

Burns & McDonnell
Engineering Library

GEOLOGY

OF

HARDIN COUNTY

BY SAMUEL WALKER BEYER

FROM IOWA GEOLOGICAL SURVEY, VOL. X

ANNUAL REPORT, 1899, pp. 245-313

DES MOINES:
F. B. CONAWAY, STATE PRINTER.
1900.

SG/1A 8:1900

GEOLOGY OF HARDIN COUNTY.

BY

SAMUEL WALKER BEYER.

GEOLOGY OF HARDIN COUNTY.

BY S. W. BEYER.

CONTENTS.

	PAGE
Introduction	245
Location and Area	245
Previous Geological Work (Historical resume).....	246
Physiography.....	247
Topography.....	247
Loess-Kansan	247
Iowan Drift Plain.....	248
Wisconsin Drift Plain.....	248
Table of Elevations.....	250
Drainage.....	250
Iowa River System.....	251
Iowa, proper	251
South Fork.....	256
Other Drainage Systems.....	257
Stratigraphy.....	258
General Relations of Strata.....	258
Table of Geological Formations.....	259
The Ackley Well.....	260
Geological Formations.....	263
Carboniferous System.....	263
The Mississippian Series.....	264
Kinderhook.....	264
The Pennsylvanian Series.....	271
Des Moines	271
Pleistocene System.....	278
Glacial Series.....	278
Kansan.....	279
Iowan.....	280
Loess.....	281
Wisconsin.....	282
History of Drainage Lines.....	285
Terraces.....	288

Economic Products.....	289
Coal.....	289
Clay Industries.....	291
Eldora.....	292
Gifford.....	294
Iowa Falls.....	295
Building Stones.....	297
Kinderhook.....	298
Des Moines.....	299
Pleistocene.....	300
Soils.....	300
Road Materials.....	302
Post-Glacial Gravels.....	302
Indurated Rocks.....	302
Water Supply.....	303
Water Power.....	305
Acknowledgments.....	305

INTRODUCTION.

LOCATION AND AREA.

Hardin county is located in the north central portion of the state. It is the fifth county from the north and east borders, sixth from the south and seventh from the west border of the state. Franklin county bounds it on the north, Story and Marshall on the south; while Grundy and Hamilton counties form its east and west boundaries respectively. The second correction line crosses the county and breaks its rectangular symmetry by causing a shift of the northern tier of townships nearly two miles to the westward. The county is composed of approximately 516 square miles divided into fifteen townships. The three southern tiers are standard congressional townships save Jackson which takes one-half square mile from *Ætna*. Alden and Hardin of the north tier divide equally three of the regular townships.

Geologically the county is of especial interest because it is one of the border counties of the productive coal measures, and its surface has been modified by at least three ice invasions. It is instructive physiographically on account of its varied surface. It presents three topographic types; true erosional in the southeast, semi-erosional in the northeast and typical glacial undrained in the western and by far the greater portion of the county. It merits attention economically because of its stone and lime of the Lower Carboniferous, coal measure shales; and above all on account of its agricultural wealth, due to its well watered surface and fertile soils of the Pleistocene.

HISTORICAL RESUME.

Hardin county was one of the most inviting of the interior counties to the pioneer settler. This was due in large part to the broad timber belt which flanked the north branch of the Iowa river. Thriving settlements early appeared in the "Big Woods" and Steamboat Rock, Hardin City and Alden flourished long before the railroad invaded the territory.

Geologically the county received early attention. Although not mentioned in detail it was included in the area represented on Nicollet's map of 1841.

David Dale Owen* in exploring the "Iowa Coal Basin" ascended the Iowa river to Alden in 1849, and in his classic report gives a general description of the rocks which constitute the Iowa river section. His is the first specific mention of the geology of the region and he was the first definitely to refer the beds to the Carboniferous.

A. H. Worthen,† under the direction of James Hall, visited Iowa Falls and traversed the Iowa river from Eldora to Steamboat Rock. He briefly describes the Iowa Falls section and discusses the assemblage of rocks near Eldora in some detail. Worthen notes in particular the distribution of the coal and the structural peculiarities of the region.

White,‡ a score of years later, under the title of county geology, gives a brief statement concerning the Eldora coal basin which is much more general than either Owen's or Worthen's.

McGee,§ in his Pleistocene History of Northeastern Iowa, casually mentions the Kinderhook beds at Iowa Falls and the gorge of the Iowa river between Iowa Falls and Eldora.

*Report of a Geological Survey of Wisconsin, Iowa and Minnesota, pp. 102-104. Philadelphia, 1852.

†Hall, Geology of Iowa, Vol. I, Pt. 1, pp. 181-182 and 268-272. Des Moines, 1852.

‡White, Geology of Iowa, Vol. II, pp. 257-258. Des Moines, 1870.

§11th Ann. Rept., U. S. G. S., Washington, 1889-1890.

PHYSIOGRAPHY.

TOPOGRAPHY.

Hardin county breaks up into three well-marked topographic provinces coincident with the three drift sheets which are in large measure responsible for the surface features of the county.

The first may be designated the loess-Kansan type and comprises about one-sixth of the superficial area of the county. In this province are included the east half of Providence, all of Union, all save the western tier of sections in Eldora, and the southeastern third of Clay township. The surface is characterized by being perfectly drained, and the salient features are in complete harmony with the drainage lines. In fact they are the results of stream dissection, and hence the fitness of the name erosional topography, of which this area may be considered typical. The large streams flow through well developed valleys and have deposited some alluvium, while their secondary and tertiary tributaries have reached a less advanced stage of development, yet have cut well headwards until the divides are thoroughly drained. In their middle courses these streams flow through sharp gorges. Of this style of stream the north fork of the Iowa may be taken as a type, and this, with its immediate tributaries, is responsible for the most rugged topographic features in the county.

The maximum surface inequalities in this province exceed 150 feet and the upland salients approximate 100 feet above the minor drainage lines. The surface features in the province are believed to be the oldest of any in the county and are graven largely in the later deposits of drift and loess. Away from the stream the elongated hill of the "paha-type" of McGee so characteristic of the marginal portions of the Iowan drift, may be viewed along the south half of the Grundy-Hardin county line. These eminences trend northwest-southeast.

The second topographic province is the Iowan drift plain and comprises the east half of Ætna and the northeast third of Clay township. This is a portion of the great Iowan drift plain which extends from the Minnesota line across Worth, Cerro Gordo, Franklin and the northeast corner of Hardin to Johnson county and forms a broad plain of several thousand square miles area. It is characterized by extreme surface monotony, the streams having done comparatively little cutting. They have low gradients and the reliefs are much more subdued than those of the loess-Kansan. The surface is moderately well drained and the topographic features are in general accord with the drainage lines. Upland surface irregularities scarcely exceed twenty to forty feet in Ætna township.

The third topographic province comprises the area covered by the Wisconsin drift sheet and constitutes more than four-fifths of the area of the county. Its eastern margin is marked by a sinuous chain of hills and knobs, which together form a broad but varying ridge which rises from thirty to sixty feet above the adjoining upland, and is known as the Altamont moraine. The morainal tract varies from two to five miles in width, enters the county west of the middle line of Ætna township, extends east of the Iowa Central at Abbott crossing, turns westward of Abbott, then south, crossing the Iowa river above Steamboat Rock, forms the ridge north of Eldora and Eldora hill upon which the town is built, continues southward and then southwestward, crossing the south fork of the Iowa river just east of the Pleasant-Eldora township line, and looping strongly to the westward forms New Providence hill, whence it turns to the south entering Marshall county. Excluding the morainal belt the third topographic province may be designated the Wisconsin drift plain. Its general surface departs but slightly from a plane. It is characterized by great numbers of saucer-like depressions and knob-like eminences. There is a great scarcity of drainage lines and broad areas are almost wholly undrained. The principal streams have cut deep trenches and often flow between abrupt

walls, and still retain high gradients, showing that their work of down-cutting is not yet completed. In fact the general surface features are those of topographic immaturity.

As in Story so in Hardin county, certain concentric chains of ridges may be observed more or less paralleling the outer moraine. As a rule these recessional moraines lack continuity and cannot be traced any great distance. One such ridge may be noted. It crosses Tipton township from southwest to northeast, cuts the southeast corner of Ellis and northwest corner of Jackson, and continues into Hardin township. This moraine is largely responsible for the complicated bends in Tipton creek and south and north forks of the Iowa river.

Tipton, southern Ellis and Pleasant townships, although they lie wholly within the Wisconsin province, are deeply trenched by the South Fork, Tipton creek and their tributaries, and show some of the most vigorous reliefs in the county. The morainal crossings of these streams are marked by boulder barriers which form rapids.

The Altamont moraine forms a more or less broken ridge extending entirely across the county with crests reaching an altitude of more than 1,100 feet above tide. West of Ackley the ridge has an elevation of more than 1,200 feet; the highest points in Ætna, Jackson and Clay townships where the moraine crosses the river, above 1,150 feet; Court House hill in Eldora 1,110; and New Providence hill 1,130 feet. The highest point in the county is believed to be the crest of a morainal hill north of the Iowa river between Iowa Falls and Alden, which has an altitude of about 1,225 feet. The lowest point is where the Iowa river crosses the Marshall county line at an elevation of 910 feet, giving a maximum surface relief of 315 feet.

The following table of elevations alphabetically arranged is appended:

Table of Elevations.

STATION.	Feet above tide.	AUTHORITY.
Abbott.....	1099	B., C. R. & N.
Abbott.....	1091	Iowa Central.
Ackley.....	1092	Iowa Central.
Ackley.....	1101	Illinois Central.
Ackley Crossing.....	1095	Iowa Central.
Alden.....	1170	Illinois Central.
Clives.....	1070	B., C. R. & N.
Eldora.....	1068	Iowa Central.
Eldora Court House.....	1110	Barometer.
Mill at Eldora, low water level below dam.....	955	Barometer.
Gifford.....	945	Iowa Central.
Gifford.....	948	C. & N. W.
Hubbard.....	1094	C. & N. W.
Hughes.....	1120	Barometer.
Iowa Falls.....	1107	B., C. R. & N.
Iowa Falls.....	1108	Illinois Cent. crossing.
Moraine west of Ackley.....	1200	Illinois Central.
New Providence.....	1130	Barometer.
Owasa.....	1110	Barometer.
Robertson.....	1175	B., C. R. & N.
Radcliffe.....	1189	C. & N. W.
Steamboat Rock.....	976	Iowa Central.
Union.....	928	Iowa Central.
Whitten.....	1036	C. & N. W.

DRAINAGE.

As implied in the discussion of topography the development of drainage lines bears a close relationship to topographic development. So close is the relationship that it is impossible to give a complete exposition of the one without a thorough understanding of the other. The amount of work the streams of a given area may do depend largely upon the "run off," *i. e.*, the amount of water which actually runs off of the surface. The run-off, barring factors of minor importance, is a function of the rainfall and topography. In an area with a vigorous surface relief, the percentage of run-off to rainfall is high, while when the features are more subdued the percentage is correspondingly less. The mean annual rainfall for the county is about thirty inches, and it is believed that about thirty per cent of this is carried away by the principal streams and is, therefore, efficient in sculpturing the land.

In the loess-Kansan province water courses are well developed, the divides are thoroughly dissected by the numerous small tributaries and the surface is completely drained. In the Wisconsin topographic province the drainage systems are barely outlined. Branchless streams when traced headwards lose themselves in a maze of more or less disconnected chains of prairie swales and sloughs. Ponds and kettle-holes are everywhere the rule, often overlooking the best developed drainage lines in the region. Formerly water persisted in many of these basin-like depressions throughout the year, and muskrat houses were familiar features of the landscape. At present tile-drainage and cultivation has rendered these natural basins transient receptacles for the excess of rainfall, although a few still persist even during the driest seasons.

With the exception of inconsiderable areas in the southwest and northeast corners of the county drained by tributaries of the Skunk and the Cedar river systems respectively, the Iowa river with its tributaries drains the entire county. The Iowa river system, as is true of the majority of the river systems of the state, is asymmetric, with the greater number of important branches joining it from the south and west. The system comprises the Iowa, proper; with South Fork, Honey, Mud and Minerva creeks from the west; Elk, School, Pine and Bear creeks constitute the more important tributaries from the north and east.

Iowa river.—The Iowa has its source in the lakes and ponds of Hancock county, enters Hardin county near the middle line of Alden township and takes a most sinuous southeasterly course across the county, entering Marshall about two miles west of the east line of Hardin county. Below its junction with South Fork, the Iowa flows through a broad terraced valley, varying from three-fourths to one and a half miles in width, and has a flood plain averaging a half mile in width. The gravel terrace measures twenty feet above the flood plain at Gifford, ten feet at Union, and is scarcely recognizable

beyond the Marshall county line. The Iowa Central is built on this terrace.

The stream meanders greatly over this broad alluvial flat. Indurated rocks appear in place in the stream channel below the mill at Union, and support the flood plain, rising above

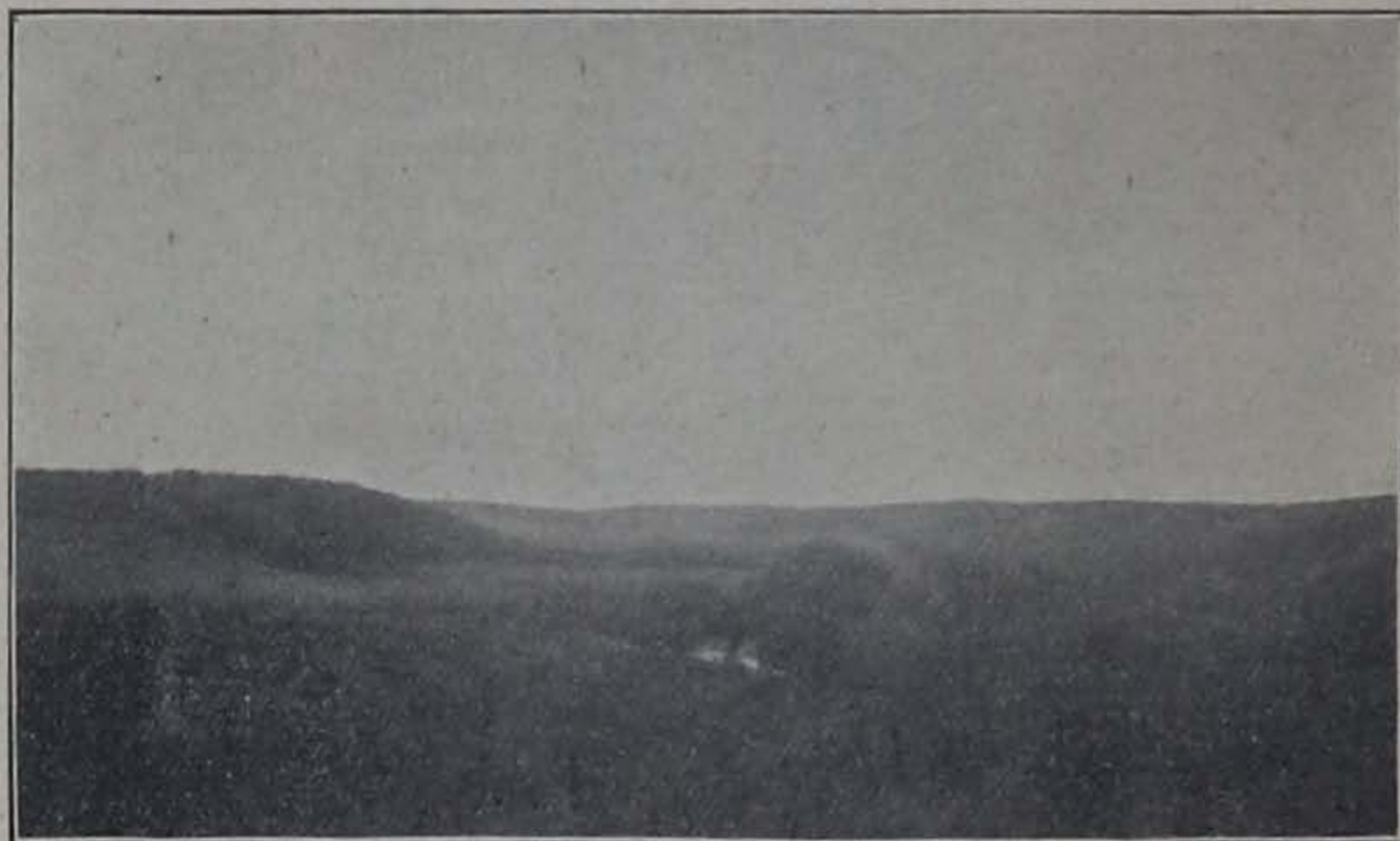


FIG. 23. Iowa river valley between Xenia and Eldora, looking north. Here the river flows through a narrow valley and has deposited little alluvium.

low water level, between Union and Gifford. These facts would indicate that this portion of the stream was extremely old. While it had apparently reached a base level sometime since, it has done but little filling and at present is deepening its channel slightly between Gifford and Union. North of the junction there is a decided change in the landscape. The valley contracts sharply and the flood plain is too narrow to be represented on a map of the scale used in these reports. In this portion of its course almost no alluvium has been deposited. The stream flows over bed rock through a gorge whose walls are rock supported. The convex sides of the bends are often marked by mural escarpments of red sandstone varying from forty to sixty feet in height, crowned by drift bluffs which rise more than 125 feet above low water level. Beyond Steamboat Rock the sandstone ledges are obscured by drift

talus but the restraining bluffs lose none of their precipitousness and range even higher than along the lower course, attaining a height of at least 150 feet above the present channel, between Steamboat Rock and Hardin City, and again between Hardin City and Eagle City. These eminences are largely composed of glacial debris. An impure limestone at the base of the bluff, near the Jackson-Clay township line on the south side of the great bend at Hardin City, forms a shattered ledge some eight to ten feet above the level of the water in the river. The extremely circuitous meanders in the vicinity of Eagle City and Hardin City marks the Altamont moraine crossing. The Gifford terrace is easily traceable to Hardin City, where it has an elevation of thirty-five feet above the flood plain. At Steamboat Rock where it reaches its maximum it is sixty-five feet above the flood plain. The constituent gravels are much coarser at both of these points than at Gifford and Union. At least two other terraces may be noted above this and the stream is engaged at present in cutting one below. At Hardin City the upper terraces are forty-five and seventy feet, and at Steamboat Rock ninety-five and 110 feet, above low water in the river. Iowan boulders were noted in abundance on the ninety-five-foot bench. Northeast of Eldora the gravel bench, which rises about seventy feet above the river, is probably the continuation of the second terrace at Steamboat Rock. The materials are much finer and stratification planes, though much interrupted, are very prominent. Fragments of these terraces may be viewed at other points. The terrace now forming is already out of reach of high water. It varies from fifteen to twenty feet above low water level. The Iowa Central railway is built on it between Steamboat Rock and the point where the railway leaves the river valley north of Eldora. This terrace is also sought out by the C., I. & D. railway for a mile or two either side of Xenia. In the latter region the bench is in part rock supported. Below Union the Gifford terrace merges with the one now forming and thus continue into Marshall county.

