GEOLOGY OF BOONE COUNTY.

BY

SAMUEL WALKER BEYER.

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CONTENTS.

INTRODUCTION.

SITUATION AND AREA.

Boone county forms one of the middle tier of counties, lying immediately to the west of the center county, Story, of the state. It comprises an area of approximately 576 square miles.

PREVIOUS GEOLOGICAL WORK.

Like that of many other counties of the state, the literature pertaining to its natural resources is extremely meager. The first published account of observations made on the geological structure of the county appears in a report of a geological survey of Wisconsin, Iowa and Minnesota, and incidentally of a portion of Nebraska territory, by David Dale Owen.* This description deals mainly with the general features of the county, and is accompanied by a sketch of the Des Moines river and vicinity, with several sections illustrative of the strata in the southern half of the county. It is based on an excursion up the river between the Raccoon and Lizard forks during the summer of 1849, the primary object being to determine the delimitations of the Iowa and Illinois coal area.

In 1856 A. H. Worthen made a general geological reconnoissance of the Des Moines valley†, and incidentally gives detailed sections of the strata occurring at Elk Rapids and Milford, which, with some slight modifications, may be considered as fairly typical for the southern and middle portions of the county respectively. White in his second annual report, and again in his final report‡, speaks of the coal industry and definitely refers the strata of the whole county to the coal measures.

*Report of a Geological Survey of Wisconsin, Iowa and Minnesota, and incidentally a Portion of Nebraska Territory. By David Dale Owen. Pages 123-125. Washington, 1852.

†Geology of Iowa, vol. I, part 1, pages 172-173. 1858.

‡Geology of Iowa, vol. II, page 259. 1870.

PHYSIOGRAPHY.

TOPOGRAPHY.

The surface configuration of the county belongs to McGee's third type, the "Drift Plain" topography*. Under this general type three sub-types may be distinguished: the intermorainal, morainal and extra morainal portions. The area lying within the moraine comprises a narrow tract in the northern part of the county, characterized by an extremely flat surface broken only by occasional small eminences and depressions. The moraine is composed of a chain of interlocking hills having a north of west trend and running three-fourths of the way across the county. The belt varies from one to two or three miles in width, and is the most prominent topographic feature in the region. The extra-morainal area comprises by far the greater portion of the county. The general surface of this area is undulating and slightly inclined toward the south. The land bordering the principal streams is much broken, and as a rule supports a vigorous growth of timber. The inland portions present a billowy appearance, the general trend of the corrugations being northwest to southeast.

The watershed between the Skunk and the Des Moines river has an average altitude of nearly 1,200 feet, this being the most elevated divide in the county. That between the Beaver and the Des Moines is about seventy-five feet lower. The subjoined table, based upon railroad profiles, gives the altitudes of some of the most important points.

Table of Elevations.

STATION.	Altitude above sea level.	AUTHORITY.
Angus	1028	M. & St. L. Ry.
Beaver Station	1031	C. & N-W. Ry.
Boone	1143	C. & N-W. Ry.
Dayton (Webster county)	1090	C. & N-W. Ry.
Madrid	1006	C., M. & St. P. Ry.

* Eleventh Am. Rep. U. S. G. S., page 367.

Table of Elevations.

STATION.	Altitude above sea level.	AUTHORITY.
Midway	1086	C. & N-W. Ry.
Moingona	909	C. & N-W. Ry.
Ogden	1098	C. & N-W. Ry.
Pilot Mound	1220	M. & St. L. Ry.
Stratford (Hamilton county)	1120	C. & N-W. Ry.
Summit between the Beaver and Des Moines	1111	C. & N-W. Ry.
Summit between the Skunk and Des Moines	1186	C. & N-W. Ry.

DRAINAGE.

The streams in this region belong to McGee's* second class, and their homologues in northeastern Iowa have been well described by that writer as follows: "The most striking characteristics of all these streams is their great length in proportion to their volume, and the striking characteristic of the basins is their length and slenderness. Moreover there is a dearth of small tributaries, and so occasional lakes and ponds, swamps, and extensive sloughs are common." As has been mentioned, the general surface inclines gently toward the south and a natural inference would be that the principal water courses flow in the same direction. This is true in the main, the streams in the northeast portion of the county being the exception. The streams belong to two river systems; a major, comprising the Des Moines river with its tributaries, all flowing nearly due south with the surface incline and draining the southwest three-fourths of the county; a minor, drained by tributaries of the Skunk river, the general trend of which is nearly at right angles to the surface incline. As a rule all the larger channels of both systems have deeply incised the county through which they flow. This is particularly the case with Squaw creek and the Des Moines river with its short branches.

* Ibid, p. 359.

DES MOINES RIVER.

The Des Moines river enters the county about two and one-half miles west, and leaves it a little more than three miles east of the median line, thereby dividing the county into two almost equal east and west halves. The valley formed by the river varies from a half mile to two miles in width. The present flood plain comprises about one-third of the area, though, during periods of ultra high water, at least one-half of the valley is inundated. The stream meanders from side to side of its flood plains, but very rarely impinges upon its restraining bluffs. It has cut through the drift and deep into the coal measure strata throughout its course in the county. The valley is included between precipitous bluffs, deeply lain with glacial debris, and the continuity of its walls is broken only by the incursions of its numerous side branches. These mural walls vary in height from rather more than 100 feet at their entrance into, and exit from the county, to a maximum of 200 feet west of Boonesboro.

Terraces.—Terraces marking distinct stages in the development of the river are characteristic features in this region. The most prominent and persistent terrace appears about fifty feet above low water and, in the main, marks the limit of the present flood plain. The valley farms are largely located on this bench, and amply testify to the value of its soil for agricultural purposes. Another terrace of less pronounced character may be observed, at various points, at an elevation of about 100 feet above the river.

The Des Moines basin proper is extremely narrow. The tributaries which become confluent within the confines of the county are extremely short. The watersheds between the Skunk and Des Moines, on the east, and the Beaver and Des Moines, on the west, average scarcely nine miles apart and might be crossed and re-crossed without their presence being suspected. The valleys of the short lateral branches of this system partake of the general canyon-like character of the parent stream, and give a very broken aspect to the river

belt. They possess steep declivities and become torrential during seasons of high water, but very few flow in extended periods of drouth. The majority, although they may be creeks of some importance in their upper reaches, lose themselves entirely in the sands of the river flood plain. The principal tributaries are Mineral, Honey, Peese and Hull creeks from the east, and Bluff, Bear, Caton and Preston creeks from the west, all of which tend to parallel the greater stream.

