GEOLOGY OF ADAIR COUNTY

BY

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THE GEOLOGY OF ADAIR COUNTY[1]

INTRODUCTION

Adair county is located in the third tier of counties north of the southern boundary of Iowa, and in the third tier east of the western boundary of the state. It is a square, consisting of sixteen geographical townships, and is bounded on the north by Guthrie county, on the east by Madison, on the south by Union and Adams, and on the west by Cass. To the northeast and northwest it corners with Dallas and Audubon respectively. Adair is essentially a prairie county. Lying well to the south of the Wisconsin glacial lobe, whose moraine passes through Guthrie county, it shows no trace of constructional topography. It is thoroughly dissected by streams and its drainage system is complete. Its soil consists of typical Kansan till, and its rolling topography is typically Kansan. The grand divide between the Mississippi and Missouri rivers passes through Adair county, in an almost due northwest-southeasterly direction, so dividing it that approximately one-third of the county lies to the northeast of the divide and two-thirds to the southwest. Owing to the extremely dissected character of the topography, the "draws", or shallow valleys in which the smaller streams take their rise, interlock along the crest of the divide, so that the latter is very crooked. The county drains to the north and east through North river, Middle river, and Grand river, on the south and west through East and Middle Nodaway rivers. North and Middle rivers flow into the Des Moines, and so form part of the Mississippi drainage system. Grand river and the Nodaways flow into the Missouri. Of these streams, Middle river (and Bush Branch, a small tributary of Middle river) are the only

[1]The manuscript which was submitted by the late Doctor Gow was revised after his death by Dr. John L. Tilton. Changes were made with regard to some phases of the Carboniferous rocks and the Pleistocene deposits.

ones that cut to bedrock in Adair county. Grand river cuts through rock in Madison county not very far from the county line. The Nodaway cuts into rock near Mount Etna, in Adams county, and north of that point flows over a clay bed.

PREVIOUS GEOLOGICAL WORK

In 1849 Owen probably passed through the southern part of Adair county, or skirted along its southern border, on his way from Des Moines to Council Bluffs. In his "Report of a Geological Survey of Wisconsin, Iowa and Minnesota," published in 1852, Owen thus describes this portion of his journey:

"On Grand River, in the vicinity of Pisgah, nothing but drift is to be seen. Some miles down the stream, however, near a mill-site, I was told by the Mormons that a kind of 'soapstone' could be found at a low stage of water, which I suppose to be an indurated argillaceous shale; these deposits being popularly known by that name in the west. This I was unable to examine in person; indisposition, from fatigue and exposure, having brought on a relapse of intermittent fever, contracted while exploring the Des Moines.

"The distances from Fort Des Moines to Pisgah are as follows:

To the crossing of North River	10 miles
To Middle River	12 miles
To the South or Clanton Fork of Middle River	2 miles
To Clanton's	2 miles
To Big Hollow	14 miles
To forks of road leading to Bellevue	4 miles
To Pisgah	6 miles
Total distance	50 miles

"On the route from Pisgah to Council Bluffs, I crossed Grand River, the Platte branch of Grand River, two branches of the Nodaway, a Hundred and Two River, and the east, middle, and west branches of the Nishnabotna River. It was only on this latter stream that any rocks were found in place."

The writer cannot find that the memory of any such place as "Pisgah" lives at this time, though he has not had the privilege of interviewing all the old settlers of the region in question.

From the somewhat detailed table of distances given by Owen the place can be approximately located, and it must have been at or near the site of the present village of Macksburg, in Madison county. Scattering exposures of shale occur in that neighborhood. The reference to the mill site would seem to indicate Macksburg as the site of Pisgah. Owen's journey from Pisgah to Council Bluffs probably took him through the southern edge of what is now Adair county, but in the latter region he found no indurated rocks.

In 1868 White made some observations on the Geology of Adair county, and these were published in his Geology of Iowa, Volume I, pp. 336 to 339. In this report he described in considerable detail exposures of Carboniferous rock found on sections 11 and 12 in Grove township, a bed of modern peat in section 22 of Summerset township, and other points of interest. White's work is useful to the geologist of the present day, and references will be made to it in the pages of this report.

In the late seventies a Geological Survey of Adair county was undertaken by Fox, but the work was barren of results and was soon abandoned.

In 1894 Keyes, in Volume II of the Reports of the Iowa Geological Survey, reported on the presence of coal in Adair county. Further reference will be made to this report.

In 1911 Norton and Simpson reported on the underground waters and deep wells of Adair county, in Volume XXI of the Iowa Reports. This article embodies data with regard to eighteen deep wells in various parts of the county.

The writer began work on the geology of Adair county in 1901, under direction of the State Geologist, the late Professor Samuel Calvin. In 1902 it was found necessary to drop the work for the time being, and it was not possible to take it up again until 1912, when it was resumed and pushed to completion.

ELEVATIONS ABOVE SEA LEVEL

The official elevation as given for Greenfield was taken as a standard, the figures being supplied by the officials of the Chicago, Burlington & Quincy Railway, and after the aneroid had

been set in accordance with this datum readings were taken at the other points as indicated below. The readings for Stuart, Casey, Adair and Fontanelle were verified by comparison with Gannett's Index of Elevations, and were found to be in substantial agreement.

	FEET	
Railway station at Stuart	1,216	
" " " Casey	1,248	
" " " Adair	1,442	
" " " Orient	1,334	
" " " Greenfield	1,368	
" " " Fontanelle	1,244	(old station)
" " " Fontanelle	1,282	(new station)
" " " Bridgewater	1,188	
Summerset Township:		
Se. ¼ sec. 14	1,278	
W. line Nw. ¼ sec. 13	1,388	
Nw. corner sec. 13	1,298	
E. line Se. ¼ sec. 18	1,282	
Jackson Township:		
Se. ¼ sec. 34	1,198	
Washington Township:		
Se. ¼ sec. 16	1,155	
Union Township:		
Se. ¼ sec. 16	1,312	
Se. ¼ sec. 1	1,079	
Jefferson Township:		
Se. ¼ sec. 31	1,361	
Grove Township:		
Se. ¼ sec. 19	1,360	
Sw. ¼ sec. 1	1,098	
Nw. ¼ sec. 12	1,098	
Harrison Township:		
W. line Se. ¼ sec. 18	1,068	
Se. ¼ sec. 20	1,060	
Se. ¼ sec. 21	1,038	
Se. ¼ sec. 27	988	
Se. ¼ sec. 26	943	
Ne. ¼ sec. 36	940	

EXPOSURES AND DEEP SHAFTS

The Chicago, Burlington & Quincy railway in Adair county follows the crest of the divide as far north as Greenfield. The track is very crooked and heads practically every "draw" in the entire twenty miles from Creston to Greenfield, and there

are consequently no cuts in that disance. At Greenfield it drops into the valley of the Nodaway, which it follows as far as Fontanelle, there being some culverts and bridges but no cuts in the seven miles between the two towns. West of Fontanelle are a few shallow cuts in the drift.

The Chicago, Rock Island & Pacific railway skirts the northern edge of the county, and there are a number of rather deep cuts along its right-of-way. These nowhere extend below the Kansan drift, but are useful as offering an opportunity to study the drift in vertical section.

The working of the roads in every part of the county has led to the making of many shallow cuts from two to fifteen feet in depth, and much of the information with regard to the surface clays of the county has been derived from this source. As a rule it is best to study the cut immediately after it has been made, as a very few rains cause a washing of the clay that obscures things, but very often a few minutes' work with a spade is sufficient to reveal the underlying materials in their natural relations. Natural gullies developing in pasture and meadows occasionally make it possible to secure information regarding the underlying materials.

The various branches of the Nodaway dissect the western half of the county but do not cut below the drift. At most points the drift is masked by alluvium, but there are some good exposures. In the eastern part of the county Middle river cuts through the Kansan drift and into the Carboniferous limestone below. At half a dozen points between Perry's quarry and the county line the river flows over a rock bottom, the bottom at intervening points consisting of clay, sand, or alluvium. Between the deposition of the Carboniferous strata and the advance of the ice sheet was an immense interval of elevation and consequent erosion, and the present exposures of Carboniferous rock represent the summits of the hills of the old eroded Carboniferous land surface. The Kansan drift rests unconformably upon this eroded surface. Nebraskan and Aftonian materials underlie the Kansan at many places in Adair county, but no trace of them is to be found in the Middle river exposures.

Most of the wells in this county do not penetrate into the bedrock, but merely reach "hardpan" or stiff, impermeable Kansan clay. The writer secured data with reference to eleven wells which penetrate below the level of the drift, reaching either Carboniferous or Cretaceous rock. Besides these eleven, eight more are reported by Simpson in Norton's report on the Ground Waters of Iowa. With regard to most of these nineteen wells the available data are extremely meager. In only one case was a complete and accurate record of the section preserved. Data regarding the shallower wells are more readily obtained, and throw some light on the relations of the various clays, sands and gravels making up the complex Kansan drift. It is through an examination of these wells also that the evidence as to the presence of the Aftonian in Adair county has been chiefly brought to light.

There is but one mine shaft in the county, and while it is not now accessible for examination the writer has been able to obtain an authentic record of the section.

SYNOPTICAL TABLE OF FORMATIONS.

GROUP	SYSTEM	SERIES	STAGE		SUBSTAGE	CHARACTER OF ROCKS
		Recent	.....		.....	Alluvium and other surface soil, clay and sand.
	Quaternary	Pleistocene.	Peorian ...		.....	Deposits of loess.
			Yarmouth .		.....	Kansan gumbotil.
Cenozoic ..			Kansan ...		.....	Drift (bowlder clay).
			Aftonian ..		.....	Nebraskan gumbotil.
			Nebraskan		.....	Drift (bowlder clay).
	Tertiary ..	Pliocene ...	Ozarkian ..		.....	Bog and other deposits.
Mesozoic ..	Cretaceous	Upper Cretaceous ...	Dakota ...		.....	Sandstone, a little shale.
			Missouri	(Shawnee Division)	Scranton ..	Shale.
					Howard ...	Limestone.
					Severy	Shale; Nodaway coal.
					Topeka	Limestone.
					Calhoun ..	Shale.
					Deer Creek.	Limestone.
					Tecumsey..	Shale.
					Lecompton	Limestone.
					Kanwaka ..	Shale.
				(Douglas Division)	Oread	Limestone.
					Lawrence .	Shale.
					Iatan	Limestone.
					Weston ...	Shale.
Paleozoic ..	Carboniferous...	Pennsylvanian ..		(Lansing Division)	Stanton ...	Limestone.
					Vilas	Shale.
					Plattsburgh	Limestone.
					Lane	Shale.
				(Kansas City Division)	Iola	Limestone.
					Chanute ...	Shale.
					DeKalb (Drum) . .	Limestone.
					Cherryvale.	Shale.
					Winterset .	Limestone.
					Galesburg .	Shale.
					Bethany Falls.....	Limestone.
					Ladore	Shale.
					Hertha	Limestone.

Exposures East of the Divide

As has been said, the sections east of the divide include only two classes of materials, drift and Carboniferous rock. The Carboniferous rocks in the eastern central portion of the county belong somewhere in the Missouri stage above the Westerville limestone, probably with the Iatan limestone. The relations are discussed by Tilton in the section on Comment on Correlation and Structure.

The first exposure investigated is on the west side of Middle river at Perry's quarry in the northeastern corner of Grove township. The rock is exposed in a ravine which approaches the river from the west. At two points—near the river on the north side of the ravine, and about fifty rods back from the river on the south side of the ravine—quarrying operations have been carried on in the past but were discontinued some years ago. The bottom of the ravine is flat, being in fact the flood plain of an intermittent brook which has cut in the middle of the plain a narrow gully three to five feet in depth. In the bottom of this gully is exposed a stratum of brittle black shale. The section exposed on the south side of the valley, including the shale found in the gully, is as follows:

		FEET.
10.	Drift, Kansan	5
9.	Limestone, massive, nonfossiliferous, weathering rectangular	4
8.	Shale, soft, light gray	1
7.	Limestone, buff to white, with narrow partings of light shale	2
6.	Shale, soft, light gray	5/6
5.	Limestone, similar to No. 7	3
4.	Shale, soft, gray to brown	1
3.	Limestone, massive, without shale	3
2.	Hidden by alluvium	10
1.	Shale. hard, black	¼
	Total	30

The exposure nearer the river and on the opposite side of the gully is practically identical with the one just given, except that a band of chert is found in the massive limestone five feet above the foot of the cliff. At either end the chert is concealed by talus. It is probably a lenticular mass of no great extent Specimens of *Athyris subtilita, Spirifer cameratus,* and *Pro-*

ductus nebrascensis were found in the massive limestone of both these exposures. The shale is nonfossiliferous. Some calcite crystals are present in the massive limestone. The Perry's quarry exposures are mentioned by White in his "Geology of Iowa" page 336 of volume I, but no details are given. A third exposure, similar to those at Perry's quarry, is found in the same section (12, Grove township) and less than half a mile down the river. This is in the valley of the little tributary spoken of by White as "Drake's Creek". The elevation is the same as that of Perry's quarry, and the section is as follows:

		FEET	INCHES
4.	Drift, Kansan	5	
3.	Limestone, light buff, with frequent shaly partings, varying in thickness from ¼ inch to 1 foot	12	
2.	Limestone, heavy, dark, cherty		5
1.	Limestone, darker, without chert and without shaly partings	5	
	Total	22	5

White, in the "Geology of Iowa" volume I, pp. 336-339, described another exposure on Drake's creek, which, according to his account, extended twenty-seven feet below the level of the exposure at Perry's quarry, and of the one just given. Of this the writer has been able to find no trace. The section as given by White is as follows:

		FEET.
6.	Black carbonaceous shale, a few inches at top consisting of impure coal	2
5.	Marly clay	½
4.	Hard, bluish, impure limestone	1
3.	Brownish clayey shale	1
2.	Hard dark-colored impure limestone	½
1.	Fine-grained, micaceous, sandy shale, becoming darker and more clayey at the top	22
	Total	27

Passing down Middle river, the next exposure is on the Keating farm just above Port Union, and within sight of the mill at the latter place. On a sloping bank fifteen feet above the low-water level stands a large bowlder of hard, well cemented breccia. Although the hillside is badly masked by drift an examination shows that the bedrock at this point consists of similar breccia, but the exposure is so unsatisfactory on account of the mantle of drift that it is impossible to say how far up

and down the valley it extends. It appears to dip sharply to the southwest. The fragments of which this breccia consists are of a fine-grained, light buff limestone, are quite angular, and vary in size from a quarter of an inch up to eight or ten inches in diameter. The cementing material is similar but somewhat coarser in texture, and inclined to be crystalline. A few broken specimens of *Athyris subtilita* appear in the angular fragments of the breccia.

