone that have not been transported for any considerable distance are not rare. Similar rock fragments are commonly disseminated through the Kansan. A large proportion is dark-colored greenstone, with a high percentage of the individual fragments planed and scored. Certain granites and representatives of other rock species are completely decayed, so that blocks a foot in diameter fall to pieces under a single blow of the hammer. The gravel is exceedingly ferruginous in places and is everywhere much stained and weathered, particularly near the top of the deposit, the weathered portion taking on a characteristic reddish-brown color. These characteristics are often found in the gravels overlying the drift of Lyon and Sioux counties. In these counties there is a high percentage of quartzite present, which would be expected when the nearness of the quartzite exposures is taken into account.

On the west bank of the Big Sioux near Canton and on the east bank near Klondike there are exposures of gravel which, except for the added element of quartzite, correspond in composition and structure in every way to the description quoted above. A finely developed Wisconsin gravel train follows the Big Sioux, whose fresh gravels are in marked contrast to the rusted and decayed material in the two localities mentioned. On account of these contrasts it is impossible to associate the gravels at these points with the Wisconsin train, though their position would not necessarily exclude them. They are probably relics of a former train dating back to the time when the Buchanan gravels elsewhere were being deposited along the edge of the retreating Kansan ice. Their position favors this belief, though not compelling it, for they lie slightly above the level of the Wisconsin gravels, relics of a former terrace. On the Illinois Central in Tp. 99 N., R. XLV, Sec. 10, Se. ¼, near Edna, similar gravels are exposed. While there is a gravel horizon almost invariably above the drift the age of the material at many points does not seem as great as at the points noted. This raises the question whether the gravels are not of different age and origin, the older beds being Buchanan gravels and the younger a residual deposit belonging to the interval following the Kansan ice, called by Leverett the Yarmouth. The Buchanan gravels as intrepreted by Calvin are a definite outwash of the Kansan ice, and as the ice retreated gradually the deposits of glacial floods would be found not along the limits of the Kansan drift but on its surface. The cross-bedding of the Buchanan gravels suggest such an origin. If the Kansan drift was long exposed as surface soil, gradual erosion of the lighter material would leave on its surface the gravel and bowlders that were once mingled with the clay. Such gravels would represent the Yarmouth interval. Most of the gravels on the drift of Lyon and Sioux seem to belong to this latter class.

The study of Lyon and Sioux counties, then, furnishes the following suggestive points with reference to the age of the drift in the northwestern part of the state. (1). The slope of the streams is no greater than that of like streams on undisputed Kansan. (2). Oxidation in places has been carried as far as in Kansan. (3). Gravels are present at various points above the drift like the Buchanan gravels above the Kansan. On the other hand, most of the drift, while oxidized to a certain degree, seems fresher than the Kansan where it is typically developed. Secondly, the drift is generally unleached, while the lime has been removed from the upper part of the Kansan. From this it does not necessarily follow that the drift is young. The amount of leaching is determined in part by the quantity of water that circulates through the lime-bearing stratum, and if the surface of a given region is relatively low so that there is little or no tendency for water to penetrate the soil, long lapses of time may result in very little leaching. On the other hand, if the gradients were high, surface drainage would be increased and little water would penetrate the drift. This also would account for absence of leaching. Leaching goes on most rapidly where slopes are moderate. High gradients also result in rapid erosion, and for this reason Mr. Bain, in Carroll county, accounts for the absence of ferretto and leaching in certain parts of the Kansan drift. The amount of rainfall* in the northwestern part of the state is less than that farther south, amounting to

*Iowa Geol. Survey, Vol. IX, p. 87.

twenty-two inches, as compared with twenty-five to thirty-two in the southeast†. The rainfall is confined more to certain seasons and is more abundant in limited periods. This also would help to explain the unleached drift.

It is possible to correlate the drift with the Iowan of the eastern part of the state, which it resembles somewhat in its limited oxidation and leaching. The loess has often been regarded as related with the Iowan drift, something after the manner of an outwash. If this is true the drift beneath it could not be Iowan, for the underlying drift shows that a considerable interval elapsed before the loess was deposited. In a later paragraph on the origin of the loess, reasons for questioning whether the loess is a water deposit are advanced. It is, therefore, doubtful, whether any argument in regard to the age of the loess-covered drift, can be made from stratigraphic relationship.

Topographically the drift is, perhaps, more closely related to the Iowan. The valleys are not as extensive as those on the Kansan drift in the southern part of the state. It is clearly distinguished from the typical Wisconsin, however, by the completeness of its drainage. The average rainfall of Lyon county is eight inches less than that of southern Iowa. This fact permits the drift of Lyon county to be Kansan, even though its topographic features are not so fully developed as might be expected from study of the same drift in other regions.

Considering everything, it seems safer to consider the loess-covered drift of Lyon and Sioux counties as Kansan until something is found in the way of a southern boundary to distinguish it from the recognized Kansan farther south.

THE ALTAMONT MORAINE.

The topographic features of northeast Lyon county have already been described, and from the ridges and hummocks that characterize the region it will readily be put down as morainic. This inference from topography is borne out by

†Report Iowa Weather and Crop Service, 1894, p. 52.

the nature of the hummocks, since they are for the most part composed of gravel. The accompanying sketch from photograph, taken in Tp. 100 N., R. XLIII W., Sec. 23, Se. ¼, just north of the town of Little Rock, shows a morainic knob on the very top of which is a gravel pit. The limits of the moraine are best shown by the accompanying map of the Pleistocene. There is no loess covering the morainic area

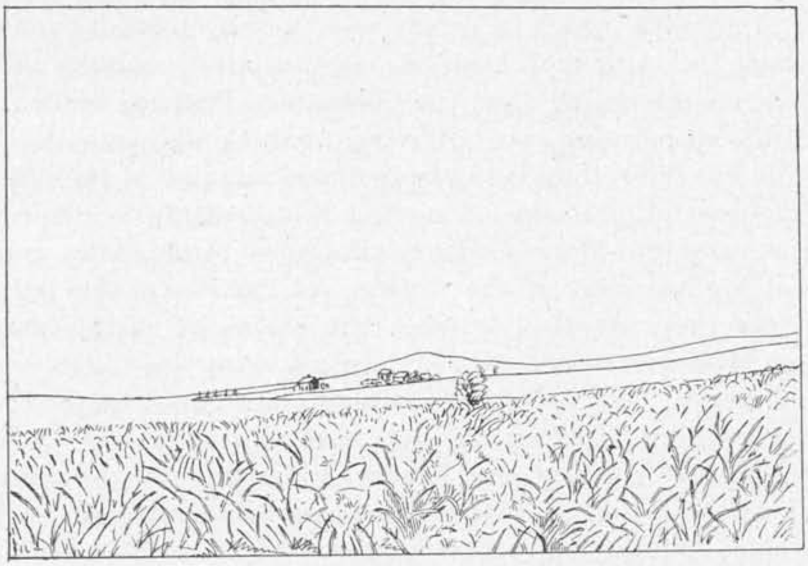


FIG. 11. Morainic knob near Little Rock, Lyon county.

and surface bowlders are common. The material of the moraine is fresher than that which underlies the loess. Its color is yellow and it is but slightly oxidized. It often contains rock fragments, but they are as abundant in the lower part of the drift as near the surface. It is invariably unleached. The outer ridge of the moraine, from Lyon county, trends to the northwest, and on it is located the town of Adrian, Minn. In Lyon county all of the region not loess-covered is morainic, and to determine what lies within the moraine it is necessary to go north into Minnesota. Going east from Adrian the moraine is found to be three miles wide. It gives place to level country with gradually increasing elevation till the surface is raised 100 feet above Adrian. On this elevated ground the town of Rushmore is located. Three miles east of Rushmore is the moraine of the Coteau des Prairies. The characteristics of this moraine are in the main those of the outer moraine already described. In each case the hummocks that so definitely mark a region as morainic are abundant in certain localities and almost wholly absent in others. When Upham described Murray and Nobles counties in Minnesota, which lie directly north of Lyon county and into which the Altamont moraine—as the outer moraine of the Wisconsin is called—and the Coteau des Prairies extend, the Altamont moraine was not recognized, though attention was called to the rolling till outside of the moraine of the Coteau. His description in this connection is interesting.* "Here and northerly into Murray county this most prominently rolling and highest part of the Coteau des Prairies in this latitude forms the watershed between the basins of the Mississippi and Missouri rivers. Its connection with the roughly hilly and knolly outer terminal moraine traced from central Iowa northward to Spirit Lake and thence westerly to Ocheyedan mound south of this county, and still more prominently exhibited along the crest of the Coteau des Prairies in western Nobles county, and thence northwesterly to the head of the Coteau, shows that the border of the ice in the last glacial epoch extended to this belt of massively rolling till; but though it thus represents the outer moraine of that epoch, it nowhere in Nobles county has such roughly broken knolls and small, short, steep ridges as are common along nearly all of the rest of this morainic line. *Farther westward the surface of Nobles county is in swells of till which trends mostly from north to south, more massive and smoother than those which form the outer terminal moraine and of about the same elevation; or in nearly level equally high plateaus of till, as at Rushmore, ten miles west of Worthington.*" The italics are ours. The till outside of the Coteau des Prairies in Lyon county is more typically morainic

*Geol. and Nat. Hist. Survey, Minn., Vol. I, p. 520.

than that described by Upham in Nobles county. But, taking his description for the region outside the Coteau, with the added light given by study of the relative oxidation of the drifts of the region, and our present understanding of the loess, we would be justified in expecting a moraine on the outer edge of the non-loess-covered drift west of the Coteau.

Outside of the Altamont moraine in Lyon county and following its course is the level belt spoken of in connection with the topography of this part of the county. This belt averages four miles in width. It persists as a border for the moraine into Minnesota and into Osceola county, Iowa. In Nobles county, Minn., Upham thus describes it.* "The only noteworthy deposit of this kind (modified drift) is that found in Grand Prairie, the most southwest township in Nobles county. Here a plain composed of stratified gravel and sand, but covered with a fertile soil, reaches six miles east from Kanaranzi creek, with a width of about four miles, including the southern two-thirds of this township." The thickness of this gravel as shown by well borings at Ellsworth, Minn., is six feet. In Lyon county exposures of this water-laid gravel may be found in Tp. 100 N., R. XLIV, Sec. 36, Se. ¼, in a sand pit near the roadside; in Tp. 100 N., R. XLIV, Sec. 14, Sw. ¼ on the banks of Tom creek, and cellars at the following points:

Tp. 99 N., R. XLIV W., Sec. 1, Ne. ¼.
Tp. 100 N., R. XLIV W., Sec. 25, Sw. ¼.
Tp. 99 N., R. XLIII W., Sec. 4, Se. ¼.

In Iowa as noted by Upham for Minnesota, the sand and gravel of this strip are covered with a fertile soil. This soil is akin to loess but more sandy. It does not have the mottled appearance noted in the loess that is common to Lyon and Sioux counties, and Upham for Nobles county, Minn., excludes the region from the loess-covered area.† The nature of this soil is variable, at times closely resembling loess in texture, while in the immediate neighborhood it appears as moderately coarse sand. In two instances this sandy loam appears at

*Geol. and Nat. Hist. Survey, Minn., Vol. I, p. 527.
†Geol. and Nat. Hist. Survey, Minn., Vol. I, p. 526.

some distance from the moraine on the banks of streams over gravel which appears to be of Wisconsin age. The first is in southeast Lyon county on the banks of Otter creek in Tp. 98 N., R. XLIII W., Sec. 32, Se. ¼; the second is on the banks of the East Floyd just west of Hosper in Tp. 95 N., R. XLIII W., Sec. 10, Nw. ¼. The more conspicuous gravel trains of the Wisconsin are covered with alluvium which does not so closely resemble loess. In a railroad cutting on the Burlington, Cedar Rapids & Northern, in Tp. 100 N., R. XLV W., Sec. 23, Se. ¼, typical loess mottled, having the black specks spoken of, is found under three feet of this sand and loam. This cutting is shown in the photograph.