Age of the Des Moines river.—Sufficient data is not at hand to definitely determine the age of the river; but several significant facts, all of which point toward the youthfulness of the system, may be noted. (1) The extreme shortness of its tributaries, taken in conjunction with their high grades, are indicative of brief careers. (2) The river itself has done comparatively little lateral corrasion. Only in rare instances does it impinge on the limiting walls of its valley, and "truncated salients," which form such a prominent feature in the topography of the Mississippi valley, are almost unknown. (3) According to data derived from coal mines and well sections the position of the stream appears to be out of harmony with the topographic features of the older formations; i. e. the Des Moines is a superimposed stream, younger than the glacial deposits.

Beaver creek.—Beaver creek, with its long meandering branches, drains the western tier of townships and belongs to the greater Des Moines system. It is essentially a prairie stream of low grade. In fact the northern ten miles of its course might be more properly denominated a system of prairie sloughs and ponds which become almost impassable during prolonged periods of rainy weather, but do not persist during the dry season. As might be expected from the low declivity of the stream ways, and the transient character of the waterflow, the streams have done but little work in channeling or in valley formation. Only in the southern portion of the county, after the several branches have become confluent, is there a

well defined valley. At no place is the superimposed drift sufficiently removed to reveal the older formations.

SQUAW CREEK.

Squaw creek, a tributary of the Skunk, with its long sinuous branches, amply drains the northeastern fourth of the county. Unlike the Beaver, this system possesses a higher declivity, and the several components have cut for themselves well defined valleys. Furthermore, small lateral branches are more numerous, and sloughs and ponds less common. The streams with their flood plains are from fifty to eighty feet below the general level of the surrounding country. Like the Beaver, these streams seldom persist throughout the entire year.

STRATIGRAPHY.

General Relations of Strata.

The geological formations represented in Boone county may be referred to two systems, an older, the Carboniferous, comprising the indurated rocks of the county, and a younger, the Pleistocene, including the non-indurated beds. The relative rank of the individual formations is shown in the subjoined table.

Classification of Formations

GROUP.	SYSTEM.	SERIES.	STAGE.	SUB-STAGE.
Cenozoic.	Pleistocene.	Recent.		Alluvium.
		Glacial.	Wisconsin.	Upper till.
			Kansan.	Lower till.
Paleozoic.	Carboniferous.	Upper	Des Moines.	

Boone county, so far as now known, lies wholly within the region of the lower coal measures, or Des Moines formation. For many years it has been one of the most important coal producing counties of the state. The Lower Carboniferous

formations, while present at no great depth below the surface, as evidenced by numerous well borings both within the limits of the area and also in the adjoining counties of Story and Hamilton, are nowhere exposed within Boone county. The Saint Louis limestone occurs in typical exposure about two miles from the eastern boundary of the county, on a tributary of the Skunk river. This is the only outcrop of the Mississippian series in the vicinity. The drift is everywhere present, varying from fifty to more than two hundred feet in thickness. It entirely conceals the subjacent formations, save along the Des Moines river and a few of its tributaries; and even here talus slopes and landslides of glacial debris largely conceal the country rock. Inland, there are no natural sections of importance; but, fortunately, certain public spirited citizens have been instrumental in preserving careful records of several artificial excavations which give reliable information not only concerning the coal measures, but concerning the deeper lying strata as well.

TYPICAL SECTIONS.

The following sections taken from various parts of the county illustrate the lithological character of the formations present.

Traversing the county from south to north along the Des Moines river a considerable number of sections may be observed, which may be considered fairly typical of the coal measure stratigraphy of the region.

On Preston branch, about one mile from its confluence with the Des Moines, the following sequence of strata may be observed.

SECTION I.

(Tp. 82 N., R. XXVI., Sec. 33, Ne. qr.)

		FEET.	INCHES.
11.	Drift	20	
10.	Shale, blue	2	
9.	Sandstone in which plant impressions are numerous	2	
8.	Shale, somewhat bituminous below	3	

		FEET.	INCHES
7.	Coal		2
6.	Sandstone, fine-grained; argillaceous in the lower portion	15	
5.	Shale, bluish-buff; containing numerous interesting concretions near the top and one or two hard bands toward the bottom	18	
4.	Coal, not persistent		4
3.	Shale, interstratified with irregular, friable, sandy bands toward the top	15	
2.	Sandstone, ferruginous, concretionary		6
1.	Shale, blue	2	

The base of the section is at the bottom of the creek. To show the great variation in details, even in closely situated exposures, the outcrop on the side of the bluff, about 200 yards to the northeast, may be considered.

SECTION II.

		FEET.	INCHES.
7.	Soil and drift	10 to 50	
6.	Shale, light blue, iron mottled		3
5.	Shale, compact, brittle; strongly calcareous and highly fossiliferous, containing a marine fauna	1	6
4.	Shale, blue; carbonaceous and fissile below	3	
3.	Coal ("coal blossom" of miners)		1 to 4
2.	Sandstone, calcareous, deeply bedded.	6	
1.	Shale, blue (exposed)	1	

The lowest member visible at this point is about seventy feet above low water in the Des Moines river. No. 2 comprises a heavy-bedded calcareous sandstone, only the lower portion of which is thoroughly cemented. The upper layers take on a variegated appearance due to the anomalous distribution of ferric oxide. This portion contains an abundance of plant remains, which may have been instrumental in the removal of calcite and a redistribution of the iron constituent. False bedding, on a small scale, is not uncommon, yet the sands must have been laid down with extreme gentleness,

for in many instances the Lepidodendron stems retain their leaves extended, in presumably perfectly natural position.

In the south central part of the county, the older Carboniferous formations have been cut out and replaced by a younger massive sandstone. A casual observer traversing the river valley cannot but notice the sudden change in topographic form, when this sandstone is reached. The rounded salients of the coal measure shales and argillaceous sandstones, give place to mural escarpments and bold buttresses of the "Ledge" sandstone, amply testifying to the change in stratigraphy. This terrain is typically exposed near the mouth of Peese creek, a tributary of the Des Moines entering from the east. The section exhibited at this point is as follows.

SECTION III.

(Tp. 83 N., R. XXVI W., Sec. 33, Sw. qr., Sw. ¼.)

		FEET.
4.	Drift	80 to 100
3.	Sandstone, fine-grained; very friable and of a brownish color; iron-stained	50
2.	Sandstone, heavy bedded; containing numerous ferruginous and quartzitic (?) concretions	35
1.	Sandstone, thinly bedded; often showing false-bedding	5

The base of the section is but little above the river level. The creek valley is extremely narrow and walled in by vertical cliffs, often overhanging ledges; hence the name of the formation.