Beyond Hardin City there is a marked change in the topographic features; the bluffs recede from the river, and the contours are markedly softened. The gravel terraces which characterize the valley cross-section in its lower course become less prominent and beyond Eagle City practically disappear. The Eldora sandstone, underlain with shales which



FIG. 24. Elk Run, showing the transition from the gorge to the valley stage; near Iowa Falls.

engender a bold relief, has given place to the limestone of the Lower Carboniferous. The change in indurated rocks is clearly recorded in the landscape. At Eagle City the river has made an incision into the limestone of some forty feet. This state of affairs, although more or less obscured by drift talus, persists to the vicinity of Iowa Falls. Here the stream flows through a limestone gorge which attains a maximum depth of seventy feet at the Iowa Central railway bridge. The retreating drift bluffs rise some fifty feet higher. At this point the stream has been displaced in very recent times. There is a well marked channel south of the Bliss annex, now sought out by the C., I. & D. railway. This depression closely parallels

the present channel to the eastward, and also toward Alden. The so-called "Rapids of the Iowa," or "Iowa Falls," from which the town is named, the canyon-like gorge of the river itself, and its inlets, Rock Run, Wild Cat Glen and Elk Run, all owe their origin to this displacement. In fact the accidental blocking of the old channel by the ice, which necessi-



FIG. 25. "Wildcat Glen," looking toward the head of the gorge, near Iowa Falls, Hardin county.

tated the cutting of a new one, has given the surface a picturesque ruggedness which renders Iowa Falls unique among interior Iowa towns; and for natural beauty it is without a peer. Westward the stream walls are less gorge-like. Low rock walls appear almost constantly on one or both sides of the stream as far as Alden. North of Alden the indurated rocks disappear, the bluffs become more subdued and the stream, soon after passing over into Franklin county, takes on the character of a drift prairie stream. Briefly told the Iowa flows through a more or less close walled gorge from Alden to near its junction with South Fork, where it suddenly emerges into a broad valley with a well developed flood plain, and is terraced from Eagle City to the Marshall county line. Its

minor tributaries partake of the characters of the parent stream, with this exception, that those from the east have well developed flood plains, relatively low gradients and other characters common to maturely developed streams. It may be of interest to mention that above the forks the Iowa river does not receive a single tributary from the west worthy of a name. The area drained is inconsiderable, drawing almost no tribute save from the north and east.

South Fork.—The South Fork, with its tributaries, Beaver and Tipton creeks, drains more than one-third of the county. The South Fork takes its rise in the ponds and swales of Wright county, flows south across Alden township, where it is little more than a series of prairie sloughs and marshes, continues diagonally across Buckeye, Ellis and Pleasant townships, and joins the Iowa in northern Union. From north central Buckeye to the Tipton-Pleasant township line its course is extremely crooked, the stream doubling and redoubling on itself. The principal morainal ridges are crossed in the southeast corner in Ellis and in Tipton townships, and this is also the region of the greatest meanders. The river has cut to a depth of from fifty to one hundred feet below the general upland, but has deposited little alluvium. Near Point Pleasant the river enters a broad, terraced valley, with a flood plain which varies from one to three-fourths of a mile in width, in every way similar to, and comparable with, the valley of the lower Iowa. Only at rare intervals does the stream lay bare the indurated rocks, as in southern Ellis and northern Tipton townships. South Fork, above the junction of Tipton creek, as in the upper course of the Iowa, shows a dearth of small tributaries.

Beaver creek occupies a broad depression behind the extreme advance of the Altamont moraine and is essentially a prairie stream. The lower course is gravel terraced and possesses a mapable flood plain. The stream is not walled in between bluffs as in the case of South Fork, nor does it bear

any evidence of having done any considerable amount of cutting. It appears rather to occupy simply a depression not of its own making. Its branches are symmetrically disposed, and the width of the area drained as compared to its length is about one to three.

The general features of Tipton creek are almost exactly identical with those of the South Fork. It has its source in Hamilton county, cuts a deep and extremely crooked trench across Tipton township, and joins South Fork in west and central Pleasant township. Springs are quite common along both Tipton creek and South Fork, and both streams throughout their entire courses become completely dry or are reduced to detached basins during seasons of protracted drouth. The portions of Honey, Mud and Minerva creeks in Hardin county are essentially prairie sloughs and swales. Honey creek, from Hubbard southeastward, resembles Tipton creek, though it has done less cutting, and its restraining bluffs are less rugged. All are waterless during dry seasons.

Of the tributaries that enter the Iowa from the east all of those outside of the Wisconsin topographic province, flow through erosional valleys of considerable importance when the size of the stream is taken into account, and have well marked flood plains. Elk and Pine creeks show gravel bars where they enter the Iowa, and bear evidence of being older than the parent stream. Bear creek enters the broad valley of the lower Iowa.

Elk Run and School creeks in Hardin township have cut gorges in the indurated rocks and are exact counterparts of the Iowa itself in that region.

Indian creek, a tributary of the Skunk river system, affords partial drainage for ten square miles in Concord township, while tributaries of the Cedar drain half of Ætna and the northeast corner of Clay townships.

Desiccated lake beds of small size are common. Two of the most prominent of these may be observed in Grant township. They occupy the general depression inside of the moraine.

The two best defined lake beds are on sections 13 and 21. The former extends into section 18 in Providence township. These depressions have quite regular boundaries and the sand flats have not yet received sufficient silt and wash to support more than a meager vegetation. Depressions similar to these, and in which water persists throughout the year, appear in Hamilton county.

STRATIGRAPHY.

GENERAL RELATIONS OF STRATA.

Hardin county must be classified as one of the frontier counties of the Iowa coal basin. Coal measure strata are known to extend east of Eldora and Steamboat Rock and are believed to cover more than two-thirds of the superficial area of the county. Norton reports over 200 feet of coal measure strata penetrated in sinking the Ackley deep well. This would make the distribution most anomalous, for according to the field relations the coal measures extend but little beyond Steamboat Rock. The Kinderhook is the country rock over the remainder of the county.

The Pleistocene deposits represent at least three ice invasions, the first of which covered the entire county, the second the northern portion, and the third and last the western two-thirds of the county. Interglacial deposits separate the second and third, while post-glacial deposits may be observed along the principal streams. The taxonomic relations of the formations represented are shown synoptically in the subjoined table.

GROUP.	SYSTEM.	SERIES	STAGE.	FORMATION.
Cenozoic.	Pleistocene.	Recent.		Alluvium. Post-glacial gravels.
		Glacial.	Wisconsin.	Drift.
			Iowan.	Loess. Drift.
			Yarmouth? Kansan	Buchanan gravels. Drift.
Paleozoic	Carboniferous.	Upper Carboniferous or Pennsylvanian.	Des Moines	Eldora sand- stone. Lower shales.
		Lower Carboniferous or Mississippian.	Kinderhook	Limestone and dolomite. Shale.

The Pleistocene deposits rest unconformably upon the Paleozoic group and are separated by an enormous erosion interval which probably occupied all of Mesozoic and Tertiary times, for no strata representing this interval are known to occur within the confines of the county. On section 23 of Providence township fragments of a shaly sandstone were obtained from the drift talus along Honey creek which contained Cretaceous fossils; but the blocks bear evidence of ice action and were undoubtedly brought in through that agency.

The surface croppings of the indurated rocks are confined, with a few unimportant exceptions, to the Iowa river and its immediate tributaries.

Rocks older than the Carboniferous are not known to appear at the surface in the county. The nearest Devonian outcrops are in the valley of the Cedar almost a score of miles to the east, and which, according to the Ackley and Eldora wells, dip at least 300 feet beneath the surface before the Hardin

county line is reached. The deep well at Ackley shows the complete Paleozoic series below the Carboniferous. According to Prof. W. H. Norton* the strata penetrated are as follows:

ACKLEY WELL.

(Elevation 1115 feet above tide)

NO.		DEPTH.
87.	Alluvium or drift.....	
86.	Shale, fine, blue.....	100
85.	Shale, fine, blue, somewhat calcareous.....	115
84.	Limestone, buff, vesicular.....	135
83.	Shale, fine, blue, slightly calcareous.....	140
82.	Shale, fine, blue.....	150
81.	Sandstone, fine, bluish-white, friable.....	163
80.	Shale, fine, blue.....	225
79.	Shale, fine, blue.....	249
78.	Shale, fine, blue.....	250
77.	Sandstone, as No. 82.....	260
76.	Shale, blue and white, with black ferruginous concretions.....	265
75.	Shale, fine, blue, somewhat calcareous.....	290
74.	Limestone, buff, magnesian, highly pyritiferous, containing a little chert.....	307
73.	Shale, blue, calcareous and limestone, some blue, argillaceous and some gray and purer, fossiliferous, with a few particles of black bituminous shale....	320
72.	Limestone, dark gray, magnesian.....	335
71.	Limestone, argillaceous, non-magnesian, with a fragment of <i>Atrypa reticularis</i> Linn.....	400
70.	Limestone, light yellowish-gray, argillaceous, slightly magnesian, with some green shale.....	410
69.	Limestone, light, bluish-gray, non-magnesian.....	460
68.	Limestone, light yellowish-gray, argillaceous and slightly siliceous.....	473
67.	Limestone, blue, argillaceous, non-magnesian.....	500
66.	Limestone, blue, argillaceous, slightly magnesian.....	555
65.	Limestone, brown, slightly magnesian.....	570
64.	Limestone, brown, slightly magnesian.....	600
63.	Limestone, brown, slightly magnesian.....	610
62.	Limestone, light brown, magnesian.....	635
61.	Dolomite.....	730
59.	Dolomite, with much chert.....	735
58.	Dolomite, with much chert.....	740
57.	Dolomite, with much chert.....	750
56.	Dolomite.....	751
55.	Dolomite.....	757

*Iowa Geological Survey, Vol. III, pp. 189-192.

54.	Dolomite.....	759
53.	Dolomite.....	760
52.	Dolomite.....	764
51.	Dolomite, with chert.....	775
50.	Dolomite, with chert.....	787
49.	Dolomite, with green shale.....	797
48.	Dolomite, with green chert.	800
47.	Dolomite, with green chert.....	803
46.	Shale, green, samples of this from 815 to 960 feet. A hard, brown dolomite, crystalline, cherty, occurs at 875 and 896 feet, thus being interbedded in the shale.....	960
45.	Limestone, light gray, cherty.....	975
44.	Limestone, light gray, cherty.....	995
43.	Limestone, light gray, soft.....	1015
42.	Limestone, light gray, darker.....	1040
41.	Limestone, light gray.....	1080
40.	Limestone, light gray, softer.....	1100
39.	Limestone, light gray, softer	1150
38.	Limestone, soft, light gray, with some darker bluish-gray.....	1160
37.	Limestone, light gray.....	1180
36.	Limestone, light bluish-gray, fossiliferous.....	1205
35.	Limestone, light bluish-gray, fossiliferous.....	1230
34.	Limestone, light bluish-gray, fossiliferous.....	1238
33.	Limestone, light buff.....	1250
32.	Limestone, dark gray.....	1257
31.	Limestone, light gray.....	1275
30.	Limestone, drillings are a fine bluish-black cal- careous sand mixed with some of lighter color, highly pyritiferous, considerable argillaceous material and many microscopic particles of quartz.	1300
29.	Limestone, bluish-gray, fossiliferous.....	1320
28.	Shale, green.....	1325
27.	Shale, bright green, indurated, slaty, highly pyrit- iferous.....	1335
26.	Shale, bright green, slaty.....	1350
25.	Sand, white, grains rounded, somewhat uniform in size.....	1360
24.	Sand, white, grains rounded, somewhat uniform in size	1405
23.	Sand, white, grains rounded, somewhat uniform in size, finer.....	1415
22.	Limestone, white, subcrystalline.....	1445
21.	Dolomite, in fine, light yellow powder.....	1480
20.	Dolomite, with considerable light green shale.....	1490
19.	Dolomite, buff, with shale and ocherous grains.....	1500
18.	Dolomite, white, with some chert and quartz and green shale.....	1505

GEOLOGY OF HARDIN COUNTY.

17. Dolomite, white, with some chert, quartz and green shale.....	1515
16. Dolomite, light yellow	1530
15. Dolomite, hard, gray, subcrystalline, with grains of quartz.....	1540
14. Dolomite, white.....	1548
13. Dolomite, hard, rough, light buff, subcrystalline..	1550
12. Sandstone, white, rounded grains, with numerous minute chips of dolomite.....	1565
11. Sandstone, as above.....	1580
10. Sandstone, light, fine grained, friable, grains rounded, varying widely in size, the largest being about one millimeter in diameter.....	1595
9. Sandstone, hard, light gray, moderately fine grained, with considerable green shale.....	1610
8. Sandstone, white, grains rounded and resembling the Saint Peter in general uniformity in size; many from seven to nine millimeters, largest over one millimeter.....	1635
7. Dolomite, buff.....	1645
6. Dolomite, arenaceous or calciferous sandstone....	1675
5. Dolomite, hard, gray, subcrystalline, pyritiferous.	1685
4. Dolomite, light gray.....	1720
3. Dolomite, siliceous, gray, with admixture of quartz grains, and some chert.....	1820
2. Dolomite, like above, but with more chert.....	1950
1. Sandstone, grains rounded, moderately large, with considerable gray dolomite..	2000

In his summary Professor Norton refers samples seventy-five to eighty-six, inclusive, to the coal measures. In the light of the known field relations this reference is scarcely tenable. The Eldora sandstone has thinned materially at Steamboat Rock, and the coal-bearing shales are entirely absent. The top of the Kinderhook, hence the base of the coal measures, is 950 feet above tide at Eldora, 970 feet at Steamboat Rock, and 1,110 feet at Iowa Falls. The top of the indurated rocks reached in the Ackley well is 1,010 feet above tide, which would accord very well with the above figures for the top of the Kinderhook and the base of the coal measures. It is also well known that rocks of Kinderhook age appear along Wolf creek at Conrad, in Grundy county, near Hampton, in Franklin county, and were recognized by Calvin* in southwestern Cerro Gordo county. With the present light it would appear

*Iowa Geological Survey, Vol. VII, pp. 170-171.

altogether probable that the upper 200 feet of shales with intercallated limestone should be referred to the Kinderhook. The corrected summary of formations would then stand as follows:†

	Thickness.	Depth.	At top.
Pleistocene	100	100	1,010
Kinderhook.....	207	307	803
Lime Creek.....	28	335	775
Devonian unclassified.....	300	635	475
Niagara.....	180	815	295
Maquoketa	160	975	135
Galena-Trenton.....	385	1,360	-250
Saint Peter.....	85	1,445	-335
Upper Oneota.....	120	1,565	-455
New Richmond.....	70	1,635	-525
Lower Oneota.....	185	1,820	-710
Jordan.....	210	2,023	-920

The Carboniferous series has not been penetrated at any other point in the county, with the probable exception of the well at Iowa Falls, where a hard, close-textured limestone was reached at about 310 feet below the level of the I. C. and B., C. R. & N. railroad crossing.

GEOLOGICAL FORMATIONS.

CARBONIFEROUS SYSTEM.

The Carboniferous system in the county is represented by two discordant series of beds which are supposed to mark the earliest and latest deposits of that great period, as represented in the immediate region. The first in its surface outcrops is essentially a limestone and belongs the Mississippian series, while the second comprises ferruginous sandstone and shale and is referred to the Des Moines.

†Norton, Iowa Geol. Surv., Vol. VI, pp. 219-220.

THE MISSISSIPPIAN SERIES.

KINDERHOOK.

Only the lowest member of the series is known to be present in the county. Owen* in his reconnaissance survey of the Iowa coal basin recognized the limestone walls of the Iowa river at Iowa Falls and Alden as Carboniferous, but it remained for White† to refer the beds to their proper division, the Kinderhook of Meek and Worthen.‡ Worthen,§ in his discussion of the section at Iowa Falls, tentatively referred the brown magnesian limestone to the Burlington and the lower compact limestone to the Chemung stage of the Devonian. The Kinderhook is believed to envelop the entire county. Superficially it is composed chiefly of a brown, earthy to sugary dolomite, followed by layers of compact, white to gray limestone often exhibiting semi-oolitic facies and sometimes appearing argillaceous or even arenaceous. The principal outcrops are along the Iowa river from Eagle City to Alden. At Iowa Falls there appears to be a decided arching up of the strata and a maximum section of eighty feet is exposed in the river gorge. The limestone beds so far as known are everywhere underlain by a thick deposit of shales, believed to be continuous with the shales which outcrop along the Mississippi river at Burlington. The river gorge at Iowa Falls, taken together with the city well, gives the most important section of the Kinderhook in Central Iowa. The well record shows the following sequence. ||

*Geol. Surv. of Wis., Iowa and Minn., pp 102-104, 1852.

†Geology of Iowa, Vol. I, pp. 197-198.

‡Am. Jour. Sci. (2), Vol. XXX(I), p. 228, 1861.

§Hall, Geology of Iowa, Vol. I, pt. I, pp. 180-181.

|| I am indebted to Mayor W. H. Woods of Iowa Falls for a carefully preserved set of drillings upon which the record is based. Mayor Woods also furnished a complete record of the flow and pumping tests.