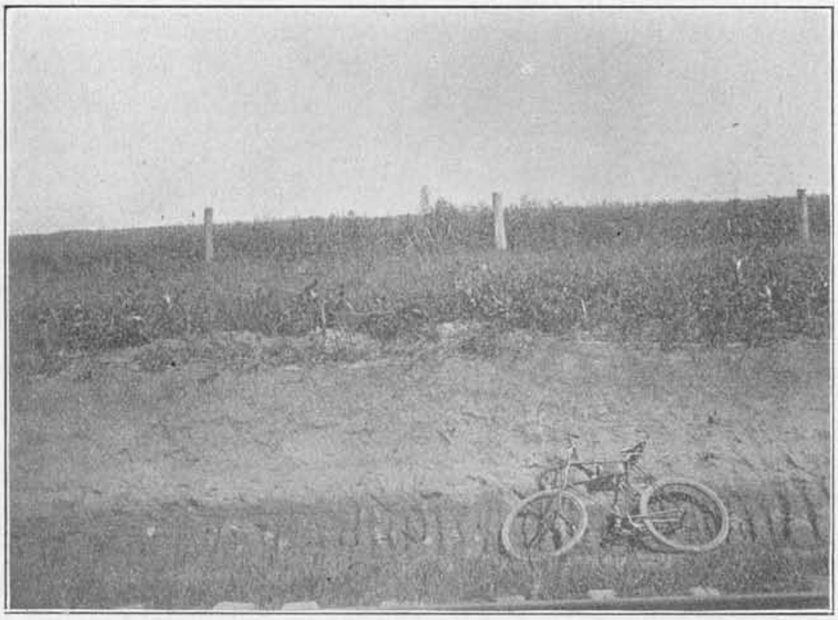


FIG. 12. Sandy loess and sand, overlying typical loess in Lyon county.

The difference in color between the two deposits is in part due to the fact that the loess below holds the moisture longer than the more sandy material above. Similar conditions are shown in a road cutting three miles northwest of Rock Rapids in Tp. 100 N., R. XLV W., Sec. 22, Sw. ¼. Here, however, the loess-like material above the true loess contains coarser matter, not infrequently rock fragments a fifth of an inch in diameter being found. This cutting is on the banks of Kanaranzi creek.

The evidence seems sufficient to prove that the gravel area is a real outwash from the Wisconsin, and it is probable that the loess-loam above it had a similar origin. It is much easier to think of this deposit which covers a limited area and is directly associated with other water deposits as a phase of the outwash, than it is to conceive of the normal loess as due to the agency of water.

Altamont Moraine in Western Lyon County.—Lyon and Sioux counties lie between two lobes of the Wisconsin drift. A portion of the eastern lobe is found in northeast Lyon county. The western lobe is found in Dakota, its western boundary consisting of a moraine which follows the Missouri river as far south as Vermillion. It then bends north and east to Canton. In this connection Todd writes: "There comes a gap between Vermillion river and Brule creek, probably caused by a narrow ice lobe. The moraine extends along Brule creek northward to Beresford and on to a high point south of Canton. It is then feebly developed or entirely absent from that point to the west side of the Big Sioux opposite the northwest corner of Iowa. There it forms a ridge running westward to the East Vermillion river."* The study of Lyon and Sioux counties leads to a partial restatement of the nature of the moraine along the Big Sioux. Instead of being absent from Canton to the northwest corner of Iowa, data will be brought forward to show that at one point at least it is found just east of the Big Sioux river, and that instead of running west from northwest Iowa as a ridge to the East Vermillion river it extends northwest to Sioux Falls, then across the river just northeast of that town, and continues almost due north on the east side of the river. If these points are satisfactorily demonstrated it will be impossible to account for the great

*Prelim. Report on Geol., S. Dak., 1894, p. 115.

bend in the Big Sioux at Sioux Falls as deflection caused by the moraine, and a cause antedating the moraine must be ascribed.

The most conspicuous topographic feature along the Big Sioux is the difference in elevation between its east and west banks. From Canton to Granite the bluffs on the Iowa side are 150 feet above those on the Dakota side. The drift on the Dakota side has the characteristics of the Wisconsin and has been so regarded. The drift on the east side is that which in this report is regarded as Kansan. The only available explanation for this difference in elevation is found in supposing that at this point the Wisconsin ice removed more material than it deposited as ground moraine. The older drift so removed, however, must have been deposited at the edge of the ice as terminal moraine or carried away by stream action as fast as brought by the ice. Precisely at the points where a very strong moraine would be expected it is weak or lacking altogether. Well drillings at Hudson, in the valley of the Big Sioux, show that the valley of the stream at that point is cut deep in the Benton shale and is partly filled with drift. The valley of the Missouri at Sioux City is filled with drift to a very great depth. A gravel train of unusual size attends the Big Sioux from northwest Iowa to Sioux City. These facts lead to the belief that the material that would otherwise remain as a moraine at the eastern edge of the Dakota lobe has been removed by the river that ran along its edge, and deposited in these valleys. Certain facts lead to the belief that remnants of the moraine are still to be found on the Iowa side for ten miles south of the state line, and then on the Dakota side.

In the northwestern corner of Lyon county, west of the town of Granite, in Tp. 100 N., R. XLIX W., Secs. 25 and 26, the Big Sioux flows through a narrow gorge in no way commensurate with the valley above or below. Looking down the river from the vicinity of Rowena, S. Dak., one would hardly suspect that the river flowed through the narrow pass to the right, but would think that it turned to the left and followed the broader valley of Blood Run creek. Reference to the accompanying topographic map gives the same impression. On the west side of this gorge is a knob that is a conspicuous feature of the landscape and shows plainly on the topographic map. This is the end of the morainic ridge recognized by the South Dakota Survey. On the east side of the river at this point there is a most interesting cutting on the Burlington, Cedar Rapids and Northern railroad. It is shown in part in the accompanying photograph. Beneath a younger drift is

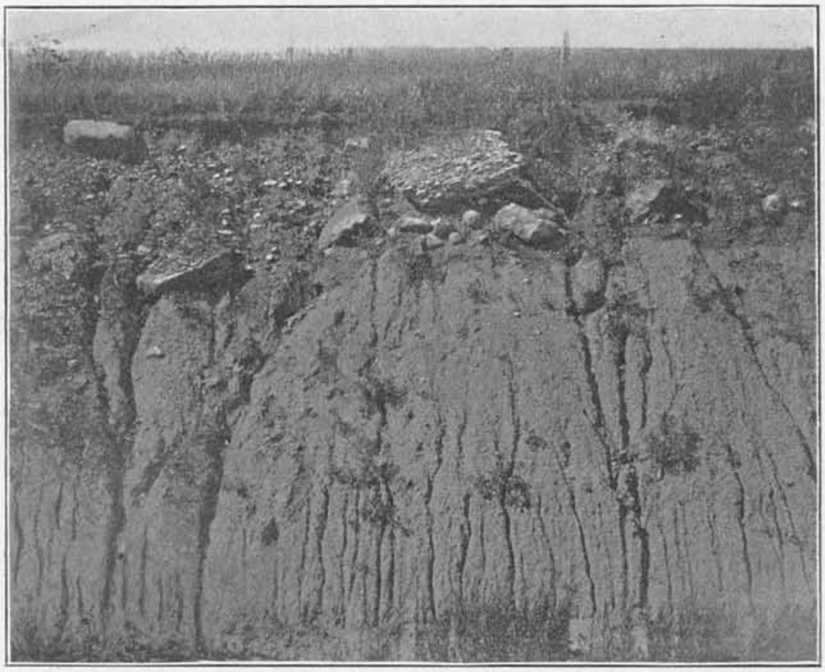


FIG. 13. Railroad cutting west of Granite, showing Wisconsin moraine over older drift.

the older characteristic drift of Lyon county. The surface of the older drift is uneven, having evidently been exposed to erosion for a long time before the younger drift was deposited. The upper drift completely fills the hollows in the older and caps the crests. The line between the two is very sharp.

The upper drift abounds in huge bowlders, many of them of fossiliferous limestone. A brachiopod, *Orthis testudinaria* is abundant in these limestone blocks. The surface at this point is dotted with gravel knolls, from five to ten feet high and varying in diameter from twenty to fifty feet. They are irregularly distributed and are hard to account for unless a morainic origin is ascribed to them. Traces of flint implements and shells are not sufficiently abundant even to suggest for the mounds an artificial origin, and the hummocks are too numerous and too limited to this area to be regarded as freaks of erosion. Evidently the ice crossed the river at this point and this is a part of the moraine. Following the east bank of the river still farther south other proofs that the ice reached the Iowa side appear. The drift is fresher looking than that outside the Wisconsin. This is true, however, only for a strip not more than two miles wide along the river. The moraine that crosses the river at Granite as a distinct ridge does not long so continue, and if farther south it ever was in the form of a ridge, its definite form has been broken down by erosion. Two miles south of Granite and a mile east of the river, by the roadside, the older drift is exposed under loess and above the loess is a thin layer of drift. For a considerable distance, on a line a mile east and parallel with the river, bowlders are common on the surface of the loess. These bowlders and the drift spoken of as at one place overlying the loess may represent remnants of the moraine. It is possible, though hardly probable, that they are but a part of the older drift washed down on the loess from greater elevations.

The valley of the Big Sioux from Granite to Canton is narrow as compared with the valley above at East Sioux Falls or below at Hawarden, at which points it does not appear to have been interfered with by the Wisconsin ice. The only explanation that offers itself is that it was in part filled by morainic material.

Three miles northeast of Canton distinct morainic signs are found west of the river. Here a knob 140 feet high and a mile long is conspicuous from every point for miles around. At the northeast corner of the town of Canton there is a similar gravel mound sixty feet high, on which the water tower stands. Both of these mounds are brought out plainly on the topographic map.

From the point where the moraine crosses the river, west of Granite, to Sioux Falls it is easily traced as a well defined, bowlder-strewn ridge. It passes east of Sioux Falls and crosses the river two miles northeast of the town. At the point of crossing several well-defined kames were developed. Thence for ten miles it was traced nearly due north.

While the ice blocked the valley of the Big Sioux west of Granite the water normally drawn off by this stream must have been thrown over into tributaries of Rock river, and particularly into Mud creek. The natural outlet toward the east was the valley of Blood Run creek and this fact would account for the great quantities of gravel, sufficient almost to be considered a gravel train, along the banks of this creek. Typical exposures of these gravels are found in Tp. 100 N., R. XLVIII W., Sec. 16, center, in cuttings on the Burlington, Cedar Rapids & Northern railroad. In any other way it is difficult to account for these gravels, for they are too abundant to be regarded as residuum from the wash of the slope, and the sources of the streams are not near the moraine. Topographic maps of northwest Lyon county, and Rock county, Minn., in which both Blood Run and Mud creeks have their sources, show that such a diversion of the waters of the Big Sioux would follow if the glacial dam increased the height of the water 100 feet. Back of the dam there must have been a temporary lake. Perhaps this lake was responsible for the silt found in the vicinity of Sioux Falls. A subsequent slightly greater advance of the ice would cover it with the Wisconsin drift, leaving it as now found.

Wisconsin Gravel Terraces.—Attention has been called to the unusual quantity of gravel present as outwash along the Altamont moraine in northeastern Lyon county. Where streams already existed the water that issued from the ice flooded the banks and the current was strong enough to carry rounded rock fragments, two inches in diameter and under, long distances. The rivers so flooded were the Big Sioux, and Rock river with its tributaries in Lyon county. Throughout its entire course between South Dakota and Iowa the Big Sioux ran along the edge of the moraine and while the Wisconsin ice lasted must have discharged vast quantities of water into the Missouri. If the two lobes of the ice were synchronous it is possible that the interlobate position of this region accounts for the abundance of the outwash gravels. The gravel train in the older portion of the Big Sioux valley is a mile and a half wide. The present flood plain lies below the gravel terrace about ten feet and is relatively insignificant, averaging perhaps a fifth a mile in width. At Fairview, eight miles south of Canton, the Chicago, Milwakee & St. Paul railroad has taken a great deal of gravel from this terrace for ballast. In this pit bowlders are present in great numbers. In other localities where the Wisconsin gravel terraces have been exposed by cuttings, the material of which they are composed is shown to be very uniform in size and bowlders are rare. Bowlders in this pit are often two feet in diameter and may have come from the Wisconsin moraine, which is eight miles away. Taken in connection with facts which will be considered in a paragraph on the pre-Wisconsin course of the Big Sioux, it seems more probable that they were washed out of the Kansan drift, through which the stream was cutting when the gravel terrace was formed. In Tp. 100 N., R. XLIX W., Sec. 25, Nw. ¼, a mile west of Granite, the Burlington, Cedar Rapids & Northern has a gravel pit from which a limited amount of material has been taken. The Rock river touches the Wisconsin moraine in Minnesota, and its branches, the East Rock and Tom creek, drain portions of the outwash region in eastern Lyon county and western Osceola. The gravel terraces on the Rock river and its main tributary, the East Rock, are half a mile wide in Lyon county, while in Sioux county the terrace of the Rock river is even wider, the two streams having united above. Extensive gravel pits in the Rock river terrace have been developed by the Chicago, Milwaukee & St. Paul, on the west bank of the river at Rock Valley, and by the Sioux City & Northern at Doon. The gravel is finer than in the Big Sioux terrace, and more evenly sorted. Abundant examples of oblique lamination occur in these pits.