Examples of water sculpture are numerous and beautiful. The ridges and less precipitous slopes support a luxuriant vegetation. In short, the inorganic and organic worlds have conspired to make this one of the most picturesque spots in the region. This formation presents many interesting lithological variations, the manifestation of which, in all probability is due to, or at least has been accentuated by, the weathering processes. The second member contains numerous ferruginous concretions varying in size from a few inches to many feet in the direction of their greater dimension. Others take

an almost quartzitic facies and are so hard that they will strike fire with steel. These nodules are commonly lens-shaped or spherical, but in some instances are cylindrical. By reason of their relatively greater refractoriness, they often project beyond the softer matrices, and closely simulate the trunks of trees, and they are currently known as such.

FIG. 16. Ledge sandstone on Des Moines river.

To make the delusion more complete, these pressed cylinders weather concentrically and have a striking resemblance to the truncated bodies of exogenous trees of gigantic proportions. The lower bed of the section shows in many places cross-bedding the appearance of which is intensified by the differential corrasive and corrosive effects of the present stream. This sandstone is known to have a thickness of upwards of 100 feet and has been represented in the section as occurring in three stages.

The divisions are arbitrary rather than real; the external differences being due to accidents of weathering rather than

to variable conditions during sedimentation. The ledge sandstone may be considered as a geological unit representing a period of continuous deposition. As in most deposits of its kind it is of limited extent. It thins out rapidly both to the north and the south. At Bear creek half a mile down the river it is reduced to forty feet, and two miles in either direction from its typical exposure it entirely loses its identity, giving place to alternating sands and shales. One mile and a

FIG. 17. Differential weathering of the ledge sandstone.

half toward the source of Peese creek the older measures pass uncomformably under the ledge sandstone. Approaching from the south about one mile below the mouth of the Bear, two seams of coal are easily seen outcropping along the river bank, the lower being twenty feet above the water. Where first observed these coal beds are separated by a considerable thickness of shale and clay. Proceeding northward

the intervening strata gradually disappear, and before reaching the mouth of the creek the veins themselves end abruptly, and the ledge sandstone comes into view. Both stratigraphically and lithologically the ledge sandstone seems to have its homologue in the massive sandstone exposed in Marion county and currently known as the "Redrock sandstone."*

The Redrock sandstone is indicative of a considerable oscillation of the shore line during Carboniferous times, by which the land in that vicinity was elevated, profoundly eroded and then submerged by gradual tilting of the surface on an axis more or less parallel to the shore line. This was a period of vigorous erosion on land and of rapid sedimentation in the area in question. The ledge sandstone was laid down during this time and was followed by re-elevation.

The four following sections may be considered representative for the central coal-producing area of the county.

SECTION IV.

Honey creek section (Tp. 83 N., R. XXVI W., Sec. 7, Se. qr., Ne. ¼).

		FEET.
8.	Drift containing an abundance of selenite crystals near the base	40+
7.	Shale, compact, brittle, calcareous and highly fossiliferous	2
6.	Shale, bituminous	2
5.	Coal	2
4.	Fire clay and alternating shales and argillaceous sandstone	50
3.	Shale, black, containing many clay-ironstone concretions—nigger heads	2
2.	Coal	2
1.	Fire clay to bottom of creek	1

No.7 is lithologically and faunally very similar to No. 6, in Section II. Both terrains have about the same altitudes and it is highly probable that they belong to the same horizon. The following species have been identified from this stratum.

Athyris argentea Shepard.

Discina nitida Phillips.

*Iowa Geological Survey, vol. I, pp. 99 et seq. 1893.

Productus costatus Sowerby.
Rhynchonella uta Marcou.
Spirifer (Martinia) lineatus Martin.
Aviculopecten, Sp.
Clinopistha radialis Hall.
Pleurotomaria grayvillensis Norwood & Pratten.
Pleurotomaria illinoisensis Worthen.
Soleniscus newberryi, Stevens.

The iron nodules, which occur so abundantly in No. 3, often contain well preserved specimens of gasteropods.

SECTION V—MOINGONA.

Coal measure strata exposed about one-half mile northwest of the town of Moingona, along the Chicago & Northwestern railway, are as follows.

		FEET.	INCHES.
11.	Drift, in the main, a light blue, gritty clay, with numerous small lime concretions, extends about fifteen feet below the road bed	50	
10.	Sandstone, shaly, alternating with sandy shales; predominantly ash-gray in color and calcareous	12	
9.	Shale, blue	4	
8.	Sandstone, shaly and sandstone, compact	4	
7.	Shale, black	2	
6.	Coal		3
5.	Fire clay and shale	7	
4.	Shale, containing many ferruginous concretions and stems of Lepidodendra	4	
3.	Shale, blue-black, containing *Lingula umbonata* Cox, in places	2	
2.	Coal	2	
1.	Fire clay, exposed	2	

This section extends to the water level in the river. According to data derived from the coal shafts in the vicinity, a soft sandstone underlies the fire clay at the base of the section. About one mile north of this point the following sequence of strata may be observed.

SECTION VI.

(Tp. 83 N., R. XXVII W., Sec. 1, S. ½, Se. ¼.)

		FEET.
7.	Drift and displaced material	40
6.	Sandstone, compact ledge	1
5.	Sandstone, ash-colored, clayey and somewhat fissile; state of induration very variable, pockets of fine sand occur in the upper portion while the lower part takes on a concretionary structure	45
4.	Shale, blue-black	2
3.	Coal	2
2.	Fire clay	3
1.	Sandstone, exposed	3

Numbers 2, 3 and 4 are undoubtedly the same as 1, 2 and 3 in Section V. Above this point on the river the country rock is rarely exposed and in no case can more than a partial section be observed.

At Milford the following section may be made with some degree of accuracy, the partial natural exposure being supplemented by shafts in the vicinity.

SECTION VII—MILFORD.

		FEET.
8.	Drift	100
7.	Sandstone, alternating with shaly sandstone	60
6.	Shale, bituminous; containing Lingula and Lepidodendra	10
5.	Coal	1
4.	Fire clay, sandy shale and shale	20
3.	Coal at water level	2
2.	Fire clay and shales, the latter often containing septarian nodules	10
1.	Coal	1 to 4

The correlation of the strata at this point with those of previous sections cannot be definitely made. It is highly probable that numbers 2, 3 and 4 are the equivalents of 2, 3 and 4 in Section VI. No. 1 in this section may be present at Section VI, but it has been proved to be absent at Moingona as the numerous coal shafts in that vicinity attest. Proceeding northward there is an exposure on the west bank of the river opposite Wilson's mine (Tp. 85 N., R. XXVII W., Sec.