FIG. 37.—Exposure at the west end of the dam at the Port Union mill (Arbor Hill), Adair county. Below the dam the stream flows over a rock bottom, No. 1 of the section as described.

The third exposure is at the west end of the dam at the Port Union mill. The section is as follows:

		FEET.
5.	Alluvium, black	10
4.	Till, yellow, somewhat gravelly	5
3.	Limestone, hard, light buff, varying to white or light gray, richly fossiliferous	2
2.	Shale, very soft, homogeneous, blue-black, richly fossiliferous	4
1.	Limestone, hard, light colored, fossiliferous	2
	Total	23

Below the dam the stream flows over a rock bottom consisting of limestone No. 1 of the section just given. At high water No. 2 is covered. Strata Nos. 1 and 3 bear the following fossils:

Spirifer cameratus
Productus (fragments)
Crinoid stems in great abundance.
Rhombopora lepidodendroides.
Composita subtilita.
Fenestella—sp.
Derbya crassa.
Myalina subquadrata.

Number 2 of the section at Port Union bears the following:

Nucula (ventricosa?).
Aviculopecten occidentalis.
Monotis (gregaria?).
Nuculana bellistriata.
Unidentified gasteropods.
Numerous molluscs.

A complete list of the fauna must be reserved for a future report. It is essentially molluscan in its character, and is characterized by the absence of *Productids, Spirifers,* and crinoid stems, all of which are present in the limestones both above and below, and by the absence of *Chonetes verneuilianus,* a fossil that is characteristic of the shales farther down the river.

Exposure No. 4 is on the south bank of the river, in section 21 of Harrison township. Twenty-two feet of limestone is here exposed.

		FEET.
6.	Till, blue below, yellow at surface, slightly gravelly in places	5
5.	Limestone, light-colored, massive	1
4.	Limestone, fragmental, fairly compact below, then with frequent partings of soft clay, finally shading up into a soft purple clay in which but few hard limestone fragments occur	14½
3.	Limestone, hard, light colored, fossiliferous	1
2.	Shale, soft, blue-black	2½
1.	Limestone, light buff, fossiliferous, largely concealed by talus	3
	Total	27

Stratum No. 1 of this exposure bears *Composita subtilita* and fragments of an unidentified *Spirifer.* The only fossil found in No. 2 is *Chonetes verneuilianus,* but the search was not long continued at this point. No molluscs were observed. In color and texture the shale is precisely similar to that found at Port Union. The limestone fragments of No. 4 are light in color, of variable hardness, and inclined to be angular. The clay is of about the consistency of the harder Kansan till, or "hard-pan," breaks in the same way, checks on drying, and loses color on exposure to the weather. The original color is not the blue-black of the typical shale, but a blue-purple which approximates the color of the deeper Kansan drift. On leaching it passes through the various shades of purple-brown, dark-brown, light-brown and yellow-brown. It is nonfossiliferous, and contains no rock fragments other than the nodular masses of limestone already mentioned. It seldom shows distinct marks of stratification. Strata Nos. 4 and 5 are again exposed in a ravine which comes down parallel with the course of Middle river and enters the latter a few rods below the exposure just described. The characteristics differ in no way from those already given, ex-

cept that stratum 5 is two feet or more in thickness. On a small tributary in section 22 three feet of buff limestone is exposed, the underlying rock being hidden. In this exposure were found specimens of *Productus nebrascensis.*

The next exposure is in a narrow ravine on the Pemberton farm in section 27, Harrison township. A second section is exposed somewhat further down the ravine, and the two in combination give the following:

		Feet
10.	Till, Kansan, with small bowlders	3
9.	Clay, blue, similar to that found in stratum No. 4 of the fourth exposure	2
8.	Limestone, buff	1
7.	Limestone, fragmental, with much purple clay	6½
6.	Limestone, buff	1
5.	Limestone, fragmental	3
4.	Limestone, buff to dark brown	2
3.	Hidden by sand, clay and bowlders accumulated in stream bed	3
2.	Limestone, buff to dark brown	1
1.	Shale, dark blue-black	2
	Total	24½

Fig. 38.—Exposure near the mouth of a ravine on the Pemberton farm in section 27, Harrison township, Adair county.

Near the top of No. 9 is a band of very brittle black shale about half an inch in thickness. No. 10 is unconformable upon No. 9, the difference in color and texture being readily distinguishable at a distance of twelve or fifteen feet. The Kansan here is leached to a light yellow, and bears a few pebbles and small bowlders. The blue clay is nonfossiliferous. The blue shale (No. 1) contains specimens of *Chonetes verneuilianus*. This shale is almost black in color, and similar in texture to that found at Port Union. Limestone No. 4 contains an abundance of *Rhombopora lepidodendroides*. Many crinoid stems are present also.

In section 26 of Harrison township the following exposure is found in the valley of a small brook putting in to Middle river from the south:

		Feet	Inches
11.	Till, Kansan, gravelly, dark colored	3	
10.	Limestone, hard, brown-buff		8
9.	Clay, purple, weathered brown to yellow	1	6
8.	Shale, black, laminated, very soft		1
7.	Limestone, fragmental, grading upward into clay	10	
6.	Limestone, buff, with 2 shale bands	5	
5.	Limestone, fragmental	5	
4.	Shale, very fossiliferous, blue-black	2	
3.	Limestone, hard, bluish	5	
2.	Shale, very soft, blue-black	2	
1.	Shale, brittle, black		6
	Total	34	9

Stratum 6 of this exposure contains quantities of *Fusulina cylindrica*. Number 10 is entirely nonfossiliferous. Number 3 contains *Spirifer cameratus, Productus punctatus, P. costatus, P. longispinus, Derbya crassa, Rhombopora lepidodendroides,* many crinoid stems, and other fossils. Number 4 contains *Chonetes verneuilianus*. The last of the Middle river exposures in Adair county is near the east line of section 36, Harrison township. Several feet of blue-black shale occur capped by massive limestone.

On Bush's Branch, in section 13, Grand river township, occurs the following exposure:

		Feet
2.	Alluvium	3
1.	Soft black shale	5

The black shale is extremely rich in specimens of *Chonetes verneuilianus* which, when the spot was last visited, had weathered out clean and formed a small talus at the foot of the bank. This is the last of the Carboniferous exposures in Adair county. Near the old mill at the village of Webster, in Madison county, something over a mile east of the exposure found in section 36 of Harrison township, several feet of rusty-colored *Fusulina* limestone is exposed, but its relations to the beds above and below have not been traced by the writer.

The general dip of the limestone in Adair county is toward the south. Middle river, cutting in a southeasterly direction through these southerly dipping strata, gives them an apparent dip to the southeast. The apparent southeast dip is of course less than the actual southerly dip. The former amounts to about ten feet to the mile, or about the same as the gradient of the bed of Middle river.

Sections of Indurated Rock West of the Divide

The west half of the county is covered by a thick mantle of drift, and no streams cut to bedrock. Consequently the only obtainable evidence as to the nature of the indurated rocks is to be obtained from deep borings, and the number of the latter records of which have been preserved is all too small. The results indicate that the surface of the Missouri is at places covered by a veneer of Cretaceous sandstone belonging to the Dakota stage. The following shafts have been investigated.

On the farm of J. A. Hulbert, in Washington township, four and one-half miles southeast of Bridgewater, rock was encountered at the depth of 275 feet. After penetrating twelve feet of soft sandstone, further drilling was abandoned.

At the residence of J. G. Hendry, one mile south of Bridgewater, a well was sunk about 1897, and the record, carefully preserved by Mr. Hendry, reads as follows:

	Feet
Blue clay	65
White clay	40
Gravel	1
Dark, soft, sandstone	12
Hard clay, dark in color	2
Sandstone	18
Slate	2
Coal	1.8
Limestone	18
Quicksand and water	
Total	159.8

The gravel occurring just below the white clay is described as consisting of pebbles which were much water worn and very hard, and of rather uniform size. The white clay was of such a character as to color the water milky when it was first drawn from the well. Both it and the blue clay above contained few pebbles. Eighty feet lower down the hillside, and half a mile or less from the site of the first well another shaft was put down with the following result:

	Feet
Blue clay	177
Red clay with many pebbles	3
Blue-black Carboniferous shale	40
Total	220

The black shale contained two or three narrow bands of coal, but was otherwise homogeneous in its nature, and of a smooth even consistency. The "red clay with many pebbles" is probably a phase of the Dakota sandstone. In the first section the line of separation between the Missouri and Dakota is the two feet of black shale lying immediately above the stratum of coal.

On the farm of E. Stacey, one mile northwest of Bridgewater, in the digging of a well shaft a forest bed was struck at the depth of forty feet. After taking out a section of a good sized log, probably of cedar, digging was resumed. Ten feet lower the auger entered black shale. The water was dark in color, and had a bad taste. No indication of the presence of Cretaceous materials appeared in this well, the drift lying in immediate contact with the Missouri shale.

On the farm of W. W. Witham, in Summerset township, a short distance west of Greenfield, a well was sunk to the depth of 275 feet. At about 240 feet the drill passed into limestone with bands of black and blue shale. No Dakota gravels or sandstones were present. The Missouri limestone was covered by 240 feet of blue clay, with some small pebbles and bowlders.

A shaft sunk by the city of Greenfield for the purpose of securing a water supply for the municipal electric lighting plant passed through 208 feet of bowlder clay and 13 feet of Missouri limestone and shale. No gravels were encountered. A few small pebbles were found in the clay, and at one point a thin bed of sandy clay was encountered. As usual, the complete record was not preserved.

A shaft sunk on the farm of F. H. Seers, five miles north of Fontanelle, is reported as passing into soft sandstone at a depth of 260 feet. About twenty feet of the sandstone was penetrated without any change in the nature of the materials being noted.

On the farm of Henry Rose, two miles north of Bridgewater, Missouri limestone was struck at a depth of 270 feet, while a shaft on the farm of Al. Bowers, a mile or two north of the Rose farm, passed into Dakota sandstone at a depth of 260 feet. Forty feet of "fine-grained sandstone" is also reported from a well bored by William Turner near Adair.

The only record of Dakota sandstone east of the divide is given by Simpson in Norton's report on the Underground Waters of Iowa. This is a well bored on the Whittum farm in section 19 of Lincoln township.

Enough has been said to indicate that the surface of the Missouri rock in the northwestern half of Adair county is dotted with scattered outliers of Dakota sandstone. Probably no part of the county is covered with a solid and continuous mass of Cretaceous rock. The variation in the depth at which rock is encountered indicates two things: the depth of the erosion to which the drift has been subjected, and the depth of erosion to which the underlying rocks were subjected before the coming of the ice-sheet.

The abandoned Eureka coal shaft, six miles south of Adair, passes entirely through drift and Missouri rock. The shaft is now partly filled, and is not in condition for examination, but it was described by Keyes (Iowa Geological Survey, Volume II) as follows, in the year 1894:

The shaft is 262 feet in depth, the coal varying from twenty to thirty-two inches in thickness. The roof is bituminous shale. The bottom of the shaft shows:

	Feet	
Clay shale (exposed)	2	
Coal	2	
Fire clay		2-3
Shale, dark (exposed)	1	1-3
Total	6	

The mine is worked on the long wall plan. There are a few unimportant clay seams, but no other breaks in the continuity of

the bed. This is a new mine. The coal has been taken out only from about 150 to 200 feet to the east and west of the bottom of the shaft. It is reported that there are two other seams below the one now worked, one at a depth of about forty-five feet and the other at a depth of about fifty-five feet from the bottom of the shaft.

In June, 1892, a correspondent of the Greenfield Transcript wrote as follows:

The size of the shaft is 6x16 feet and is divided into three apartments. At the depth of over a hundred feet they found a cedar post. The dirt passed through was very hard and had to be dug with a pick. Thence through different kinds of clay and into soapstone. The caprock is four feet and nine inches thick. After passing that, came into two feet of black looking substance which contained coal blossom; passing on into slate, thence into a three foot vein of good coal. The shaft is 228 feet deep, and the coal is deposited 268 feet from the top of the ground.

The evidence of a forest bed, in the shape of a cedar log, is suggestive of Aftonian deposits. No Cretaceous rocks appear at this point. The coal in the shaft near Bridgewater is probably to be referred to the horizon of the Nodaway coal as described by Smith for the counties south and southwest of Adair, but the information is so scanty that no definite correlation is yet possible.

COMMENT ON CORRELATION AND STRUCTURE

JOHN L. TILTON

The blue-black shale which Gow mentions as being present in section 36 of Harrison township, Adair county, is Lawrence shale, between the Iatan limestone below and the Oread limestone above, in the Douglas division of the Missouri stage.

The isolated group of outcrops in the central part of Harrison township belongs to the Oread (Plattsmouth) substage, Douglas division of the Missouri stage. The outcrop described by Gow that is located in section 27 (northwest quarter of the northwest quarter) is an almost exact reproduction of the section at the brickyard south of Plattsmouth, Nebraska, and of the outcrop

at Fox quarries, Cass county, Iowa, together with beds of limestone and associated shale found along the river from Fox quarries to Reno. The Oread limestone in Adair county is more shaly than that in Nebraska, but there is the same general distribution of fossil content in all three regions: Adair and Cass counties, Iowa, and eastern Nebraska. At the bridge in the southwest quarter of the southwest quarter of section 22, Harrison township, low water in the river is at the level of a lower portion of this limestone. Near the old mill in the next section northwest (section 22) the river crosses the eight feet of shale that appears in the lower third of the cliff in section 27, above which the next group of limestone appears in the river bank. The topmost, very fossiliferous beds of section 27 have been eroded away near the mill.

Four miles further up the river (northwest quarter of section 12, Grove township) the thick limestones in the hillsides apparently are the Cullom and Cedar Creek limestones, with accompanying shale, of the Nebraska section, the Lecompton limestone of the Missouri section.