Pre-Wisconsin Course of the Big Sioux.—In a single glance at the course of the Big Sioux as shown on the map the attention is caught by the peculiar bend near Sioux Falls. After flowing south to this point, the river turns abruptly to the northeast, holds this course for eight miles, and then as suddenly resumes its course to the south. The morainic ridge east of Sioux Falls at once suggests that the stream was deflected by the Wisconsin ice and the material that accumulated along its face. The map shows that at the point where the river again turns to the south it is joined by Split Rock creek, a stream of some importance. The first inference would be that the Big Sioux, when diverted from its normal course by the ice, was thrown over into the valley of Split Rock. This attractive hypothesis, however, is not sustained by a more careful study of the region. In the first place, the Big Sioux was not deflected by the moraine, but cuts through it, east of Sioux Falls. North of this point it flows along the inner edge of the moraine, while to the south it follows the outer edge for some distance, with the exception noted near Granite. The valley of the Big Sioux at the "big bend" is too large to have been wholly developed since Wisconsin times. In importance it is equal to that of Split Rock creek, which this hypothesis would regard as the older. It is true that the Big Sioux at present has the greater volume and so, though younger, might have the larger valley, yet it seems hardly possible that so large a valley can be younger than the last ice sheet. Until evidence to the contrary is presented it is easier to believe that the stream at the bend flows through a pre-Wisconsin valley which was not wholly obliterated by the Wisconsin ice.

The valley at East Sioux Falls is more mature than at any point for some distance above or below. It is outside of the Wisconsin moraine, which here lies two miles to the west. Near the state line the moraine crosses the river, producing the gap mentioned. From this point south to Canton the valley has been partly filled in by morainic material.

On the course of the stream between Canton and Hudson the United States topographic map of the Canton quadrangle throws much light. The difference in the amount of erosion on the two drift areas makes it easy with the map to draw the line between them. It is clear that near Canton the stream leaves the margin of the Wisconsin moraine and flows through

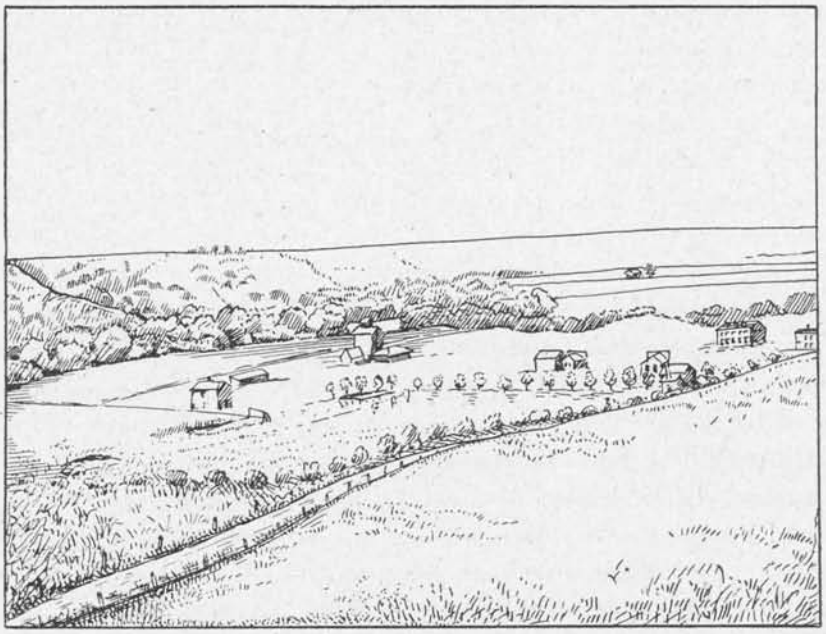


FIG. 14. Sketch of valley of the Big Sioux at Fairview.

the older drift. This portion of the valley is narrow, as the accompanying sketch made at Fairview shows, its slopes abrupt, and not covered with loess, but instead abundantly bowlder strewn. Tributaries to the stream during this portion of its course are insignificant. The inference is that the stream which above followed the edge of the Wisconsin moraine, here, while the ice sheet still remained, found a new course across the older drift, probably following the course of some tributary of the Rock river till it united with that stream. This last inference is made necessary by the fact that the valley at Hudson is deep, cutting down through the Benton shale more than 100 feet, and now partly filled with drift. Below the point where the Big Sioux and Rock rivers unite, the valley is two miles wide and loess often covers the slopes to the gravel terrace, leaving no doubt that it is pre-Wisconsin. This valley is too large to be ascribed to the Rock river before the waters of the Big Sioux were added to it, or even to the work of these two after they united, and an explanation must be found in the belief that the tributary which here united with the Rock river, whose course was later appropriated by the Big Sioux, was a stream of some importance, yet small enough to necessitate the reworking and enlarging of its channel when its waters were augmented by those of the deflected stream.

ORIGIN OF THE LOESS.

The study of Lyon and Sioux counties adds something to the theories regarding the origin of the loess. The presence of the wind-polished bowlders already described, in the surface of the drift and projecting into the loess, favors the belief that the loess at least in many places is a wind deposit. Probably the weightiest argument in favor of the loess as a wind deposit is made by Professor Shimek, based on the fossils of the loess. He finds that the great majority of the loess fossils are shells of terrestrial species and he is able in many instances to duplicate the fauna of the loess with material now found living on the surface of the same region. "If the molluscs of the loess be used as an absolute measure of the amount of moisture occurring during loess times," he says, "then we must conclude that Iowa was without streams, for practically no fluviatile molluscs occur in the loess, and that there were but few ponds in which aquatic molluscs found a favorable habitat.*" He adds that† "this, however, does not prove that the loess regions were entirely devoid of lakes and streams, but rather that the loess proper was deposited chiefly upon high grounds." A sheet deposit like loess occurs for wind-blown material if the area is evenly grass covered, while ridges result if the vegetation is in patches. The black specks of vegetable matter scattered through the loess of Lyon and Sioux suggest that there was a uniform grass covering which caught and held the fine dust particles. If the loess is an eolian deposit differences in behavior of the material may be expected and along streams where trees abounded ridges may be looked for, while in a prairie region an even mantle is the logical result.

Udden's‡ careful discussion of the mechanical composition of wind deposits, is of interest in connection with the loess. His table of approximate maximum distances over which quartz fragments of different dimensions may be carried by the wind is given below:

(1) Gravel (diameter from 8 to 1 mm.) a few feet.
(2) Coarse and medium sand (diameter 1 to $\frac{1}{4}$ mm.) several rods.
(3) Fine sand (diameter $\frac{1}{4}$ to $\frac{1}{8}$ mm.) less than a mile.
(4) Very fine sand (diameter $\frac{1}{8}$ to 1-16 mm) a few miles.
(5) Coarse dust (1-6 to 1-32 mm.) 200 miles.
(6) Medium dust (1-32 to 1-64 mm.) 1,000 miles.
(7) Fine dust (1-64 mm. and less) around the globe.

These figures of Udden are based on careful experiments and long continued observation. From them he deduces the statement that "different grades of material are so far separated from each other in the direction of the wind movement that even with considerable change in velocity the principal area of the deposition of sediments of one grade will not far encroach on that of the deposition of materials much

*Proc. Iowa Acad. Sci., Vol. VI, p. 103.

†l. c. p. 109.

‡The Mechanical Composition of Wind Deposits, Lutherian Augustana Book Concern, Rock Island, Ill.

coarser or finer." He points out the fact that the western plains and the Mississippi valley sustain the windward-leeward relation to each other, and that dust stirred up on the plains must be carried east by prevailing winds, and that part of it without doubt settles over the great central valley. The loess which is spread over most of the surface of this valley resembles atmospheric sediment in mechanical composition. That loess is certainly a wind deposit he does not affirm, yet he makes clear that the arguments against the eolian origin of loess based on the facts that it is uniform in texture and unstratified are in large measure invalid.

Opposed to these facts, is the statement of the Minnesota geologists that the loess seems to be practically limited by the 1500-foot contour. If this is true it would not necessarily force the conclusion that the loess is a water deposit though the fact would be most readily so explained. It would not be wise at present to venture an assertion in regard to the origin of the loess, but much of the evidence that has recently been collected bearing on this question, favors its eolian origin.

ECONOMIC PRODUCTS.

BUILDING STONE.

The Quartzite.—The supply of suitable building material is a matter of great importance to the many growing towns in Lyon and Sioux counties. Where elegance and permanence are desired the Sioux quartzite supplies the demand. The stone is of great value for building purposes, for paving and for curbing. Its value for paving is due to the ease with which it is shaped into square or rectangular blocks of convenient size, and to its hardness, which renders it almost indestructible even under the heavy traffic of the busiest portions of our great cities. It is not practical to reduce the face of quartzite pavers to the smoothness of vitrified brick, and this fact, taken with the greater expense of the quartzite blocks, renders impossible competition between these two kinds of paving material. Vitrified brick are rapidly and rightly increasing in favor, yet there will always remain a steady demand for quartzite pavers for streets where truckage is heavy and constant. As building material it is often used in the rough in the vicinity of the quarries. Much of it is dressed, however, and in nearly every town in the two counties there are business blocks and churches built wholly or in part of quartzite, while a greater quantity is used for trimmings in brick buildings. Freight rates greatly restrict the use of the stone, but it is shipped in limited quantities as

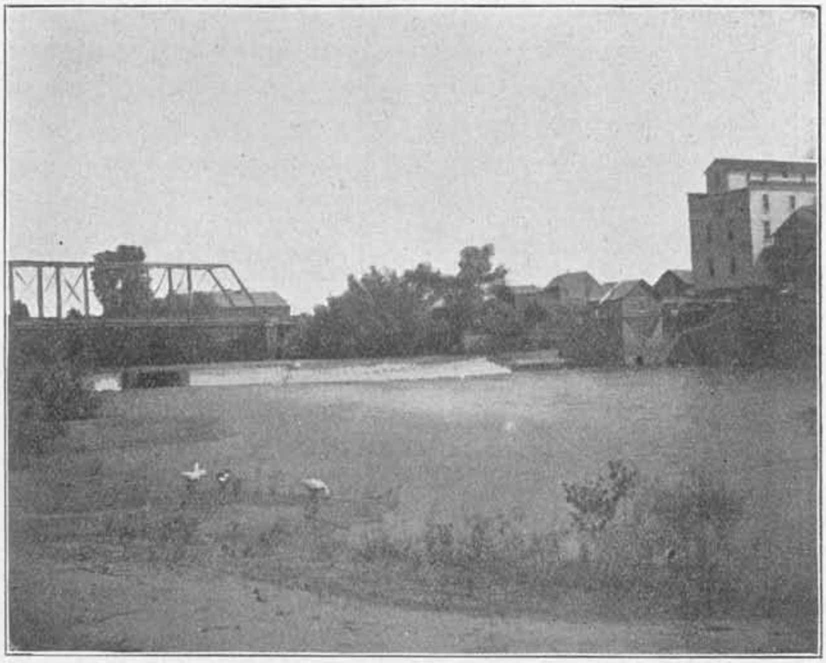


FIG. 15. Dam on the Big Sioux at Hawarden. Ensign & Gordon's mill.

far as Chicago. Within this radius the quantity used increases as the source of supply is approached. Most of the quarries now operated are located in Minnesota and South Dakota. Imperfect railroad facilities are all that prevent Iowa from entering this market with her sister states. The stone in Iowa is in every way suitable for the purposes mentioned and an abundance of it is exposed on the surface. The outcrops in Iowa, however, are removed two miles from any railroad.

The Illinois Central and the Burlington, Cedar Rapids & Northern run at equal distances from the Iowa exposures, the first to the north, the second to the south. In view of the fact that vast quantities of the stone have direct access to the railroad not five miles away at East Sioux Falls and Rowena, S. Dakota, it does not seem practical at present to attempt an extensive development of the quartzite in Iowa.

CLAYS.

While the Sioux quartzite to a limited extent supplies the demand for building material there is an increasing demand for good brick in both counties. Very few are at present produced in either county, regardless of the fact that on account of freight rates from Le Mars and Sioux City, the nearest important producing points, they sell at from seven to eight dollars a thousand. This condition is not due to lack of suitable material, nor wholly to lack of effort to utilize the material, but rather to peculiar conditions in connection with the management and operation of the various brick plants that have from time to time been established.