22, Se. qr.). Six feet of a micaceous fissile sandstone appears along the roadside, about thirty feet above low water. A workable vein of coal is found about ten feet below the bed of the stream as evidenced by the mine across the river. The last outcrop of coal measure strata in the county may be seen on the Se. qr. of Sec. 10, same range and township as the preceding. A twelve-inch seam of coal appears about four feet above the water in the river and is capped by a bituminous shale which is followed by a shaly sandstone. This vein is peculiar in that it contains a persistent clay parting.

Away from the Des Moines river and its immediate tributaries natural exposures of the coal measures are wholly wanting. Our present knowledge of the stratigraphy of the inland regions of the county is almost entirely based on drillers' records. It is very generally admitted that the record of a well that has been dug, or of a shaft that has been sunk, when not accompanied by sample drillings, soon becomes a matter of legend. Notwithstanding the somewhat unreliable character of the data derived from such sources, when minor details are concerned, the general fact has been quite clearly demonstrated that the Des Moines strata underlie the entire county. Of the sections away from the Des Doines river the well record at Ogden is instructive in giving the depth of the drift and the general character of the coal measures for the western part of the county. In sinking the city well the following strata were penetrated.

SECTION VIII—OGDEN.

		FEET.	DEPTH OF SAMPLE.
8.	Soil and drift clays	108	108
7.	Sand and gravel, water-bearing	2	110
6.	Shale, light-colored, sandy	7	117
5.	Shale, black; more or less concretionary, and containing some coal at the base	8	125
4.	Fire clay	2	127
3.	Shale, bituminous	---	228
2.	Shale and sandstone mixed at	---	256
1.	Coal, penetrated at	---	270

This section gives the thickness of the drift as 110 feet and shows the presence of coal under a good roof within a workable distance of the surface. The amount of coal penetrated at this point would not seem to warrant the sinking of a shaft, but the presence of at least two coal horizons is established, and further prospecting may develop the fact that coal exists in sufficient quantity to be economically important.

SECTION IX—BOONE WELL.

One of the most important artificial sections in the state is that afforded by the deep well put down in the city of Boone.* Here, a magnificent section of 3,000 feet is presented for inspection. The following sequence of strata, based on drillings taken at short intervals is appended.

		DEPTH OF SAMPLE.
110.	Clay, yellow, sandy, variegated	10
109.	Clay, light-blue; mixed with angular gravel which gives it a gritty character	24
108.	Clay, light-blue; gravel more conspicuous	34
107.	Clay, yellowish-gray; slightly arenaceous and containing fragments of wood, closely resembling red cedar; gravel still persists, but is less angular	45
106.	Clay, gray-blue, more even in texture than the preceding, but still containing a considerable percentage of arenaceous material; strongly calcareous	60
105.	Clay, yellow-gray, but gradually changes to yellow at 140; even textured, almost free from gravel, but slightly arenaceous throughout	100, 110, 140
104.	Clay, grayish-yellow, containing angular sand and gravel	150
103.	Gravel, coarse; imbedded in a matrix of blue clay; composition of gravel; quartzitic, cherty and of basic rocks; many of the individual pebbles are faceted	155
102.	Clay, deep brown	165

*The writer desires to express his obligations to Mr. E. E. Chandler, chairman of the committee on water works for the city of Boone, who kindly supervised the collecting of sample drillings. The writer has been the recipient of many helpful suggestions from Prof. W. H. Norton, who also has verified many of the above determinations.

		DEPTH OF SAMPLE.
101.	Clay, blue, massive	175
100.	Sand, quartz, fine uniform grain and containing a few grains of calcareous chert	185
99.	Gravel, coarse, composed chiefly of granite, vein quartz, basic rocks, quartzite and nodules of clay ironstone. The latter two bespeak strongly of a coal measure origin. Many of the constituents, by their rounded forms, bear evidence of prolonged attrition	195
98.	Shale, buff arenaceous; containing a small amount of fine gravel, probably carried down from the overlying strata; slightly calcareous	200, 210, 220, 230, 250
97.	Shale, blue, compact, brittle	270
96.	Shale, blue, containing a small amount of coal	275, 308
95.	Shale, blue, calcareous and slightly arenaceous	325
94.	Shale, light-blue, strongly calcareous and more arenaceous than the preceding	335
93.	Shale, black, bituminous; its fissile character is rendered apparent on exposure	345, 353
92.	Shale, bituminous, mixed with ash-colored fire-clay, coal, iron pyrites and clay ironstone	355
91.	Shale, black non-calcareous, brittle and containing an abundance of iron pyrites	370
90.	Shale, gray blue, slightly arenaceous at 400 but practically non-calcareous throughout	380, 390, 400, 415
89.	Shale, ash-colored, brittle, calcareous	430
88.	Shale, gray, containing a small amount of black shale and a great abundance of flint which partakes the geodetic character; also, some limpid quartz	445, 450
87.	Shale, grayish-black, calcareous and arenaceous	455
86.	Limestone, containing rhombs of calcite	460
85.	Limestone, slightly oölitic	470, 475, 490, 500
84	Shale, blue and strongly calcareous	515, 525, 540
83	Shale, gray-blue, more marly than the preceding	550
82.	Limestone, bluish-gray, close textured, brittle, drillings sharply angular	552
81.	Limestone, drillings show conchoidal or hackly fracture	560
80.	Limestone, an abnormally large amount of chert is present	562