The very small exposure of limestone in section 16, Jefferson township (southwest quarter of the southwest quarter), is judged to be one of the lowest beds of the Deer creek (Forbes) limestone. The reason why no more of this limestone appears up the river is because the limestone has been removed from the upthrow side of a normal fault* near at hand. Strata of the lowest part of the Kansas City division of the Missouri stage have been encountered beneath the drift at the Eureka shaft in the northwest part of the county (north center of section 4, Eureka township).

The difficulties in determining the relation of the strata in this part of the state have been due (a) to the presence of thick drift concealing all beds except in these isolated positions; (b) to the near proximity of Kansas City beds immediately north of the Stuart-Casey region† without recognition of a fault of about 284 feet throw between that district and Arbor Hill; (c) to the presence of a nearly complete section of the Kansas City division

*Note Gow's description of brecciated limestone.

†In the summer of 1920 the writer was convinced that the strata north of Stuart, mapped by Bain as of the Missouri stage, are not Missouri in age, but belong to the Des Moines stage and are located well down in that stage.

nine miles east of the county, with the thinned shale and limestone concealed by drift between that locality and Adair county. The thinning of these beds has not previously been recognized for this region.*

The relation of conditions in these adjacent regions will now be more fully stated.

Adjacent Regions

Nineteen miles a little north of west of the isolated outcrops of Missouri limestone in Harrison township is the location of an old mine in section 4 of Eureka township, Adair county, reported by Keyes and also by Gow, with shaft passing through the base of the Missouri stage into the Des Moines, reaching a seam of coal at a depth of 262 feet below the upland and apparently ending in coal eighty-six feet below the Bethany Falls (Earlham) of the Madison county section, and thirty feet below the Hertha limestone.†

Bain mapped the most western exposure of the Des Moines stage in Guthrie county, three miles north of Stuart, thirteen miles to the north of the isolated outcrops.

Twelve miles east of the outcrops and a little south the base of the Missouri stage passes beneath the bed of Middle river, while Cherryvale shale and DeKalb limestone are in the upland.

Such a relation to the west, north and east, in a region where the dip is slight, might lead to the expectation that the isolated outcrops of Harrison township belong near the base of the Missouri stage. When, however, the sections described by Gow are compared with sections near Earlham and Winterset it is found that the sections described by Gow do not fit into the sections found in those places. Unfortunately, neither individual fossils nor the entire assemblage of fossils named in Gow's lists aid in fixing precisely the position of the beds. All the fossils listed are found throughout the central portion of the Missouri stage in Missouri, and also throughout the central portion of the Missouri stage as far as known in Iowa.

Referring to adjacent regions to the southeast and to the southwest, the writer found in Clarke county, the next county to

*John L. Tilton, The Thurman Wilson Fault through Southwestern Iowa, and its Bearing: The Journal of Geology, Vol. XXVII, pp. 383-390, 1920.

†According to the note on page 298 this stratum of coal is farther down in the Des Moines stage.

the southeast, that an average dip of 9′ 26″, fourteen and a half feet per mile, was all that was necessary, even without a thinning of beds in the intervening region, to carry the Bethany Falls (Earlham) limestone, outcropping in the hillsides north of Osceola, down so that the Westerville limestone, which belongs considerably above the Bethany Falls limestone, is at the level of Grand river near the southwest corner of Clarke county. Between these two points the strata in Clarke county are completely concealed by the overlying drift; but there can be no southeast-northwest fault concealed there, for directly south in Decatur county Bain found no break in his section along Grand river from the base (Hertha) up to the last outcrop which he describes, which is that of the beds of Westerville limestone just mentioned.

Twenty-one miles to the southwest of the outcrops in Harrison township coal has been reported near Bridgewater, a few miles north of the area where G. L. Smith found that the coal mined was Nodaway coal, with which decision the results of the work in and near Cass county by the present writer are in accord. This coal, far up in the Missouri stage, is thus found only thirteen miles south of the old shaft above mentioned, in Eureka township, where coal was formerly obtained from the Des Moines stage—a stratigraphic difference of 743 feet, according to the Clarinda well record, which should be diminished by 70 feet to 673 feet because of thinning of strata as stated in the report on the "Geology of Cass County, Iowa." This is an average of 51.8 feet to the mile, that would require only an average dip of 33′ 44″ straight south, or of 1° 7′ 8″ southwest, in the supposed general direction of the dip.

HOW THE HORIZON AT BRIDGEWATER WAS ASCERTAINED

As no section east and west across southwestern Iowa can be made directly from exposures, without referring to data from elsewhere, recourse must be had to results of work along Missouri river. A number of years ago Bain correlated the Winterset and the Decatur county sections with the beds at Bethany Falls, Missouri, but unfortunately he mistook the limestone at the mills at Bethany Falls for his "Fragmental" limestone (Hertha). It was to test the criticism by F. C. Greene, and also to correlate the strata in Clarke county, that the present writer

went with Greene to Bethany Falls, and later reported in a paper that some of the writers on Geology seem to have overlooked[2]. Hinds and Greene have since then completed their section across the Carboniferous of Missouri, reviewing Broadhead's section; and, while their work was progressing, G. L. Smith[3] connected the Carboniferous section of southwestern Iowa with Broadhead's section, including in his correlation the beds at Stennett, Montgomery county, Fox quarries[4], Cass county, and the coal at and near Briscoe[5], Adams county. At Briscoe the coal is about eighteen inches thick, at a depth of 121 feet from the hillside; Gow gives its thickness as twenty inches at Bridgewater at a depth of 140 feet, or about the same distance beneath the level of the upland as the coal at Briscoe. Limestone lies beneath the coal at both places. Since at the old shaft, fourteen miles north in Eureka township, the coal is 262 feet below the level of the upland, and the general dip is to the southwest in that region, that seam of coal should be far below the seam of coal found at Bridgewater, even if the shaft in Eureka township were not on the upthrow side of a fault plane between the two locations. Further, the only other seam of coal between the Hertha limestone and the Nodaway coal seam that could possibly claim attention from its relations, that is the seam four to six inches thick in the Ladore shale, beneath the Bethany Falls (Earlham) limestone, does not meet at all the conditions found south of Bridgewater and near Briscoe. Thus the argument from relations north of Bridgewater agrees with conclusions G. L. Smith reached in a study to the southwest toward Briscoe. Under these conditions it seems indisputable that the coal seam found near Bridgewater is the Nodaway coal seam.

A Fault Plane

Todd[6] first recognized the presence of a fault near Thurman and the Wilson quarries in Fremont county. Later Smith deter-

[2]John L. Tilton, "The Proper Use of the Geological Name, Bethany:" Proc. Iowa Acad. Sci., Vol. XX, p. 207, 1913.

[3]G. L. Smith, "Carboniferous Section of Southwestern Iowa:" Iowa Geological Survey, Vol. XIX, pp. 627, 628 and 654.

[4]The relation of the beds at Fox quarries was not worked out. It was misjudged, apparently because of the proximity of Fox quarries to Briscoe. A fault with a throw of 284.5 feet passes between these two points.

[5]Keyes thought the coal seam near Briscoe was "apparently the Nodaway coal seam." See Iowa Geological Survey, Vol. II, p. 440, 1894, (but Briscoe is there incorrectly located as in Cass county).

[6]J. E. Todd, "On the Folding of Carboniferous Strata in Southwestern Iowa:" Proc. Iowa Acad. Sci., Vol. I, Part 1, p. 61, 1887; also, "Some Variant Conclusions in Iowa Geology," Proc. Iowa Acad. Sci., Vol. XIII, p. 184, 1906.

mined the throw at that point to be three hundred feet[7], with uplift to the north, and suggested that: "A continuation of the line of displacement from Jones Point to the Wilson section would pass south of the exposure of the Forbes limestone at Malvern, Stennett and Grant, and would thus give an explanation of the appearance of the limestone at those places[8]." He also states concerning the extension of this fault line: "The fault near Lake Wabonsie has, probably, in its eastward extension, become an anticline[9]," etc.

The present writer finds that the fault does not become an anticline near Stennett. He finds it to be a normal fault passing between Briscoe and the Fox quarries, at which point the displacement is 284.5 feet, with the upthrow on the north[10]. If this throw continued to diminish northeastward at the same small rate it would continue northeastward beyond the limits of the state. On tracing relations across the county the fault is found to pass northwest of Bridgewater, and apparently northwest of section 21, Jefferson township. At the northeast corner of section 11, Grove township, not far from the fault plane, the dip of the limestone is found to be 1° 15′ N. 80° W., as if on the southeast side of the fault plane. The effect passes on toward the northeast for a distance beyond Arbor Hill, but the main displacement is farther north at a parallel fault in Guthrie county.

In the above let it be noted (a) that north and south along the east side of the county no displacement of strata exists; (b) that along the west side there is a displacement of 284.5 feet with upthrow on the north; and (c) that the plane of the fault passes diagonally across the county from north of the southwest corner to west of the northeast corner.

A FURTHER TEST

The above argument is complete, but a further discussion dependent on general dip may be acceptable. The exact level of the base of the Hertha limestone at the old shaft in Eureka township, and of the coal at Bridgewater, are not known, but the estimates obtainable are believed to be sufficiently close to bring out the general relation.

[7]G. L. Smith, "Carboniferous Section of Southwestern Iowa:" Iowa Geol. Surv., Vol. XIX, p. 612, 1908.
[8]Idem, p. 649.
[9]Idem, p. 636.
[10]See report on the Geology of Cass County, this volume.

On the north side of the fault plane two points can be selected for the determination of the dip between them in a direction approximately parallel to the fault plane: On Turkey creek two miles north of Lewis, in section 1 of Cass township, Cass county, the thick bed of the Oread limestone is at 1,123 feet above sea level. In section 4 of Eureka township, Adair county, the bottom of the Missouri stage is estimated to be at 1,239 feet above sea level. The thickness of the strata between these two points, according to the record of the Clarinda diamond drill hole,[11] is 470 feet, which should be changed to 400 feet because of thinning of beds as stated in the Cass county report. To this should be added the 116 feet difference in elevation, making 516 feet to be accounted for in a distance of twenty-two miles, which difference must be accounted for by dip (modified by thinning of strata), by faulting and by unconformity. There is no recorded evidence of faulting or of marked unconformity in this part of the section, except as stated in this discussion, but the strata do become thinner toward the northeast. The difference of 23.45 feet per mile would correspond to an average dip of 15′ 16″ if referred to dip alone.

On the south side of the fault plane a determination of the dip may be made in a similar manner. From the base of the Nodaway coal seam at Briscoe to the base of the Hertha limestone, the record of the diamond drill hole at Clarinda gives a thickness of 656 feet, which should be lessened by 70 feet to 586 feet because of thinning out of strata as stated in the Cass county report. From this must be subtracted 82.5 feet, the difference in level between the Nodaway coal (1,014.5 feet above sea level) at Briscoe and the base of the Hertha limestone (932 feet above sea level) at the "Backbone." This difference of 503.5 feet must be accounted for in a distance of 42 miles between Briscoe and the "Backbone," nine miles east of Adair county. At present there is no recorded evidence of a fault plane running northwest-southeast through this region. There is, however, a thinning of strata toward the northeast, which, because of the proximity of the two regions on opposite sides of the fault plane, is here overlooked. The entire difference of 503.5 feet could be accounted for by an average dip of 12 feet per mile (7′ 49″) along the line from the "Backbone" to Briscoe, which is half that found in the same direction along the north side of the fault plane, with the difference in part, at least, due to thinning of strata.

It is not necessary to assume any considerable continuation of the Wilson fault north and south along the east side of the county past Harrison township, so far as thickness of strata is concerned. At Stuart the base of the Hertha limestone is taken to be at 880 feet above sea level. Ten miles south it is, according to the section from Briscoe to the "Backbone", at 802 feet above sea level, a fall of 7.8 feet per mile, or of 5′ 5″, which would give 15.6 feet per mile southwest. This accords fairly closely with the dip of 17 feet per mile southwest obtained from the fall in the strata in ten miles from 1,000 feet above sea level at Earlham to 915 feet above sea level at Stuart.[12]

North and south along the west side of the county, however, from the old shaft in Eureka township to the coal south of Bridgewater, a distance of thir-

[11] Smith, G. L., Idem, p. 618.

[12] H. F. Bain, "Geology of Guthrie County, Iowa:" Iowa Geological Survey, Vol. VII, p. 428.

teen miles, across the fault plane, there is, as above stated, a stratigraphical difference of 743 feet according to the Clarinda well record, which should be diminished by 70 feet to 673 feet because of thinning of strata. At this point (Bridgewater) the Nodaway coal seam is not far from 1,076 feet above sea level, and the base of the Hertha not far from 403 feet above sea level. To this should be added 163 feet for the difference in level between the Nodaway coal at Bridgewater and the base of the Hertha at Eureka shaft. The 836 feet if referred to dip alone would require an average dip of 64.3 feet per mile, or 41′ 52″, to the south. If from this an average dip to the southwest were computed it would be 1° 23′ 44″, an average even greater than the dip found to the northeast near the fault plane, in section 12, Grove township.

Thus north to south along the west side of the county the difference is 8.24 times the difference along the east side of the county, while east and west along the general direction of the fault plane the difference per mile on the south side, where the strata are thinned out more than on the north side, is about half that along the north side. The differences are clearly in harmony with the presence of the fault as worked out in Cass county, and without field evidence that suggests warping in this locality.