SAMPLE.	Thickness.	Depth.
1. Drift and weathered material.....	50	50
2. Limestone, light-gray, compact.....	15	65
3. Limestone, brown, dolomitic, subcrystalline.....	29	94
4. Limestone, gray-blue, magnesian, cleavage fragments of calcite not uncommon; compact; grading downward into a light-colored and less magnesian limestone.....	16	110
5. Limestone, gray, semi-oolitic in texture.....	5	115
6. Limestone, gray-brown, dolomitic and porous; drillings of a gray, compact limestone abundant.....	11	126
7. Limestone, brown, dolomitic, with considerable light-colored chert.....	37	163
8. Dolomite, gray-brown.....	7	170
9. Dolomite, yellowish-brown, sugary.....	7	177
10. Sandstone, gray-blue, shaly.....	7	183
11. Sandstone, white, friable and very fine-grained.....	10	193
12. Sandstone, gray, fine-grained and compact; slightly argillaceous and non-calcareous.....	14	207
13. Limestone, blue-gray to yellowish-gray, compact; slightly argillaceous and exhibits an almost earthy fracture.....	6	213
14. Shale, plastic, even-textured, light gray-blue and slightly calcareous above.....	62	275
15. Limestone, hard, compact (penetrated).....	2	277

The mouth of the well is located near the head of Rocky Run gorge and is about thirty-five feet lower than the Burlington, Cedar Rapids and Northern railroad depot. The limestone represented by sample No. 2 is believed to be identical with the white limestone which appears just above the water level along the river. The river section is as follows:

	FEET.
6. Drift reduced to a heterogeneous mixture of boulders and fragments of county rock at the face of the escarpment but thickens greatly in the bluffs.....	0-80
5. Dolomite, brown, saccarhoidal, heavy-bedded below, but thinner-bedded and much shattered above; often exhibits an earthy fracture when weathered. Numerous casts of <i>Straparollus obtusus</i> present in places.....	20-30
4. Limestone, light gray, composed largely of shell breccia and containing a Brachiopod fauna; has a mealy appearance, but on close inspection is found to be but slightly concretionary.....	5
3. Limestone, gray-brown, is finer textured, more compact and evenly bedded than the above.....	3

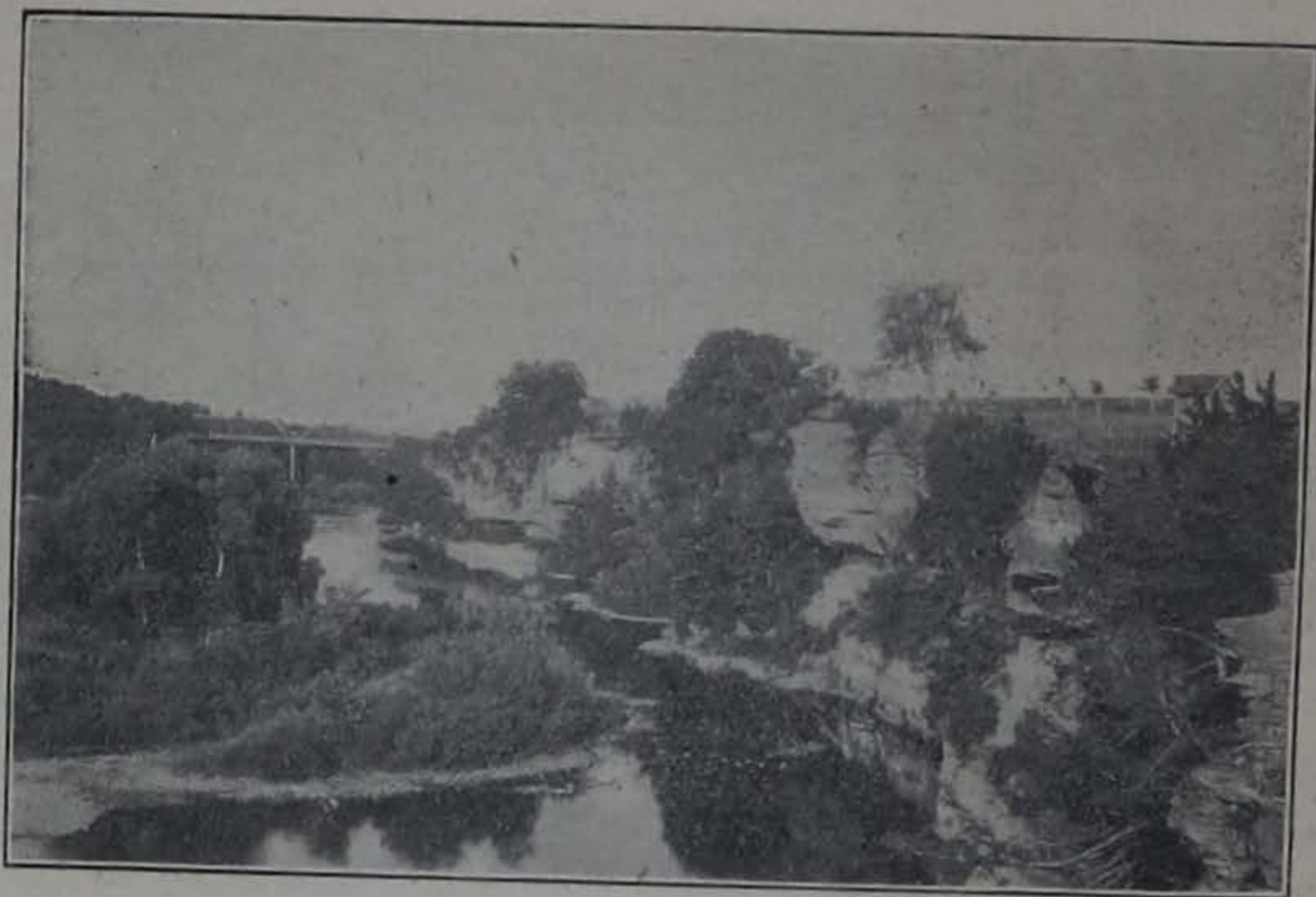


FIG. 26. Gorge of the Iowa river, Iowa Falls.



FIG. 27. Iowa Falls section showing the arching up of the Kinderhook beds below the mill

2. Limestone, light-gray; weathers white and so appears in the gorge walls, exhibits a conchoidal fracture and is heavy bedded..... 5
1. Limestone, shaly to slightly arenaceous in certain layers; in places forms a slight re-entrant in the cliff-walls; exposed above water level..... 5-10

Combining the well and river sections the Kinderhook is seen to possess a thickness of 310 feet and is composed of

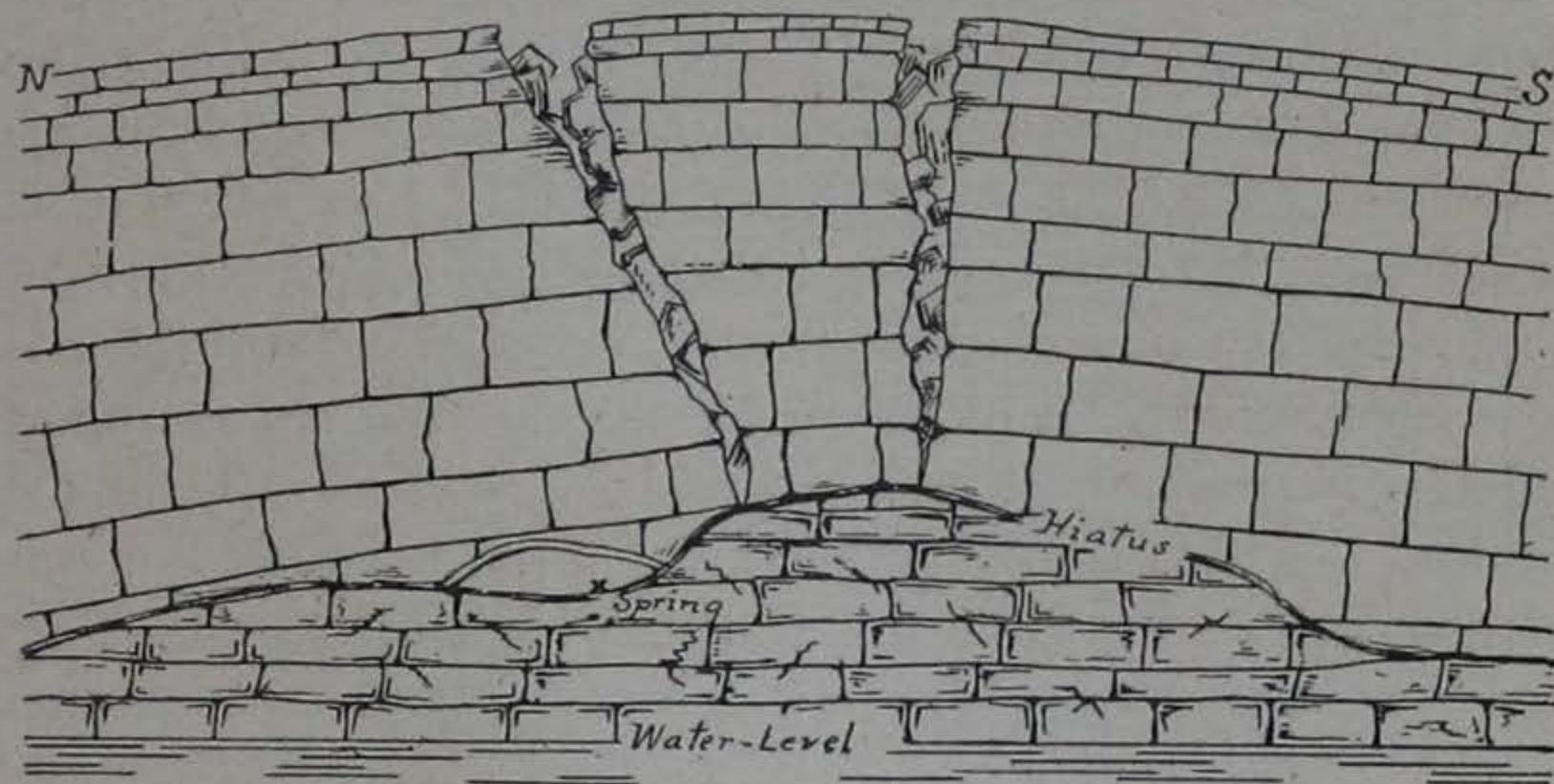


FIG. 28. Section at Ivanhoe quarry showing the local unconformity and the shattering of the upper beds.

alternating beds of limestone and dolomite above, which are underlain by water-bearing arenaceous beds resting on a heavy shale floor.

Below the flouring mills a beautiful flexure in the upper layers may be observed. This anticlinal is of short length and slight amplitude, scarcely more than ten feet, and pitches southward. At this point the Kinderhook beds reach their maximum exposure in Hardin county. To the east and to the west the beds continue in a series of gentle undulations which find expression in the stream channel itself in the numerous recurrence of ripples and pondings. Westward the rocks become sub-crystalline in texture, more shattered, and thinner bedded. At the Ivanhoe quarries the following layers may be viewed:

	FEET.
3. Drift (of great depth in the bluff).....	0- 3
2. Limestone, grayish white, subcrystalline, very hard and much shattered; thinly bedded.....	20

Apparently a local unconformity.

1. Limestone, much disintegrated and cavernous. In places a residual clay appears between 1 and 2. Surface very uneven, exposed.....	6
--------------------------------------------------------------------------------------------------------------------------------------------	---

The river at this point runs nearly due south. At the point where it turns south a ripple appears. Fifty yards below, No. 1 reaches its maximum exposure. No. 2 is rent by a large fissure immediately above the old salient. Just north of the fissure large springs appear, and the water which issues from them is highly charged with iron. The subcrystalline limestone above forms an overhanging scarp. Diligent search was made for fossils in both beds but without reward. Beyond the Ivanhoe quarries to Alden the river flows between low limestone walls varying from ten to thirty feet in height. These limestone barriers are almost cut out in one or two instances by coal measure outliers. In Alden the beds greatly resemble No. 1 in the Ivanhoe section. The beds observed were:

	FEET.
3. Drift, as in previous sections, is thin at the face of the scarp; a number of large granitic boulders were noted	3
2. Limestone more or less evenly bedded; appears to be lithologically the same as No. 1; a marly or shaly band separates 1 and 2 generally	12
1. Limestone, light-gray, hard, sub-crystalline and oolitic in texture. The lower four feet show marked cross-bedding; false beds dip to the southwest; the upper surface is somewhat undulating and dips gently to the south.....	5

Here, as in the preceding exposures, the beds are much rifted and shattered. Individual layers rarely exceed four or five inches in thickness, and two well developed series of fissures are visible. The fissures of the major series trend north and south, and are apparently parallel to the corrugations, while those of the minor series stand approximately at right angles to the folds. Genetically the two series probably form

but one great system and were formed at the time of rock crumbling.

North of Alden the indurated rocks dip rapidly and were not observed beyond the corporate limits of the town.

Eastward of the Falls limestone, ledges are more or less continually present to Eagle City, where the following section is exposed:

	FEET.
5. Drift, exposed	5-10
4. Dolomite, yellowish-brown, much shattered where viewed; contains a few siliceous nodules.....	10-25
3. Limestone, gray, sub-crystalline and semi-oolitic..	1½
2. Dolomite, yellow to gray, sugary.....	3
1. Limestone, gray, oolitic; very similar to the Bedford oolite in texture, and also to the oolite exposed at Conrad, in Grundy county.....	4

The base of the section is about five feet above low water in the river. These indurated beds support a bench which rises forty or fifty feet above water level and continues some distance on either side of the wagon bridge. Numerous remains of *Straparollus obtusus*, and several species of Brachiopods, including *Spirifer biplicatus* H. and *Orthothes irregularis* H., were noted in the oolitic layers. The beds here may be correlated with the upper portion of the Iowa Falls section, and the fossils recognized are identical with those found in the upper oolitic layers of the Kinderhook beds exposed at Rockton quarry and Timber creek, in Marshall county. Beyond Eagle City the beds disappear rapidly, and the surface outcrops of the Kinderhook beds are almost entirely obscured by glacial debris and coal measure talus. At Hardin City, Steamboat Rock, and one or two points between, No. 4 of the Eagle City section is visible and rises some six or eight feet above the water level. In all cases it is greatly weathered and shattered, making its identity difficult to establish. Between Steamboat Rock and Eldora the Lower Carboniferous passes entirely below the stream channel, but rises again immediately south of the wagon-road bridge at Eldora.

Going down stream from the Eldora bridge a weathered dolomite appears in the stream-bed and also in the right bank about sixty rods below the road crossing. The ledges rise eight feet above the water and appear to be identical, both lithologically and faunally, with the upper member at Iowa Falls. Straparollus casts and a cystophylloid coral were found. These beds appear more or less interruptedly from this point to Union, forming low benches on one or both sides of the river. At Xenia, and again between Gifford and Union, the white limestone member is visible. The maximum exposure is south of Gifford, near a small stream which enters the Iowa from the west. The beds exposed to view are:

	FEET.
4. Drift and wash.....	0-3
3. Limestone, light gray; white, when weathered.....	0-3
2. Dolomite, yellowish brown, much shattered and unevenly bedded.....	6-8
1. Dolomite, red-brown, heavy but unevenly bedded, exposed.....	4-6

Numbers 1 and 2 are, in a sense, complementary. Where one thins the other thickens and the two aggregate twelve feet exposed. Not the slightest trace of organic remains could be found. Southward and southeastward the beds are cut out within 100 yards by the coal measure shales, only to come into view again a quarter of a mile down the branch on the terrace of the Iowa. Beyond Union the Kinderhook beds are carried below the river, but reappear west of Liscomb in Marshall county. The oolitic member appears at Conrad in Grundy county, where the following section is exposed:

	FEET.
5. Drift (modified Kansan probably).....	5
4. Limestone, residual, consists chiefly of cherty concretions imbedded in a matrix of greenish clay streaked and mottled with ferruginous and marly material...	3
3. Limestone, slightly oolitic, composed essentially of a shell breccia almost identical with No. 1 in the Eagle City section.....	4
2. Limestone, hard, subcrystalline containing numerous brachiopod casts.....	2
1. Limestone, typical oolite in heavy beds; a straparollus and a turreted form of gasteropod were noted; also numerous brachiopod casts.....	5

The base of the section is about four feet below the Chicago & Northwestern railway track and 1,010 feet above tide.

Away from the Iowa and its immediate tributaries, but a single exposure of the Kinderhook is known within the confines of the county. In northern Tipton and southern Ellis townships, low ridges of white, subcrystalline limestone appear along South Fork. The ledges rise eight to twelve feet above the water; form a constriction in the valley and rapids in the stream. Lithologically the beds appear to be identical with those quarried at Alden and vicinity.

Well records from various portions of the county demonstrate that the Kinderhook beds may be reached at from 100 to 250 feet over the entire county.

THE DES MOINES SERIES.

The coal measure sandstones and shales form an irregular lobe which extends entirely across the county from east to west and covers perhaps more than two-thirds of its superficial area. The beds referred to this stage of the Carboniferous consist of an upper heavy-bedded, ferruginous sandstone which often presents conglomeratic to concretionary facies and is cross-bedded throughout; and lower shales which carry some coal and often contain highly calcareous, fossiliferous ledges. The sandstone reaches its maximum development in the vicinity of Eldora, where it attains a thickness of eighty feet, while the shales are more extensive in the southwestern portion of the county.

The floor of the coal measure series is most uneven. At Gifford the top of the Lower Carboniferous is 940, at Eldora 950, at Steamboat Rock 970, Ackley 1,010, Iowa Falls 1,110 and in the southwestern portion of the county it is about 1,000 feet above tide. The Iowa Falls flexure evidently almost cuts out the coal measure beds. Outside of the general area detached basins are known to exist, as at Gifford the "Marble" and the "Honestone" quarries west of Iowa Falls.

The best sections of the Des Moines may be viewed between Xenia and Steamboat Rock along the Iowa river. On the

southwest quarter of section twenty-one, in Eldora township, a cut along the C., I. & D. railway exposes the following sequence:

	FEET.
4. Drift at the face of the cut almost <i>nil</i> , but thickens greatly towards the bluff.....	0-50
3. Sandstone much shattered and unevenly bedded, ferruginous.....	6
2. Sandstone, medium bedded, darker colored and coarser textured; contains layers conglomeratic. Some concretionary structures seen.	30
1. Sandstone, heavy-bedded (exposed).....	8

Fossil tree trunks (identified by Macbride as *Dadoxylon*) project from the face of the cut, some of which are more than a foot in diameter. The species has been identified by Prof. T. H. Macbride as belonging to the conifers of Carboniferous times.