		DEPTH OF SAMPLE.
79.	Limestone oölitic facies, slightly quartzitic; drillings not angular	580
78.	Sandstone, friable, fine-grained	590
77.	Shale, greenish-gray, slightly arenaceous	600
76.	Shale, slightly calcareous	610, 620
75.	Shale, more marly	630
74.	Limestone, gray	640, 650
73.	Limestone, gray, marly	660–777
72.	Limestone, blue, compact, brittle	790
71.	Limestone, apparently brecciated	800
70.	Shale, gray	805
69.	Limestone, sub-crystalline, gray	815, 830
68.	Limestone, containing numerous reddish-brown spots, probably due to oxidation and hydration of iron pyrites	840–920
67.	Limestone, magnesian, light-buff	930–1,015
66.	Limestone, more or less argillaceous and containing fragments of a dark colored shale	1,028, 1,040
65.	Shale, slightly calcareous	1,050
64.	Limestone magnesian, similar to 930-1,015	1,065, 1,070
63.	Shale, gray-blue, similar to 1,050; some sand present	1,080, 1,090, 1,100
62.	Shale, arenaceous, containing a considerable number of larger sand grains	1,120
61.	Limestone, gray, dolomitic	1,130, 1,140, 1,150
60.	Limestone, magnesian, buff, saccharoidal	1,160, 1,170, 1,180
59.	Limestone, magnesian with some quartz grains	1,190
58.	Limestone, dolomitic, marly	1,200, 1,210
57.	Shale, greenish-gray	1,220
56.	Limestone, dolomitic; similar to 58	1,240, 1,250
55.	Limestone, more argillaceous	1,260
54.	Quartz, vari-colored, chalcedonic	1,280
53.	Clay, residual, a red ochreous substance, charged with white, calcareous grains	1,282
52.	Sand, quartz, vari-colored	1,290
51.	Limestone, crystalline, purplish; some fissile, green shale present	1,298
50.	Limestone, buff, considerable green shale present	1,305
49.	Dolomite, gray, fine even textured, brittle; reduced to a fine sand by the drill	1,315, 1,325
48.	Shale, green, soft, plastic; but slightly calcareous	1,335–1,385

		DEPTH OF SAMPLE.
47.	Shale, black, carbonaceous	1,395
46.	Shale, buff, magnesian	1,405, 1,430
45.	Limestone, argillaceous	1,440
44.	Limestone, gray, magnesian	1,450, 1,480
43.	Limestone, argillaceous, marly	1,490
42.	Limestone, gray, magnesian	1,500, 1,510
41.	Limestone, buff, magnesian, finely granular	1,537
40.	Limestone, slightly cherty	1,545–1,560
39.	Limestone, buff, magnesian; containing flakes of gray limestone and small cleavage plates of gypsum	1,580, 1,590, 1,600
38.	Dolomite, brownish-yellow, marly	1,610
37.	Dolomite, becoming progressively lighter colored	1,620, 1,630
36.	Dolomite, buff	1,640
35.	Dolomite, sacchroidal	1,650
34.	Dolomite, buff	1,660, 1,680
33.	Dolomite, shaly	1,690
32.	Dolomite, bluish-gray, marly, argillaceous	1,700
31.	Dolomite, buff	1,710, 1,720, 1,730
30.	Clay, residual, with some fine-grained quartz sand	1,740
29.	Shale, greenish-gray	1,750
28.	Dolomite, brownish	1,760
27.	Shale, greenish-gray with dolomite sand	1,770
26.	Dolomite, deep brown	1,780
25.	Dolomite, color gradually changes from buff to greenish-gray, and texture becomes shaly	1,795–1,810
24.	Shale, bluish-gray	1,830
23.	Shale, green, non-calcareous	1,835
22.	Shale, bluish	1,840
21.	Sandstone, clear-white; grains well rounded	1,845
20.	Shale, green, with small amount of sand	1,850
19.	Shale, arenaceous	1,860, 1,870
18.	Sandstone, clear-white, even grained quartz sand	1,880, 1,890, 1,895
17.	Shale, similar to No. 19	1,990
16.	Dolomite, gray with fine quartz sand	1,910
15.	Dolomite, greenish-gray, marly	1,915
14.	Dolomite, same as No. 16; sand finer than in No 18 and much more angular	1,940, 1,950
13.	Dolomite, cream-colored, slightly shaly	1,955
12.	Dolomite, gray, shaly	1,975
11.	Shale, red, non-calcareous	2,075

		DEPTH OF SAMPLE.
10.	Shale, buff, highly calcareous, slightly arenaceous	2,165
9.	Shale, green	2,200
8.	Shale, green	2,250
7.	Shale, dark-blue and marl, light-gray	2,310
6.	Sandstone, highly calcareous, buff, fine-grained	2,510, 2,515
5.	Shale, yellowish-green, highly calcareous	2,560
4.	Sandstone, yellowish, fine-grained; mostly subangular or rounded, many angular grains	2,585
3.	Sandstone, light-buff, grains fine, mostly angular	2,640, 2,660
2.	Sandstone, calciferous, in the mass brown, fine-grained	2,700
1.	Alternating bands of shale, red marl, and soft-red sandstone, without limestone	2,700–3,000

The total absence of type fossils renders the interpretation of the above section difficult. Fully realizing the somewhat unreliable character of correlations based on lithological grounds only, the following summary is offered tentatively.

Summary of Formations.

NUMBERS.	NAME	SAMPLES.	THICKNESS.	DEPTH.
110–99	Pleistocene	0-200	200	200
98–83	Des Moines	200-460	260	460
82–58	Lower Carboniferous and Devonian	460-1,210	750	1,210
57–49	Upper Silurian	1,210-1,325	115	1,320
48–46	Maquoketa shales	1,325-1,440	115	1,445
45–22	Galena-Trenton	1,440-1,840	400	1,840
21–18	Saint Peter	1,840-1,895	55	1,890
17–7	Oneota	1,895-2,450	475	2,455
7–1	Saint Croix	2,450-3,000	550	3,000

The top of the well has an elevation of 1,140 feet above tide. The drift is apparently 200 feet in thickness. The next seventy feet is most anomalous in character. It has a distinct soil odor and is loess-like in appearance. The gravel present is similar to that in the overlying drift which is undoubtedly its source. The W. D. Johnson shaft, three miles to the westward, penetrates no strata which can be correlated with this terrain. Two hundred feet of coal measure shales follow.

The data at hand does not warrant the separation of the Lower Carboniferous from the Devonian, to say nothing of attempting to delimit the subdivisions of these systems. The material deposited during these periods are predominantly limestones, although interbedded with numerous bands of shale and some sandstone. The oölitic character so well exemplified in the typical outcrops of the Lower Carboniferous strata in central and southeastern Iowa may be noted in 85 and 79.

The Upper Silurian possibly begins with 57, which is followed by a magnesian limestone similar to 58. This formation contains a considerable amount of siliceous material. Sample 54 is composed almost wholly of quartz; the limestone has been removed probably by washing. The residual material may represent a cavern or an old surface. The Maquoketa shales are characteristically developed at this point although reported absent at Ottumwa and Centerville by Prof. W. H. Norton*. The heavy deposits of magnesian limestone and dolomite from 45 to 31 may be referred to the Galena and Upper Trenton formations. Interstratified dolomites and shales comprise the Lower Trenton with an easy passage into the white sands of the Saint Peter. The Oneota and Saint Croix attain great thicknesses in central Iowa, as evidenced by the lower 1,100 feet of the section.

Geological Formations.

CARBONIFEROUS.