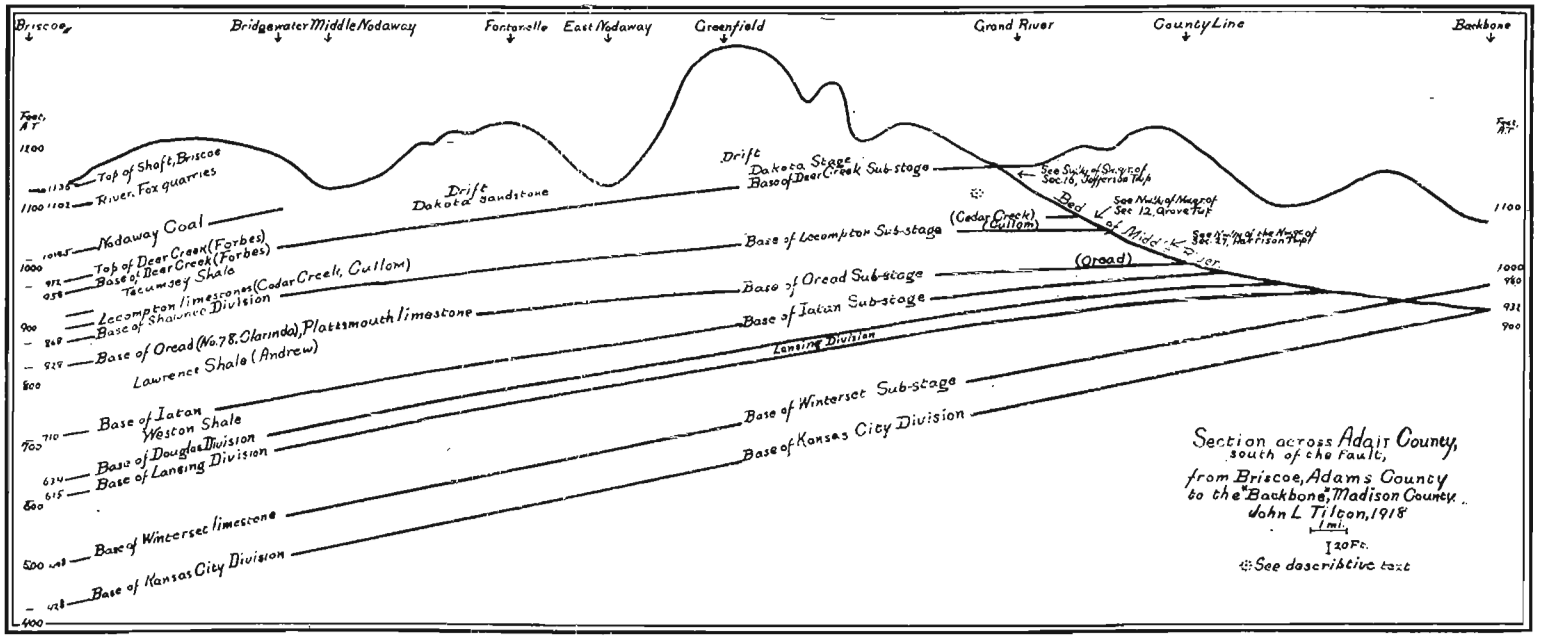
It is further noted that the dip measured in Grove township near the fault is, as stated above, northwest instead of southwest.

Location of the Beds

With an average dip of twelve feet per mile (0° 7′ 49″) on the south side of the fault plane for the entire distance of forty-two miles from the "Backbone" to Briscoe, the base of the Hertha limestone in Harrison township would be 132 feet below the level of Middle river at the "Backbone." If the slope of the river bed is 5.5 feet per mile, as was determined farther down the stream, although it may be more here, sixty feet must be added to the 132 feet, giving 192 feet. This number of feet above the base of the Hertha limestone is a stratum 519 feet from the surface in the Clarinda diamond drill hole. From this computation it is evident that the Stanton limestone is below the bed of the river where the limestone outcrops in the eastern part of Adair county, and that the limestones found in Adair county are a part of one of the important divisions not far above the Stanton.

The following facts also have a bearing on the question:

1st. The Kansas City division thins out from 165 feet thick at Clarinda to 125 feet at the "Backbone."



Section across Adair county, south of the fault, from Briscoe, Adams county, to the "Backbone," Madison county.

2d. "The thinning of the Lawrence shale is from south to north, as is the case of most of the other thick shale members[13]."

3d. There are apparently faunal breaks at the base of the Lansing, beneath the Oread, and in the Shawnee[14], with some evidence of erosional unconformity.

4th. The Deer creek limestone (Forbes) suffers a very pronounced diminution in thickness between Nebraska and Stennett.

5th. Between Briscoe and Bridgewater the Nodaway coal is essentially horizontal, so that at Bridgewater the seam is forty feet below what the average dip from the "Backbone" to Briscoe would lead one to expect to find it.

6th. There is no bed of limestone seen by the writer nor reported either by Gow or by others in the river valleys of Adair county west of Arbor Hill.

All six of these points agree, forcing the conclusion that the Missouri stage as a whole not only has disappeared by erosion at the exposed preglacial surface of the entire stage, but that the various members thin out rapidly to the northeast in this portion of the state.

The Iatan limestone lacks the persistency as a formation that marks the limestone in Harrison township, and the sequence of limestone and shale reported elsewhere for the Iatan does not agree with what is found in Harrison township. The Oread limestone is a resistant ledge, with divisions corresponding to what is here found, less the uppermost portion removed by erosion, and with fossil content agreeing in relative abundance—most pronounced in *Fusulina* beds.

It is therefore the judgment of the writer that these isolated outcrops in Harrison township of Adair county belong to the Oread and associated limestones. He also finds that, situated on the south side of the fault plane, they are the equivalent of the beds at Fox quarries, Lewis and Turkey creek, Cass county, situated on the north side of the fault plane. Other beds of the Missouri stage in which shale is the important element lie concealed beneath the thick deposits of drift along the divide between Arbor Hill and Bridgewater.

[13]Hinds and Greene, "The Stratigraphy of the Pennsylvanian Series in Missouri:" Missouri Bureau of Geology and Mines, Vol. 13, 2d Series, p. 170.
[14]Idem, pp. 155, 169 and 183.

SECTION ACROSS ADAIR COUNTY

The section across the county east and west south of the fault plane is expressed in the accompanying diagram, which may be compared with a diagram of a section east and west across Cass county along a line north of the fault plane. It should be noted that the fault is a dip or slightly oblique normal fault, with offset of thirty-five and one-half miles, and a thinning of strata toward the northeast.

In order to express the relation of the beds that outcrop along Middle river in the eastern part of the county it has seemed desirable to represent the base of the Deer creek substage as it meets the bed of Middle river, which in a straight line is ten and three-fourths miles northwest of the base of the Oread substage where it outcrops in Harrison township. As the strata rise to the north this makes it appear as if the Tecumsey shale became thicker, when in reality all the strata become thinner to the northeast. To obtain the average component of dip in the direction indicated the dip illustrated should be divided by 88 1-3.

THE GLACIAL AND INTERGLACIAL DEPOSITS

JOHN L. TILTON

The glacial and interglacial deposits consist of the Nebraskan, or oldest drift, the Aftonian interglacial deposits, and the Kansan, or uppermost, drift. The lower portion of the loess may also be mentioned here, for the deposition of the loess probably began while the northeastern and northern parts of the state were occupied by ice sheets later than the Kansan, and continued in varying amounts up to the present.

The Nebraskan drift underlies the Kansan drift in parts of Adair county, but it is impossible from existing evidence to define its distribution exactly. From the few places where the stratified rock appears at the surface and from the many more locations where wells reach the stratified rocks without encountering it, it is evident that the Nebraskan drift is now absent from a portion of the county. That it was once present even in those places is evident from its present position in other parts

of the county, from the evidence of weathering that the surface of that drift presents, and from evidence that the surface of that drift has been removed in places by stream erosion in the Aftonian interglacial interval that followed the deposition of the drift. Some of the Nebraskan drift lying in places exposed to erosion by the Kansan ice sheet undoubtedly was removed as that sheet spread over the country. The Nebraskan drift has also in post-Kansan times been removed somewhat in places by streams that have cut through the Kansan drift into the Nebraskan drift.

It has been shown recently by Kay that in many places in Iowa there has been developed on each of the older drifts, the Nebraskan, the Kansan, and the Illinoian, a sticky, tenacious clay, to which the name gumbotil has been given[15]. In Adair county the Nebraskan gumbotil has been found in many places underlying the Kansan drift, and the Kansan gumbotil is found consistently at or close to the surfaces of the remnants of the Kansan upland plain[16].

In the following localities the Nebraskan gumbotil, which separates the Nebraskan drift from the Kansan drift, is about eighty feet below the level of the upland or at a level of 1,136 feet above sea level, since the level of Stuart is given as 1,216 feet above sea level. The Nebraskan gumbotil is three to four feet thick in a few places where its thickness could be noted:

Lincoln township	Se qr of the Se ¼ of section 35
	Eastern portion of section 30
Grove township	Se qr of the Se ¼ of section 14
Harrison township	Sw qr of the Nw ¼ of section 24
	Ne qr of the Ne ¼ of section 30
Summerset township	Sw qr of the Sw ¼ of section 28
	Se qr of the Sw ¼ of section 29
	Ne qr of the Sw ¼ of section 16
Grand River township	Se qr of section 10
Washington township	Sw qr of the Se ¼ of section 29
Orient township	Se qr of the Se ¼ of section 3
	East center of section 9
	Sw qr of the Sw ¼ of section 29
Union township	Se qr of the Se ¼ of section 19.

There are numerous places where the roads cross the level of the Nebraskan gumbotil on the slopes of the hillside, so that the

[15]Kay, George F., Gumbotil, a New Term in Pleistocene Geology: Science, new series, Vol. XLIV, November 3, 1916.

[16]Kay, George F. Some Features of the Kansan Drift in Southern Iowa: Bull. Geol. Soc. of Amer., Vol. 27, pp. 115-117; also Iowa Geol. Surv., Vol. XXV, pp. 612-615.

gumbotil if there present merges with the black soil at the surface.

The tendency of the ravine bottoms to widen out at this same level was so conspicuous that it did not seem fortuitous, but seemed rather to be dependent upon the porosity of the gumbotil and the ease with which it was eroded, thus extending the flat and allowing the Kansan drift above it to be eroded further back. Some of these conspicuous flats are the following:

Walnut township	Southern part of section 32
Jefferson township	Section 8, and Sw portion of section 14
Prussia township	Se qr of the Se ¼ of section 26
	Centers of sections 9 and 10
Summerset township	Section 8
	Sw qr of section 20, and southern part of section 22
Richland township	West part of Se qr of section 21
	Se qr of Se ¼ of section 25
	South central part of sections 27 and 28
	Nw qr of section 28

It will be observed that none of the above locations are in the northwestern portion of the county, nor in the upland anywhere in the county. The Nebraskan gumbotil can be found only where stream valleys and ravines have been cut deep beneath the surface.

What the thickness of the Nebraskan drift, and what the character of it may be beneath the gumbotil can be ascertained only from well records, none of which, unfortunately, give us the necessary data, though two records, numbers 11 and 12, page 314, give depths of 208 and 240 feet respectively, which reach 128 and 160 feet below the level at which the upland phase of the Nebraskan drift, that is the Nebraskan gumbotil, was noted. It is possible that the deepest portions of such wells are really in Nebraskan drift which from meager evidence it is impossible to differentiate. It is also possible that such wells are in Kansan drift only. In this case some of the valleys eroded in the Nebraskan drift in Aftonian times and since then filled in by Kansan drift were from 128 to 160 feet deep, which is a considerably greater depth beneath the Nebraskan gumbotil plain than is yet reported in other counties.

The Aftonian interglacial deposits include such deposits of sand, gravel and related deposits as were laid down in the long

interval of time that elapsed between the melting of the Nebraskan ice sheet and the advent of the Kansan ice. The material was obtained largely from erosion of the Nebraskan drift, and partly from erosion of such sandstone, limestone and shale of underlying formations as may have been exposed. Here also must be included the gumbotil developed from the Nebraskan drift. While the gumbotil itself is a part of the Nebraskan drift the surface of it marks the level of an extensive plain developed first as weathering proceeded and later trenched by stream action following uplift, or change that quickened the streams, through whose work the sand, gravel and clay were sorted and distributed to lower levels. Here also are included forest beds and peat developed in the latter part of the Aftonian times. Evidence of such accumulations in this county must be derived largely from well records, a number of which are included in the description that follows that of the Kansan drift. Evidence of interglacial conditions is especially noticeable in well records numbered 2 and 3, and in the general statement of well diggers.

The Kansan drift is the bowlder-bearing clay that can be seen exposed on the hillsides in all parts of the county. On it and related topographically to the upland plains is Kansan gumbotil. The gumbotil apparently is composed of the former surface deposits of the Kansan plain so changed by long continued weathering that the pebbles and bowlders have been almost completely lost by solution. The soluble portion has been carried away and the clayey portion has thus been relatively increased. By these processes the surface of the drift has been converted into gumbotil, with loss of the characteristics that may have originally marked the surface of the ground moraine.

It is the surface of this Kansan gumbotil or the overlying loesslike clay that forms the rich soil of the upland, from which surface much material which was formerly there has been washed to lower levels and in many cases transported completely away from the county. It is from the Kansan gumbotil that water seeps out upon the hillsides after rainy weather forming the springy ground there so noticeable. Pebbles and sand are sometimes found above this level upon the hillsides, but bowlders, never.

Beneath the gumbotil a yellowish red oxidized portion of the Kansan drift with numerous accompanying pebbles is a marked characteristic along roads and ravines at about forty feet below the general level of the upland. A count of the pebbles in the drift was made in Jackson township, southwest quarter of the southeast quarter of section 13, with the following result:

Red quartzite	30	Quartz schist	2
Dark quartzite	1	Hornblende schist	2
Light quartzite	13	Dark schist	1
Greenstone	30	Limestone, gray	3
Dark granite	1	Chert, gray	6
Light granite	4	Sandstone, reddish brown	1
Decomposed granite	1	Iron concretions from sandstone	1
Quartz	4		
			100

A deeper phase of the same bowlder-bearing portion of the Kansan drift is dark blue in color, and even black. This phase is seen only in material taken from wells, and on the sides of ravines where water has cut back through the weathered portion of the drift. Drift of this character is to be seen immediately south of the wagon bridge over Middle river a mile east of Casey (Walnut township, northwest of the northwest quarter of section 1). Here in a cliff twenty-three feet high from low water level the exposure is as follows:

	Feet
Clay, brown	6
Sand	2
Clay, dark brown above to black below; containing pebbles up to six and eight inches in diameter	15

The following count of pebbles was made at this location:

Red quartzite	16	Quartz	5
Dark quartzite	2	Quartz schist	2
Gray quartzite	2	Sandstone (not native)	4
Light quartzite	3	Sandstone (native)	6
Greenstone	23	Iron concretions from sandstone	1
Dark granite	5	Black shale	1
Light granite	8	Chert	18
Decomposed granite	4		
			100

The clay contained also pieces of spruce, and a streak of reddish yellow sand three inches thick, exposed for a horizontal distance of six feet. One of the greenstones was subangular and striated. The largest stone included in the count was six inches

in diameter and was obtained from the black clay. As the pebbles in the clay were of the same type as those on the clay, the pebbles listed above were picked up indiscriminately.