Over the greater part of both counties the loess is from two to ten feet thick and in many places is available for brick. The presence of lime concretions is sometimes considered a hindrance, but in many localities concretions are not abundant, and even when present in numbers they do no harm if the material is thoroughly ground. At Sioux City loess having the same characteristics is successfully worked.

The earliest attempt at brick making in these counties seems to have been at Elm Springs in northwest Sioux county. About fifteen years ago two or three kilns were burned at this point. The material used was glacial clay and the fuel was wood. The product, as might be expected, was not uniform and the manner of production laborious and expensive. At Orange City the plant of the Orange City Brick company began operations in 1895 and ran only one year. An updraft kiln was used and 500,000 brick were burned that are still being sold. Five thousand repress brick were made with a simple hand machine. Loess was used and but little effort was made to remove or crush the concretions and the appearance of the brick was thereby marred to some extent, interfering in a measure with their sale. The proprietors state that in their opinion a down-draft kiln, permitting the use of slack coal, could be made to pay. Differences of opinion on the part of the owners have prevented the use of the plant of late years. The price obtained for brick was from seven to eight dollars per thousand. A brickyard was established at Alton in 1893 which ran irregularly for three years. At the end of that time the machinery was sold. An up-draft kiln was used and a United States dry press with a capacity of 10,000 a day. Loess was used which is reported as free from concretions. Brick sold at from seven to nine dollars per thousand. Former owners of the plant report that the trouble was in the management. Those consulted reported that they thought, with proper kilns, presses and management a factory at that point would succeed. As formerly handled it was impossible to compete with Sioux City.

At Beloit the J. A. Smith brickyard was for some time in operation. Loess, and to some extent an underlying drift clay, was used. The clay was first washed through a screen to remove the concretions. It was afterward plugged by a wheel, moulded by hand and burned with wood in an open kiln. A good red brick is said to have been produced which found a ready market.

The brickyard at Hawarden promised success in every way before it burned in 1895. From a small plant working loess by hand it had gradually developed into a large establishment using the modern devices for brick making. An excellent exposure of Benton shale was located and at the time of the fire this was being made into an excellent grade of brick. Much of the product of this yard is at present in the buildings and pavement of Hawarden, and public opinion regards it as in every way satisfactory. The market was good and prospects for a large business excellent when the factory burned. The loss amounted to $10,000, with an insurance of $2,000. The present owners are not in a position to invest further and in the fall of 1899 an effort was being made to sell the remaining machinery. The selenite in the shale is not in quantities sufficient to injure in any way the quality of the brick, which are hard and of a clear yellow-red color.

Orton & Son, during the summer of 1899, opened a yard at Maurice. Loess is used which at the point of excavation is twelve feet thick and wholly free from sand and concretions. It overlies a sandy loess which contains considerable lime. A "Little Wonder" side cut machine, manufactured by the Walrus Mfg. Co., Elkhart, Ind., is used. It has a capacity of 25,000 in ten hours. The bricks are dried in sheds without artificial heat and burned in simple up-draft kilns. Four kilns of 25,000 each have been burned and the product is very satisfactory. The bricks are smooth, hard and of good color.

Summing up the experiences of Lyon and Sioux counties in brick making, it is evident that the same material is present that is worked successfully at Sioux City. A little more care must be taken to find localities where the loess is free from concretions, or else to crush them, but loess without lime has been located in many places. Experience in building and handling kilns so far has been the main thing lacking. On account of freight rates the local producer is given control of an excellent market, and with fuel nearly as cheap as at Sioux City the field is a promising one for investment.

CEMENT.

The rapid increase in the use of Portland cement in this country has led the Iowa Geological Survey to carefully determine whether suitable material is not present in our own state for its manufacture. At present a large percentage of the cement used in northwestern Iowa is the product of the Yankton mills. Among other samples submitted for expert analysis was material from the limestone in the Benton of the exposure south of Hawarden. The report on these Hawarden samples shows that while the material is soft and could be easily worked it is too low in lime for cement purposes. Purer material would have to be added to render it available.

An analysis of the Hawarden limestone is as follows:

Insoluble	21.92
$Si\ O_2$	.75
Fe and Al. oxides	6.68
$Ca\ CO_3$	64.30
$Mg\ CO_3$	5.38
	99.03

The insoluble matter consists of clay.

There is no considerable supply of purer material in the neighborhood and in view of the more favorable conditions elsewhere in the state it would be impossible to look to this locality for cement material. A more complete discussion of the nature of Portland cement and the conditions necessary for its successful production will be found in other reports of the Geological Survey.*

GRAVEL AND ROAD MATERIALS.

The gravel terraces of Rock river and the Big Sioux yield vast quantities of valuable ballast to the railroads in Lyon and Sioux counties. In the previous discussion of these terraces, points at which gravel is being taken for railroad purposes have been noted. Gravel in equal abundance may be counted on as occurring at any point near these rivers in both counties. Sand for building purposes is at times found associated with these gravels. In northeastern Lyon county the knobs of the Wisconsin moraine yield an abundance of gravel that is chiefly used for road improvement. The loess that is nearly everywhere found on the surface is itself a valuable road material. It dries quickly and after drying is firm and compact. To one traveling with horse or wheel in unsettled weather the change from the loess country to the Wisconsin drift is striking and decidedly in favor of the loess. Where the roads need artificial stiffening, as on the alluvium of bottom lands, the material is usually at hand in the gravel terrace.

*Iowa Geol. Survey, Vol. VIII, p. 355.

WELLS.

The gravel layers in the drift yield an abundance of water for farm purposes. Water is obtained at depths varying from thirty to two hundred feet. Such wells frequently yield 150 barrels per day. A larger flow may be counted on if the wells are continued through the drift and shale to the sand and sandstone that underlie them. This requires for wells on the upland a depth of 400 to 550 feet. Wells penetrating the Dakota sandstone frequently yield 100,000 gallons in twenty-four hours. The water rises in the wells to within 100 feet of the surface. For reasons discussed in connection with the Dakota sandstone, flowing wells from this formation are hardly possible. Small flowing wells from the drift may be obtained but it is impossible to predict localities where they may be found.

COAL.

The chances of finding coal in either county are very few. The Cretaceous of this region is not a coal producer. Under the Cretaceous there may be coal measures in the Carboniferous strata, but the region is outside of the Carboniferous area that so far has proved productive. Careful drillings were made with the best machinery and by experienced and reliable men, between Chatsworth and Hawarden, and while a number of lignite veins were developed in the Cretaceous nothing of value was found.

GAS.

While drilling for water in Tp. 99 N., R. XLV W., Sec. 34, Sw. ¼, in Tp. 99 N., R. XLVII W., Sec. 9, Sw. ¼, and in the vicinity of Doon, in three wells Mr. M. E. Layne encountered gas or air, which when the well was closed developed a pressure of twenty pounds per square inch. The gas was met with in the drift at depths varying from 180 to 290 feet. When the wells were cased the flow ceased. The gas was not inflammable and is said to have had a disagreeable odor. Beyond these points its nature was not determined. To one of these wells a steam whistle was attached and allowed to blow for two days. The gas seems to have no economic value and the supply would probably soon be exhausted. It doubtless has its origin in decaying vegetable matter in the drift, possibly between two drift sheets.

WATER POWER.

The bed of the Big Sioux throughout its course along the western boundary of Lyon and Sioux counties has a slope of three feet per mile. It is a stream of considerable volume and, therefore, furnishes valuable power. At Hawarden, Ensign & Gordon's grist mill, by means of a seven-foot dam, obtains fifty-horse power from two turbine wheels. For two years they have been able to run without intermission, though at times have been troubled by scant water supply during August and September. The water is set back by the dam a little over two miles. They report no trouble from ice. At Fairview, S. Dak., just across the river from Elm Springs, Iowa, A. Spencer & Co. operate a flour mill and use thirty-five-horse power which they obtain from two turbine wheels and a dam giving a head of eight feet. They report that during nine months they have plenty of water and often during the entire year. At Beloit and Klondike there are similar mills operating under practically the same condition.

While the slope of Rock river is sufficient to furnish a good head of water with a dam of very moderate height, its volume is not sufficient for milling purposes during the summer months.

SOILS.

The soils of these counties may be classified as loess, drift and alluvium. The drift is practically confined to a few square miles in northeastern Lyon county. The loess covers the remainder of the surface except along the rivers where it is replaced by alluvium. The maps accompanying this report indicate fairly the location of the three soils, the gravel trains along the streams being alluvium covered.

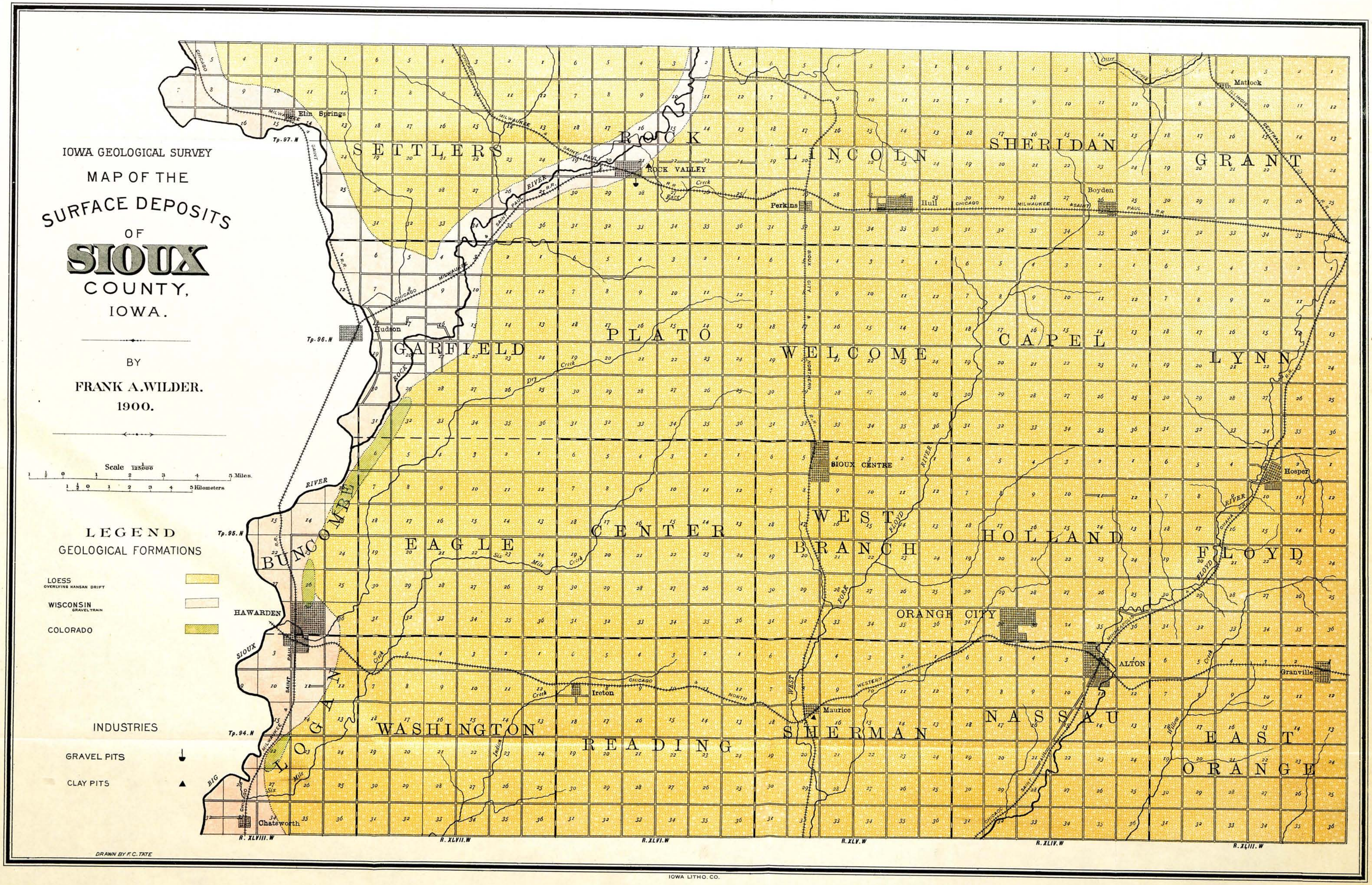
The alluvium is very fertile and bears abundant crops. It is so thoroughly drained by the underlying gravel that it is particularly productive during wet seasons and for the same reason suffers first during times of insufficient rainfall.