DES MOINES STAGE.

As has been mentioned, the lower coal measures completely underlie the county. The Des Moines river has cut into this formation a channel averaging 100 feet in depth, and revealing a series of sandstones and shales with several veins of coal, which are interbedded in a most intricate manner. The following general section, which is to some extent ideal, gives the most important relations of the strata. It is based on

*Iowa Geological Survey, vol. III, p. 209.

the natural exposures along the rivers taken in conjunction with data derived from coal shafts and well sections in the vicinity.

Thickness.—The coal measures have never been entirely penetrated save at a single point within the limits of the county. The Boone deep well section shows a thickness of 260 feet. The drift at this place is 200 feet thick, while the surface altitude is 1,140 feet. Three miles to the westward, the drift is but 100 feet in thickness, while the surface elevation has been reduced but sixty feet. It is probable that the coal measures may reach a thickness of nearly 300 feet at that point. Whether or not there is a gradual thickening to the westward must remain an open question until more data is at hand.

Lithologically, the coal measure strata consist essentially of sandstone and shales which contain several seams of coal, of greater or less extent. The sandstones and shales are extremely variable, not only in composition, texture and state of induration, but also in their lateral and vertical distribution. The sandstones are composed of fine, rounded quartz grains which are, as a rule, imbedded in a matrix of calcareous, ferruginous or argillaceous cement.

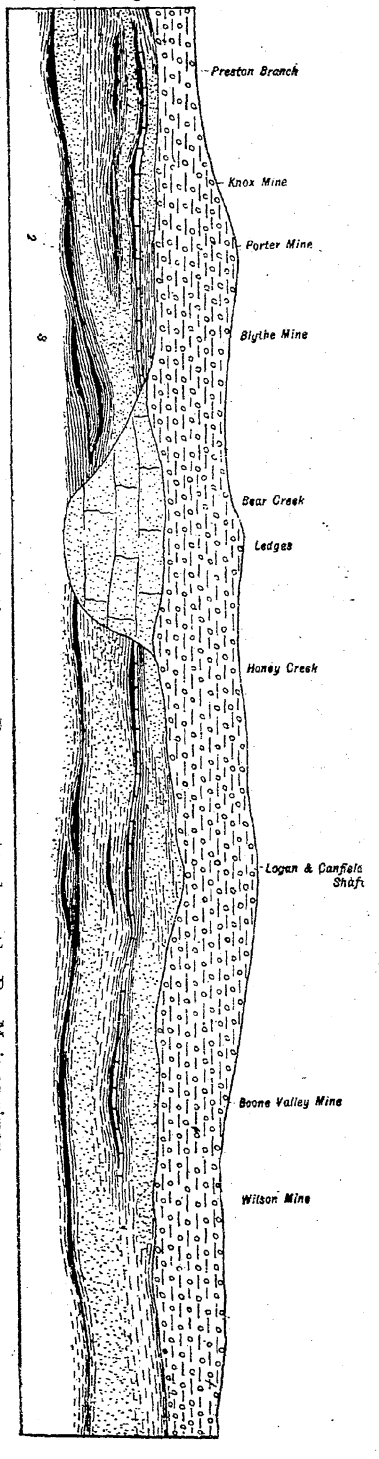


FIG. 18. General geological section across Boone county along the Des Moines river

The individual sand grains are often coated with ferric oxide, which indicates that they were not subjected to vigorous or prolonged shore action during the period of deposition and accumulation. In texture, all gradations may be observed from the massive "Ledge sandstone," where a single layer may reach a thickness of twenty feet and is practically a free-stone, to fissile sandstones which readily separate into laminæ less than one-tenth of an inch in thickness. The former deposit is indicative of rapid, continuous deposition, while the latter predicates rapidly recurring conditions and, perhaps, slow accumulation.

The state of induration is most anomalous. Sand, friable sandstone and compact sandstone,—almost quartzitic in character oftentimes—rapidly replace one another both laterally and vertically. The prevailing color of the Boone county sandstones is buff, reddish-brown or ash-colored, depending largely as to whether the cement is calcareous, calcareo-ferruginous or calcareo-argillaceous, respectively.

The shales are equally as variable as the sandstones. There are all gradations from argillaceous sandstones to fire-clays. The color varies from a gray or ash-color in the leached fire-clays, through massive blue shales, to the black, bituminous shales, which usually immediately overlie the coal seams.

The state of aggregation varies greatly from the soft, plastic clays, which may be readily molded between the fingers, to the brittle, calcareo-argillaceous rocks which emit brilliant sparks when struck with the hammer. The carbonaceous shales often contain septarian nodules and clay ironstone concretions.

The coal belongs entirely to the variety known as bituminous. As a rule, it is composed of upwards of 80 per cent of oxidizable elements, chief among these being carbon. The coal will be more fully treated in a later portion of this report. In addition to sandstone, shales and coal there are certain bands of argillaceous limestones, which are the most persistent features of the coal measures. Such bands may be observed near Moingona and on the river west of Madrid.

PLEISTOCENE.

Deposits later than the coal measures and usually designated by the general term "drift," completely cover the county save where they have been removed by the present streams. They cover the underlying deposits unconformably and may be differentiated into a lower and upper till and an alluvial deposit. Most of the present topographic forms find expression in the easily molded materials of this terrain. The average thickness of the drift in this area is upwards of one hundred feet. At Zenorsville, in the northeastern portion of the county, it varies from sixty to one hundred and twenty feet; in the city of Boone it is 200 feet thick; at Ogden, 110, and the coal shafts near Angus reveal a thickness of from fifty to one hundred feet. A deduction of the thickness of the drift at certain points from their respective altitudes, along a line from the agricultural college in Story county, by way of Boone, the Logan and Canfield shaft, Milford and Ogden to Beaver station, renders apparent an interesting and

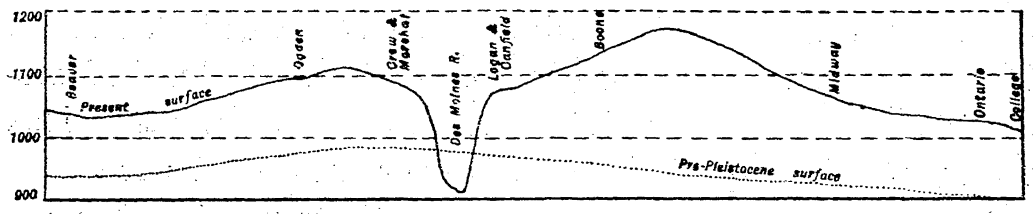


FIG. 19. Relations of the present and pre-Pleistocene surfaces.

important fact. The surface features at the beginning of the Pleistocene must have been less pronounced than at the present time. It would seem that the region had suffered profound erosion during the preceding period and that the area under consideration was practically base-leveled at the beginning of the present epoch. The Des Moines river appears to have the characters of a superimposed stream. Its present position is clearly out of harmony with the older land surface. In fact it is highly improbable that any of the streams of the present drainage systems are coincident with those of pre-Pleistocene times.