In both the above counts the sandstone last named, the iron concretions, black shale, limestone and chert are such as may have been derived from such strata as are found in the county. The remainder of the stones came from distant regions.

WELL SECTIONS

JAMES E. GOW[17]

The thickness of the Kansan, and the general nature of the materials composing it, may best be indicated by the sections of a number of well shafts.

1. On the Conway farm, west of Macksburg in Madison county, but not far from the Adair county line, a well shaft was dug which passed through fifty feet of alluvium and Kansan drift. For the most part the latter consisted of a stiff blue clay, unstratified, and without bowlders, though containing a few small pebbles. Below this there was struck a bed of sandy clay in which was imbedded a log of hard wood, probably walnut, four feet in diameter.

2. On the same farm, at about the same depth, the auger entered a bed of rather soft, ill preserved peat. The peat seemed to consist principally of compacted grass and grass roots, and was roughly but not inaptly described by the well digger as a "fossil haystack." Above it lay a nodule of brown haematite the size of a goose egg.

3. On the farm of J. M. Wilson, in section 12, Union township, a well was dug with the following result:

		Feet
2.	Stiff joint clay, yellow near surface, blue beneath	49
3.	Black surface soil with much humus	1
1.	Black silt, with many small wood chips	3

The yellow and blue clay was entirely unstratified, contained a very few pebbles and small bowlders, and *in places* numerous lime concretions.

[17]The remainder of the report was written by Doctor Gow.

4. On what is known as the Ed. Baker farm, northwest of Macksburg, a well was dug, the auger passing through twenty feet of stiff joint clay, varying in color from yellow to blue-black. An impediment was then encountered in the shape of a mass of sticks and twigs lying criss-cross and very slightly compacted. Associated with these were pebbles and bog-iron nodules. The larger sticks were as large as a man's arm, or larger, and were much broken and apparently gnawed at the ends, but not decayed.

5. The well digger reports that on the Funk farm, northwest of Greenfield (Section 2, Summerset township), at a depth of twenty-three feet he was obliged to chop through a willow log six inches in diameter.

6. Some years since the writer watched the boring of a well on lot 3, block 36, original town of Greenfield. The auger passed through two feet of black surface soil, then entering yellow brown joint clay the upper three inches of which had a slightly reddish cast. It passed through fifty feet of stiff joint clay, varying in color from yellow-brown to dark blue-brown, absolutely unstratified, and containing no sand, gravel, or bowlders.

7. A second well on the same lot passed through thirty feet of stiff blue joint clay without pebbles, sand, or bowlders. The lower part of this was the so-called "stinking clay." The two wells are about a hundred yards apart.

8. In the northwest corner of section 7, Jefferson township, a well was sunk to the depth of about thirty feet. The first twenty feet passed through fine-grained black sand with an admixture of barely enough clay to bind it somewhat. The auger then entered stiff blue Kansan clay. The sand is doubtless post-Kansan, and was laid down as part of the old flood plain of Middle river.

9. In digging a well on the Sears farm, in Jackson township, the driller encountered a number of logs at a depth of thirty or forty feet. The overlying material is unstratified blue and yellow clay with many pebbles and small angular fragments of quartzite.

10. In a well on the farm of E. Stacey the auger penetrated to the depth of forty feet through stiff blue clay. At that depth a section of a good sized log of some coniferous wood was removed from the shaft. After digging an additional ten feet through gravelly clay, black Carboniferous shale was encountered. The water was reported to be unfit for use.

11. The city well at Greenfield is bored through 208 feet of stiff blue joint clay, very slightly sandy in places, unstratified, and containing a few small angular pebbles. This is four blocks distant from the Greenfield well already mentioned. The Kansan rests directly on Missouri limestone.

12. In the well on the Witham farm, already mentioned, the clay is reported as having a thickness of 240 feet and as resting directly on Missouri limestone. The clay is blue, unstratified, showing typical joint structure, and containing a very few small angular pebbles and bowlders.

13. About 1897 the writer watched the boring of a well in section 31, Jefferson township. The well was sunk to the depth of about thirty-five feet and the material consisted of a stiff blue clay, unstratified, and without pebbles below the first four feet, very few being present there. The material from this well was piled near the shaft and left there permanently. In 1911 it was examined by the writer. The clay still showed the joint texture but as a result of leaching it crumbled somewhat more readily than it had when first taken out, and the color had changed from dark blue to light brown-yellow.

14. Two wells were dug on section 26, Orient township, under the writer's immediate observation. The section of one is as follows:

		Feet
5.	Black soil	1
4.	Unstratified yellow-brown joint clay grading insensibly down into	3
3.	Unstratified stiff blue joint clay without pebbles or bowlders. This again grades insensibly into	8
2.	Blue joint clay, containing numerous angular pebbles and this in turn grades insensibly into the next	3
1.	Blue joint clay without pebbles or bowlders	15

The shaft of the second well is almost identical with the foregoing except that a very few angular pebbles were scattered

through strata Nos. 1, 3, and 4. Stratum No. 2 shows no signs of stratification, but consists of perfectly typical Kansan clay.

In addition to collecting the foregoing data, the writer has made careful observations wherever the working of the roads has exposed good sections. The individual points at which observations of this sort have been made it is unnecessary to catalog, since the entire county has been quite thoroughly covered in this respect, and the results everywhere agree. The surface soil everywhere except where covered by alluvium or modified by the presence of abundant plant humus is a joint clay—that is, a clay that when crushed dry in the fingers becomes coarsely granular in texture. It is usually light in color, grading through the shades of brownish yellow and brown. The granular surface clay, when exposed in a fresh cut, at some localities shows lime nodules, and at others does not. Where the clay has been penetrated by plant roots the latter are in some cases surrounded by iron, and the soil at the lower limit of the portion penetrated by the grass roots at some places shows a reddish streak. It is nowhere fossiliferous. Pebbles, and small quartzite fragments as large as one's two fists are not uncommon, larger bowlders are occasionally present, and in very many instances the clay is—like the underlying blue clay—entirely without stone fragments of any sort whatever. Where pebbles and bowlders are present they are usually very angular. The largest bowlder the writer has seen was one about three feet in diameter on section 31, Jefferson township, and in Greenfield a number of quartzite bowlders two feet in diameter are used as corner stones and hitching posts, but stones of this size are extremely rare. This yellow joint clay grades down insensibly into the stiff blue clay beneath, and it is impossible ever to draw a definite line of separation between the two. In fact, when the stiff blue clay is exposed at the surface the action of the weather leaches it out to a yellow tint, it becomes somewhat more porous, and takes on all the characteristics of the surface clay as here described. In view of these facts the writer is driven to believe that they are in fact identical.

Loess is a deposit of fine dust, brought by wind from river valleys and dry upland. The surface is generally of a yellowish

hue due to the hydrated oxide of iron which the loess contains, but the deposit is sometimes of a bluish cast. In Adair county only the yellowish loess is observed. Where this loess is present in conspicuous quantities it represents long continued action of the wind in transporting soil from other localities, especially from river valleys, and represents the excess of deposition over erosion by wind and water from Kansan times to the present. The most favorable place for deposition and accumulation of loess is at and near the crest of hills on the lee side of a valley where the upward winds from the valley eddy as they pass over the hill allowing the dust to settle in quiet air.

The best exposure of loess in Adair county is at the railroad cut in the town of Adair (northwest quarter of the northwest quarter of section 3). Here are at least six feet of loess with fossils and concretions capping the divide where a long sweep

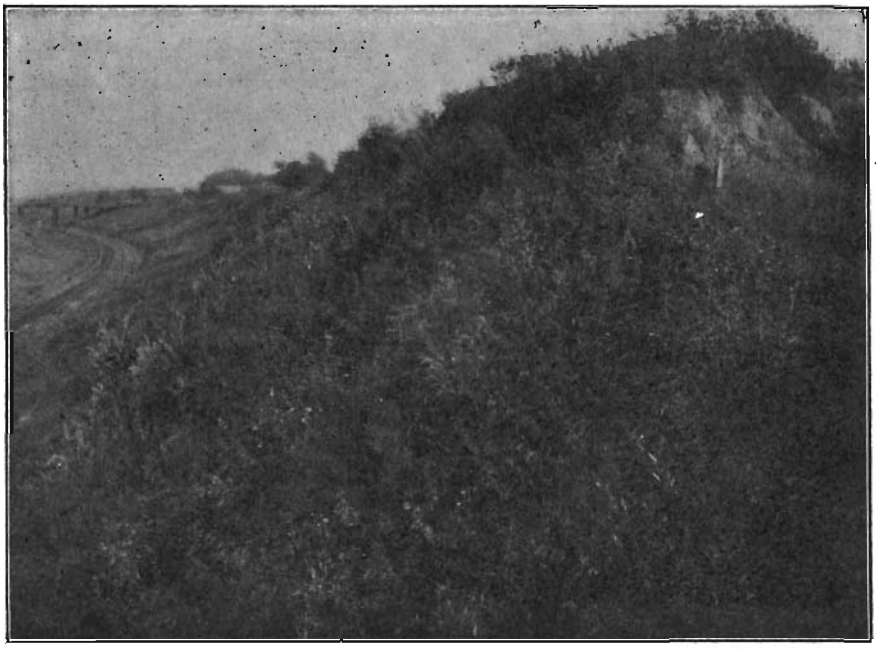


FIG. 39. The railroad cut at Adair reveals a thick bed of loess in the upland where it is now largely concealed by grass. The long sweep of the wind up the valley of Turkey creek in Cass county has transported fine material from the lower to the higher ground and deposited it as a blanket over the adjacent upland to the east, where the deposits are conspicuous for several miles south of Adair. Beneath the loess is the Kansan gumbotil and below this is the Kansan drift with its pebbles, which is exposed in grading the streets in the city of Adair.

of the southwest wind up the valley of Turkey creek has allowed the accumulation of a deposit so located that erosion could not remove it. Southward along the hills east of Turkey creek loess is prominent in the upland soil for about three miles. (The creek flows southwest into Cass county.) What may have been deposited on the sides of ravines has not remained there. So, too, eastward from the valley of Turkey creek the loess on the upland becomes a less conspicuous factor in the upland soil, till, even five miles away, it is not recognizable as a distinct bed, though undoubtedly it is there to a minor extent as a part of the soil. Similarly, in the upland bordering the Nodaway, the light color of the subsoil is due to loess, but loess here is not so conspicuous as it is near Adair. Throughout the entire northeastern half of the county the weathered surface of the Kansan drift is what is converted into a soil, the loess being an inconspicuous portion. Here, in cuttings only two or three feet deep on the edge of the upland, loess is completely wanting and the sticky, dark Kansan gumbotil appears everywhere, while beneath it the pebble-bearing portion of the Kansan drift appears on the hillsides. Loess does not here mantle the hillsides like an undulating carpet.

To sum up: the lower Pleistocene of Adair county includes Nebraskan till, with its uppermost phase, gumbotil, and a sheet of gravels and silts, and old soils, peat and forest beds, representing the Aftonian interglacial period. The upper Pleistocene is the bowlder clay so conspicuous along the hillsides, representing the Kansan drift, and the lower part of the loess in the northwest part of the county, representing post-Kansan glacial and interglacial deposits. The cases of Aftonian deposits mentioned here in detail are but a few of many that might be found. So general is this condition that well diggers tell the writer that below a depth of thirty-five or forty feet they "expect to strike logs" and the Aftonian gravel is well recognized among local well diggers as a water-bearing stratum[18]. Above the Aftonian lies the Kansan drift, of variable thickness depending upon the two factors of pre-Kansan erosion and post-Kansan erosion, but

[18]Mr. Jesse Hines, a veteran well digger residing in Greenfield and well known to the writer for many years, writes thus: "We find pieces of wood in this county *anywhere* when we go down through blue or black clay." Many other well diggers bear witness to the correctness of this statement.

perhaps 270 feet at its maximum. This is a heterogeneous mass of clays, sands, gravels and bowlders, the various materials being arranged in no discoverable order. They nowhere show signs of stratification, nor do they at different points in the county sustain a uniform relation to each other. The materials lie as they were left by the ice, and are, as one would expect, absolutely heterogeneous. Large bowlders are rare, while smaller fragments are not uncommon, the prevailing stone being Sioux quartzite. Sands and gravels are not very common. The typical material is stiff blue joint clay, which on exposure to the weather becomes lighter in color except where stained by iron or darkened by the products of vegetable decay. The blue clay varies in density. Where it is very dense it is when once wet, impermeable by water from above, and is known as hardpan. The hardpan grades insensibly into the softer clay above and below. It sustains no constant relation to the other materials, and may be found at any depth.

Post-Pleistocene Deposits

Typical alluvium as found in Adair county is when dry a very dark gray-brown, when wet it becomes black. It is usually more or less distinctly stratified. Occasionally sand and alluvium are found interstratified, the former of course representing an old bar, the latter being laid down on top of the bar after it had become a part of the overflow plain, through the deepening and shifting of the stream's course. The flood plain is usually broader on the north and east sides of the valley than on the south and west. In the former case it slopes gently back to the hills bordering the valley, in the latter case it usually forms a more acute angle with the hills at their base. The hills to the south and west have a steeper gradient than have those to the north and east. The latter slope southwesterly and face the noonday and afternoon sun. The former are shaded during much of the day, and consequently hold the frost longer in the spring and are not so subject to erosion. This variation in the contours of the two sides of a valley is constant throughout the county for all the larger streams. The best sheltered flood plains are on the

south side of the valleys, and it is there that the timber is densest and there the moisture-loving and shade-loving plants flourish most luxuriantly.