Cross-bedding is the rule throughout the section. At Eldora the above section is repeated and beds lower in the series come into view. The Eldora section is as follows:

	FEET.
7. Drift (on the face of the scarp).....	0-3
6. Sandstone weathered and shattered; ferruginous, conglomeratic and concretionary; quartz pebbles ranging up to a third of an inch are common. False bedded throughout; some fossil wood fragments present.....	40
5. Sandstone, heavy-bedded.....	10
4. Talus slope.....	20
3. Shale, Carbonaceous.....	1
2. Shale, light colored above and variegated below....	20
1. Kinderhook limestone (top about ten feet below the water level).....	6

This makes the total thickness of the Des Moines at this point approximate ninety feet. The sandstone above the mill is much less firmly aggregated and lighter in color. The degree of induration and shade of color appear to be a function of the iron constituent. North of the mill and also along the roadway east of the river the sandstone appears to be divided by a thick deposit of plastic shales. East of the river the section is about as follows:



FIG. 29. Buttness of Eldora sandstone, northeast of Eldora along the east bank of the Iowa river.

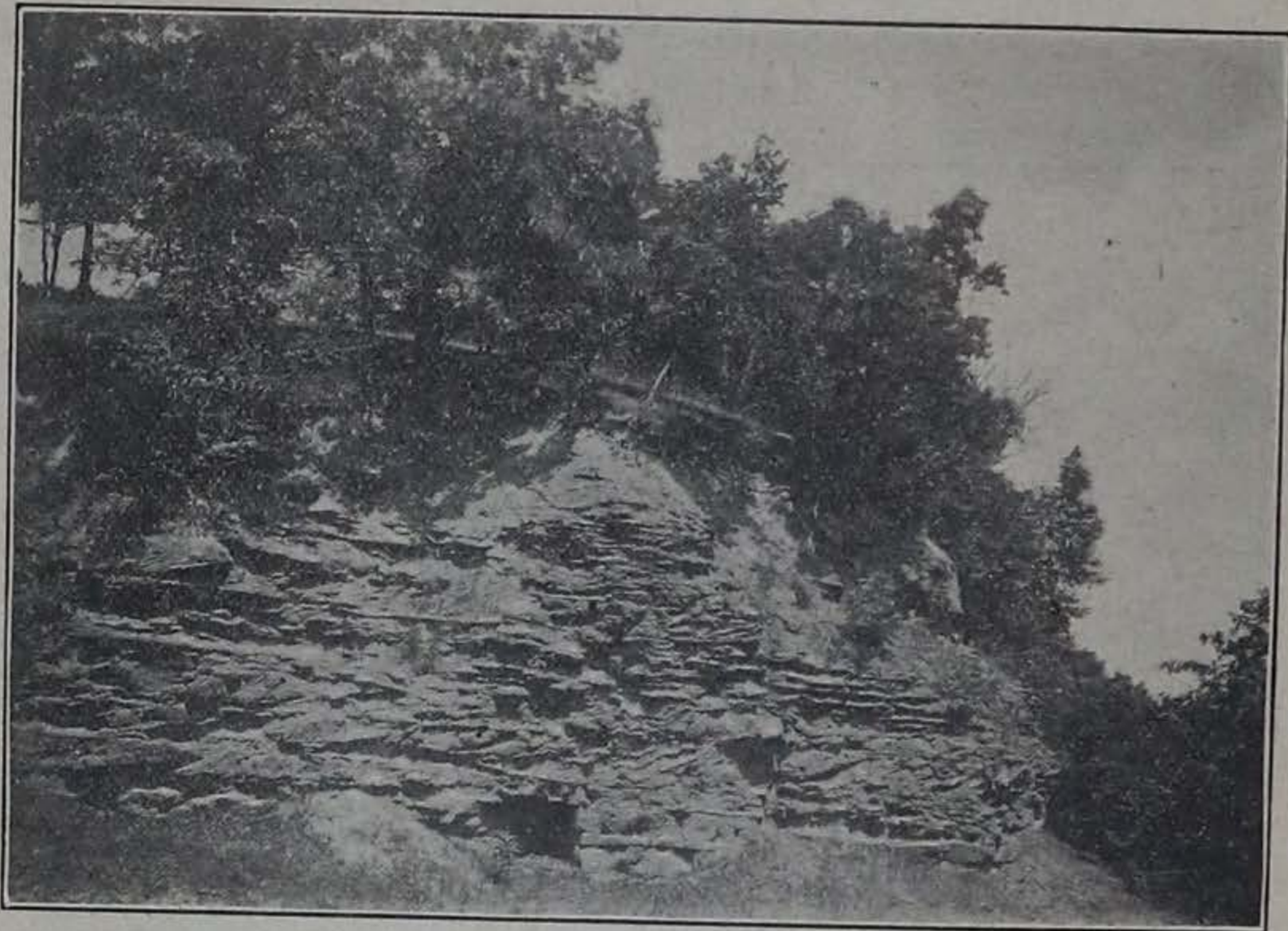


FIG. 30. Eldora sandstone, showing the effects of wind and water, near Eldora, Hardin county, Iowa.

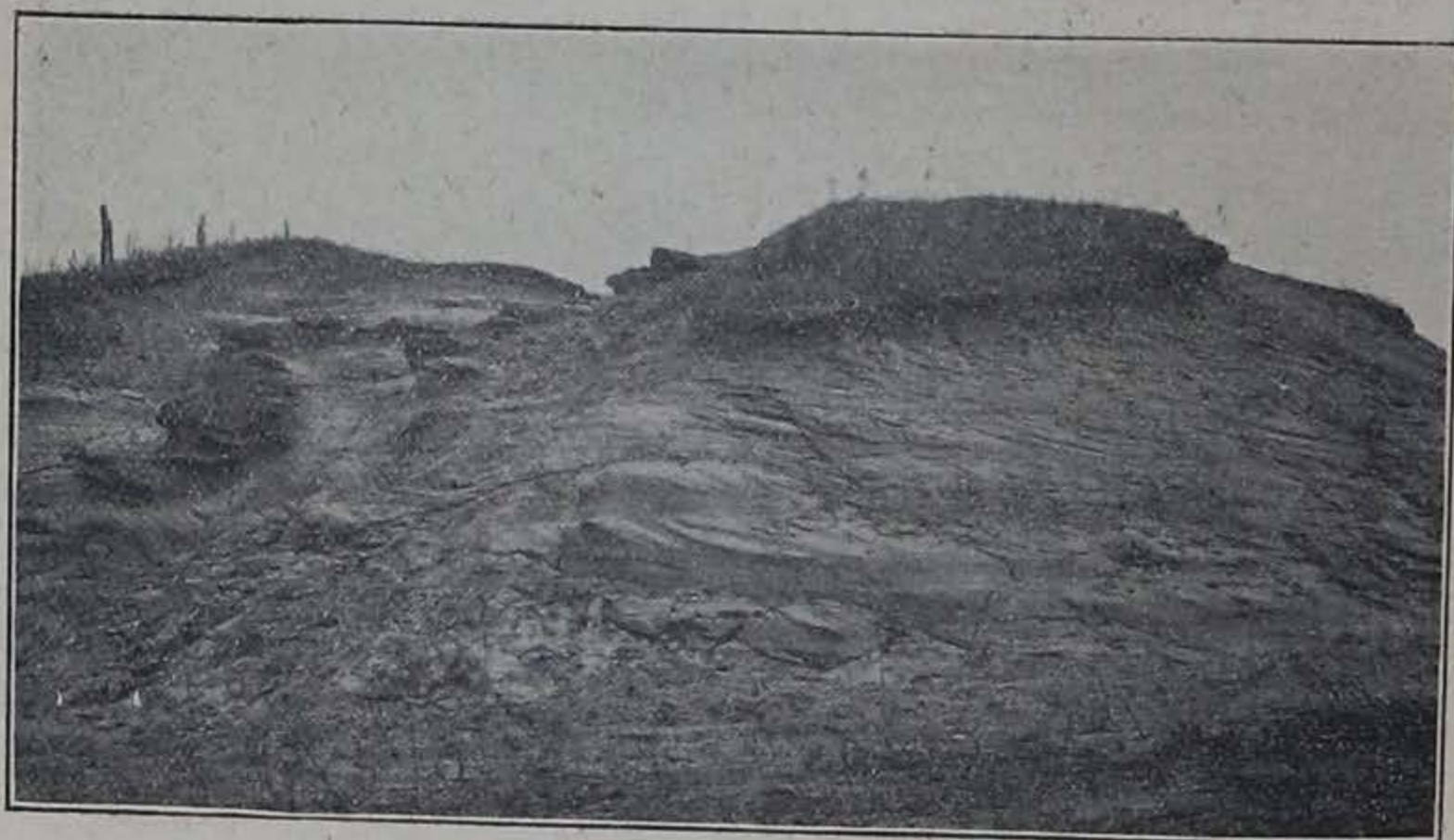


FIG. 31. Eldora sandstone showing wind erosion. On the line between sections 10 and 15, Eldora township, Hardin county, Iowa.

	FEET.
5. Drift	5-15
4. Sandstone, red, ferruginous; same as the red sandstone west of the river.....	30-40
3. Shales, variegated, fissile; oxidized to a yellowish brown above but gray-blue to deep blue below. The variegated appearance is due in large measure to thin seams and flattened lenses of fine-white sand.....	12
2. Talus slope.....	20-30
1. Sandstone, soft, friable; similar to the loosely aggregated sandstone outcrop near the mill.....	10-20

East and southeast of Eldora the ferruginous sandstone appears in the roadways well up to the crests of the hills for a distance of several miles. On the southeast $\frac{1}{4}$ of the southwest quarter of section 10, Eldora township, a low hill exhibits a beautiful example of wind sculpturing in the Eldora sandstone. Here the sandstone particles are rather loosely aggregated and yield readily to the wind.

Between Eldora mill and Steamboat Rock sandstone escarpments are maintained wherever the river impinges upon its restraining bluffs. The sandstone sections are almost exact duplicates of those already given. Near the Clay-Eldora township line the coal-bearing shales rise above the water level, and owing to the slight resistance offered by these shales to undercutting, mural buttresses are quite the rule. The first escarpment north of the mouth of Pine creek on the east side of the river gives the maximum exposure of sandstone known in the region, and is as follows:

	FEET.
4. Talus; from what can be seen in a lateral gorge near by, appearing to be made up of the variable sandstone of the Eldora section.....	40
3. Sandstone, slightly indurated and in heavy beds, light-yellow.....	15
2. Conglomerate, quartz pebbles up to one centimeter in diameter are conspicuous; highly ferruginous and vesicular; concretionary.....	10
1. Sandstone, more evenly bedded and conglomeratic in certain bands.....	40

Here as before the entire section exhibits cross-bedding.

At the sharp angle where the river changes its direction from northeast to south, two thin seams of coal can be seen about five feet above the water level. A thin, sandy parting separates the two veins. Below follow several feet of Carbonaceous shales, highly charged with pyrites occurring as crystal aggregates. There appears to be no stratigraphic break between the overlying sandstone and the coal-bearing shales at this point. The best section of shales in this locality is seen on the south bank of the river, Sec. 5, Sw. $\frac{1}{4}$ of the Nw. $\frac{1}{4}$, Eldora Tp. Here three feet of argillaceous limestone appears about three feet above the water level and forms the caprock for the lower coal seam exploited in the basin. The ledge contains the remains of a rich molluscan and brachiopod fauna.

Professor Calvin has identified the following species:

Productus costatus Sowerby (The costæ are finer than on typical *P. costatus*.)

Spirifer cameratus Morton.

Aviculopecten neglectus? Geinitz.

Bellerophon percarinatus Con.

B. urii Fleming. *B. carbonarius* Geinitz.

Naticopsis subovatus.

Soleniscus newberryi Stevens.

Straparollus pernodosus M. & W.

Orthoceras rushensis McChesnev.

The upper coal seam occurs some twelve to fifteen feet above the ledge separated by shale and fire clay. At the bridge the beds rise about ten feet higher, eastward from which the beds dip rapidly and the lower vein disappears below the river 100 yards east of the bridge. Fragments of argillaceous sandstone containing Cretaceous fossils were found at the base of the bluff by Professor Woodford, who still retains them in his collection. Much prospecting has been done on both sides of the river and considerable coal has been mined. The beds are lenticular and run from nothing to five feet in thickness. South of the great bend in the river the contact

between the sandstone and shales is very uneven and bears some of the characteristics of an eroded surface. This suggestion is borne out by mining explorations, the coal seams being cut out abruptly by the overlying sandstone. This unconformity is not believed to be general.

At Steamboat Rock the sandstone has thinned greatly and the shales are entirely absent. An escarpment south of town shows forty feet, while along Elk creek low overhanging walls appear, rising ten or twelve feet above the water. The sandstone has not been recognized beyond this point. The Iowa river gorge continues strong beyond Hardin City, though the character of the walls is almost wholly obscured by the great thickness of drift and talus. As has already been mentioned there is a marked topographic change between Hardin City and Eagle City, which is believed to be due to the cutting out of the Des Moines and to mark the appearance of the Mississippian series. Eastward from Steamboat Rock the coal measure shales appear on the northeast quarter of section 3, where the wagon road crosses Pine creek. A terrace thirty to forty feet in height appears to be supported by indurated rocks.

Between Eagle City and Iowa Falls the coal measures are entirely superseded by the Lower Carboniferous. West of Iowa Falls at the "Honestone quarries" where the river crosses the line between sections 14 and 15 in Hardin township, fifty feet of shales and sandstones appear. The section is as follows:

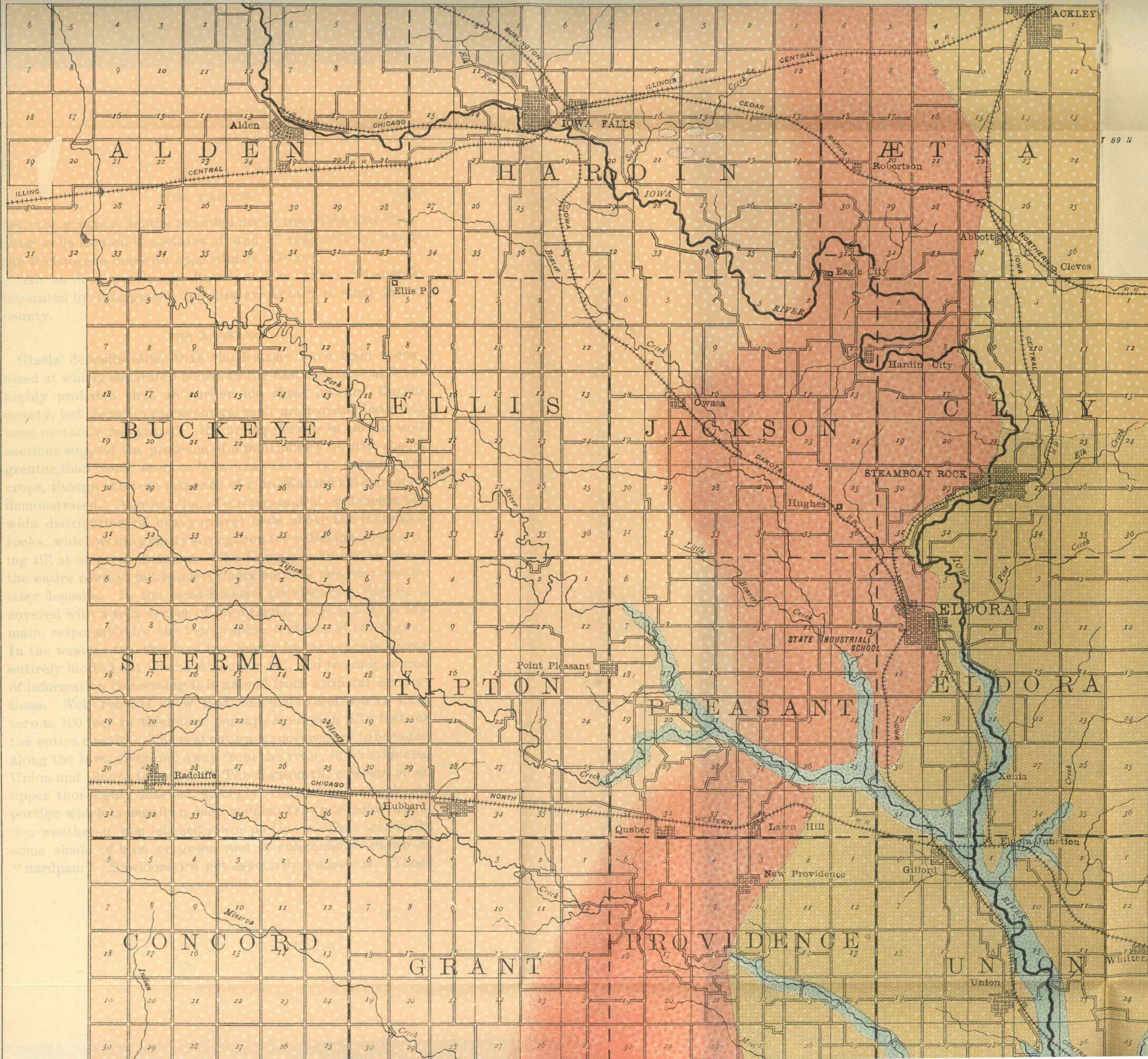
	FEET.
5. Drift.....	40-90
4. Sandstone, fine-grained, slightly argillaceous, breaking up in large blocks and forms a projecting ledge.....	2- 5
3. Shale, arenaceous, blue-gray and but slightly indurated; certain hard layers appear throughout the section.....	30
2. Shale, blue, fissile; in some places almost black....	15
1. Limestone, dolomitic; in many places a cherty layer appears on top. The limestone is weathered, a red-brown; arenaceous; minimum exposed above water.....	1

Large blocks from the sandstone ledge appear in the river and partially obstruct the channel. It is from this ledge that the material used in the manufacture of honestones is obtained. The beds cut out in less than a quarter of a mile but appear again in the southeast quarter of section 16 in Alden township. This marks the last exposure of the Des Moines along the Iowa within the limits of the county. Another detached basin occurs in the vicinity of Gifford, where ten to fifteen feet of shales are visible. No other coal measure exposures are known west of the Iowa and away from the immediate vicinity of the river. Well sections show the presence of the Des Moines over the southwestern portion of the county and in many instances some coal is penetrated.