The loess-covered country is an ideal farming region, favored alike by drainage and soil. It yields abundantly and without fail crops of wheat, oats, rye and corn. Indeed, of the grains and grasses nothing appears to be excluded on account of the nature of the soil. The loess readily absorbs moisture and holds it for a long time, never bakes hard, and is always mellow and easily cultivated.

The drift of northeastern Lyon county furnishes a clay soil of great strength and fertility. The outwash region is particularly a region of beautiful farms, with level fields, yet free from ponds and waste land. The bowlders on the surface of the drift are nowhere abundant enough to interfere with cultivation.

ACKNOWLEDGMENTS.

Thanks are due Mr. H. F. Bain for much assistance and advice in the preparation of this report. Professor Calvin identified all of the fossils collected by the writer and on his determinations some of the more important results of this report depend. Mr. M. E. Layne of Rock Rapids furnished accurate and valuable well data and gave the results of his observations in regard to the depth of the drift. Professor Shimek added much to the interest in problems associated with the loess. Very many persons in Lyon and Sioux counties generously contributed information that was of prime importance in preparing the report.


IOWA GEOLOGICAL SURVEY
MAP OF THE
SURFACE DEPOSITS
OF
SIOUX
COUNTY,
IOWA.
BY
FRANK A. WILDER.
1900.
Scale 1/125000
5 Miles.
5 Kilometers
LEGEND
GEOLOGICAL FORMATIONS
LOESS
OVERLYING KANSAN DRIFT
WISCONSIN
GRAVEL TRAIN
COLORADO
INDUSTRIES
GRAVEL PITS
CLAY PITS
SETTLERS
ROCK
LINCOLN
SHERIDAN
GRANT
GARFIELD
PLATO
WELCOME
CAPEL
LYNN
BUNCOMBE
EAGLE
CENTER
WEST BRANCH
HOLLAND
FLOYD
LOGAN
WASHINGTON
READING
SHERMAN
NASSAU
EAST ORANGE
Elm Springs
ROCK VALLEY
Perkins
Hull
Boyden
Matlock
Hudson
SIOUX CENTRE
Hosper
HAWARDEN
ORANGE CITY
ALTON
Granville
Ireton
Maurice
Chatsworth
Tp. 97. N
Tp. 96. N
Tp. 95. N
Tp. 94. N
R. XLVIII. W
R. XLVII. W
R. XLVI. W
R. XLV. W
R. XLIV. W
R. XLIII. W
DRAWN BY F.C. TATE
IOWA LITHO. CO.

THE FLORA OF LYON COUNTY.

BY B. SHIMEK.

The geographical position of Lyon county, its proximity to the dry western plains, its altitude and topography, and the fact that it is the only county in the state containing exposures of crystalline rocks (Sioux quartzite), make it one of the most interesting counties in the state from a botanical standpoint, for these varied conditions naturally have their influence upon the flora, which for its relationship looks rather toward the high dry western plains than toward the more moist prairies and forest regions to the east. For this reason a somewhat detailed report upon the flora may be of interest.* The surface of the county is for the most part a rather high prairie, which in the vicinity of the rivers becomes more rolling or quite rough, especially in the western part. No extensive swamps, or ponds or lakes are found. The Rock and Little Rock rivers are the only streams within the county that approach the dignity of rivers, and the Big Sioux, the largest stream, forms the western boundary of the county.

The greater part of the county is tillable. The river valleys are alluvial, and in some places somewhat sandy. The prairies are covered with a good black loam, the subsoil being loess clay in the southern part of the county and drift clay to the north. The latter makes quite as good a soil as the

*The observations herein recorded were made during three seasons in the months of June, July and August, and notes upon woody plants, etc., were also made in January. The vernal flora was not studied.

former, except on knolls and ridges where there is occasionally an excess of sand and gravel. The poorest soils are found in the western part of the county, in the hilly country bordering the Big Sioux river. Here in many places, especially on southerly slopes, the surface is gravelly and the soil is unproductive. The Sioux quartzite exposures in the extreme northwest corner of the county present a number of interesting botanical features.*

Upon and adjacent to them are found several species of plants which have not been found elsewhere in the state, such as *Opuntia fragilis*, *Potentilla pennsylvania strigosa*, *Euphorbia obtusata*, *Artemisia frigida*, *Aphyllon ludovicianum*, *Schedonnardus texanus*, *Buchloe dactyloides*,† *Woodsia scopulina*, *Marsilea vestita*, and several mosses and lichens. Other species found on the drier portions of the exposures are rare in the state. Such are: *Talinum teretifolium*, *Hosackia purshiana*, *Polygonum tenue*, *Oxytropis lamberti*, *Chrysopsis villosa*, *Pentstemon gracilis*, *Gilia linearis*, *Carex stenophylla*, *Selaginella rupestris*.

In addition to this the more shaded portions of the rock exposures, the adjacent streamlet and the more or less permanent pools of water with their outlying bits of marsh and moist prairie, the adjoining alluvial Big Sioux river valley with its mud flats, sandbars and moist shaded banks, the drier prairie hills bordering the river valley on the east, and the not remote cultivated fields on the broad upper terrace of the river valley, all bring here together a variety of conditions scarcely to be found within any equal area in the state, and all this in a strip lying along the northern boundary of the state, and measuring scarcely two miles in length, and but a few rods in width. This area, as might be expected, contains a greater variety of plants than any other part of the county indeed but few species which belong to the county are not found within these restricted limits.

Aside from this the county offers but little variety in the conditions which determine the distribution of plants. The

*For the author's discussion of the flora of these exposures see the Proc. Iowa Acad. Sci., Vol. IV, pp. 72-77, and Vol. V. pp 28-31.

†Professor Macbride now reports this from Osceola and Dickinson counties.

valleys of the larger streams present the usual alluvial conditions, the rough western part of the county with its rounded hills, capped with loess or drift clay, is in surface and flora like the dry loess hills along the Big Sioux and Missouri rivers farther south, while the greater part of the county is rather high prairie, with occasional gravelly knolls or ridges, and low marshy "draws." Each of these regions, of course, develops its characteristic flora.

The names of plants which are employed in the following discussion are, with few exceptions, those of Gray's Manual of Botany, sixth edition. These are chosen not because they are in all cases deemed correct, but because the manual is still the most widely used work on systematic botany in the state. This will make the list intelligible to a great number of those who have not followed the recent attempts at changes in nomenclature, while those who have done so will have no difficulty in understanding to which plants reference is being made.

NATIVE TREES AND SHRUBS.

So proportionately small is the forest area of Lyon county that in any account of the botany of the county the woody plants would stand among the last to be considered. But much greater importance must be attached to them when we seek in their distribution and habits the key to the solution of the problems of tree-planting which are of so much importance in the economy of the prairie regions.

Such natural groves as occur are practically restricted to the three larger streams of the county. They are found in part in alluvial valleys, and in part upon the lower slopes of the adjacent hills. Along some of the smaller tributaries are found small clumps of the willows *Salix amygdaloides* and *Salix discolor*, and of wild plum and white ash, but these can scarcely be called groves.

The finest natural grove is found in the southwestern corner of the county along that part of the Big Sioux river which flows westward toward Canton, S. Dak. The river here approaches close to the high and broken bluffs on the south side, being separated from them only by a narrow strip of alluvial plain. For two miles these bluffs present a rugged face to the north, seamed and scarred by ravines and gullies which run back toward the higher crests to the south. Almost everywhere these northern slopes, as well as the narrow alluvial plain below, are covered with a well developed forest. On the alluvial plain soft maple, box elder, white elm and white ash are most common, basswood is abundant on the lower slopes, while on the higher slopes bur oak is the prevailing form. But in no place does the grove reach the very summit of the bluffs to any considerable extent.

Upon the lower slopes true arboreal conditions exist. Mosses and smaller species of flowering plants characteristic of wooded regions, are abundant, and springs flow from the base of the wooded bluffs. This is in reality the only place in the county where true forest conditions, as we understand them in the rougher eastern and southern sections of the state, exist. Here, too, are found practically all of the species of woody plants which are native to the county, and on the lower slopes and the adjacent flats they are quite as vigorous and thrifty as in more easterly forest regions. It is only on the higher, more exposed slopes that the stunted bur oak displaces all other trees, or rather, is alone able to gain a foothold. In these more exposed portions of the grove the surface conditions are quite different. The stunted trees, growing more stunted with greater exposure, are scattered, forming "open" groves. The intervening ground surfaces are in large part covered with tufts of grasses and other prairie plants, and there is an almost total absence of leaf mould, of moss-covered decaying sticks and logs, and of the masses of smaller vegetation so characteristic of deeper woods. Northward from the Chicago, Milwaukee & St. Paul railroad the bluffs on the Iowa side are still rugged, but as the river flows almost due south, they are here more exposed to the southerly winds, and consequently but few groves have developed, and these are of the stunted, open type, chiefly in ravines and "pockets" below the crests of the hills, on the leeward side.

The alluvial valleys of the large streams present the usual conditions which prevail along prairie streams which are skirted with clumps and bands of timber. As compared with more typical alluvial valleys southeastward they show a smaller number of species of trees, the trees are more scattered with a lesser variety of small plants growing beneath them, and there are frequent encroachments of species from the adjacent prairies.

The native woody plants of the county may be divided into three groups according to habitat:

1. *Species of the alluvial lowlands.*—As noted, these are found chiefly along the larger streams, but straggling specimens of the species already enumerated may be found here and there along smaller streams.

The following species were collected:

Acer dasycarpum Ehrh. Soft Maple. Common.*

Negundo aceroides Moench. Box Elder. Common.

Populus monilifera Ait. Cottonwood. Common, but probably chiefly introduced.

Salix amygdaloides Anders. Black Willow. Common.

Salix longifolia Muhl. Sand-bar Willow. Common.

Salix cordata Muhl. Heart-leaved Willow. Not rare.

Salix missouriensis Bebb (?)† Missouri Willow. Not common.

Sambucus canadensis L. Common Elder. Quite common.

Amorpha fruticosa L. False Indigo. Quite common.

Cratægus coccinea L. Red Haw. Not rare.

Prunus americana Marsh. Wild Plum. Common.

Fraxinus americana L. White Ash. Common.

Celtis occidentalis L. Hackberry. Common.

Vitis riparia Mx. Wild Grape. Quite common.

*All references to abundance of these woody plants are intended merely to convey a general idea of relative abundance of species in the restricted timbered area. The sum-total of any one species, of course, amounts to comparatively little because of the limited total forest area.

†Identified by Mr. Ball.

Viburnum lentago L. Sheep-berry. Not rare.

Salix discolor Muhl. Pussy Willow. Quite frequent.

The last six species of the preceding list also sometimes occur on banks and lower slopes; indeed this is true to a very limited extent of nearly all of the species in the list, the line of demarkation being by no means sharply defined. The intergrading of conditions naturally results in a mingling of species in any case, and this is intensified by the greater adaptability of some species to conditions which are not normal. For this reason in any system of plant grouping based on habitat it is practically impossible to draw sharp lines between the groups so defined.

2. *Species growing on protected banks and lower slopes.*—Most of these species also extend more or less into the lowlands. This group most nearly presents the species and conditions which characterize hilly woods eastward. This is especially true in the large grove already described, which is really the only typical locality in the county. The following is a list of the species:

Tilia americana L. Basswood. Common, especially in the large grove.

Ulmus americana L. White Elm. Common.

Ulmus fulva Mx. Red Elm. Rather common.

Ostrya virginica Willd. Hop Hornbeam. Frequent.

Fraxinus pubescens Lam. Red Ash. Found sparingly only near the Sioux quartzite exposures. Stunted forms of this and White Ash occasionally ascend to the crevices in the rock-ledges.

Gymnocladus canadensis Lam. Kentucky Coffee-tree. Quite common in the large grove.

Amelanchier canadensis T. and G. Juneberry. Found occasionally in the large grove.

Prunus virginiana L. Choke Cherry. Quite frequent.

Rosa blanda Ait. Smooth Rose. Not common.

Rubus strigosus Mx. Wild Red Raspberry. Not rare.

Xanthoxylum americanum Mill. Prickly Ash. Quite common, occasionally forming dense thickets.

Ribes floridum L'Her. Wild Black Currant. Not rare.

Ribes gracile Mx. Missouri Gooseberry. Very common locally, sometimes forming dense clumps.

Celastrus scandens L. Climbing Bittersweet. Not rare.

Euonymus atropurpureus Jacq. Burning Bush. Not common.