An interesting deposit of stratified gravels and peat is found on the Burrell farm, two miles southwest of Greenfield. At the extreme edge of the flood plain of a small tributary of the East Nodaway, a gravel pit has been sunk to the depth of eight feet. On the side toward the hill the gravel is distinctly stratified with much cross-bedding. On the opposite side (i. e. next the flood plain) the section shows a more uniformly horizontal stratification without cross-bedding, the material being the same coarse gravel mixed with many nodules and cysts of bog iron, the whole bound together by layer after layer of coarse dark colored peat. The peat is very recent, as is evidenced by the fact that the topmost layer forms the present ground surface and shows the hummocks characteristic of the slough grass growing here before the bottom was sowed to blue-grass. The peat consists merely of layer after layer of solidified or semisolidified grass roots to the thickness of about five feet. Many of the tinier roots are more or less intact and are surrounded by red tubules of bog-iron. The hollow bog-iron cysts so common at this point are frequently filled with a matted tangle of grass roots. The cysts differ in diameter from that of a hazel nut to ten or twelve inches. The pebbles making up the gravel exposed at this point are extremely waterworn, *more so than are those usually found in the beds of streams cutting through the Kansan drift.* Their rounded condition, and the fact that quartzite fragments are not present, would suggest an Aftonian origin. The writer suspects that this gravel deposit was originally an Aftonian bowlder, ploughed up by the Kansan ice sheet in its advance, and buried in the Kansan till. Subsequent erosion cut the valley, and in doing so cut through one side of the bowlder. Owing to a local imperfection in the post-Kansan drainage system, however, the material was not carried down into the Nodaway, but was caught in a small bog at the foot of the hill and there redeposited with horizontal stratification. Much coarse grass was growing in the bog, and the peat thus formed was interstratified with the gravel washed down from the hillside. Hematite cysts and nodules

would necessarily form under these conditions. The area of the peat may be traced in the alluvial bottom by the poor growth of the blue-grass, and the fact that it is of a much darker color than is the surrounding grass. The little peat-bog is only a few rods in diameter. It is interesting to note that this tiny and inconspicuous peat bed was discovered by White and is noted by him in his Geology of Iowa. He did not, of course, discover the gravels, as they were not uncovered until 1910.

Another peat bed is known to the writer (Mr. Gow). This one is in the northeast corner of Walnut and the northwest corner of Jefferson townships. This is a part of the flood plain of Middle river, and was originally covered with hummocks of coarse slough grass. It was an area of imperfect drainage, about thirty rods in diameter, having been originally doubtless an oxbow lake and having been filled up by successive crops of grass. Years ago this was turned into a pasture, and the blue-grass turf finally covered it. A well sunk in the turf to the depth of three feet gave an inexhaustible supply of extremely clear water. In wet seasons the place showed a tendency to revert to its boggy condition, owing to the fact that the cattle trampled out the turf, and it was decided to drain the bog into Middle river. The ditch was dug to a depth of five feet, through a rather coarse but densely compacted dark brown peat. Doubtless many peat bogs of this sort might be found along the alluvial plains of the larger streams.

Loess is still in process of deposition, though it may be not so rapidly as formerly, except in dry seasons, for the winds that now sweep from the southwest up the river valleys find the source of supply largely protected by vegetation. Conditions in the past, especially when ice occupied the northeastern portion of the state, may not have favored such a growth of vegetation. The interglacial conditions apparently compared favorably with the changing conditions of the present.

PALEONTOLOGY

The shells of modern land snails are frequently found in the alluvium of flood plains and terraces. No systematic investigation of these has yet been made, and the subject must be reserved for a future paper.

The joint clay which makes up the greater part of the Kansan drift sheet is entirely nonfossiliferous. Many species of land molluscs dwell on the surface of the drift, and are buried by caving banks or become covered by the humus which forms a veneer over the surface, but careful search has failed to reveal any imbedded in the body of the drift. The leached portion of the drift sheet, which has been sometimes mistakenly described as "loess," is nonfossiliferous equally with the deeper and more compact clay.

Owing to the extremely limited opportunities for observation nothing is known as to the fossiliferous character of the Dakota deposits in Adair county. No fossils are reported from the few shafts which penetrate this formation.

The uppermost limestone contains the following species:

Productus nebrascensis
P. punctatus
Athyris subtilita

The massive ledges found below this level reveal the following fauna:

Productus nebrascensis
P. cora
P. costatus
P. punctatus
P. longispinus
Spirifer cameratus
Composita subtilita
Fenestella sp.
Rhombopora lepidodendroides
Allorisma terminale
Derbya crassa
Fistulipora nodulifera
Fusulina cylindrica

The blue shale associated with the foregoing limestone is particularly rich in *Chonetes verneuilianus*.

The shale at Port Union contains a rich and distinctive fauna, of which only the following can here be given:

Aviculopecten neglectus
Aviculopecten sp.
Myalina subquadrata

Owing to the extremely soft and brittle character of the shale at Port Union the securing of perfect fossil remains from it is very difficult, but the shale is extremely fossiliferous and will well repay future investigation on the part of paleontologists. In the Keating breccia were found remains of *Composita subtilita,* and an unidentified *Productus.*

ECONOMIC GEOLOGY

In an earlier day much limestone was quarried from the uppermost beds and the thin ledges of massive limestone below, but the cheapening of cement construction has driven the limestone out of use. For a limestone, the uppermost bed resists the action of rain and frost excellently. Many foundations, and one stone house about forty years old bear witness to its enduring qualities. For purposes of construction, the lower beds are, of course, worthless. The massive limestone will be marketable for macadam and concrete construction as soon as the Port Union country shall be opened up by the advent of a railroad, but the lower beds cannot be used even for this purpose, since they contain too great an admixture of carbonaceous clay. The shales at Port Union, and the other blue shales cropping out farther down Middle river are of smooth, even consistency, without grit, and with the limestone should make a cement of good quality. This industry also awaits the coming of a railroad to make it profitable.

The brick industry in Adair county goes back to the very early history of the county. At a very early day there were brickyards at Fontanelle, Adair, and Casey. About thirty years ago there was a brickyard just west of Greenfield, north of the old Fontanelle road which is now Main street, and at the same time the Day brickyard was in operation a short distance east of Fontanelle in the Nodaway bottom. In all these cases the brick was molded by hand, and was of rather inferior quality as measured by the standard of today, being rough and soft. About fif-

teen years ago a brickyard was established in Greenfield by Mr. J. W. Darby, and for a decade an excellent quality of brick and tile was manufactured at that point. The material used in the early manufacture of brick in the county was the black alluvium of "sloughs" and stream bottoms, since it was then believed that the joint clay was useless for this purpose. In fact, the latter cannot be used successfully where the method of molding by hand is in vogue, since it will check in drying and experience has shown that most of the brick are ruined. It often has the added disadvantage of containing many small pebbles, which of course make its use in brickmaking impossible. The material used by Mr. Darby was a deposit of drift, or joint clay, lying just east of the railway station in Greenfield. At this point the drift is practically free from small pebbles. One large bowlder was uncovered in the diggings, and in a search of an hour covering the exposure the writer found three very tiny flint pebbles. The brick and tile were moulded by machinery, and it was found that there was but little checking and very few were spoiled in the burning. Mr. Darby maintained a permanent equipment of one large brick kiln and three tile kilns, the product being taken as soon as made, and the demand usually exceeding the supply. The establishment finally passed into other hands, and the business having become involved was discontinued in a few years. The machinery was bought by Mr. C. H. Cass of Bridgewater.

Mr. Cass is a contractor and bricklayer who maintains a yard at Bridgewater and manufactures his own materials for the brick buildings constructed by him. Consequently the yard is in operation but a part of the time. The material is ordinary Kansan drift clay, which in the vicinity of Bridgewater is commonly very free from pebbles and sand, and burns into an excellent brick. Mr. Cass has the added advantage of cheap fuel, since wood is to be obtained in the immediate neighborhood. His brick is made both by the machine and the hand-moulding process, and he also manufactures drain tile which is disposed of in the local market. But little effort has been made to work up an outside trade.

The brick and tile industry in Adair county offers good possibilities. The Creston brick and tile works, using identically the

same material to be had at Greenfield, Fontanelle, and Bridgewater, have operated profitably for many years and put out an excellent product. The railway facilities are not so good in the Adair county towns along the Chicago, Burlington and Quincy Railway as at Creston, but at least one good yard could supply all the home trade for the southern half of the county and make the importation of an outside product unnecessary. The trade of the northern half of the county is to a large extent supplied by the output of the Stuart Brick & Tile Company, located just across the line in Guthrie county.

Changes Incident to Human Occupation

Open pastures in all parts of the county show much recent erosion. Gullies have been cut to a depth of a few inches to fifteen or twenty feet, and are gradually backing up from the lowlands toward the higher ground. This process is so general, and is so recent in all observed cases, as to lead to the suspicion that the region may have undergone recent rejuvenation. After careful examination, however, the writer has been led to reject the rejuvenation theory. It is noticeable that the process of gully cutting takes place only in those places where the wild grass has been replaced by tame grass. Blue grass pastures are especially subject to dissection of this sort, while the process is absolutely unknown in those places where the native slough grass still carpets the soil. It must, of course, be remembered that the slough grass is not limited to bogs and marshes, but is the normal ground covering in all shallow sloughs[19] and draws, even where the latter lie close to the crest of the divide. Originally, therefore, every place that would, by reason of its lower level, be the natural starting point for the development of a gully, was covered by the slough grass. This grass grows in hummocks, which lie usually so close together that one may step from one to the other. It roots very deep (three to six feet in cases investigated by the writer) and the root system forms a dense spongy mass that absorbs and holds water readily. The decay of the culms and

[19]This word is here used in its popular sense as meaning a shallow, prairie depression sloping down to a stream valley. It is the writer's observation that this use of the word is practically universal in the common speech of the United States. When so used the word is pronounced "sloo." Usage as general as is this should not be ignored by the makers of dictionaries.

the older roots forms a very absorbent humus, and because of the dense root mass this humus does not wash away, but remains and so increases the absorbent capacity. The grass grows very thick, to a height of three to four feet, producing a dense shade, and thus reducing evaporation. The roots are not limited to the hummocks or "stools" but penetrate between and the whole slough thus becomes a great tough sponge for the retention of moisture. Under these conditions rapid erosion is an impossibility.

When the slough grass has been replaced by blue grass, most of these conditions are reversed. The blue grass makes, it is true, a dense ground cover, but it does not root deeply, and it does not produce a heavy humus. Especially is the latter true in the case of pastures where the grass is continually eaten off short. Once erosion is started at one point it proceeds with great rapidity. The soil beneath the turf (and the latter is but a few inches in thickness) is quickly washed out, the water excavates beneath the edge of the overhanging turf, and the latter soon begins to break off by its own weight and to fall into the little gully thus forming. Each rain storm deepens the gully a little, and backs it up a few feet, until finally the greater part of a valuable pasture may be dissected by a series of several wide deep gullies and many square rods of pasturage destroyed. In the wasteful farming of the past, farmers and agricultural teachers of Iowa have alike failed to estimate at its full value the damage to the agriculture of Iowa wrought by this process. In the more economical farming of the future, effective means will have to be taken to check it.

The cultivation of the soil has, of course, greatly increased the factors of creep and sheet-water erosion, denuding the higher ground of much of its humus, and increasing the thickness of alluvium on the lower lands. To a certain extent, of course, this is unavoidable, but true economy would suggest that the steeper hillsides should not be ploughed, but should be kept in permanent meadow or pasture. The annual run-off has also been greatly modified by cultivation. Under primitive conditions the water of the spring rains was caught by every slough and held through the season, gradually seeping out, as the summer went

on, to feed the smaller streams. The whole land surface was covered by this network of reservoirs which, by reason of the conditions of shade, humus, spongy consistency and depth of root-mass, etc., made an excellent series of feeders for the streams. Under present conditions the run-off is much more rapid in the spring, and this is likely to be succeeded by a condition of semiaridity during July and August. It is no unusual thing for Middle river and the East Nodaway to cease flowing during August, the water being reduced to a few shallow pools. In the summer of 1911, the writer walked for half a mile down the bed of Middle river and not only found no water, but in that distance found the sand for the most part perfectly dry and dustlike. Above and below this half-mile stretch were stagnant pools, and there may, of course, have been a little seepage through the lower part of the sand, but there could not have been much. Such is the condition in a year of drought. Conditions of this sort were unknown in the early days before the breaking up of the prairie and the extirpation of the native grass.

The cutting of much of the timber has had a marked effect on erosion and topography. It is true that much good land has been added to the cultivable area. On the other hand, much land has been cleared that ought to have been left in timber. The clearing of the steeper hillsides has led to the washing away of the humus with which they were once carpeted. This having once occurred, the grass becomes thin, gullies begin to develop, and soon the entire slope is dissected by deep V-shaped valleys, and is perfectly bare of vegetation. If after clearing the attempt is made to put a slope of this sort under the plow, the process of erosion, of course, is hastened. In any case land which was originally productive becomes waste, and then cannot be farmed, nor can it be reforested without tremendous expense. True conservation demands that the rougher land be kept in timber.

The destruction of the brush and smaller forest vegetation has led to much destructive erosion on the steeper slopes. A blue grass surface, covered with sparse timber is readily cut into gullies in the same way as are open pastures though not at the same rate. In clearing ground the brush should be left on the

steeper slopes. With the increasing value of timber, and the advanced price of land, the problem of woodland conservation should no longer be ignored.

NATURAL HISTORY

In its broadest sense, a geological report may include observations not simply on the soil and mineral resources, and the historical geology of the region in question, but also on the plant and animal life indigenous to it. The native mammalian fauna of Adair county has, of course, been largely exterminated. The writer has made no study of the mammalian fauna, and in leaving it for another will merely suggest that the mammals of the county ought to have been catalogued at a much earlier day, and that no time should now be lost in securing as complete a list as possible of the mammalian inhabitants of this part of the state. With entomological questions the writer is unfamiliar, and this work must be left for others. The ornithology of this section, as of the entire state, is already in competent hands, and will be embodied in separate reports to be issued by the Survey. The botany of the county lies within the special province of knowledge with which the writer of this article claims some acquaintance, and his observations thereon will accordingly be included as part of this report.

Botany of Adair County

The relation of botany to geological conditions is always a close one, since the nature of the plant covering and the distribution of plant species depends very largely upon the character of the mantle rock. Conversely, the nature of the vegetation may profoundly modify the ground conditions—and this in many ways, as through the prevention or hastening of erosion, the retention of moisture through shading of the ground surface, the addition of humus to the soil, the change in consistency of the soil through the influence of roots, through chemical changes, etc., etc. This being the case, the geologist is chiefly interested in those phases of botany that relate themselves to such changes as those just mentioned, and he and the botanist

meet on common ground in the field of ecology. It is from the ecological standpoint accordingly that an attempt will be made to treat the botany of the region now under discussion.