THE PLEISTOCENE.

The Pleistocene deposits consist of a most complicated mixture of boulder clays, silts, sands and gravels, and rest unconformably upon both series of indurated rocks. They cover the entire surface of the county save where removed by the streams, and it is in this incoherent complex that the principal features of the landscape are expressed. The series varies greatly in thickness, but ranges from zero to 300 feet, and averages more than 100 feet for the entire county. With a single exception the series has been completely cut through only in the immediate vicinity of the Iowa river and in the province of the loess-Kansan.

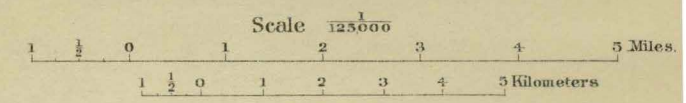
According to well sections the greatest thickness, as might be expected, is reached in the western tier of townships and in the belt covered by the principal moraine; especially in Providence township. In Alden township, starting with section 5 and progressing east of south to section 34 and continuing across Buckeye to sections 31 and 32, the drift varies from 150 to 235 feet. The western tier of sections in Alden show almost as great a depth of drift. In Providence township the wells reported give the drift an average depth of nearly 200



IOWA GEOLOGICAL SURVEY

MAP OF THE
 SUPERFICIAL DEPOSITS
 OF
HARDIN
 COUNTY,
 IOWA.

BY
S.W. BEYER
 1900.



LEGEND
 GEOLOGICAL FORMATIONS

- ALTAMONT MORAINE
- ALLUVIUM
- WISCONSIN DRIFT
- IOWAN DRIFT
- KANSAN DRIFT
LESS COVERED
- WISCONSIN PARTIALLY STRATIFIED
(KAMES)

feet; the greatest depths recorded are in the Gibbs and Fleming wells located in sections 19 and 17 respectively, where the Pleistocene deposits approximate 260 feet.

Ash as been previously stated, at least three till sheets, separated by interglacial deposits, are known to exist in the county.

THE KANSAN.

Glacial deposits older than the Kansan have been recognized at widely separated points to the east and south and it is highly probable that an earlier ice sheet invaded Hardin county, but deposits representing such an invasion have not been certainly recognized. Recurring gravels in certain well sections suggest the presence of a multiplicity of drift sheets greater than would seem to be warranted by the surface outcrops, though the true presence of a pre-Kansan till cannot be demonstrated. Another line of circumstantial evidence is the wide distribution of heavy gravel beds above the indurated rocks, which would greatly strengthen the belief in a pre-existing till at no great distance. The Kansan is known to cover the entire county, but is everywhere more or less obscured by later deposits. In the loess-Kansan province the Kansan is covered with a thin veneer of interglacial silts, but is, in the main, responsible for the topographic features of the region. In the western two-thirds of the county its existence is almost entirely blotted out by the Wisconsin till, and the only source of information concerning it is gained from artificial excavations. Well records show that this drift sheet varies from zero to 100 feet in thickness; perhaps averaging fifty feet for the entire county. The best natural exposures are to be found along the Iowa river and away from the river, in Providence, Union and Eldora townships. The Kansan till consists of an upper thoroughly leached, strongly oxidized and weathered portion which is usually a deep reddish-brown in color; and a non-weathered, non-leached lower portion which is generally some shade of blue or green and is colloquially known as "hardpan." Boulders are not especially numerous. Those

present rarely exceed one or two feet in diameter and greenstones are the prevailing type. The granitic boulders are commonly in an advanced stage of decay and disintegrate rapidly when loosed from their matrices, often crumbling at once when exposed to the air. The weathered portion measures from five to twenty feet in thickness and graduates insensibly into the unoxidized hardpan below. The Kansan surface is profoundly stream molded and is, as a consequence, perfectly drained.

THE BUCHANAN GRAVELS.

Deposits referable to the above formation are not conspicuous. In the loess-Kansan area the loess is usually separated by a more or less constant gravel layer. A well on section 29, in Union township, was reported to have penetrated a definitely marked gravel bed below the loess, and this is quite the rule for western Union and eastern Providence townships. In the area covered by the Wisconsin drift wells not infrequently encounter heavy beds of gravel from forty to 100 feet below the surface and above the heavy blue till of the Kansan. In central Buckeye township well drillers report from twenty-five to fifty feet of these gravels. Their stratigraphic position would suggest their reference to the Buchanan as highly probable.

THE IOWAN.

The Iowan drift is typically developed in eastern Ætna and Clay townships. Iowan boulders have a much wider distribution. Immense boulders of gray and red granites are found in great profusion along the Iowa river as far west as Eagle City, and scattered blocks well into Hardin township, are not uncommon. One of these ponderous invaders may be seen near the line separating sections 27 and 28 north of the river. The most marked characteristics of the Iowan in Hardin county, as elsewhere, are its almost monotonously level surface and its train of giant boulders. The till matrix is comparatively unimportant and much wasted away by subsequent

changes. The boulders form the most conspicuous features of the landscape and are found far beyond the verified limits of the till. In eastern Eldora and even in eastern Union township, granite blocks of heroic size may be observed flanking the more pronounced eminences. In other counties where the drift of this stage is more typically developed, it is seen to be composed of a yellow, often more or less porous and jointed, partially oxidized and leached till, which sometimes grades downward into a gray-blue boulder clay, aggregating a total thickness of from one to fifteen or twenty feet. Small pebbles and boulders are not uncommon but granite blocks of enormous size and perfect freshness are characteristic.

THE LOESS.

Coincident with the maximum extension of the Iowan ice was a period of land depression, and as a consequence sluggish drainage. The winds and the waters co-operated in depositing outside of the ice margin, a veneer of clays and silts over hill and dale alike. These silty deposits take the name loess, which was first applied to similar deposits along the Rhine in Germany. The loess consists of a structureless or indefinitely bedded mass of yellowish clay or sandy silt, and usually contains numerous lime balls or concretions. It is highly siliceous and a high percentage of lime is generally present in a finely divided state, sufficient to produce rapid effervescence when weak hydrochloric acid is applied. Root casts and gasteropod remains are common, and in many places are extremely abundant. The loess is easily distinguished from the drift by the absence of pebbles and boulders, its even textured character, lime balls and faunal remains. Its presence tends to strengthen the drift contours where it occurs. While loess erodes easily, it possesses the peculiar property of maintaining a vertical scarp an indefinite length of time, even when exposed to direct weathering agencies. The loess reaches its best development in the county, and is most easily observed in Providence, Union and

Eldora townships. It is thickest here, as in other counties where it occurs, along the principal drainage lines. The best exposures in the region are in the vicinity of the town of Union, west of the Iowa river. North and west of Union the loess extends well down the hill slopes and exceeds twenty feet in thickness. Many local wells formerly drew water from the sub-loessial sands; and the coarse grass and seeping springs mark the loess contact on the Kansan drift in the ravines and draws. Outcrops of the loess may be observed well across Providence township, and the loess undoubtedly continues under the Wisconsin drift and connects with the deposits near Ames in Story county. On the southeast quarter of section 6 in Providence township the loess appears in a cut along the roadway overlain by twenty feet of Wisconsin drift and resting upon the oxidized Kansan. Also in section 16, in a road cut, eight feet of loess is visible. The deposits at these exposures are closely set with root casts, some of which measure four inches in diameter. Loess concretions are numerous and a few gasteropod shells were noted, the most common being a species of *Succinea*. These are the most westerly exposures in the county. In Eldora township the loess has been observed as far north as Eldora, where it is used by the clay manufacturers.

THE WISCONSIN.

Closely following the loessial stage the western two-thirds of the county was invaded by a great ice tongue which extended down from Wisconsin and Minnesota to central Iowa, the apex of the tongue reaching Capitol Hill, Des Moines. The eastern limit of this great ice lobe is marked by a complicated series of ridges and knobs and their complementary swales and ponds. Its outline is more or less lobular and the eastern margin passes across Hardin county in an almost north and south direction. The marginal belt, which varies from two to five miles in width, and is continuous with the moraine in Marshall, Story and Polk on the south, and with the moraine of Cerro

Gordo and Worth to the north, is known as the Altamont moraine. As in Story county, certain more or less broken chains of ridges and knobs concentrically arranged may be noted within the area outlined by the Altamont. These concentric chains indicate halts in the retreat of the ice lobe and have been designated recessional moraines by the leading authorities in glacialogy. The general surface or ground moraine of the Wisconsin has undergone very little modification since the retreat of the ice. As has been previously mentioned the surface presents a pitted, hummocky appearance which is entirely independent of present drainage lines. The streams bear evidence of very recent establishment, in their narrow, high-walled channels, high gradients, dearth of small tributaries and the presence of extensive undrained areas. The drift material is markedly fresh; being little leached or oxidized. In fact the *tout ensemble* of characters mark the Wisconsin as being extremely youthful.

The Wisconsin in Hardin county plainly exhibits an earlier and a later phase. The surface tills on New Providence and Eldora Hills are decidedly different from the surface materials which cap the hills and ridges in Tipton, Ellis and Jackson townships. In the first oxidation and leaching have progressed to a considerable extent. In numerous road cuts acid tests failed to give an appreciable reaction to a depth of from two to four feet. While in the latter localities the materials even at the surface give strong effervescence on the application of dilute hydrochloric acid. The surface features themselves, present as marked contrasts. In the former area drainage lines have made considerable progress and ponds and kettles are approaching extinction. In the latter, drainage is strikingly imperfect and the surface is but little molded. It is at present impossible to trace definitely the line of separation between the older and newer Wisconsin drift. The boundary may be said to pass approximately from the Grant-Concord line on the Story county boundary, across Grant township near its middle; crossing Tipton creek at the great bends in Tipton

township, and South Fork at the great bends in Tipton and Ellis townships; continuing north of east across Beaver creek west of Owasa. From this point its course is very uncertain, but it probably continues east of north across the county. This is believed to be the northward extension of one of the limbs of the Gary moraine of Boone and Story counties. Another recessional moraine, more or less interrupted, can be observed in the extreme western portion of the county. South of Radcliffe a chain of subdued ridges appear along the Hamilton-Hardin county line. North of Radcliffe the series of ridges take an east of north trend and are responsible for the complicated meanders in the South Fork for northeast Buckeye township and continue northward between Alden and Iowa Falls, a spur extending south of the latter place.

Aside from the moraines numerous sand and boulder knobs rise above the general level and tend to break the monotony of the drift plain. These prominences are most numerous in the immediate vicinity of the morainal tracts but are widely distributed over the intramorainal areas. In certain instances the constituent sands and gravels show stratification planes evidently due to running waters. Such eminences exhibit a gregarious tendency; they are known as kames, and are very generally conceded to be the work of sub-glacial streams. One of the most conspicuous groups of kames in the county may be observed south of School creek in sections 15 and 16 in Hardin township.

The Wisconsin drift is composed of a most heterogeneous assortment of clays, silts, sands and gravels, with a liberal sprinkling of boulders of medium size, all admixed in a most complicated manner; and taken as a whole the composite is known as till or boulder clay. The clay and silt elements predominate. Below the humus charged surface, the Wisconsin till is of a pale, straw yellow, full of lime blotches, but slightly oxidized and almost wholly unleached. It grades downward into a gray blue till which is wholly unaffected by the weather. The upper slightly weathered portion varies

from two to four feet in thickness for the later Wisconsin; from five to fifteen feet for the earlier.

The total thickness referable to the Wisconsin stage is difficult to ascertain accurately. Natural sections exhibiting the drift sheets are rare or almost entirely unknown in the county because of the inability of the drift to maintain a clean cut escarpment. Along water courses which have cut through one or more of the drift sheets, talus slopes and landslides have effectually obscured the real nature of the valley walls. The best evidence obtainable comes from artificial excavations. Drillers' records show that gravel beds below the upper till are pretty generally distributed over the county. They also record a buried wood zone which is believed to be at or near the base of the Wisconsin drift. Basing the separation of the Wisconsin from the older till sheets on the above criteria the Wisconsin drift is found to vary from forty to eighty, or even 100, feet in thickness. In the vicinity of the court house in Eldora it is at least forty feet thick, while in the bluffs about Hardin and Eagle cities, and in the western tier of townships, much greater thicknesses, up to 100 feet, are reported.

Development of the Iowa river system.—From a careful study of the Pleistocene map it is obvious that the history of the drainage of the county is intimately associated with the Wisconsin drift. The Iowa proper, above the confluence of the South Fork, is evidently a superimposed stream and was established after the Wisconsin advance, while the channel below the junction meanders through a broad alluvial valley and is antecedent in character. That the upper course is superimposed and younger than the lower course is based upon the following facts: First, the stream flows through a narrow rock-walled and rock-bottomed gorge from Alden to the junction and has laid almost no alluvium. At Iowa Falls the canyon is no wider than the stream channel. Second, the all but total absence of tributaries worthy of a name from the west is certainly significant. The bluff line is broken only

by V-shaped ravines and sharp defiles from this quarter. From the east Elk and Pine creeks enter through well developed alluvial valleys more in harmony with the lower course of the Iowa, and were evidently established prior to the upper course of the larger stream. Third, the striking coin-

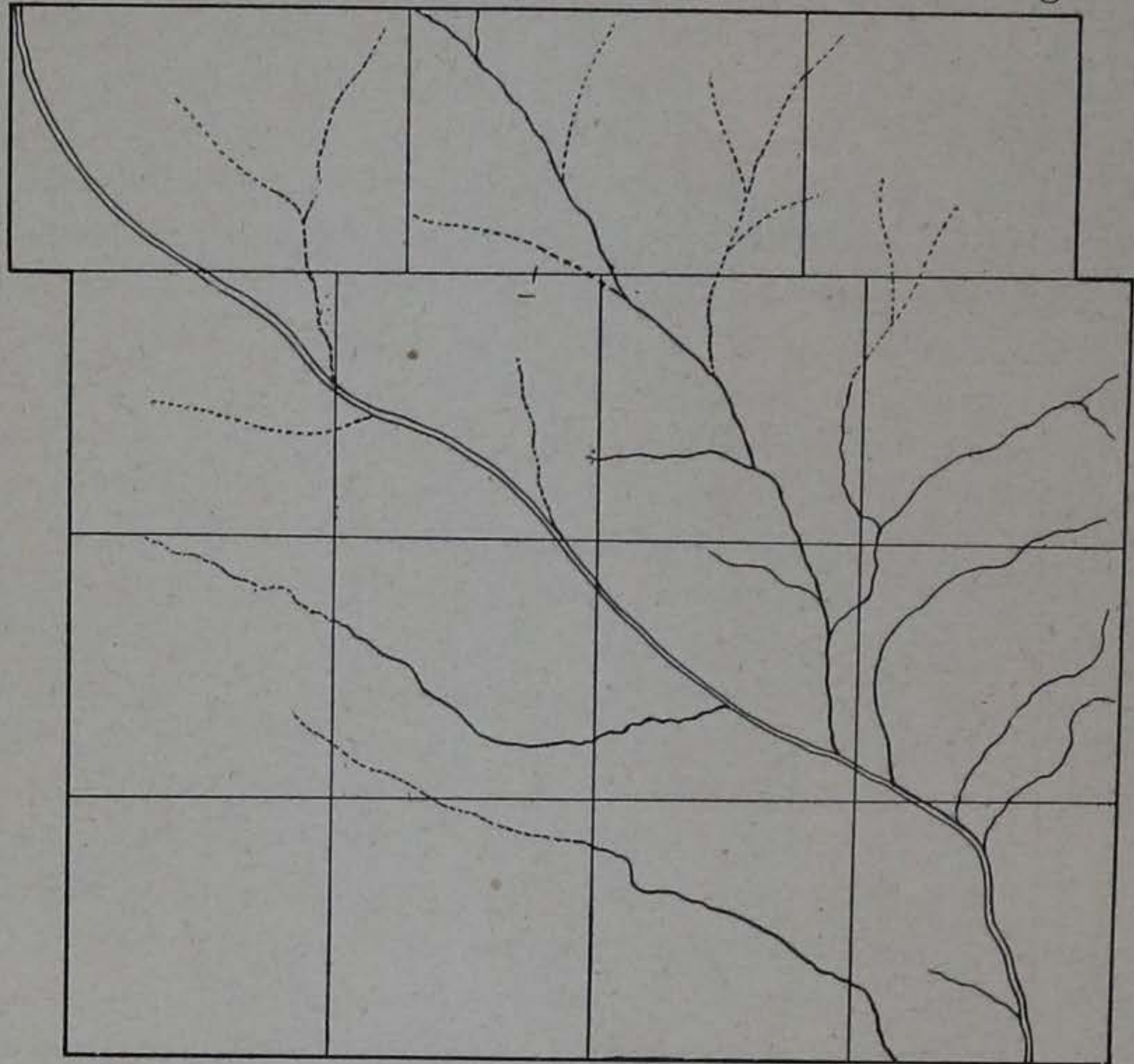


FIG. 32. Sketch map exhibiting the pre-Wisconsin drainage system, somewhat diagrammatic.

idence of the position of the present stream with the Wisconsin ice front from the point where the river takes its southerly course, points to the same conclusion. The morainal barriers are skirted by the phenomenal detours of Eagle City and Hardin City. Fourth, the departure from the northwest-southeast course so common to the chief drainage lines of east central Iowa must be considered; and fifth, the South Fork, in the main, and Beaver creek in its lower course, flow through broad depressions, have comparatively low gradients,

and have the general characteristics of streams occupying old valleys which have been partially reopened. At numerous points along South Fork, in Buckeye and Ellis townships, artesian flows are obtained from heavy gravel deposits, presumably the pre-Wisconsin stream gravels which were her-