IOWA GEOLOGICAL SURVEY

MAP OF THE SURFACE DEPOSITS OF BOONE COUNTY, IOWA.

BY

S. W. BEYER

1896.

GRANT
PILOT MOUND
DODGE
HARRISON
YELL
DES MOINES
JACKSON
AMAQUA
BOONE
BEAVER
WORTH
MARCY
COLFAX
DOUGLAS
PEOPLES
UNION
CASS
GARDEN

Boxholm
Ridgeport
Mineral Ridge
Pilot Mound
Fraser
Zenorsville
Milford
Boonesborough
Midway
OGDEN
Grayson
Berkley
Luther
Wheeler
ANGUS
MADRID
SHELDAHL

Tp. 85 N.
Tp. 84 N.
Tp. 83 N.
Tp. 82 N.

R. XXVIII W.
R. XXVII W.
R. XXVI W.
R. XXV W.

LEGEND

GEOLOGICAL FORMATIONS

WISCONSIN DRIFT

GARY MORAINE

INDUSTRIES

COAL MINES

CLAY WORKS

QUARRIES

DRAWN BY F. C. TATE

IOWA PRINTING CO. DES MOINES, IA.

No attempt will be made in the present report to delimit the subdivisions of the Pleistocene. According to present data it may be tentatively stated that the county is completely underlain by the two drift sheets.

LOWER TILL OR KANSAN FORMATION.

A yellowish-brown clay appears at several points along the Des Moines, noticeably along road-cuts at about the one hundred-foot level above low water. The deposit is characterized by a predominance of greenstone pebbles and a considerable number of small sized granite boulders, many of which are in an advanced state of decay and readily disintegrate when removed from their matrices. Occasionally, this oxidized deposit may be traced downward into a massive blue clay, of which it is probably the lower unweathered portion. At the Logan and Canfield shaft, the lower till, as above described, shows a thickness of about forty feet for the oxidized portion. The Boone deep well gives forty-five and fifty-five feet for the lower and upper portions respectively.

UPPER TILL OR WISCONSIN FORMATION.

Boone county lies wholly within the outer loup of the terminal moraine which marks the southern limit of the last great ice incursion. This extension of the great continental ice sheet is currently known as the "Des Moines lobe," and is bounded by the Altamont moraine. Upham* has shown the terminal moraine of the Des Moines lobe to be continuous with the Kettle moraine, and Chamberlain† has designated this drift sheet the "Wisconsin formation." An inner or Gary moraine, which marks a stage in the retrogression of the Des Moines ice, crosses the northern portion of Boone county in a north of west, south of east direction. Its most salient topographic forms are in the vicinity of the Des Moines river. The most prominent of these are popularly known as Mineral Ridge and Pilot Mound. The former is a long ridge

*Geol. and Nat. Hist. Surv. of Minn., p. 298. 1880.

†Journal of Geology, vol. III, p. 275. 1895.

rising from fifty to seventy feet above the drift plain, trending in a north of east, south of west direction through the town of Ridgeport, and is cut off by the Des Moines river. Pilot Mound is an isolated spur of the moraine and rises abruptly some seventy feet above the surrounding country. The town of Pilot Mound takes its name from this drift hill. The moraine in this section is rather sharply delimited on its inner edge, but it fades out gradually into a succession of low swells peripherally.

Boulders are everywhere abundant and present a familiar spectacle in fence corners and along roadways. The prevailing types are granites and gneissoid rocks, with a liberal sprinkling of the red Sioux quartzite.

Plate iv shows a large granite boulder in the foreground, with the "inner loup" of the terminal moraine in the background (Tp. 85 N., R. XXVI W., Sec. 2, Sw. qr., Sw. $\frac{1}{4}$). The boulder is coarse textured, and is composed essentially of quartz, red feldspar and hornblende.

Lithologically considered, the upper till is composed of an incoherent mass of clays, sands, gravels and boulders, which rarely occur singly but are usually intermixed in a most complicated manner. In general, this formation, as also the Kansan, may be subdivided into an upper oxidized and a lower unoxidized portion. According to numerous natural and artificial sections in this county, the basal portion of the Wisconsin drift attains a thickness of from forty to ninety feet. In color it is a grayish-blue, and contains more grit and is less massive than its anologue in the lower till. Fragments of wood are not uncommon. On the Steelworth farm, about two miles south of Boone, large fragments of wood were uncovered through the lateral corrasion of a small stream and the consequent caving of its bank. The specimens have the general character of our common red cedar (*Juniperus virginianus* L.). Although the distribution of woody fragments is general, yet, so far as now known, no well defined forest beds have been observed in this region.

THE GARY MORAINE IN BOONE COUNTY.

It seems highly probable that the erosive agencies were vigorously active early in the Wisconsin age, and the upper portion of the Kansan was thoroughly reworked and incorporated into the younger drift. The oxidized portion of the upper till is light yellow in color and averages from ten to forty feet thick. The Wisconsin formation, as a whole, is characterized by pebbles and boulders of the quartzitic and granitic types, and calcareous concretions are conspicuously present. The boulders are usually much larger than those of the Kansan drift and often present fresh, glassy surfaces.

ALLUVIUM.

Alluvial deposits accompany the principal streams, but they are of little importance away from the Des Moines valley. They consist essentially of black, sandy loam, mixed with the wash from the bluffs. In many instances the humus and river silt has been removed to a large extent, and a yellowish-gray sand results.

ECONOMIC PRODUCTS.

COAL.

Boone county has long been one of the leading coal-producing counties in the state. For nearly half a century coal has been known to exist in this region in quantities of economic importance, and has been long mined to supply local consumption. As early as 1849, Owen, in his excursion up the Des Moines river, noted the fact that the blacksmiths of the county obtained coal along Honey creek. Although coal was thus early known, a score of years elapsed before mining for export was initiated. After the advent of the railroad in 1866, mining operations were pursued with vigor, and the mining industry now ranks second only to that of agriculture.

The mining regions of the county may be considered conveniently in three groups; those of the Des Moines valley, the Squaw creek basin, and the Angus region.

DES MOINES VALLEY MINES.