The flora of the county comprises a number of fairly distinct types, and these types conform in a general way to the three conditions of moisture, shade, and soil. As the soil is very uniform over the entire area, the chief conditions with which we have to deal are those of moisture and shade. In general these types may be classified as follows:

- Prairie
  - Upland prairie flora Xerophytic to mesophytic
    - High gravel points—Xerophytic.
    - High exposed south and west slopes—partly xerophytic.
    - North and east slopes—Xerophytic to mesophytic.
  - Slough[20] flora
    - Slight depression in high prairie—Mesophytic.
    - And intermediate stages down to wet bogs on lower levels—Hydrophytic.
  - Prairie stream flora
    - Hydrophytic flora, bordered by thin fringe of mesophytic flora.
  - Unforested alluvial bottoms
    - Mesophytic on higher ground.
    - Hydrophytic in bogs and oxbows and near streams.
- Native forest
  - Steep bluff flora, usually on south or west bank of larger streams—Mesophytic
  - Ravine flora, found low in gullies cut in river bluffs, and at base of bluffs. Mesophytic to hydrophytic. This includes much the same species as the next.
  - Shaded alluvial bottoms. Mesophytic to hydrophytic.

The final paper that Doctor Gow evidently intended to prepare on the flora of Adair county was never completed, but his preliminary papers on the subject are of such value that they are reproduced in full.

[20]This word is here used in the sense in which it is universally used locally in Iowa as meaning a shallow depression in the prairie, gradually deepening until it develops into the value of a tributary brook or rivulet. It is never here used in the dictionary sense as meaning a quagmire, nor is this meaning sanctioned by American usage.

FOREST TREES OF ADAIR COUNTY[21]

In order to understand the forestry conditions of Adair county, a short description of the lay of the land and the nature of the soil is first necessary. The county lies along the crest of the "grand divide," between the Mississippi and the Missouri, so that a line drawn along the crest of the ridge traverses it diagonally from northwest to southeast. The land is undulating enough to secure an easy natural drainage, but not so undulating as to be difficult of cultivation, except in a few isolated localities. The soil is a rich, black loam, varying in thickness from a few inches to ten or fifteen feet and underlain by a stiff, yellow clay. Here and there, the larger streams may be found flowing over beds of limestone, but as a rule they flow either through the black surface soil or the yellow clay below it. Of these streams, North river and Middle river enter the Des Moines, while Grand river and the Nodaway flow into the Missouri. Although commonly called rivers, none of them attain to sufficient size, in Adair county, to deserve the name, but all become streams of considerable size before losing their identity in the Missouri or the Des Moines. The rivers along whose course is found the heaviest timber are Middle river and the west branch of the Middle Nodaway, and it is on these streams that the greatest variety of species have been found and most of the observations have been made. The prairie in Adair county is practically bare. The only trees or bushes ever found upon it in any abundance are the hazel and bur oak, and these have been largely grubbed out and destroyed. The wild plum, wild cherry and American crab, may occasionally be found on the high prairie, but they very seldom, if ever, occur there unless protected by other low timber, and as the bur oak and hazel are destroyed, they vanish also. So it is along the streams that the student of forestry must seek his information.

Even a cursory examination of these streams is sufficient to show that, with few exceptions, the southern or western bank is steep and rough, while the northern or eastern bank is smooth and rises with a gentle slope. Along most of the course of Mid-

[21]Gow, James E., Forest Trees of Adair County; Iowa Acad. Sci., Vol. VI, pp. 56-63, 1898.

dle river, through the county, the southwestern bank consists of steep clay bluffs densely wooded and rising abruptly from the water, while the northeastern bank slopes up very gradually from the water—making a wide level valley or bottom, which is usually either destitute of trees, or less heavily wooded than are the bluffs of the opposite bank. The same condition may be noticed quite generally with regard to the smaller streams. In driving along the road it is noticeable that the steepest hills face the north or east, and the gentler inclines the south or west. The reason for this must be that the erosion has been greater on the north than on the south bank, owing to the fact that the former receives the full rays of the spring sun, while the southern bluff lies in shadow most of the day. This, of course, would cause the snow and ice upon the northern slope to melt very quickly, making considerable erosion, while upon the southern bank it would melt much more slowly and hence cause much less erosion. Where the course of a stream is southward it is the left bank which shows the greater signs of erosion, because it is exposed to the burning rays of the afternoon sun, while the right bank is in shadow during the hottest part of the day. The effect of this process upon the distribution of timber is evident. The steep bluff-land upon the southern or western bank of a stream is usually heavily wooded, while the flat "bottom" upon the northern or eastern side is often very sparsely covered with trees and sometimes quite bare. Before the advent of civilization the southern bluffs often held the moisture of the winter snows and spring rains until after the season of prairie fires, thus giving the trees sprouting upon their surface a chance to grow, and, when the trees had grown large enough, they further protected themselves from fire, the surrounding grass being killed out. But the northern bank, which had to face the rays of the spring sun, was well dried by the time the grass on the prairie was dry enough to burn, and so the trees growing upon its surface were destroyed. This is the process which must have taken place during many years before the day when the plow of the first white settler cut the soil of western Iowa. Its effects are still noticeable, but not so noticeable as they must have been at an earlier day. To-day, practically all of the trees

in Adair county are of second growth. There are left only a few isolated specimens of the so-called first-growth timber. Since the days when the prairie fires ceased, seedlings have taken root in the fertile flats which form the northern and eastern banks of our streams, and have grown into trees of goodly size, and in some places the southern bluffs have been shorn of their trees. Still, in a general way, the primitive condition is still noticeable; the timber on the southern bluff is usually larger and thicker than that on the northern bottom. It is noticeable too, on the prairie wherever enough of the original brush has been left to indicate anything at all. The hazel and bur oak will grow on a southern or western slope, but they are not generally found in such a situation. Usually they seek the northeastern side of a hill, and there they flourish luxuriantly.

As has been said, there is very little of the first-growth timber remaining in Adair county. The first settlers of the county found along the streams a thick growth of large, well developed trees. Since then almost all of these trees have been removed, until there remains very little timber which was well grown at the time of the first settlement of the county, forty years ago. In its place has appeared a growth of smaller trees, which were saplings when the older trees were destroyed, or have grown from the seed since that time. Here and there may be seen a relic of the first growth—some giant of the forest who towers high above all the trees about him—but, as a rule, the forest of to-day is made up of younger and smaller trees than those which composed the forests of forty years ago.

The area, however, of the timber land along the streams remains about what it was at an earlier day. It may possibly be a trifle less, but only a trifle. The second growth covers substantially the same area that was covered by the first growth. The chief denudation of the country has come about, not through the destruction of the larger trees which grow along the rivers, but through the removal of the bur oak, hazel, and other prairie species. Before the settlement of the county—if we may trust the accounts of the earliest settlers—a large part of the prairie was covered with brush. To-day the greater part of the brush

is gone and the land upon which it grew is under cultivation. The absence of the brush from the prairie tends to increase erosion and decrease the conservation of moisture in the soil, but its destruction was inevitable because necessary to the successful carrying on of agriculture; and, as conditions grow harder and the land becomes more densely populated and more closely farmed, the destruction of that which is left will become necessary and inevitable. But as the prairie brush is destroyed greater care than ever should be taken to preserve the large and really valuable timber along the rivers, and to extend its area if possible. The people of Adair county have not carelessly destroyed their forests as have the people of many portions of the country. They have preserved them, but it cannot be said that they have preserved them understandingly. The second growth has come in so thick in many places as to choke itself. Valuable walnut, ash or hickory trees are often prevented from making a good growth by the thickets of maple, elm or elder in which they grow, and, too often, when the needs of the farmer force him to cut firewood for himself, he takes all the trees from a certain area, instead of cutting out only those which can best be spared and leaving the remainder. A little popular education on the subject of forestry might remedy these difficulties and teach our farmers to take greater interest in their forests and better care of them.

During the past twenty-five or thirty years the extent of artificial groves in Adair county has grown from nothing at all to many acres. Almost every farm house now has a yard full of trees and a wind-break to the north, and hedges of maple, willow and osage orange line many of the roads. Unfortunately, the best species for the purpose are seldom used in these groves. Instead of planting walnut, ash or white oak, our farmers usually plant the soft maple, on account of its rapid growth, and the result is that no sooner do the trees arrive at a respectable size than the winds play havoc with them. The box elder is much used, more on lawns, however, than in groves, and although rather soft it is a good tree and a very pretty one when properly trimmed. The willow figures occasionally in groves, but more frequently in hedges on low lands, where the maple is also

sometimes used. Groves of walnut or of ash are occasionally met with, but are not common. The cottonwood is used but rarely and the oak never, so far as we know. While these artificial groves are of little value in conserving moisture, preventing erosion and preserving true forest conditions, they are useful in breaking the force of the winter winds, and they exert more or less of a civilizing influence by adding to the beauty of the monotonous prairie landscape and the comfort of life on the farm.

In Adair county a few species of trees, which are common elsewhere in Iowa, are conspicuous for their absence. The butternut, sycamore and hard maple are found in Madison county, along the course of the Middle river, but we have been unable to discover that a single specimen has ever been found growing wild on this side of the line. The Missouri hickory grows along the Nodaway, it is said, north of the state line, but does not extend this far north. The pawpaw is found occasionally in southern Iowa, but has not been found in Adair county. The fact of a few birch trees having been observed, some twenty years ago, near the town of Casey, on the north line of the county, led to a search through that locality, but no birches were found and none have been found in any part of the county. Both the butternut and birch are reported as being common along the course of the North Raccoon river in Guthrie county.

Following is a list of the species of forest trees found growing in Adair county. The nomenclature of Wood has been followed throughout:

Ulmus americana L. White elm. Common on banks of streams and in valleys, sometimes growing a little way up the sides of bluffs and occasionally found on upland. Attains its greatest size on low ground. Well distributed throughout the county. Frequently planted as a shade tree.

Ulmus fulva L. Red elm. Slippery elm. Found only on low land. Common. A smaller species than the preceding.

Ulmus racemosa Thomas. Rock elm. A rare species which we have not found within the county. Has been reported by an early settler, well acquainted with the native timber, as growing in scattered locations along the west branch of the Middle Nodaway.

Quercus macrocarpa Michx. Bur oak. Scrub oak. This species is very common and occurs most frequently on the sides and summits of river bluffs and on the high prairie, where it is a gnarled, stunted, shrubby tree, varying in height from ten to twenty feet. Occasionally, however, it may be found growing in rich river bottoms, where it becomes much straighter, resembling the white oak in its habit of growth and attaining a height of thirty or forty feet. It is the most abundant species of oak and one of the most abundant trees in Adair county. On the prairie it and the hazel appear to be inseparable companions. The bur oak is almost the only tree which safely resisted the prairie fires and grew in abundance on the open prairie, before the advent of civilization. Clumps of it are found scattered over the prairie at intervals—remnants, evidently, of the more abundant growth which once covered the country.

Quercus rubra L. Red oak. A handsome, straight tree, found in tolerable abundance on the bluffs near the larger streams and occasionally on bottom land or in thickets of bur oak on the high prairie.

Quercus alba L. White oak. Not uncommon. Found along the larger streams—seldom, if ever, on prairie. Prefers rough, clay bluffs.

Quercus coccinea var. *tinctoria* Wang. Black oak. Not so abundant as the red oak and occupies the same habitat. Does not attain the size of either of the preceding species.

Negundo aceroides Moench. Box elder. This is probably the most common of all the trees native to Adair county. It is found along all the streams wherever there is any timber at all and is often planted on lawns and in groves on the prairie, where it flourishes.

Acer rubrum L. Red maple. Soft maple. Swamp maple. Quite common. Grows luxuriantly on the banks of streams and in all low, moist places. Very frequently planted in groves and on lawns, where its soft wood is often broken by high winds which it is unable to resist without the protection of larger timber.

Carya alba N. Shell-bark hickory. Common along the larger streams where it grows well up on the bluffs, and occasionally in the bottoms.

Carya glabra Torr. Pig nut. A somewhat smaller and coarser species than the preceding. Usually found on lower land. The two species are about equally common.

Juglans nigra L. Walnut. Common along the larger streams, where it grows luxuriantly and attains a good height. Never seen on the prairie, except when planted there, which is not often the case. The walnut was much more abundant a quarter of a century ago than it is today, although it is still a very common tree. Owing to the value of the wood it has probably suffered more at the hands of woodmen than has any other tree found in Adair county.

Tilia americana L. Basswood. Linden. Quite common in all river bottoms. Seldom seen elsewhere.

Populus canadensis Desf. Cottonwood. Not rare. May be found in occasional clumps in all low, moist situations. Is occasionally planted in groves or hedges.

Celtis occidentalis L. Hackberry. Not rare. Found only in timber along the larger streams, always on low land. Is occasionally transplanted and makes a very handsome lawn tree.

Aesculus flava Ait. Buckeye. A tolerably common species along Middle river and the Nodaway, but never found on Grand river.

Gleditschia triacanthos L. Honey locust. Not common. Is found in scattered groups along both the Nodaway and Middle rivers.

Prunus serotina Ehr. Wild cherry. Tolerably common along the roads and on all waste land.

Prunus americana L. American plum. Wild plum. Very common on low lands. About equally abundant in the larger timber and along the small prairie streams where it and the wild crab are often the only species of trees. Occurs occasionally on the uplands in company with hazel, bur oak and sumac.

Ostyra virginica Willd. Ironwood. Not uncommon along the Nodaway, and may be found on Middle river, but not abundantly.

Crataegus coccinea L. Hawthorn. White thorn. Red haw. Common on low land, usually in larger timber.

Crataegus tomentosa L. Black haw. Not very common. Found in greater abundance on the west than on the east side of the county.

Pyrus coronaria L. Crab apple. Very common on all low land, whether open or covered by larger timber.

Cornus paniculata L'Her. Dogwood. Common in thickets, both in valleys and on the higher land.

Rhus glabra L. Sumac. Common in thickets along the side and crest of river bluffs and on the high prairie. Found usually with hazel and bur oak.

Sambucus canadensis L. Elderberry. Common in thickets on all waste, rich land. Prefers the bottoms.

Prunus virginiana L. Chokecherry. Fairly common on all low land. Usually found in thickets of other timber.