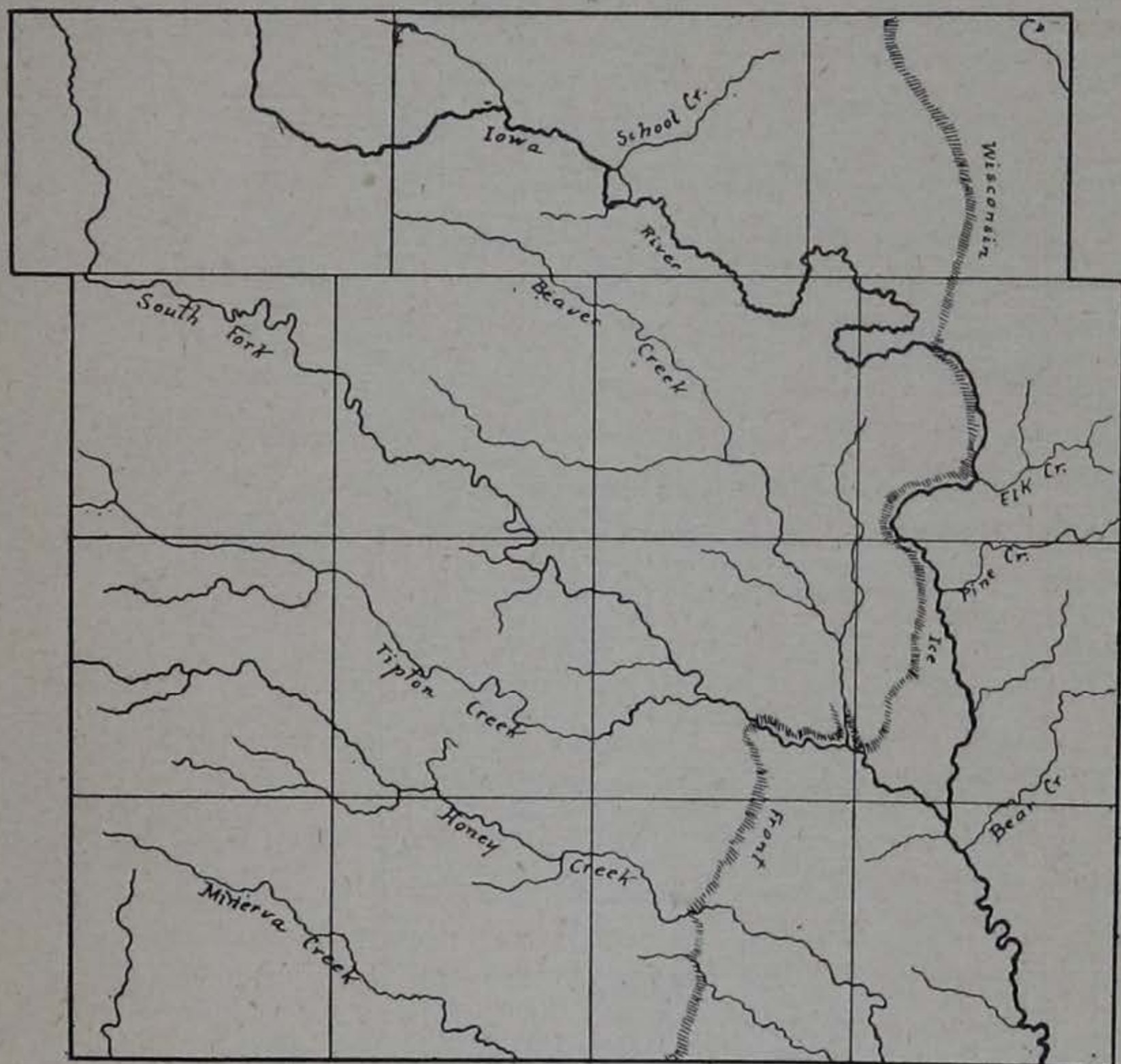


FIG. 33. Sketch map showing the relation between the present drainage lines and the Wisconsin ice front.

metically sealed in by the later drift debris. From the above facts it is believed that the pre-Wisconsin Iowa occupied, more or less approximately, the course of South Fork, and perhaps received tributaries of considerable size from the north and east. A large tributary may have occupied the depression of Beaver creek, and Elk and Pine creeks were extended to their junction with Beaver creek or South Fork. On the advance of the Wisconsin ice these maturely adjusted

streams were pushed from their courses, and the tributaries flowing to the south and west, being obstructed, would naturally be diverted and flow along the ice front and, eventually, by their coalescence establish a new stream. The newly formed stream would proceed to cut a channel, and upon the subsequent retreat of the ice would find itself caught between self-made barriers, and unable to reopen and resume its old course, now more or less completely filled by glacial debris. The tributaries would be bestruck while their upper courses would remain unaffected. The former channels of the leading streams would be, perhaps, partially reopened, but would be occupied by waterways of minor importance because despoiled of their strong tributary system from the north and east. This, in brief, is believed to have been the history of the Iowa river system in Hardin county.

Stream terraces.—All of the principal streams of the county flow from the Wisconsin drift plain, and all exhibit one or more series of gravel terraces. The greatest of the gravel trains is genetically related to and has its source at the Gary moraine. This terrace is best seen in the vicinity of Gifford, along both the South Fork and the Iowa proper. The bench along South Fork rises from twenty feet at Gifford to nearly thirty to the westward above the flood plain of the present stream. The gravels are coarsest above and show more or less evident but interrupted stratification planes throughout. The bedding is at all conceivable angles. The gravels vary from fifteen to twenty feet in thickness and rest on a basement of boulder clay, the top of which rises from five to twenty feet above low water level. On the Iowa proper the constituent materials are much coarser, indicating a higher gradient, but the bench is much narrower and more fragmentary on account of the gorge-like character of the valley. Steamboat Rock is built principally on this bench, which is fifty feet above the flood plain. Terraces referable to this system may be found along the two leading tributaries of

South Fork, and also along Honey creek. Below the junction of South Fork with the Iowa the Gary terrace continues but fades out toward the Marshall county line.

Fragmentary terraces above the Gary may be noted along the Iowa but are of little importance. A terrace below the Gary may be noted along the Iowa, South Fork and Tipton creeks, in which the streams to-day are engaged in cutting. It rises from five to fifteen feet above the present flood plain. The Iowa Central has sought it out for a roadbed below Steamboat Rock.

Post-Wisconsin deposits.—Deposits later than the Wisconsin are unimportant in Hardin county. With the exception of the Iowa below the junction, all of the streams have been busily engaged in down cutting and have had little time or opportunity for the building of flood plains. With the above exception South Fork and the lower course of Beaver creek present the only mapable alluvium.

Along the Iowa in Marshall county and the Skunk in Story, wind deposits crown their eastern bluffs and attain some importance. The materials which constitute these deposits may be traced directly to the river flood plains. In Hardin county all the alluvial deposits are unimportant; the wind deposits are not worthy of mention.

ECONOMIC PRODUCTS.

COAL.

Coal mining has been carried on more or less intermittently in the vicinity of Eldora during the past forty years. Two seams have been developed to some extent, though mining operations have been confined chiefly to the lower one. The upper seam runs the more evenly and varies from a mere "blossom" to eighteen inches in thickness. The lower seam is reported to attain a maximum of from four to five feet in thickness. The general dip of the strata is to the southeast and both seams where mined lie above the level of the water in the river. Mining operations have ceased for some years

and accurate information is difficult to obtain. In 1857 Whitney* visited the area when the mines were active and reports the following sequence on section 5 in Eldora township.

	FEET.
Ferruginous sandstone, about	50
Black slate.....	5½
Coal.....	3½ to 4
Black shale (exposed)..	7

Whitney reports that the bed of coal shows numerous slips passing through it from top to bottom, at distances of a few feet and that the beds dip rapidly southward away from the river. North of Eldora on either side of the wagon bridge in section 5 the following beds may be observed:

	FEET.	INCHES.
7. Drift.....	30-50	
6. Sandstone, ferruginous, conglomeratic and concretionary; cross-bedding evident on weathered surfaces.....	30-40	
5. Talus slope and shale more or less obscured..	3- 5	
4. Coal.....		2-12
3. Shale, black; the lower portion to the westward becoming strongly calcareous, loses its fissility and is highly fossiliferous.....	8-10	
2. Coal.....	2- 3	
1. Fire clay, exposed at or about water level ...		

This is believed to be about the average section for the Eldora basin. East of the bridge the coal seams dip rapidly and soon disappear below the river. Much prospecting has been done to the east and north of this point and considerable coal has been taken out. Dismantled diggings and deserted dumps alone bear witness to the former mining activity of the region. The coal cuts out rapidly to the westward and throughout the basin was extremely "pockety" in its distribution.

In other portions of the county but little or no systematic prospecting has been done. It is quite certain that the larger portion of the county is covered by the coal measures, and it is highly probable that workable coal will yet be found within its borders. Well drillers record the encountering of coal seams at

*Hall, Geology of Iowa, Vol. I, p. 289.

numerous points in the southwestern portion of the county, and in view of the fact that coal has been mined in the vicinity of McCallsburg in Story county this would appear to be a legitimate field for the intelligent prospector.

CLAYS.

Hardin county is abundantly supplied with crude material suitable for the manufacture of pressed, paving, fire and common brick; draintile, sewer pipe and pottery. The clays available are confined to the eastern and northern portions of the county. The southeast quarter is supplied with an almost continuous veneer of loess which is adapted to the manufacture of common and pressed brick, and draintile; while the coal measure shales outcrop at various points along the Iowa river from Gifford to Iowa Falls and furnish an abundance of material suitable for the manufacture of ornamental and the more refractory wares.

The clays at present utilized belong to two widely separated periods, and comprise the shales and shale-clays of the Carboniferous and the clays and silts of the Pleistocene.

The Carboniferous shales.—Shales belonging to this period are referable to the Des Moines stage. Important outcrops appear in the vicinity of Iowa Falls, Eldora and Gifford, but only those at the last two points are utilized. The Des Moines shales here, as in other portions of the state, comprise a complex series of beds varying greatly in composition and texture. Beds of uniform texture and composition rarely exceed a few feet in thickness, and in order that the pit may be operated economically the entire section must be utilized. There must be a thorough blending of the constituent layers in the process of manufacture, or else the ware lacks uniformity in texture and color. Pugging and tempering is more or less imperfectly done in most instances, hence the mottled appearance of the finished product where shale clays have been used.

None of the clay-working establishments use shales exclusively, so that while the two classes of crude materials are so

distinct stratigraphically and genetically, they are not kept separate in the present methods of manufacture.

Eldora.—The clay-working center of the county is Eldora and vicinity. Three factories are located within the corporate limits, while a fourth lies two and one-half miles southeast of town.

The Eldora Pipe and Tile company.—In 1893 the Eldora Clay Manufacturing company established an expensive plant along the Iowa Central railway, just north of the C., I. & D. crossing. The company undertook not only the manufacture of brick and draintile, but equipped themselves to turn out sewer pipe, flue pipes, linings and tops, lawn vases, architectural terra cotta, wall coping and fire-proof building blocks. The works were housed in good buildings and expensive modern machinery was installed. On account of the general business depression and unfortunate management the plant was practically idle during 1897 and 1898. In 1899 the Eldora Pipe and Tile company assumed control and the plant is being thoroughly renovated and overhauled. Brick and tile were the only products during the past year, but the new management hopes to resume the manufacture of sewer pipe in the near future. Both coal measure shales and Pleistocene clays are used. The former are obtained from the valley of South Fork some three and a half miles south of the factory. The shales are hauled by wagon from the pit, loaded on cars, then transferred by rail to the factory. About twelve to fifteen feet of shales are available. The layers of shale are variable in color and texture but when thoroughly mixed give promise of a creditable product of both sewer pipe and paving brick. A vein of fire clay is exposed in the section which, when wrought alone, gives a good quality of fire brick. For builders and tile the shales are mixed with alluvium or loess, the former obtained from the river flood plains and the latter east of Eldora hill. The plant is equipped with a Stevenson drypan, a Fate-Gunsaulus brick and tile machine, a two-story steam-heated drying house and three round down-draft kilns.

The equipment also includes a Stevenson wet-pan and a Stevenson press for the manufacture of sewer pipe.

The Eldora Tile works are located along the Iowa Central tracks south of the Eldora Pipe and Tile company's works. Common brick and draintile are the only products produced at present. The crude materials developed are obtained from the Pleistocene and the coal measures. The two are blended in the proportion of two parts loess to one of shale. The former pit is located about three-fourths of a mile northwest of the factory beyond the Wisconsin drift margin, and the latter is obtained from the shales east of the Iowa river along the wagon road. As in the case of the Eldora Pipe and Tile company all of the raw material must be hauled. The plant is equipped with a "Little Wonder" stiff mud machine, open drying sheds and three round down-draft kilns.

The X, Y, Z Brick and Tile company is located in the southeast part of town, just east of the C., I. & D. railway. The plant was established in 1893, is well equipped and conveniently arranged. A Nolan & Madden No. 5 B. machine is used with the pug mill. No crushing is required to prepare the clay. A large steam drying room, two down-draft kilns of 60,000 brick capacity are used for drying and burning the ware respectively. Tile from three to twelve inches in diameter and common brick are the sole manufactured products. The raw material is obtained in the immediate vicinity. The pit is located in a ravine and exhibits the following section:

	FEET.
4. Loess, slightly arenaceous below.....	10
3. Drift, yellowish and contains numerous bowlders of considerable size.....	6
2. Till, blue, joint; bowlders not numerous.....	4
1. Shale, blue-black (coal measures).....	25

Brick are made out of No. 4, while Nos. 2 and 4 are mixed in the manufacture of draintile. No. 1 has not been utilized to any great extent as yet. The brick burn to an even cherry red color, very pleasing to the eye.

Other factories located in Eldora have flourished during the past quarter of a century but those described are the only ones active at present.

About two and a half miles southeast of town is a factory operated by E. D. Perkins. Here, sand rolled brick are made from a mixture of loam and loess, in the proportion of one part of the former to four of the latter. The brick are dried in open sheds and burned in an open kiln.

Pottery making has been an industry carried on more or less intermittently in this vicinity for nearly a third of a century, but no manufactured products have been put upon the market for several years. The raw material was obtained from shallow pits about one-half mile north of Gifford, and was coal measure in age. Four feet of soil and impure clay was passed through before reaching the worked bed, which was claimed to be nearly twenty feet in thickness. The upper six feet was reported to be of a dark color and was mixed with the under clay in order that the best results might be obtained. The drab clay alone moulded easily but did not take a salt glaze, nor stand a high temperature as well as did the blue clay.

The fire clay below the lower coal seam, north of Eldora along the Iowa river, has a good reputation as a potter's clay, but is no longer utilized. All kinds of stoneware, glazed and unglazed, were formerly put out. The glazing was accomplished by the introduction of salt into the kiln, or by the use of the Albany "slip clay." The round up-draft potter kiln was used in burning. Some years since a considerable quantity of crude clay was shipped from this region to potteries in and out of the state. Nothing was reported, however, in this line for 1898.

Gifford.—The Jonker Brick and Tile company operate works just east of the Iowa Central railway and south of the C. & N. W. crossing. Tile from three to ten inches in diameter and a few brick are the only manufactured products. The raw material is obtained from a cut along a small stream just

south of the town, where the following sequence of beds is exposed:

	FEET.
2. Drift, on north side of pit arenaceous to gravelly below, loosely compacted, dirty yellow.....	0-3
On south side of pit, a heavy, blue, joint clay, oxidized along joints a red-brown.....	0-3
1. Shale, deep blue (almost black when wet), considerably oxidized where unprotected by drift; becomes arenaceous eastward and contains but little iron...	8

The raw material is wet at the yard and run through a Wallace crusher or stone separator, then carried to a Kell & Son's auger machine. The drying sheds have adjustable sides and by care the moisture can be carried off without checking the ware. Two round down-draft kilns of about 10,000 four-inch tile capacity are used in burning. Alluvium and hillside wash are mixed with the shales to heighten the color. The product bears an extremely mottled aspect, owing to imperfect mixing of the raw materials.

Iowa Falls.—The Iowa Falls Tile company operate works located one-half mile east of town and south of the I. C. and B., C. R. & N. railway tracks. The raw material is obtained from a small draw which makes back from the Iowa river and is obviously post-Wisconsin. It consists of a prairie loam and an ash-gray to blue clay, both of which belong to the Wisconsin till sheet. The clay is highly calcareous and slightly arenaceous. The entire deposit appears to be due to a partial filling of the ravine from the wash carried down from the higher ground.

The clay is run through a Wallace crusher into an H. Brewer machine. Some care must be exercised in drying to prevent checking and the ware is burnt in round down-draft kilns. DRAINTILE is the only product manufactured.