Ampelopsis quinquefolia Mx. Virginia Creeper. Quite common.

Menispermum canadense L. Moonseed. Not rare.

3. *Species of higher slopes and drier places.*—Stunted specimens of these species are likely to be found in straggling clumps almost anywhere on the prairies, especially on knolls and slopes, but they form no very considerable part of the prairie flora, being more common at the borders and in the vicinity of groves, or even extending into them.

Quercus macrocarpa Gray. Bur Oak. This is the most interesting tree in all the northwestern division of the state. It seems to be the pioneer of hard-wood trees, being the first of all trees to gain a foothold upon the knolls and slopes of the prairies. On the leeward side (*i. e.*, N. and N. E.) of the slopes the trees reach some size, though never forming the fine specimens which typify the species further east. As they ascend upward or reach out into less protected tracts they become more stunted and form the variety *olivæformis* Gray. Fruiting specimens not over a foot in height are frequently found in the exposed places. They have small leaves and small acorns, and sometimes several short stems are clustered on the same root. This species presents the best example of the stunting effect of summer winds upon the perennial plants of the northwest.

Rhus glabra L. Smooth Sumach. Quite common.

Rhus toxicodendron L. Poison Ivy. Common.

Salix humilis Marsh. Prairie Willow. Quite common.

Symphoricarpos occidentalis Hk. Wolfberry. This is the most widely distributed of the smaller woody plants, being found in almost all kinds of soils and situations. It usually grows in clumps.

Ceanothus americanus L. New Jersey Tea. Not rare.

Rosa arkansana Porter, the Prairie Rose, found commonly on the prairies may also be listed here.

CULTIVATED FOREST TREES.

The lessons which are taught by the native groves of Lyon county may well be applied in the cultivation of forest trees. The forest areas are small, it is true, and by far the greater part of the country presents a more fitting field for the study of prairie conditions, but the very fact that some trees do grow indicates that so far as general conditions are concerned they are not wholly unfavorable to the growth of trees. The native groves are uniformly found in valleys or on the north and east slopes of hills and knolls. The prevailing summer winds are southerly and southwesterly. They are strong and frequent, and being hot and dry they parch the exposed surfaces of the prairies. Both by their physical force and by their temperature and dryness, they check the growth of trees. In situations which are not exposed to these winds native trees grow readily and normally, but in exposed places, if developed at all, they are stunted and straggling. The Bur Oak, already cited, furnishes the best illustration of the effect of these winds.*

Exposure to the early spring sun on northern slopes, which hastens the early development of buds which are often nipped by late frosts, also serves to check or exterminate trees on southerly slopes.

Naturally the conditions which operate against the growth of native trees will also be unfavorable to the development of cultivated trees. To grow trees successfully in this county it is necessary that so far as possible they receive protection

*For a more detailed discussion of the effect of winds on growth of trees see the author's paper in the Proceedings of the Iowa Acad. of Sci., for 1899.

from the summer winds. There are really but two kinds of habitats in the county which are unfavorable to the growth of trees, namely the low, wet places in which the soil is "soured," and the gravelly knolls and limited rock exposures. The remaining soils are suitable for the growth of trees, and there seems to be no special difference between the drift clay soils and the loess, the latter, of course, representing merely the finer parts of the former sifted out. In both of these soils trees will grow readily if properly protected. This is best accomplished either by planting on northern and eastern slopes where this is possible, or by growing the trees in mass, in groves and not merely in rows, and surrounding the groves with rows of Cottonwood. The Cottonwood is the best nurse-tree for this purpose as it grows readily singly or in rows,—indeed it will not grow well in groves, the inner trees usually becoming dwarfed and soon dying out, while the outermost row uniformly shows greater vigor and longer life. All other trees, however, do better in groves, which should be dense at first, and later as the trees grow larger, they should be gradually thinned out. While small the trees should be cultivated, and later mulched with straw. Too much straw near the trees, however, increases the danger from mice. The weeds should be cut before going to seed, and left on the ground. No stock of any kind should be permitted to enter the grove, as nothing so quickly destroys trees. It is better to raise trees from seeds where possible, or to plant small trees. Nothing is gained by planting large trees as these are usually severely checked in their growth by transplanting. In transplanting, the roots should never be exposed to the air or permitted to dry.

With our present knowledge it is safe to say that as yet no introduced forest trees have exhibited superiority over native trees. The Russian Poplar, which has been tried, is scarcely a success, and moreover is a tree of comparatively little value. The Catalpa freezes down and is not a success. The introduced White Willow (*Salix alba*) is of the usual doubtful value. The miles of willows planted by Jesse Fell in the vicinity of

Larchwood in 1873 are now generally considered a nuisance. The Russian Mulberry will answer for wind-breaks and hedgerows, but has no superior value. Lombardy Poplars have long ago been declared worthless, and few appear in this county. Evergreens of various kinds have been tried, sometimes with success, but more frequently they have failed. In a general way it is safe to say that most evergreens will do quite well when protected by other trees in groves already established, but as pioneers they are scarcely to be recommended.

Probably the best coniferous tree is the European Larch (*Larix europæa*). It will grow in comparatively dry places, the fact that its leaves are deciduous (and hence it is not an "evergreen") no doubt being an advantage. It makes a fine tree, grows rapidly, and its long straight trunk makes desirable post timber. It is not uncommon about Larchwood, and its success has been amply demonstrated.

The Red Cedar (*Juniperus virginiana*), while rather difficult to start in the open, makes good wind-breaks, and, when established, grows well. It is more readily grown under the protection of other trees, but the bark is often attacked by mice.

The Scotch Pine (*Pinus sylvestris*) grows fairly well, though, like all other evergreens, it is hard to start. It does not, however, make a satisfactory tree in the end, becoming scrawny and unsightly after eighteen or twenty years. The Austrian Pine (*Pinus austriaca*) makes a handsomer tree than the preceding, and improves with age.

The Norway Spruce (*Abies excelsa*) and some of the western spruces have been tried, but only with indifferent success. The best evergreens may be found in the former Larchwood nursery, but here they received special care and were grown in a large grove under very favorable circumstances. But even here the White Pine (*Pinus strobus*) was not a success, and its cultivation in this part of the state seems almost impossible.

Arbor Vitæ (*Thuya occidentalis*) has been tried, but is no more promising than some of the preceding.

In individual cases evergreens have done well, but on the whole they are not adapted to open prairie country, and as they are difficult to start, their planting, excepting occasionally for ornamental purposes, is an unprofitable venture.

Deciduous trees fare better. This is probably due at least in part to the fact that the loss of leaves (partial in very dry seasons in summer, and complete in winter) results in the loss of the transpiring apparatus, and the consequent inability of the tree to throw off water during these unfavorable periods. The trees which are most widely cultivated are the Cottonwood, Soft Maple, Box Elder and White Willow, the last being introduced. These and other species are here considered separately.

Cottonwood (*Populus monilifera*). The chief value of this tree lies in its rapid growth and its ability to hold its own when planted in single rows, this fact making it of value around groves of other trees. Mr. Carter, who surrounded and quartered several sections of land in Allison township with cottonwood trees some twenty-two to twenty-five years ago, demonstrated the possibilities of this tree. Single rows of Cottonwoods, now grown to large size, give to several square miles of surface the appearance from a distance of a large forest, and within the area itself the protection from winds, and other advantages offered by timber tracts, are presented in a marked degree.

For extensive wind-breaks, and for nurse-trees (only on the outside of groves, however), it is the most valuable tree cultivated in this part of the state.

Box Elder (*Negundo aceroides*). This tree grows rapidly, and produces a dense growth in a short time. It is also easily cultivated. However, it does not produce a tree of lasting value, and could be displaced by the White Ash with profit.

Soft Maple (*Acer dasycarpum*). This tree grows rapidly and if grown in clusters forms good wind-breaks, but, as a permanent investment it is not of much value, its brittleness also making it undesirable.

White Willow (*Salix alba*). This is extensively grown in some parts of the county, chiefly for hedge-rows. It quickly forms a dense wind-break, but is otherwise scarcely desirable. With Cottonwood it may be used for the outer protection of groves.

A number of other species native to Lyon county, or common in not remote sections of the state, are suitable for cultivation, and in the end prove much more satisfactory than the four most commonly cultivated kinds. The following are among the best:

White Ash (*Fraxinus americanus*). This is undoubtedly in many respects the most satisfactory tree for cultivation for general purposes on our prairies. It forms a pretty tree, stands drouth better on the whole than any other of the species in this list, is not easily broken by the winds, and in the end produces wood of excellent quality, an item which should not be forgotten, for to the farmer upon the treeless prairies a piece of strong, durable wood, suitable for repairs, etc., is often a great desideratum. Horses, rabbits, etc., do not often gnaw the White Ash, nor is it frequently attacked by insects, and this gives it an additional advantage. It grows best in groves which are protected on the south and west. The chief objection which has been made to this tree is that it is of slow growth. This is true only during the first five to eight years. During these first years the Box Elder easily outstrips it, but is soon excelled by it, not only in quality, but in beauty and size. The fine Ash trees on the old Carter place in Allison township, the splendid groves belonging to the McGuire Brothers in Rock township, and numerous smaller groves scattered over the county, demonstrate the usefulness and desirability of this tree beyond a doubt.

Black Walnut (*Juglans nigra*). This valuable tree can be grown with success in this county. The great mistake, however, which has been made in most efforts thus far, is that the trees were planted in narrow bands or rows, and were exposed. This develops trees with short trunks and wide-spreading crowns which make but little headway, and in exposed places they soon die. If grown in groves, especially among older trees of other species, they grow readily and produce tall straight trunks. The ash and walnut may both be planted in old groves of the softer woods with the view of displacing them. Walnut seed is best planted in the fall, and should not be covered very deeply.

White Elm (*Ulmus americana*). The elm has not yet demonstrated its usefulness in this county. It does quite well, however, in groves where not exposed to the winds, and in such places makes a good rapidly-growing tree. Rabbits and horses, however, relish it, and often do much damage.

Bass-wood (*Tilia americana*). While this tree does not compare in value with some of the preceding, it makes a fine shade and ornamental tree, but must be grown in sheltered places.

Wild Cherry (*Prunus serotina*). This species is but little cultivated, but deserves greater attention. It seems to grow even in somewhat exposed places, but does better in groves. The Red Elm (*Ulmus fulva*), the Hackberry (*Celtis occidentalis*), and the Honey Locust (*Gleditschia triacanthos*) are also sparingly cultivated, but they scarcely equal the preceding species of this list in value, though they may be successfully grown. The Wild Plum (*Prunus americana*) when grown in thickets makes splendid wind-breaks, and should be more widely cultivated for that purpose.

The hard-wood trees such as Oaks, etc., can scarcely be grown to advantage until larger groves are established in which they may find necessary protection. Farmers might well begin to replace their groves of Cottonwood, Box Elder, Maple, etc., with White Ash, Walnut, and other more valuable trees. The latter could be easily grown in the shelter of the old groves, and in the end would give quite as much protection, besides yielding valuable wood. They are slower growers perhaps, but since the old soft wood groves are established and give the farmer the needed protection, this is a matter of less concern than when the groves were first planted. In case a new grove is to be established it would pay to first set out soft-woods as nurses, and then mingle the more desirable species with them, or plant in alternating rows or groups.

NATIVE HERBS.

The native herbaceous plants are here roughly grouped according to habitat. No sharp lines can be drawn, of course, and it is intended merely to indicate the ordinary or most common habitat.

1. *Species of ordinary fertile prairie.*—Some of these species encroach on the dry slopes, while others extend into the wet low-lands.

Anemone patens var. *nuttalliana* Gray. Pasque-flower. Specimens were collected as late as June.

Ranunculus rhomboideus Goldie. Prairie Crowfoot. Not rare.

Delphinium azureum Mx. Larkspur. Common.

Sisymbrium canescens Nutt. Tansy Mustard. Common.

Astragalus caryocarpus Ker. Ground Plum. Common.

Petalostemon candidus Mx. White Prairie Clover. Common.

Petalostemon violaceus Mx. Rose-purple Prairie Clover. Common.

Psoralea argophylla Pursh. Silver-leaf Psoralea. Very common.

Psoralea esculenta Pursh. Pomme Blanche. Not rare.

Glycyrrhiza lepidota Nutt. Wild Liquorice. Not rare.

Potentilla arguta Pursh. Five-finger. Very common, often in rather dry places.

Cnicus altissimus L. Tall Thistle. Common.

Coreopsis palmata Nutt. Tickseed. Common.