Corylus americana Walt. Hazel. Very common on all rough, rolling land, especially near the larger streams. Very seldom found on low land. Originally a great part of the prairie was covered with hazel, but most of it has been removed. A good deal yet remains, however, and all along the larger streams it is very abundant.

Salix nigra Marshall. Willow. Tolerably common on all low, moist ground.

Vitis aestivalis L. Wild grape. Common in all timber.

Lonicera parviflora Lam. Not common. Found occasionally in heavy thickets.

PRELIMINARY LIST OF THE FLOWERING PLANTS OF ADAIR COUNTY[22]

The collections on which this report is based were made chiefly during the summer of the year 1900, some of the work, however, having been done some years earlier. It is the hope of the author that he may in the course of time be able to supply a complete account of the flora of the county, one which will be exhaustive to the last detail. Heretofore such an undertaking has not been possible for him. The work has been done in the intervals of other work and has taken into account chiefly the more common

[22]Gow, James E., Preliminary list of the Flowering Plants of Adair County; Iowa Acad. Sci., Vol. VIII, pp. 152-159, 1900.

species. It is here presented as preliminary to the more complete report which, it is hoped, will follow it. The grasses and sedges have been purposely reserved for a separate report.

The nomenclature used is that of the sixth edition of Gray's Botany. While more recent systems may have good claims to superiority, the nomenclature of Gray is more generally known than any other, and is better understood by the majority of amateur botanists.

RANUNCULACEAE

Clematis virginiana L. Not rare

Anemone cylindrica Gray. Very common[23]

A. virginiana L. Not rare

Thalictrum purpurascens L.

Ranunculus acris. Very abundant in low grounds.

R. abortivus L.

Isopyrum biternatum T. and G.

Aquilegia canadensis L.

Delphinium azureum Ait. Low grounds. Common.

D. exaltatum Ait. Very rare. One specimen in the author's collection is certainly of this species.

Delphinium tricorne Michx. Very common in low grounds.

BERBERIDACEAE

Berberis vulgaris L. Escaped from cultivation.

PAPAVERACEAE

Sanguinaria canadensis L. Common in woodlands.

FUMARIACEAE

Dicentra cucullaria DC. Very common in woods.

Corydalis aurea Willd. Not uncommon.

CRUCIFERAE

Capsella bursa-pastoris (L) Moench.

Lepidium virginicum L.

Sisymbrium officinale (L) Scop.

Brassica nigra (L) Koch.

B. sinapistrum Boiss.

Arabis Canadensis L.

Cardamine hirsuta L.

Nasturtium armoracia (L) Fries.

N. officinale R. Br.

Raphanus sativus L. Escaped from cultivation.

[23]In the case of the more common prairie species no attempt is here made to describe the habitat, or abundance of the species, except in cases where Adair county shows features which are novel and unusual. Most of the species are common and generally known. As a rule woodland species are noted in the text.

CAPPARIDACEAE

Polanisia trachysperma T. and G.

VIOLACEAE

Viola pedata L.
V. blanda Willd. Not common.
V. cucullata Ait.
V. pubescens Ait.

CARYOPHYLLACEAE

Silene stellata Ait.
S. nocturna L.

PORTULACACEAE

Portulaca oleracea L.
Claytonia virginica L. Common in woodlands.

HYPERICACEAE

Hypericum ascyron L. Common.

MALVACEAE

Malva rotundifolia L.
Abutilon avicennae Gaertn. Escaped from cultivation, or introduced in grain seed.

TILIACEAE

Tilia americana L.

LINACEAE

Linum usitatissimum. Escaped from cultivation.
L. sulcatum Riddell. Not very common.

GERANIACEAE

Geranium maculatum L.
Oxalis violacea L.
O. stricta L.

RUTACEAE

Xanthoxylum americanum Mill. Not common. Found on steep bluffs along the course of Middle river.

CELASTRACEAE

Celastrus scandens L.

VITACEAE

Vitis riparia Michx.
Ampelopsis quinquefolia Mx. Common in timber.

SAPINDACEAE

Aesculus glabra Willd.
Acer dasycarpum Ehrh.
Negundo aceroides Moench.

ANACARDIACEAE

Rhus glabra L.
R. toxicodendron L. Rare, in dense timber.

LEGUMINOSAE

Baptisia leucantha T. and G.
B. leucophea Nutt.
Lupinus perennis L. Probably fugitive from gardens.
Trifolium pratense L.
T. repens L.
T. hybridum L.
Melilotus alba Lam. Quite common, only in the western half of the county, where the roadsides are covered with it.
Medicago sativa L.
Amorpha canescens Nutt.
Petalostemon violaceus Michx.
P. candidus Michx.
Tephrosia virginiana Pers.
Astragalus caryocarpus Ker.
A. cooperi Gray. Not common.
Desmodium acuminatum DC. Common on Middle river near northern boundary of county.
D. rigidum DC.
Lespedeza capitata Michx.
Amphicarpaea monoica Nutt. Tolerably common in woods.
Cassia chamaecrista L. Very abundant.
Gleditschia triancanthos L. Rare.

ROSACEAE

Prunus americana Marsh.
P. serotina Ehrh.
Prunus virginiana L.
Geum virginianum L.
Rubus villosus Ait. Escaped from cultivation.
Fragaria vesca L. Escaped from cultivation.
F. virginiana Mill.
Potentilla norvegica L.
P. arguta Pursh.
P. paradoxa.
P. canadensis L. Common in lowlands.
Agrimonia eupatoria L. Woodlands.
A. parviflora Ait. Woods.
Crataegus coccinea L.
C. tomentosa L.
Rosa arkansana Porter.
Pyrus coronaria L.

SAXIFRAGACEAE

Ribes gracile Michx. Common in woodlands, and cultivated.

LYTHRACEAE

Lythrum alatum Pursh. Not very common.

ONAGRACEAE

Gaura biennis L.
Oenothera biennis L.
Circaea lutetiana L. Not common.

CUCURBITACEAE

Echinocystis lobata Torr. & Gray.

UMBELLIFERAE

Heracleum lanatum Mx. Low prairie. Common.
Thaspium barbinode Nutt. Banks of streams.
Sium cicutaefolium Gmelin. Common on lowlands.
Zizia aurea Koch. Common on lowlands.
Cicuta maculata L. Common on lowlands.
Osmorrhiza brevistylis DC. Not uncommon on higher land than preceding.
O. longistylis DC. Same habitat as preceding.
Eryngium yuccaefolium Mx.

CORNACEAE

Cornus paniculata L'Her. Low thickets. Only tolerably common.

CAPRIFOLIACEAE

Sambucus canadensis L.
Lonicera glauca Hill. (?)

COMPOSITAE

Vernonia fasciculata Mx.
Eupatorium ageratoides L. Rather common in woods.
Liatris scariosa Willd.
L. pychnostachya Mx.
Solidago missouriensis Nutt.
S. speciosa var. *angustata.*
S. rigida L.
S. lanceolata L.
Aster multiflorus Ait.
Aster laevis L.
Erigeron strigosus Muhl.
Silphium laciniatum L.
S. integrifolium Mx.
S. perfoliatum L.
Ambrosia trifida L.
A. artemisiaefolia L.

A. psilostachya DC. Less common than the two preceding species.
Xanthium canadense Mill.
Heliopsis scabra Dunal.
Echinacea angustifolia DC.
Rudbeckia subtomentosa Pursh.
Lepachys pinnata T. & G.
Helianthus annuus L.
H. grosse-serratus Marteus.
Bidens frondosa L.
Dysodia chrysanthemoides Lag.
Chrysanthemum leucantheumum L. Abundant in pastures, in scattered localities throughout the county. A very troublesome weed.
Tanacetum vulgare L.
Senecio aureus L.
Cacalia tuberosa Nutt.
Arctium lappa L.
Cnicus arvensis Hoffm. Common only in isolated localities but spreading.
Taraxacum officinale Weber.
Lactuca scariola L. Very abundant as a weed in gardens, as are also the two following species.
L. canadensis L.
Sonchus asper Vill.

LOBELIACEAE.

Lobelia spicata Lam.
L. syphilitica L.

CAMPANULACEAE.

Campanula americana L.

PRIMULACEAE

Steironema ciliatum Raf. (*Lysimachia ciliata.*)

OLEACEAE

Fraxinus americana L.
F. rigidis Mx.
Asclepias tuberosa L.
A. incarnata L.
A. cornuti Dec.
A. verticillata L.
Acerates longifolia Ell.

GENTIANACEAE

Gentiana alba Muhl.
G. saponaria L.

POLEMONIACEAE

Phlox pilosa L.

HYDROPHYLLACEAE

Hydrophyllum virginicum L. Woodlands.
Ellisia nyctelea L. Not very common.

BORRAGINACEAE

Lithospermum canescens Lehm.

CONVOLVULACEAE

Convolvulus sepium L.
Cuscuta glomerata Choisy. Not common.

SOLANACEAE

Solanum nigrum L.
S. carolinense L.
S. rostratum Dunal.
Physalis lanceolata Mx.
Datura stramonium L.
D. tatula L.

SCROPHULARIACEAE

Verbascum thapsus L.
Veronica virginica L.
Catalpa speciosa Warder. Escaped from cultivation.

VERBENACEAE

Verbena stricta Vent.
V. urticaefolia L.
V. bracteosa Mx.

LABIATAE

Pycnanthemum lanceolatum Pursh. Not common. Woodlands.
Mentha canadensis L. Low prairies—common.
Monarda fistulosa L.
Nepeta cataria L.
N. glechoma Benth.
Scutellaria lateriflora L. Woods.
Brunella vulgaris L. Woodlands. Common.
Stachys palustris L. Woodlands. Common.

PLANTAGINACEAE

Plantago major L.

NYCTAGINACEAE

Oxybaphus hirsutus Sweet.
O. angustifolius Sweet. (?)

ILLECEBRACEAE

Anychia dichotoma Mx. Woods. Not very common.

AMARANTACEAE

Amarantus retroflexus L.

CHENOPODIACEAE

Chenopodium album L.

POLYGONACEAE

Rumex crispus L. Common everywhere.
R. verticillatus L. Tolerably common.
Polygonum aviculare L.
P. ramosissimum Mx.
P. incarnatum Watson. Sloughs. Only tolerably common.
P. persicaria L.
P. orientale L. Escaped from gardens.
Fagopyrum esculentum Moench. Cultivated species run wild.

EUPHORBIACEAE

Euphorbia corollata L.
E. maculata L.
E. preslii Guss.
Acalypha virginica var. *gracileus* Mueller. Not common.

URTICACEAE

Ulmus americana L.
U. pubescens Walt. (*U. fulva* Mx.)
Ulmus racemosa Thomas. Reported from the west side of the county, along the course of the Nodaway river, but very doubtful.
Celtis occidentalis L.
Cannabis sativa L. Escaped from cultivation, or adventitious.
Humulus lupulus L. Occasionally fugitive from cultivation in brush and low woody thickets.
Urtica gracilis Ait.
Pilea pumila Gray. Common in all woods.

JUGLANDACEAE

Juglans nigra L.[24]
Carya alba Nutt.
C. amara Nutt.

CUPULIFERAE[25]

Corylus americana Walt.
Ostrya virginica Willd.
Quercus macrocarpa Mx. High prairie and bluffs along river.
Q. rubra L.
Q. alba L.
Q. coccinea Wang. All four species common along larger streams.

SALICACEAE

Salix amygdaloides And.
S. alba L.
S. nigra Marsh.
S. cordata Muhl. Not common. Discovered on Middle river near Madison county line.
Populus monilifera Ait.

[24] *Juglans cinerea* occurs in Madison county, but has not been found in Adair county. The sycamore tree has also been found to the east of the line separating the two counties, but never to the west of it.
[25] The birch occurs in Guthrie county but has not been discovered in Adair.

ORCHIDACEAE

Spiranthes gracilis Bigelow. Very rare. Collected by Mr. J. G. Culver on the road between Greenfield and Orient.

Cypripedium candidum Willd. Very rare.

Habenaria leucophea Gray. Once very common. Now almost extinct.

IRIDACEAE

Sisyrinchium angustifolium Mill.

AMARYLLIDACEAE

Hypoxis erecta L.

LILIACEAE

Allium canadense Kalm. Abundant in two or three restricted localities.
Polygonatum biflorum Ell. Low woodlands or brush.
Asparagus officinalis L. Escaped from gardens.
Uvularia grandiflora Smith. Woodlands. Not very common.
Erythronium americanum Ker. Woods.
Lilium philadelphicum L.
Trillium nivale Riddell. Woods.
Melanthium virginicum L.
Smilacena racemosa Desf. Woods.

MAYACEAE

Tradescantia virginica L.

TYPHACEAE

Typha latifolia L.

ARACEAE

Arisaema triphyllum Tou.

ALISMACEAE

Sagittaria variabilis Eng.

IOWA GEOLOGICAL SURVEY

GEOLOGICAL MAP
OF
ADAIR
COUNTY
IOWA

BY
JAMES E. GOW
AND
JOHN L. TILTON
1916

Scale 1/125,000
1 ½ 0 1 2 3 4 5 Miles
1 ½ 0 1 2 3 4 5 Kilometers

LEGEND
GEOLOGICAL FORMATIONS

- DAKOTA STAGE
- MISSOURI STAGE
  - SHAWNEE DIVISION
  - DOUGLAS DIVISION
  - LANSING DIVISION
- DES MOINES STAGE
- EXPOSURE OF LOESS — L
- EXPOSURES OF NEBRASKAN TILL — N
- EXPOSURES OF LIMESTONE — Ls
- KANSAS CITY BEDS BENEATH DAKOTA IN WESTERN JACKSON TOWNSHIP — — — —
- APPROXIMATE EASTERN MARGIN NODAWAY COAL, IN SHAWNEE DIVISION — XXXXX
- EUREKA COAL SHAFT (ABANDONED) — ●

GUTHRIE COUNTY
ADAMS COUNTY
UNION COUNTY
CASS COUNTY
MADISON COUNTY
R XXXIII W
R XXXII W
R XXXI W
R XXX W
T 77 N
T 76 N
T 75 N
T 74 N
SUMMIT
WALNUT
JEFFERSON
LINCOLN
EUREKA
PRUSSIA
GROVE
HARRISON
JACKSON
SUMMERSET
GREENFIELD
LEE
GRAND RIVER
WASHINGTON
RICHLAND
ORIENT
UNION
Adair
Casey
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Canby
Berea
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