From the above brief description of the clay manufacturing plants in Hardin county it is obviously apparent that the industry lacks much of its complete development. The county is rich in crude materials, and yet the total value of the manufactured products marketed in 1898 was less than

\$17,000. Of this value three-fourths came from the top clays of the Pleistocene. The shale clays can scarcely be considered more than opened to development. There is but a single dry-pan in the county. Most of the factories are unfortunate in the matter of location. Unlimited quantities of coal

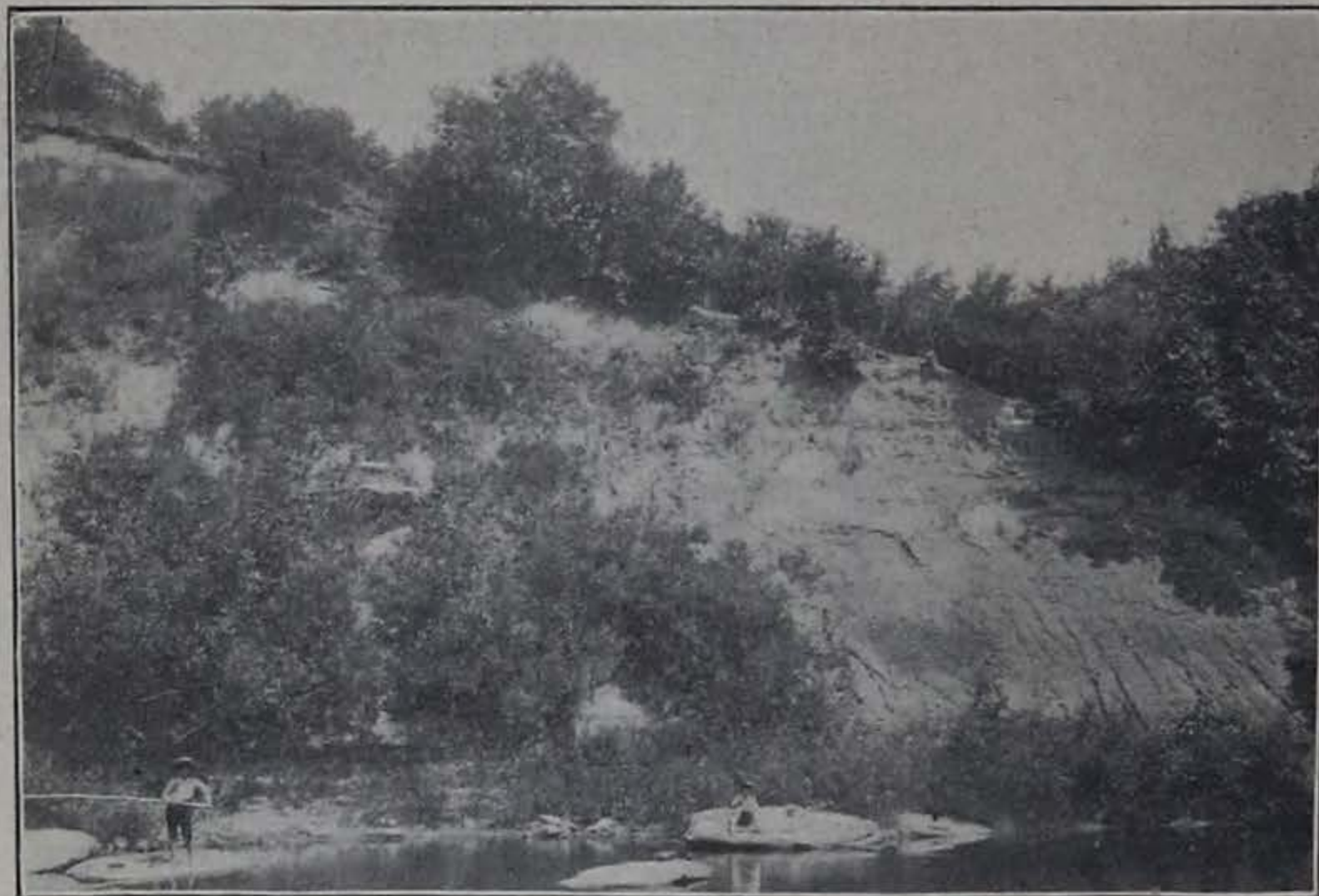


FIG. 34 "Honestone Quarries," a local coal measure basin along the Iowa west of Iowa Falls, resting unconformably upon the Kinderhook. The sandstone ledge appears well up in the section and numerous blocks appear in the stream channel.

measure shales are in sight along South Fork south of Eldora, immediately adjoining the Iowa Central railway, and yet the factories which are developing them are located three and a half miles to the north in Eldora. Almost inexhaustible quantities of shales appear along the Iowa river west of Iowa Falls, and yet not a brick has been molded from them. The sequence of beds exposed on the northwest quarter of section 14, in Hardin township, is as follows:

	FEET.
Drift (of variable thickness).....	50
Shale, arenaceous.....	10
Shale, sandy to shaly sandstone.....	3
Shale, variegated, blue to yellow.....	4

	FEET.
Sandstone, fine grained, gray-blue, forms a projecting ledge.....	2
Shale, fissile, gray-blue to deep blue when wet.....	30
<i>Unconformity.</i>	
Limestone, cherty and much weathered Exposed above water in river.....	5-10

The above section can be utilized in its entirety, save the sandstone ledge and the drift, in the manufacture of vitrified brick, building brick, and tile. Near the lower portion of the section certain layers are believed to possess the necessary properties of a potter's clay. It seems reasonably certain that with the present demand for all kinds of clay goods these deposits will not long remain undeveloped.

BUILDING STONE.

In 1898 about \$7,400 worth of all kinds of stone used for structural and road purposes, was marketed in Hardin county. The entire output came from the Lower Carboniferous and consisted of limestone and dolomite.

Two distinct geological periods have contributed structural materials to the natural resources of the county, the Kinderhook and Des Moines of the Carboniferous, and the glacial stage of the Pleistocene. The Kinderhook is the only producer of stone in commercial quantities. Quarries which work the Kinderhook beds are located along the Iowa river at Gifford, Eagle City, Iowa Falls and Alden. Small quarries have been opened near the north line of Tipton township along South Fork. In fact nearly all of the Kinderhook outcrops have been worked more or less intermittently for many years. The most important quarries are located near Iowa Falls.

Iowa Falls.—East of the I. C. railway bridge three quarries are now actively operated on the north and east sides of the river. These are known as the Talbot, Purcell and Biggs quarries, respectively. The sections exposed and the methods employed are practically identical in all of the quarries. Hand methods, only, are in use, improved machinery having yet to make its appearance. The section exposed at the Biggs quarry is as follows:

	FEET.
6. Drift, very thin; consists chiefly of a bowldery gravel	0-3
5. Dolomite, brownish-buff, much weathered in places and presents an arenaceous or earthy facies.....	4
4. Limestone, white, oolitic, fossiliferous.....	6
3. Limestone, blue, compact, of firm texture and very brittle.....	3
2. Limestone, white; lower three feet very compact and brittle; fracture conchoidal to uneven, contains numerous blebs of crystalline calcite; almost lithographic in texture.....	5
1. Limestone, gray, dolomitic, very slightly arenaceous to argillaceous; exposed.....	5

The quarry methods in vogue are to drill deep holes vertically, nearly parallel to the face of the cliff, and then to use



FIG. 35. Section of Kinderhook beds exposed at the Biggs' quarry.

heavy charges of explosives to shoot loose the ledges. This leads to great shattering, and scarcely more than thirty per cent of the entire section can be used for dimension stone. A large proportion of the remainder is considered dead material and is thrown back as detritus. This is true not only of the quarries here, but of those near Alden. Vast quantities of material now considered useless would be of great value for

ballast and concrete if crushed and properly sized. South of the river considerable stone has been taken out opposite the Purcell quarry, but active operations have ceased some time since.

West of Iowa Falls the Lower Carboniferous rocks are much more rifted and shattered than to the eastward, and the limestone layers become sub-crystalline in texture. The stone takes a good polish, possesses a pleasing color, and if large blocks could be obtained the rock would possess great value for ornamental and structural purposes. Unfortunate it is that the same agency which produced the partially crystalline structure so essential in marbles, was also responsible for the shattering and rifting of the beds. In fact the marbleization was rather a result of the rough usage to which the beds were subjected. The beds continue shattered and sub-crystalline in texture to the point of their disappearance beneath the drift at Alden. Formerly the Ivanhoe Quarry company put in a steam crusher and operated quite extensively near the C., I. & D. tracks on section 16, in Hardin township. Several years ago the building containing the machinery burned down, and the plant has since been dismantled and abandoned.

East of Alden Mr. F. N. Wheeler operates a quarry and has done some systematic prospecting for heavier beds of the sub-crystalline limestone layers. The layers quarried vary from two to five or six inches in thickness, and are of good quality. Efforts to develop thicker layers are as yet unrewarded.

Small quarries at numerous points help to supply local consumption but none are of sufficient importance to merit individual mention.

The Eldora sandstone has been used to a certain extent in the foundations of numerous structures in and about Steamboat Rock, Eldora, and Xenia, but so far as known it is not at present produced in commercial quantities. The stone is extremely variable in texture and state of induration, and these factors taken with its somber color makes it certain

that it will never be popular as a structural material. Vast quantities are available, and when the stone is carefully selected gives good service in the less imposing structures, and its use might be safely and profitably extended in backing walls faced with more expensive materials.

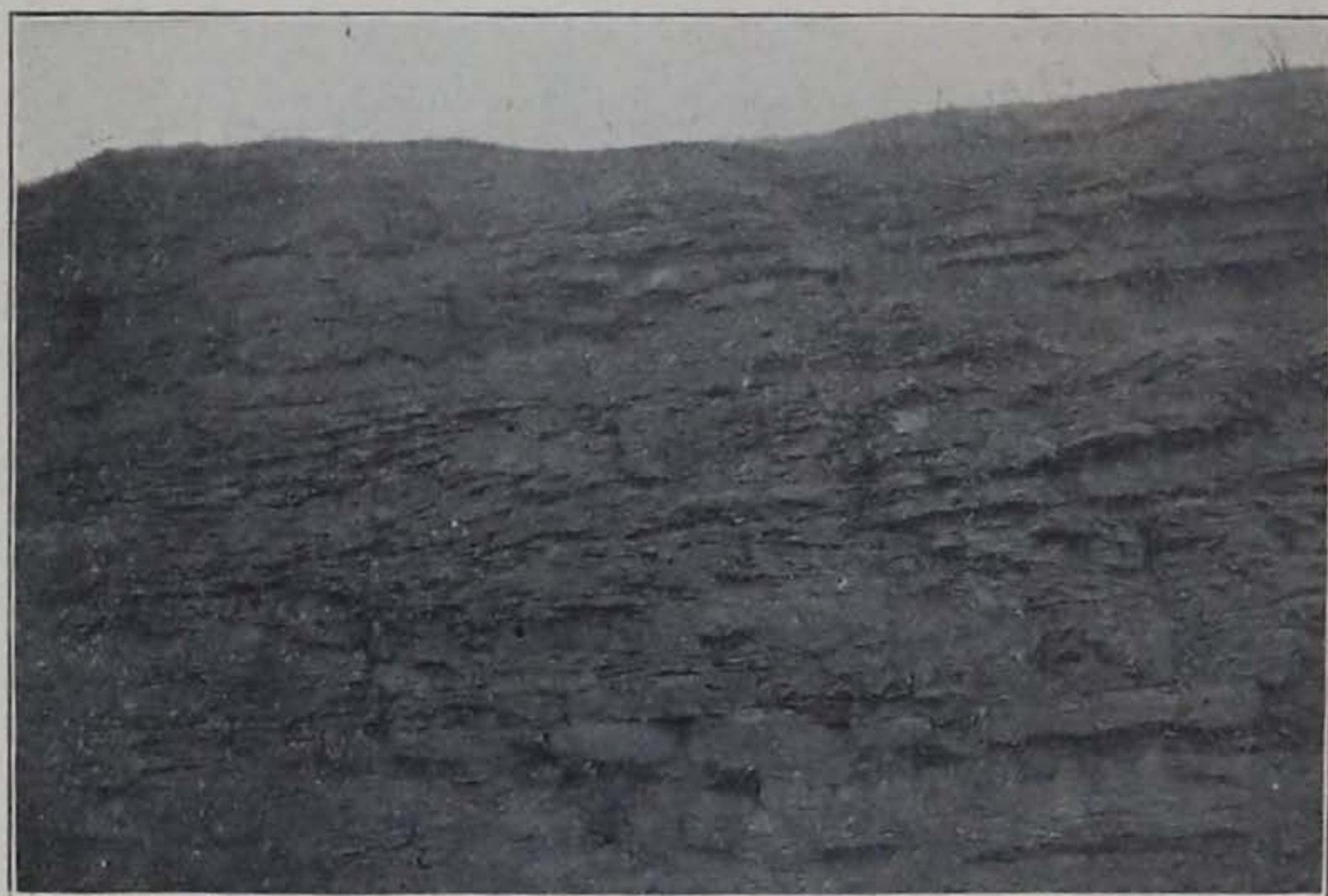


FIG. 35. Eldora sandstone as exposed along the C. I. & D. Ry., near Xenia, Hardin county, Iowa.

The drift affords an assortment of crystalline rocks which are coming into favor in the construction of foundation walls of farm buildings. They are the most enduring of all the structural materials found in the county, and at no distant day they will be prized highly in the foundation work of the more permanent structures.

SOILS.

Hardin is essentially an agricultural county and it is to the productiveness of her fertile soil that her people owe their prosperity and happiness. The products of her quarries and pits are important but the output of her mineral products for

the entire county is scarcely a tithe of the value of the products of the soil from a single township. Barren, untractable or unproductive land is unknown in the county. None of the soil has been formed *in situ* but all is rock meal brought in and deposited by the various ice sheets. It has subsequently been modified by the action of air, wind and water, and has been mixed with more or less organic matter to which its dark color and richness are, in large measure, due. Corresponding to the three drift sheets which comprise the surface deposits of the county, three types of drift soils may be recognized; and along the lower courses of the Iowa and South Fork a fourth type may be designated the alluvium or river-deposited material. The distribution of the loess-Kansan soil is coincident with the loess-Kansan province. It is characteristically a porous, clayey silt, allowing rootlets to penetrate easily and deeply, rich in lime and well drained and ventilated. Its worst properties are a tendency to gully during heavy rains and to bake when dried rapidly. It becomes slightly arenaceous where the loess is very thick on broken grounds, but on the uplands is easily tilled and is very productive.

The Iowan drift soil is confined to the northeast portion of the county,—the region of the Iowan drift plain. It is a rich deep loam, rich in lime, moderately well drained and one of the most productive soils in the county.

The Wisconsin drift soil corresponds to the area occupied by the Wisconsin drift. It has been subjected to weathering agents the shortest time and as a consequence is the least modified. It is, in other words, the least perfect soil. It is rich in available plant food but lacks proper drainage and ventilation. With the introduction of tile drains to carry off the water from inclosed basins and bring about the necessary aeration, the Wisconsin drift soil bids fair to become one of the most productive and lasting of the soils in the county. The percentage of pebbles and boulders is greater than for any other of the types, but they are not as a rule sufficiently

abundant to hinder cultivation. Alluvial soils are nothing more or less than drift worked over, the finer materials being deposited along the principal streams and constituting the soils of their flood plains. This type is, when not too sandy, very productive and tractable. It is, however, subject to inundation. The type is not important for Hardin county.

ROAD MATERIALS.

This county is richly endowed with large quantities of material suitable for road making, ballast and riprap work. All of the streams of importance which issue from the Wisconsin drift are terraced by extensive deposits of gravels, and the Carboniferous affords an almost inexhaustible supply of material easily available and suitable for all kinds of public road work, and for riprapping and ballasting railway roadbeds. Only the former deposits are at present utilized. The Iowa Central has opened up extensive pits at Gifford on the South Fork, and the Chicago & North-Western Railway company has removed enormous quantities of gravel from the terrace east of the Iowa river, near Gifford. Ten to fifteen feet of gravels are exposed at these points, and, as has already been mentioned, they are post-Wisconsin in age. Water action is apparent, and the beds have been put down at every conceivable angle. The gravels are much coarser above than below. Boulders of limestone and Eldora sandstone are very abundant.

Save the Ivanhoe quarry the Kinderhook has not been developed for road material. Millions of cubic yards are available for macadam and ballast. Three lines of railway enter Iowa Falls, and a steam crusher used in connection with the quarries to utilize the waste product could not fail to be a good investment if intelligently managed.

SAND.

All of the streams furnish an abundance of sand, either in their terraces or in their channels, suitable for building purposes. Aside from the streams considerable quantities may

be obtained from the kames and sand knobs, which are almost universally distributed over the Wisconsin drift area. Moulders' sand appears at numerous points below the loess in the loess-Kansan area. Near Iowa Falls a very clean white sand is reported, which is believed to be pure enough for the manufacture of common window glass.

WATER SUPPLY.

Only the Iowa river proper furnishes living water throughout the entire year. All of the other streams are entirely dry through seasons of drouth, or are at least reduced to a series of disconnected spring-fed ponds. Notwithstanding the apparent scarcity of surface running water, an abundant supply of good water is, as a rule, easily obtained by means of wells. A decade ago but few wells entirely penetrated the drift, but obtained a sufficient supply for domestic purposes from the interglacial gravels. During recent years the shallow wells have wholly failed during the summer season, or have proved inadequate to supply the increased demand put upon them. The old wells are being deepened, and many of the new wells pass entirely through the glacial deposits and draw their water supply from the sub-glacial gravels or from the indurated rocks of the Lower Carboniferous. Several small artesian basins are known in the county, the most important of which is the basin along South Fork in Buckeye, Ellis and Tipton townships. The wells in this area are located on the flood plain of South Fork and vary from eighty to 120 feet in depth. The aquifer appears to be the sub-glacial gravels, and the water rises some ten feet above the flood plain. Springs are also numerous in this area. The basin appears to be due to the stoppage of a pre-Wisconsin drainage line by the debris of the Altamont moraine.

The deepest well in the county supplies the town of Ackley. The well is 2,030 feet in depth and draws its water from the Jordan sandstone of the Saint Croix. The Ackley well section is incorporated into an earlier part of this report. No

data concerning the pumping capacity or character of the water could be obtained from the town authorities.

The well put down and owned by the city of Iowa Falls struck a flow in the sandy layers which separate the limestone and shale members of the Kinderhook. According to actual tests made for the city, the well has a sustained pumping capacity of more than 10,000 gallons per hour. The water is clear and sparkling, has a temperature of 50° F. and flows over the mouth of the well. A complete chemical and sanitary analysis was made by Prof. J. B. Weems and is appended below:

CHEMICAL ANALYSIS.

	GRAINS PER GALLON.	PARTS PER MILLION.
Silica (SiO ₂).....	0.83	14.3
Alumina (Al ₂ O ₃) } Ferric oxide (Fe ₂ O ₃) }	0.27	4.6
Lime (Ca O).....	8.74	150
Magnesia (Mg O).....	2.43	41.7
Soda (Na ₂ O).....	1.27	21.8
Chlorine (Cl).....	0.70	12
Sulphur trioxide (S O ₃).....	0.99	16.9
Carbon dioxide (C O ₂).....	9.45	162.1
Total.....	24.68	423.4
Less oxygen replaced by chlorine.....	0.15	2.7
	24.53	420.7

PROBABLE COMBINATIONS.

Silica (Si O ₂).....	0.83	14.3
Alumina (Al ₂ O ₃) and ferric oxide.....	0.27	4.6
Calcium carbonate (Ca Co ₃).....	15.61	267.8
Magnesium carbonate (Mg Co ₃).....	4.95	84.9
Sodium sulphate (Na ₂ S O ₄).....	1.50	25.8
Sodium chloride (Na Cl).....	1.16	19.8
Magnesium sulphate (Mg S O ₄).....	0.21	3.5
Total.....	24.53	420.7

SANITARY ANALYSIS.

	PARTS PER MILLION.
Ammonia.....	0.792
Albuminoid ammonia.....	0.068
Solids on evaporation.....	446
Solids on ignition.....	280
Oxygen absorbed in 15 minutes.....	6.1
Oxygen absorbed in 4 hours.....	9.1
Nitrogen as nitrites.....	0.0
Nitrogen as nitrates.....	0.0

The above analyses show a remarkably low percentage of solids and no trace of nitrites or nitrates, and establish the water as well adapted to both domestic and manufacturing purposes, in fact one of the best potable waters in the state.