Echinacea angustifolia D. C. Purple Cone-flower. Common.

Erigeron strigosus Muhl. Daisy Fleabane. Very common.

Helianthus annuus L. Sunflower. Locally common.

Helianthus maximiliani Schrad. Maximilian's Sunflower. Very common.

Lepachys columnaris T. and G. Prairie Cone-flower. Locally common.

Lepachys pinnata T. and G. Gray-headed Cone-flower. Common.

Liatris scariosa Willd. Blazing Star. Very common.

Prenanthes racemosa Mx. Rattlesnake-root. Not rare.

Silphium laciniatum L. Compass-plant. Very common.

Solidago speciosa var. *angustata* T. and G. Prairie Showy Golden-rod. Very common.

Asclepias verticillata L. Whorled Milkweed. Common.

Asclepias tuberosa L. Pleurisy-root. Common.

Asclepias speciosa Torr. Showy Milkweed. Not rare.

Acerates viridiflora var. *lanceolata* Gray. Green Milkweed. Not rare.

Phlox pilosa L. Downy Phlox. Locally very common.

Onosmodium carolinianum var. *molle* Gray. False Gromwell. Common.

Pentstemon lævigatus Sol. Smooth Beard-tongue. Locally common.

Juncus tenuis Willd. Slender Rush. Very common, also often in wet places.

Elymus macouni Vasey. Macoun's Wild Rye. Not rare.

Agropyrum repens Beauv. Couch-Grass. Common locally.

Agropyrum glaucum R. & S. Blue-joint. Very common.

Bouteloua racemosa Lag. Racemed Bouteloua. Locally common.

Stipa spartea Trin. Porcupine Grass. Very common locally.

2. *Species of dry prairies, gravelly knolls*, etc.

Cerastium nutans var. *brachypodum* Eng. Short-stalked Chickweed. Locally common.

Silene antirrhina L. Sleepy Catch Fly. Common.

Linum sulcatum Rid. Wild Flax. Locally common.

Oxalis violacea L. Violet Wood-Sorrell. Not common.

Polygala verticillata L. Milkwort. Not common.

Vicia americana var. *linearis* Wat. Vetch. Occasional.

Hosackia purshiana Benth. Locally common. Native?

Amorpha canescens Nutt. Lead Plant. Very common. Really a shrub.

Oxytropis lamberti Pursh. Loco-weed. Quite common locally in the western part of the county.

Cassia chamæcrista L. Partridge Pea. Common, introduced?

Potentilla norvegica L. Five-finger. Common.

Potentilla pennsylvanica var. *strigosa* Lehm. Hoary Five-finger. Rare, found only in the vicinity of the Sioux quartzite.

Œnothera serrulata Nutt. Evening Primrose. Common.

Œnothera biennis L. Common Evening Primrose. Common.

Opuntia rafinesquei Engelm. Prickly Pear Cactus. Reported from Lyon county by Professor Pammel.*

Pimpinella integerrima B. & H. Yellow Pimpernel. Common.

Kuhnia eupatoroides, L. False Boneset. Common.

Liatris punctata Hk. Blazing Star. Common.

Grindelia squarrosa Dun. Gum Plant. Not common.

Chrysopsis villosa Nutt. Golden Aster. Common.

Solidago rigida L. Stiff Golden-rod. Very common. The most characteristic plant on the dry hills.

Solidago missouriensis Nutt. Missouri Golden-rod. Common.

Aster oblongifolius Nutt. Aromatic Aster. Common.

Aster amethystinus Nutt. Amethyst Aster. Rare.

*Proc. Iowa Acad. Sci., Vol. III, p. 119.

Aster sericeus Vent. Silky Aster. Common.

Aster ptarmicoides T. & G. Upland White Aster. Locally common.

Helianthus rigidus Desf. Stiff Sunflower. Very common.

Achillea millefolium L. Yarrow. Frequent.

Artemisia caudata Mx. Wild Wormwood. Common.

Artemisia frigida Wild. Wormwood Sage. Rare.

Artemisia ludoviciana Nutt. Western Mugwort. Common.

Artemisia canadensis Mx. Canada Wormwood. Not common.

Lygodesmia juncea Don. Rush-like Lygodesmia. Common.

Specularia perfoliata A. DC. Venus' Looking-glass. Common.

Gilia linearis Gray. Narrow-leaved Collomia. Common in the vicinity of the Quartzite exposures.

Lithospermum hirtum Lehm. Puccoon. Common.

Castilleia sessiliflora Pursh. Downy Painted-cup. Not rare.

Gerardia aspera Dougl. Rough Purple Gerardia. Rare.

Pentstemon gracilis Nutt. Beard-tongue. Quite common.

Pentstemon grandiflorus Nutt. Large-flowered Beard-tongue. Very common on the gravelly banks and bluffs along the Big Sioux river.

Verbena angustifolia Mx. Narrow-leaved Vervain. Not rare.

Hedeoma hispida Pursh. Mock Pennyroyal. Common.

Hedeoma pulegeoides Pers. American Pennyroyal. Common.

Isanthus cæruleus Mx. False Pennyroyal. Rare.

Scutellaria parvula Mx. Small Skull-cap. Not common.

Plantago patagonica var. *gnaphaloides* Gray. Pursh's Plantain. Locally common.

Oxybaphus nyctagineus Sweet. Heart-leaved Umbrella-wort. Quite common.

Oxybaphus hirsutus Sweet. Hairy Umbrella-wort. Not common.

Polygonum tenue Mx. Slender Knotweed. Common only in the vicinity of the Quartzite.

Comandra umbellata Nutt. Bastard Toad-flax. Rather common.

Euphorbia glyptosperma Engel. Ridge-seeded Spurge. Not common.

Euphorbia marginata Pursh. White-margined Spurge. Occasional.

Euporbia obtusata Pursh. Blunt-leaved Spurge. Not common.

Tradescantia virginica L. Spiderwort. Common.

Allium stellatum Nutt. Wild Onion. Not rare.

Carex stenophylla Wahl. Involute-leaved Sedge. Common in the vicinity of the Quartzite.

Carex adusta (?) Boott. Sedge. Not common.

Carex cephalophora Muhl. Sedge. Not rare.

Carex pennsylvanica Lam. Sedge. Not common.

Carex straminea var. *brevior* Des. Sedge. Common.

Carex straminea Willd. Sedge. Not rare.

Chrysopogon nutans Benth. Indian Grass. Still common on native prairie.

Agrostis scabra Willd. Rough Hair-grass. Rather common.

Poa pratensis L. Blue Grass. Probably introduced in such places.

Bouteloua hirsuta Lag. Muskit Grass. Local.

Bouteloua oligostachya Torr. Muskit Grass. Common.

Buchloe dactyloides Engelm. Buffalo Grass. Found now only in the vicinity of the Quartzite exposures.

Andropogon furcatus Muhl. Beard Grass. Common.

Andropogon scoparius Mx. Beard Grass. Common.

Festuca tenella Willd. Fescue Grass. Local.

Hordeum pusillum Nutt. Little Barley. Quite common locally.

Koeleria cristata Pers. Quite common on unbroken prairie.

Panicum scribnerianum Nash. Scribner's Panicum. Not rare.

Schedonnardus texanus Steud. Not rare in the vicinity of the Quartzite exposures.

Sporobolus cuspidatus Torr. Rush Grass. Common.

Equisetum lævigatum Braun. Scouring Rush. Frequent.

3. *Species growing on rocks, in crevices*, etc.—These are found on the Sioux Quartzite.

Aquilegia canadensis L. Wild Columbine. Occasional.

Talinum teretifolium Pursh. Fame-flower. Common.

Opuntia fragilis Haw. Prickly Pear Cactus. Not rare.

Woodsia scopulina D. C. Eaton. Rocky Mountain Woodsia. Common on the Sioux Quartzite ledges near the Big Sioux.

Selaginella rupestris Spring. Not common.

Numerous mosses and lichens are also found on and near the Quartzite. The latter group is especially well represented, the rocks being in large part covered with numberless specimens of numerous species.

4. *Mesophytic species of wood and meadow.*—This group includes species which require an average amount of moisture, and in most cases prefer more or less shade. They are the species of our ordinary wooded tracts. (*a*) Species of deeper woods, moist banks, borders of thickets, etc.

Clematis virginiana L. Common Virgin's Bower. Common.

Anemone cylindrica Gray. Long-fruited Anemone. Not rare.

Siline stellata Ait. Starry Campion. Quite frequent.

Amphicarpœa pitcheri T. & G. Hog Peanut. Frequent.

Desmodium canadense D. C. Tick Trefoil. Common.

Geum virginianum L. Avens. Common.

Heuchera hispida Pursh. Alum-root. Rather belonging to the following group.

Solidago serotina var. *gigantea* Gray. Golden-rod. Common.

Erigeron philadelphicum L. Common Fleabane. Common.

Campanula americana L. Tall Bellflower. Common.

Apocynum cannabinum L. Indian Hemp. Not rare.

Hydrophyllum virginicum L. Water-leaf. Not common.

Pedicularis canadensis L. Lousewort. Not rare.

Laportea canadensis Gaud. Wood Nettle. Rather frequent.

Pilea pumila Gray. Richweed. Rather common.

Polygonatum giganteum Diet. Great Solomon's Seal. Occasional.

Smilax herbacea L. Carrion Flower. Not rare.

Elymus canadensis L. Wild Rye. Common.

Leersia virginica Willd. White Grass. Common.

Panicum dichotomum L. Forked Panicum. Common. A weed.

Asplenium filix-fœmina Bernh. Spleenwort. Local. (*b*) Species of rocky, sometimes more or less shaded, banks.

Thalictrum purpurascens L. Purplish Meadow Rue. Frequent, but probably more common with the following group.

Oxalis corniculata var. *stricta* Sav. Yellow Wood-sorrel. Very common, and occurring in a variety of habitats.

Senecio aureus L. Squaw-weed. Common.

Ellisia nyctelea L. Quite common.

Ipomœa pandurata Mey. Wild Potato-vine. Occasional.

Parietaria pennsylvanica Muhl. Pellitory. Locally common. (*c*) Alluvial species, growing near streams and ponds. Most of these species also commonly occur on the borders of wet prairie meadows.

Ranunculus abortivus L. Small-flowered Crowfoot. Common.

Viola palmata var. *cucullata* Gray. Common Blue Violet. Quite common.

Echinocystis lobata T. & G. Wild Balsam Apple. Common in low woods.

Cryptotænia canadensis D. C. Honewort. Not rare.

Galium aparine L. Goose Grass. Common.

Galium triflorum Mx. Sweet-scented Bedstraw. Common.

Artemisia biennis Willd. Wormwood. Common.

Eupatorium purpureum L. Purple Boneset. Not rare.

Helianthus tuberosus L. Jerusalem Artichoke. Not rare.

Helenium autumnale L. Sneeze-weed. Common.

Rudbeckia laciniata L. Cone-flower. Common.

Silphium perfoliatum L. Cup Plant. Common.

Vernonia fasciculata Mx. Iron weed. Common.

Steironema ciliatum Raf. Loosestrife. Common.

Gerardia tenuifolia Vahl. Slender Gerardia. Common.

Scutellaria lateriflora L. Mad-dog Skull-cap. Common.

Polygonum ramosissimum Mx. Bushy Knot-weed. Not rare.

Humulus lupulus L. Common Hop. Common.

(*d*) Species growing in open places in wooded tracts, but also running into the prairie.

Fragaria virginiana Mill. Strawberry. Common.

Solidago serotina Ait. Golden-rod. Common.

Aster lævis L. Smooth Aster. Very common.

Aster novæ-angliæ L. New England Aster. Quite common.

Helianthus grosse-serratus Martens. Saw-tooth Sunflower. Common.

Heliopsis scabra Dunal. Ox-eye. Common.

Scrophularia nodosa var. *marylandica* Gray. Rather common.

Monarda fistulosa L. Wild Bergamot. Frequent.

Sisyrinchium angustifolium Mill. Blue-eyed Grass. Not rare.

Hypoxis erecta L. Star-grass. Common.

Smilacina stellata Desf. False Solomon's Seal. Not rare.

(5) *Species growing in sandy places along streams.*

Strophostyles angulosa Ell. Wild Bean. Common.

Eragrostis major Host. Strong-scented Eragrostis. Common. Introduced.

Panicum virgatum L. Prairie Grass. Common.

Some of the species in the following group also frequently appear in sand, especially if it is mingled or covered with alluvium.

(6) *Species growing in swamps, or at least in wet places.* These may be roughly divided into those which manifest a preference for wet places, and those which are distinctly swamp-species.

(*a*) Species growing in localities which are more or less moist.

Anemone pennsylvanicus L. f. Bristly Crowfoot. Not rare.

Nasturtium palustre DC. Marsh Cress. Common.

Nasturtium palustre var. *hispidum* DC. Rare.

Nasturtium sinuatum Nutt. Water Cress. Frequent.

Stellaria longifolia Muhl. Long-leaved Stitchwort. Not common.

Lathyrus palustris L. Swamp Vetchling. Not common.

Penthorum sedoides L. Ditch Stone-crop. Quite common.

Rotala ramosior Koehne. Rare. Near Quartzite exposure.

Lythrum alatum Pursh. Loose-strife. Quite common.

Ammania coccinea Rottb. Rare. Found only near Sioux Quartzite exposures.

Cicuta maculata L. Water Hemlock. Frequent.

Asclepias incarnata L. Swamp Milkweed. Common.

Mimulus ringens L. Monkey-flower. Not rare.

Ilysanthes riparia Raf. False Pimpernel. Occasional.

Pedicularis lanceolatus Mx. Swamp Louse-wort. Not common.

Lycopus sinuatus L. Water Horehound. Common.

Physostegia virginiana Benth. False Dragon-Head. Not common.

Mentha canadensis L. Wild Mint. Common.

Teucrium occidentale Gray. Germander. Locally very common.

Acnida tuberculata Moq. Water-Hemp.

Rumex salicifolius Weinm. White Dock. Frequent.

Rumex altissimus Wood. Pale Dock. Common.

Polygonum acre H. B. K. Water Smartweed. Common.

Polygonum pennsylvanicum L. Smartweed. Common.

Allium canadense Kalm. Wild Garlic. Rather common.

Carex hystricina Muhl. Sedge. Quite common.*

Carex sartwellii Desv. Sedge. Not common.

Carex vulpinoidea Mx. Sedge. Common.

*The sedges mentioned in this report were reviewed by Mr. R. I. Cratty, of Armstrong, Iowa.

Carex trichocarpa Muhl. Sedge. Common.

Carex cephalophora Muhl. Sedge. Common.

Carex straminea Willd., *var.* Sedge. Not common.

Cyperus erythrorhizos (?) Muhl. Not common.

Cyperus aristatus Rottb. Quite abundant.

Cyperus diandrus Torr. Common.

Cyperus speciosus L. Rather frequent.

Alopecurus geniculatus L. Foxtail Grass. Common.

Calamagrostis canadensis Beauv. Blue-joint. Still very common on undisturbed prairie.

Muhlenbergia glomerata Trin. Drop-seed grass. Not rare.

Muhlenbergia mexicana Trin. Drop-seed grass. Common.

Spartina cynosuroides Willd. Tall Marsh-grass. Common locally.

Calamagrostis longifolia Hook. Reed Bent-grass. Quite common.

(*b*) Swamp species.

Sium cicutæfolium Gmel. Water Parsnip. Not rare.

Herpestis rotundifolia Pursh. Hedge-Hyssop. Found in and around the edges of pools in the vicinity of the Quartzite exposures. Rare.

Veronica anagallis L. Water Speedwell. Not common. With the preceding.

Juncus nodosus var. *megacephalus* Torr. Rush. Locally common.

Sparganium eurycarpum Engelm. Bur-reed. Not rare.

Alisma plantago L. Water-plantain. Common.

Sagittaria variabilis. Engelm. Arrow leaf. Common in spots.

Eleocharis acicularis R. Br. Spike-Rush. Common.

Eleocharis ovata R. Br. Spike-Rush. Rather frequent.

Eleocharis palustris R. Br. Spike-Rush. Quite common.

Eleocharis tenuis Schultes. Not common.

Scirpus atrovirens Muhl. Bulrush. Common.

Scirpus lacustris L. Common.

Scirpus americanus Pers. Not common.

Beckmannia erucæformis var. *uniflora* Scrib. Found only in streamlet near Sioux Quartzite exposure.

Scolochloa festucacea. Link. Not rare.

(7) *Aquatic species.*

These are of two kinds—those which are rooted in mud, etc, but remain submersed, and those which are floating. Both of course are restricted in their distribution.

(a) Species which are rooted, but submersed.

Ranunculus circinatus Sibth. Stiff Water Crowfoot. Not common.

Nuphar advena sit f. Yellow Pond Lily. Rare.

Nymphæa reniformis DC. White Water Lily. Rare.

Myriophyllum heterophyllum Mx. Water Milfoil. Not common.

Polygonum muhlenbergii Wats. Knot-weed. Locally common.

Ceratophyllum demersum L. Hornwort. Locally common.

Elodea canadensis Mx. Water-weed. Locally common.

Heteranthera graminea Vahl. Mud-Plantain. Not common.

Potamogeton amplifolius Tucker. Pond-weed. Rock river. Not common.

Potamogeton fluitans Roth. Pond-weed. Rock and Big Sioux rivers. Common.

Fotamogeton pauciflorus var. *niagarensis* Gray. Rock river. Not common.

Potamogeton pectinatus L. Rock river. Not rare.

Potamogeton zosteræfolius Schum. Rock river. Quite common.

Marsilea vestita H. & G. Found sparingly in pools on the Sioux Quartzite.

(*b.*) Floating species.

Lemna minor L. Duck-weed. Locally common.

Spirodela polyrrhiza Schleid. Common in a pond in the northwest corner of the county.

(8.) *Parasites.*

To the foregoing list should be added the following parasites:

Cuscuta arvensis Beyr. Dodder. On low prairie plants. Locally common.

Cuscuta gronovii Willd. Dodder. On weeds, etc. Not rare.

Cuscuta glomerata Choisy. Dodder. On coarse weeds. Locally common.

Cuscuta tenuiflora Engelm. Dodder. On shrubs and coarse weeds. Common.

Aphyllon ludovicianus Gray. Broom-rape. Two specimens only were found on the quartzite tract. Introduced, no doubt.

FORAGE PLANTS.

The prairies were formerly covered with good forage-grasses. These are rapidly becoming exterminated, but virgin prairie still produces a number of species in abundance.

Of the species already listed the following may be classed as still valuable: *Andropogon furcatus*, *Calamagrostis canadensis*, *Agropyrum glaucum* and *repens*, *Panicum virgatum*, *Elymus canadensis* (of some value) and *Kœleria cristata*. The following would be useful if they occured in sufficient quantities: *Chrysopogon nutans*, *Poa pratensis*, *Beckmannia erucæformis* var. *uniflora*, *Buchloe dactyloides*, and the three species of Gamma Grass (*Bouteloua*) which are of some use on poor lands.

A few species add to the bulk, but not much to the value of prairie hay. Such are: *Spartina cynosuroides*, *Muhlenbergia glomerata* and *mexicana*, *Alopecurus geniculatus* and *Leersia virginica*.

The yellow Fox-tail (*Setaria glauca*) a common weed, is of some value as fodder in stubble. The remaining grasses and the sedges are of very little value.

WEEDS.

Both introduced and native plants appear as weeds. Of the introduced forms the following were observed:

Mustard; Charlock (*Brassica sinapistrum* Boiss.). Very common in fields. It is said that sowing Millet in fields infected with it will exterminate this pest.

Pepper-grass. Two species, *Lepidium virginicum* L. and *intermedium* Gray, both probably introduced, are not uncommon, but they are not specially harmful.

False Flax (*Camelina sativa* Crantz.). Sparingly introduced, probably with flax.

Purslane (*Portulaca oleracea* L.). Not very common.

Alsike Clover (*Trifolium hybridum* L.). Sparingly introduced.

Horse weed (*Erigeron canadensis* L). A nuisance in waste places.

May-weed; Dog-fennel (*Anthemis cotula* DC.). Not in sufficient abundance to be harmful.

Hog-weed (*Ambrosia artemisæfolia* L.). Becoming more common and a nuisance in waste places.

Great Ragweed (*Ambrosia trifida* L.). Common, and becoming troublesome.

Marsh Elder (*Iva xanthiifolia* Nutt.). Becoming more common and growing very troublesome, especially on lower lands.

Cockle-bur (*Xanthium canadense* Mill.). Common and troublesome, especially on lower grounds.

Burdock (*Arctium lappa* L.). Not yet common.

Dandelion (*Taraxacum officinale* Web.). Not very abundant.

Sow-Thistle (*Sonchus asper* Vill.). As yet scarcely noticeable.

Prickly Lettuce (*Lactuca scariola* L.). Not yet common.

Black Nightshade (*Solanum nigrum* L.). Occasionally in lower cultivated grounds.

Ground-cherry (*Physalis pubescens* L.). In fields, etc.

Bindweed (*Convolvulus sepium* L.). Occasionally in cornfields.

Plantain (*Plantago major* L.). Becoming troublesome in lawns, etc.

Mullein (*Verbascum thapsus* L.). Not specially troublesome.

Neckweed (*Veronica peregrina* L.). Common in cornfields, etc., but insignificant.

Curled Dock (*Rumex crispus* L.). Not very common.

Black Bindweed *Polygonum convolvulus* L.). Quite common, and sometimes troublesome in fields.

Pig-weed (*Amarantus retroflexus* L.). Quite common in waste places.

Tumbleweed (*Amarantus blitoides* Wats.). Quite common, and somewhat troublesome.

Russian Thistle (*Salsola tragus* L.). Quite common. In barren places or gravelly slopes the plants are often quite small and simple-stemmed. The species has not become specially troublesome.

Lamb's Quarters (*Chenopodium album* L.). Common in waste places.

Foxtail (*Setaria glauca Beauv.*) Common.

Old-Witch Grass (*Panicum capillare* L.). Rather frequent.

A few other forms, presumably native, also occur as weeds and do not appear in the preceding lists. They are:

Maple-leaved Goosefoot (*Chenopodium hybiridum* L.). Not common.

Three-seeded Mercury (*Acalypha virginica* L.). Quite common in fields, etc.

Nettle (*Urtica gracilis* Ait.). Locally common, especially in rather low places.

Prostrate Vervain (*Verbena bracteosa* Mx.). A common weed in waste places. Probably introduced?

Hoary Vervain (*Verbena stricta* Vent.). Very common, and becoming a nuisance in pastures and waste places.

Blue Vervain (*Verbena hastata* L.). Rather common, especially in lower grounds, and becoming a weed.

Squirrel-tail Grass (*Hordeum jubatum* L.). A pernicious weed, now already troublesome locally.

Of the species already given in the preceding lists several may be classed as weeds. The following appear chiefly in cultivated grounds or waste places: Wild Liquorice(*Glycyrrhiza lepidota*), Partridge Pea (*Cassia chamæcrista*), Daisy Fleabane (*Erigeron strigosus*), the wild sunflowers (*Helianthus annuus, H. maximiliani, and H. grosseserratus*), Yellow Wood-sorrel (*Oxalis corniculata* var. *stricta*), and Pleurisy-root (*Asclepias tuberosa* L.).

A much larger number of native plants encroach upon pastures.

The following interfere chiefly with pastures on rather dry grounds: Loco-weed (*Oxytropis lambertii*), Lead-plant (*Amorpha canescens*), Yarrow (*Achillea millefolium*), Tall Thistle (*Cnicus altissimus*), Stiff Sunflower (*Helianthus rigidus*), Stiff Golden-rod (*Solidago rigida*), Rush-like Lygodesmia (*Lygodesmia juncea*), White-margined Spurge (*Euphorbia marginata*) Evening Primrose (*Œnothera biennis*), False Gromwell (*Onosmodium carolinianum* var. *molle*), and Porcupine Grass (*Stipa spartea*). The Stiff Golden-rod is so common on the hills in the western part of the county that it is decidedly troublesome. The Loco-weed, the White-marginal Spurge, and the Porcupine Grass are dangerous to cattle, but fortunately are not so common as to cause apprehension.

In pastures upon grounds which are more or less moist the following may be troublesome: Sneeze-weed (*Helenium autumnale*), Cone-flower (*Rudbeckia laciniata*), Iron-weed *Vernonia fasciculata*), Swamp Milkweed (*Asclepias incarnata*), Germander (*Teucrium occidentale*), Smartweed (*Polygonum pennsylvanicum*), and the Slender Rush (*Juncus tenuis*.)

Most of the weeds herein enumerated can be exterminated by persistent cutting before seed is produced. Fire and the plow also render material assistance. Individual effort, however, counts for but little, and if weeds are to be subdued in any section, a joint effort to keep them down in the fields, in waste places, and by the roadsides, must be made by all landholders.