The Eldora well is 250 feet in depth, penetrates about ninety feet of drift and sixty feet of coal measures, and reached water in the Kinderhook at a depth of about 180 to 200 feet. The water stands at 135 feet from the surface, which is approximately the level of the water in the Iowa river. The pumping capacity is 50,000 gallons per day.

The railways and the towns of Gifford and Union find an abundant supply of good water in the terrace gravels at a depth of twenty to thirty feet.

Away from the streams modern wells which afford a sufficient supply for stock farms and domestic purposes vary from seventy to 400 feet in depth.

WATER POWER.

The Iowa river is rock-walled and rock-bottomed, and has a high gradient from Alden to Union. A good volume of water flows throughout almost the entire year. As a consequence excellent mill sites are numerous. Mill properties have been located at Alden, Iowa Falls, Eagle City, Hardin City, Steamboat Rock, Eldora, Xenia and Union. All of the above, save the Xenia mill, were more or less actively operated in 1899. A head of from seven to nine feet was readily obtained at all of these points, and from fifty to 100 horse power can be developed during the greater portion of the year. None of the other streams afford more than temporary power for brief seasons during each year, and flood and drouth prove equally fatal to their utilization.

ACKNOWLEDGMENTS.

In the preparation of the foregoing report the writer has received much assistance from those in charge of the various clay and stone industries, and the well-drillers of the county. The Survey is especially indebted to Mayor W. H. Woods and

B. B. Bliss, of Iowa Falls; E. Claud Hecker, of Alden; Superintendent Woodward, of Eldora; and W. W. Rodwell, of Union, for the hearty co-operation and interest in the work. The writer has received the invaluable advice and assistance of the State Geologist, Professor Calvin, and the Assistant State Geologist, H. F. Bain, during the progress of the work. To all who have in any way facilitated the work acknowledgments are gladly given.

THE FOREST FLORA OF HARDIN COUNTY.

BY L. H. PAMMEL.

One of the interesting phases of botany is a study of plants with reference to their adaptation. Plants of widely different relationship are frequently associated in communities. Such plants show the same adaptations as regards their structures and growth.

Certain physiographic features of the country have a marked influence on the plant communities. Sandy, moist rocks support a very different class of plants from limestone rocks, or the alluvial bottoms of the streams. These features often determine the geographic limitations of some trees. The White pine (*Pinus strobus*) is a very local tree in this state, being confined to the sandstone ledges of eastern and central Iowa. The White pine is not, however, found in this state wherever the sandstone ledges occur. Extensive Carboniferous sandstone deposits occur along the Des Moines from Moingona south, and while the forest growth at various points is somewhat similar to that of Hardin county, three of the prevailing species do not occur, namely, *Pinus strobus* and two birches, the White birch (*Betula papyrifera*), and the Cherry birch (*B. lenta*). Botanists have long recognized that species tend to move northward or southward, and less frequently plants move eastward and westward. The westward extension of the eastern trees in Iowa is marked by certain valleys. Taking the White pine as an illustration its western limits is marked by the Iowa valley. Dr. S. W. Beyer calls

my attention to the report of David Dale Owen,* in which he refers to the occurrence of White pine on the summits of the hills along the Iowa river in Hardin county. Its southern extension is Pine creek in Muscatine county. The Davenport locality Reppert† Watson and Coulter Gray's Manual (6th Ed.) 490 is clearly an error, as I have shown elsewhere. The White birch,‡ *Betula papyrifera*, has its western limit in the same valley, and is clearly more local than the White pine. Macbride§ reports as follows: "Occurs in cultivation, and is reported abundant along the Boone river east. Perhaps comes within the limits of the county in the northeast corner." Its occurrence there would be extremely interesting, since to my knowledge the species does not occur in the vicinity of Webster City along the Boone river. The occurrence of the Cherry birch in the vicinity of Steamboat Rock is another equally interesting discovery. So far as I know this is the only recorded locality in the state. The Cherry birch is a distinctly northern tree, found in moist, sandy, rocky soil in western Wisconsin. The White birch occurs in the more exposed and drier places, conforming to its habitat, in western Wisconsin and northeastern Iowa, as I indicated in a paper in *Garden and Forest*|| on the forest vegetation of the Upper Mississippi. Macbride,¶ in his paper on the forest trees of Allamakee county, says: "Certainly confined to the northeast corner of the state."

Until finding the species last fall I had not known of its occurrence in Iowa except in the counties north of Dubuque along the Mississippi river.

The flora of this region is a typical northern or, more properly, the transition of C. Hart Merriam.**

The arboreal vegetation is accompanied by many typical northern species. It has many more northern species than

*Rept. Geol. Surv., Wis., Iowa, Minn., 102.

†Iowa Geol. Surv., Vol. IX, p. 387.

‡Plant World, Vol. II, p. 186.

§Iowa Geol. Surv., Vol. IX, p. 152.

||Vol. IV, p. 409; Iowa Acad. Sci., Vol. I, p. 80.

¶Iowa Geol. Surv., Vol. IV, p. 119.

**Year Book U. S. Dept. of Agri., 1894, p. 209.

Clinton or Dubuque counties and but few of their southern species. *Asimina triloba*, *Carya olivæformis*, *Cercis canadensis*, and *Q. muhlenbergii* occur at Clinton but are entirely wanting near Steamboat Rock. The typical transition species occur for some four or five miles north of Steamboat Rock but disappear south. These are practically confined to the sandstone ledges. Beyond these ledges the timber presents nothing unusual for central Iowa.

This small area is well watered and where it was not pastured it was decidedly swampy, as evidenced by the profuse growth of *Impatiens fulva* and *Lobelia siphilitica*. The *Cypripedium spectabile* was less common in open places. In the densely shaded woods the ground was covered with a species of *Hypnum*. *Phegopteris Dryopteris*, *P. polypodiodes*, *Asplenium Felix-foemina*, *Polypodium vulgare* and *Aspidium marginale*. The latter to my knowledge has not been recorded for the state, and certainly is much beyond the usual range given to it. In Wildcat Den, Muscatine county, where the physical conditions are somewhat similar, it is entirely absent. The two species of *Phegopteris* have been reported from other sections of the state. All of these are northern species. The small Bush Honeysuckle (*Diervilla trifida*) has a range from Newfoundland to mountains of North Carolina west to Minnesota. Reppert also reports it from Muscatine county. It is, therefore, much beyond its usually given range. The *Cornus circinata* is a common shrub on sandy rocks in western Wisconsin, its natural range being from Nova Scotia to Dakota, south to Virginia and Missouri. Its Missouri occurrence is like the Iowa, usually in isolated places. Reppert records it from Muscatine county along Sweetland creek* and I have observed it as a rare shrub at the ledges in Boone county. The *Cornus asperifolia* is more common. The sandy piny woods are covered with *Danthonia spicata*, which is true also of the woods along Pine creek in Muscatine county and the Carboniferous sandstone ledges in Boone county.

*I. c. 384.

The timber along the Iowa river in former days was much used for railroad ties; the best has, however, long since been removed. There is, however, still some merchantable timber which is being cut into lumber, and much is used for fuel. Of the *Betula lenta* there were trees twelve inches in diameter which might very profitably be used for lumber.

The forests have been much injured; there is, in fact, general complaint that the forests do not do as well as formerly. Several causes have led to this. The unseasonable winter of 1898-1899 killed many trees or injured them so severely that they will never recover, and should at once be cut out. Trees varying from saplings to those one and a half and two feet were destroyed by this freeze. Some of these trees have attained an age of fifty to seventy-five years. Is it possible that during all these years Iowa has not experienced such a winter? Where there are solid bodies of large trees still standing it is reasonable to suppose that the conditions during the past season were unusual, or man has so modified present conditions that trees have been unable to resist unseasonable climatic conditions. In going through these forests one cannot help but notice that man is responsible. I passed through acres of timber in which the ground had scarcely a weed growing,—the ground was bare. It had been stocked to such an extent that there was no longer any covering or protection to the roots. The farmer in Hardin county and elsewhere in the state, is attempting to grow two crops on the same ground at the same time. The first principle in forestry has not been learned. It is evident that unless the farmers adopt a different system of treating the forest they must, sooner or later, lose what little timber is remaining. There are many points along the Iowa river, in Hardin county, that can never be utilized for farming purposes, which should be devoted to forestry.

LIST OF TREES.

TILIACEÆ.

Tilia americana L. Common in narrow valleys and hillsides along the Iowa river.

SAPINDACEÆ.

Acer saccharum Marsh. What I take to be this species occurs along the Iowa river.

A. nigrum Michx. This is the most common maple in central Iowa along the Iowa river. Large trees a foot to one and a half feet in diameter.

A. saccharinum L. (*A. dasycarpum* Ehrh.). The Silver maple or Soft maple is the most abundant of the maples; grows in alluvial bottoms of the Iowa river, frequently attaining large size. The species is much used for fuel. Also frequently planted as an ornamental tree.

Negundo aceroides Moench. The Box elder or Ash-leaved maple is abundant in low, rich grounds.

LEGUMINOSÆ.

Robinia pseudacacia L. Naturalized at several points in the county.

Gymnocladus canadensis Lam. In bottoms of Iowa river; frequent.

Gleditschia triacanthos L. Frequent in bottoms along the Iowa river.

ROSACEÆ.

Prunus americana Marshall. Frequent not only along the Iowa river, but along all the smaller streams.

P. virginiana L. The Choke cherry is common in woods throughout the county.

P. serotina Ehrh. Frequent in woods throughout the county.

P. pennsylvanica L. In upland woods is frequent.

Pyrus iowensis Wood. Common, forming thickets, second bottoms and uplands.

Cratægus coccinea L. In bottoms common.

C. mollis Scheele. The most common species in second bottoms along all of the streams, forming thickets.

C. punctata Jacq. In bottoms.

C. tomentosa L. In upland woods.

Amelanchier canadensis Torr & Gray. The species occur not only upon the sandstone ledges, but in woods throughout the county.

CORNACEÆ.

Cornus alternifolia L. Common in sandstone ledges and in sandy second bottoms of woods. The following additional species occur, but none become trees: *C. sericia* Michx., *C. asperifolia* Michx., and *C. paniculata* L'Her.

OLEACÆ.

Fraxinus americana L. Common in low, wet places along the Iowa river.

F. viridis Michx. The most common ash in the region.

URTRICACÆ.

Ulmus fulva Michx. The Slippery elm is abundant in all upland woods, and forms one of the chief characteristics of the woods. A valuable species for lumber and posts.

U. americana L. The American or White elm is common in woods along the alluvial flood plains of the river. Here the species attains its greatest size. Many of the most valuable of these trees have been cut. The species also grows along all the tributaries of the Iowa river throughout the county.

U. racemosa Thomas. The Cork elm probably also occurs but the writer did not observe the species.

Celtis occidentalis L. The Hackberry is common in the flood plains of the Iowa river. The trees are of medium size.

Maclura aurantiaca Nutt. The Osage orange was much used for hedges, but the trying winter of 1898-1899 killed nearly all of the plants in the county.

Morus rubra L. The Red mulberry was not observed, although it occurs farther south along the Iowa river.

PLATANACEÆ.

Platanus occidentalis L. The Sycamore occurs along the Iowa between Steamboat Rock and Marshalltown, but was not observed in the immediate vicinity of Steamboat Rock.

JUGLANDACEÆ.

Juglans cinerea L. Common throughout the county in upland woods.

J. nigra L. Common in flood plains of Iowa river and its tributaries.

Carya alba Nutt. Common in upland woods.

C. amara Nutt. Common in moist soil, especially ravines and moist hills.

CUPULIFERÆ.

Betula lenta L. Some large trees one foot in diameter occur in the moist woods below the sandstone ledges. Much of the birch has been removed. This is very valuable wood and is much used by cabinet makers. Its occurrence in central Iowa is quite unusual.

B. papyrifera Marshall. The Paper or Canoe birch occurs on the upper exposed sandstone ledges. The bark of the trees is white and splits into paper-like layers. None of the trees remaining would make merchantable timber. Its occurrence in central Iowa is quite unusual.

Betula nigra L. Iowa river bottoms.

Ostrya virginica Willd. Slopes of hills; common.

Carpinus caroliniana Walter. The Hornbeam is less common than the *Ostrya*. It occurs in similar situations; like hop-hornbeam it produces an exceedingly tough wood.

Quercus alba L. Fine bodies of White oak once occurred on the beach lands of the Iowa river, but this has long since been removed. The second growth is not coming on rapidly because of the injudicious pasturing.

Q. macrocarpa Walt. The Bur oak occurs rather commonly on the bench lands and in bottoms.

Q. rubra L. The Red oak is the most common oak of the region. The old timber has been pretty well culled out.

Q. tinctoria Bartram. The Black oak occurs in gravelly or somewhat sandy soil along the Iowa river.

SALICACEÆ.

Salix nigra Marsh. The Black willow is common along the Iowa river.

S. amygdaloides Anders. Along the Iowa river.

S. alba L. Commonly cultivated for wind-breaks and hedges.

S. rostrata Richardson. Common in moist meadows and banks along streams.

Populus alba L. Widely introduced as a cultivated plant and a frequent escape.

P. tremuloides Michx. The Trembling aspen is not infrequent, forming small groves.

P. grandidentata Michx. Occurs in rich woods along the Iowa river, especially with the White pine and birch.

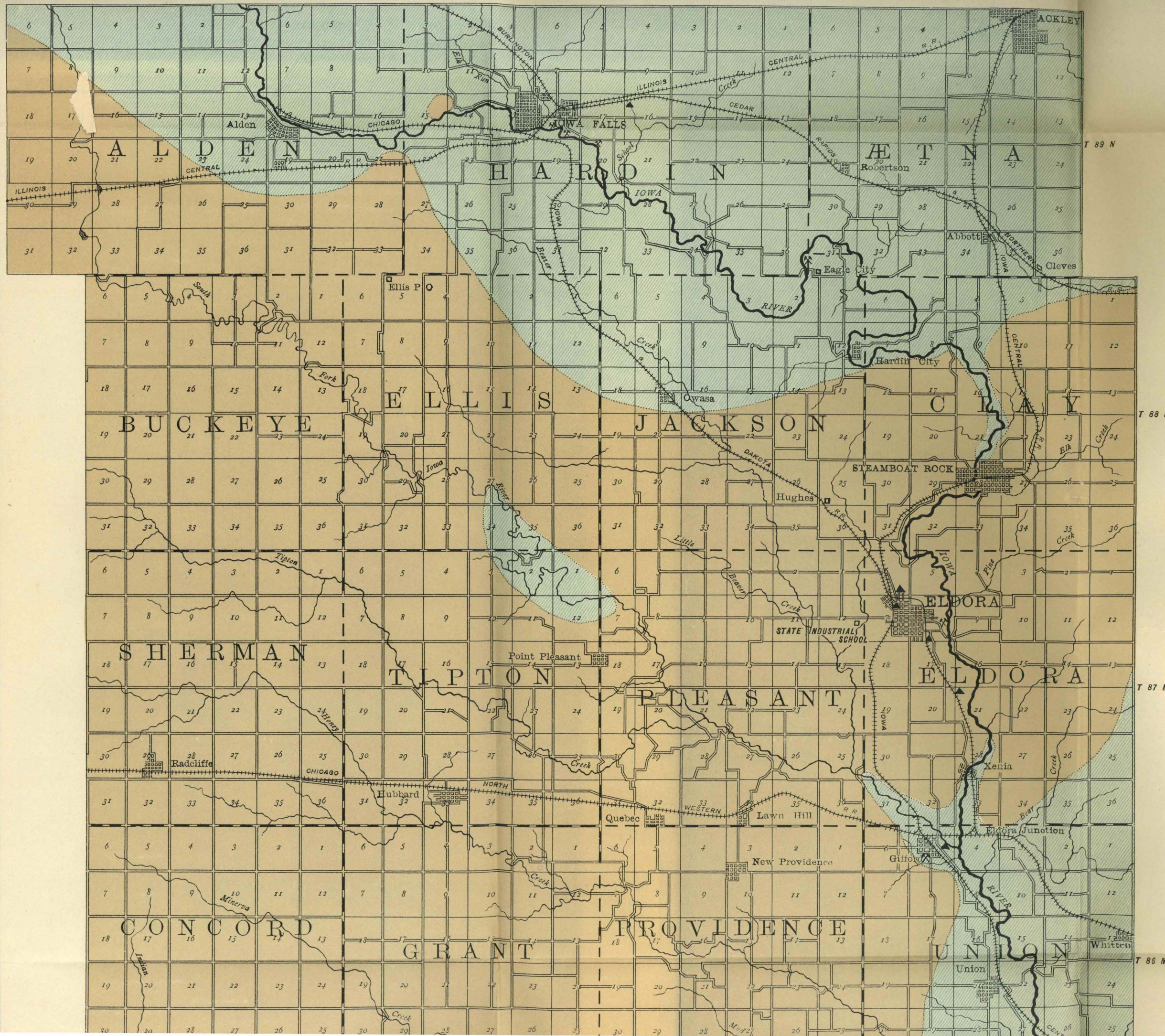
P. monilifera Ait. Common everywhere in bottoms along the Iowa river and the smaller tributaries.

CONIFERÆ.

Pinus strobus L. The White pine occurs for several miles along the Iowa river near Steamboat Rock and along the smaller creeks. This is the most western locality in the state.* The most southern locality in the state is Muscatine. It is more frequent in northwestern Iowa.

Juniperus virginiana L. The Red cedar is not common, but occurs on the hills along the Iowa river about Steamboat Rock. The trailing shrub *J. communis* also occurs below Steamboat Rock on the damp hillsides.

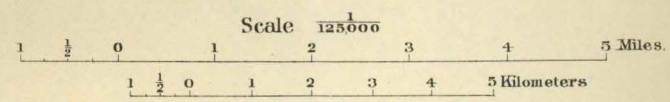
*Plant World, 2:186. Contr. Bot. Dept. Ia. St. Coll. Agr. and Mech. Arts 14.



IOWA GEOLOGICAL SURVEY

GEOLOGICAL
MAP OF
HARDIN
COUNTY,
IOWA.

BY
S.W. BEYER
1900.



LEGEND
GEOLOGICAL FORMATIONS

- DES MOINES
- KINDERHOOK

INDUSTRIES

- CLAY WORKS
- QUARRIES

STATE LIBRARY OF IOWA



3 1723 02106 2393