In the vicinity of Madrid local mines have been opened from time to time along the river south and west of the town, but all of these have been operated intermittently and only to supply the immediate neighborhood during the winter seasons. The more important mines are in the north central portion of the county.

MADRID DISTRICT.

Knox Brothers have, for years, operated a mine about four miles northwest of Madrid (Tp. 82 N., R. XXVI W., Sec. 10, Sw. qr. Sw. ¼). The vein worked at this point outcrops in the side of a ravine, some seventy feet above low water in the river. The seam averages about twenty-six inches in thickness, is of fair quality, has a good roof and is readily mined by drifting into the bank. About four miles from the south boundary line of the county is the Porter slope (Tp. 82 N., R. XXVI W., Sec. 8, Ne. qr., Ne. ¼). The section near the coal bed is as follows.

		FEET.	INCHES.
5.	Limerock, impure, compact, bituminous "cap-rock"	1	
4.	Shale, bituminous		7
3.	Coal	2	6
2.	Fire clay	4	
1.	Shale, black, bituminous	7	

FIG. 20. Coal seam at Porter slope on the Des Moines river. Below Moingona.

The so-called "cap rock" is a black, very compact and brittle calcareous shale, highly fossiliferous and separated from the coal by a few inches of dark fissile shale. The vein of coal is about sixty feet above low water in the Des Moines river. The seam opened up here appears to be the same as that worked in the preceding mine. Two miles beyond, near a short bend in the river, is the Blyth slope (Sec. 5 of the

same township and range), where two veins of coal are exposed; the lower one being about three feet above low water in the river and the other about four feet higher up. The lower seam ends abruptly toward the southward, being cut out, and the channel filled with clay. This vein is three feet in thickness, while the "upper" one is two and one-half feet thick. The upper seam especially, has a good roof. Figure 21 shows the above relations.

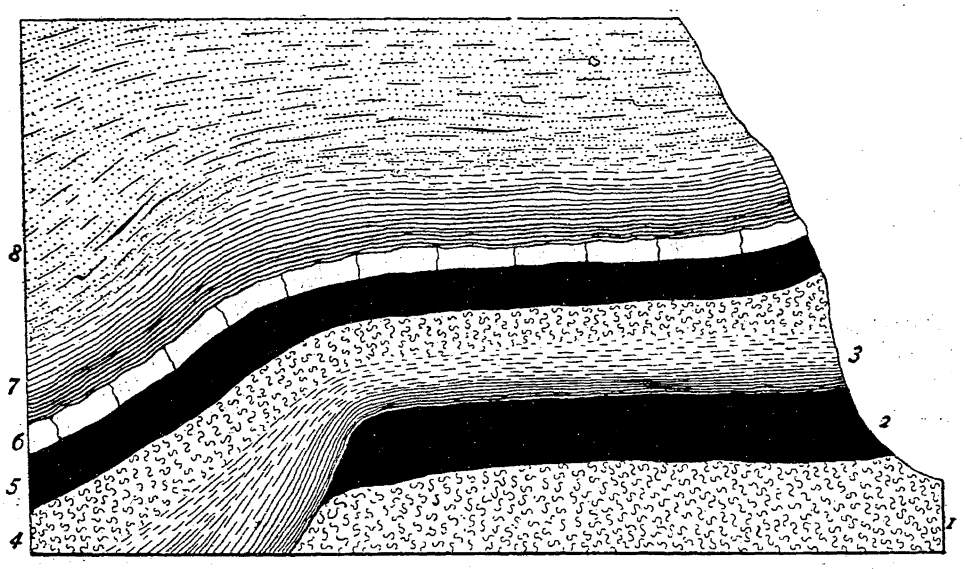
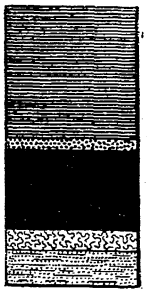


Fig. 21. Coal seams at the Blythe mine.

Continuing northward along the river, there are occasional outcrops of coal on either bank. On section 29 (Tp. 83 N., R. XXV W.), two veins of coal appear on the left bank of the stream. The lower of these is about twenty feet above water level. The seams are separated by a considerable thickness of clay and shale which, gradually thinning northward, finally disappears, the veins coalescing. Near the point of coalescence they are cut out by the Ledge sandstone. Between this point and Moingona the bluffs form high, mural escarpments of sandstone, through which deep labyrinthine ravines have been gouged out by numerous small streams as they approach their embouchures.

MOINGONA DISTRICT.

A mile below Moingona, on the west river bank (Tp. 83 N., R. XXVI W., Sec. 18, Nw. qr., Nw. ¼), is the Highland Chief mine which has been in operation for many years. It is a shaft sixty feet in depth and works the "upper vein" which is here from two to three feet in thickness. Near by is the Moingona Coal Co.'s shaft No. 6, the last mine opened by the company in the neighborhood. In the vicinity of the town coal crops out in many places in the sides of the Des Moines valley, and along the minor streams flowing into the river. Directly opposite the railroad station at Moingona is the White Smoke mine. This is a shaft put down in 1892; it is about fifty feet in depth and reaches the "upper vein," which has a thickness of about two and one-half feet. The section is:



		FEET.	INCHES.
5.	Shale, bituminous	4	
4.	Limerock, impure, very compact, bituminous, ferruginous		4
3.	Coal	2	6
2.	Fire clay		7
1.	Sandstone (exposed)	1	

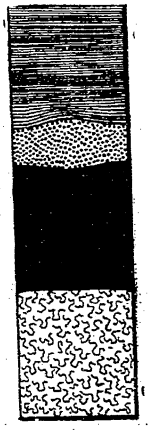
FIG. 22. Vein at White Smoke mine. Moingona.

There are several country banks in the vicinity which furnish considerable fuel for local use. This locality was formerly an important mining region, but at the present time comparatively little coal is being taken out. North of Moingona about one and one-half miles is the Clyde mine No. 2, which is now deserted. Still farther northward is the Ogden (Tp. 84 N., R. XXVII W., Sec. 27, Se. qr., Ne. ¼).

The coal mined at the Ogden mine was encountered at a depth of ninety feet; the mouth of the shaft is about eighty feet above the water level in the Des Moines river. An "upper" vein exists about seven feet above the lower but is not worked. A mile north of the Ogden is the Clyde No. 1, now abandoned. This is the southernmost of the more important mines which are comprised in the Milford area.

MILFORD DISTRICT.

The Rogers & Crow shaft (Tp. 84 N., R. XXVII W., Sec. 14, Sw. qr.), is located on the summit of the bluff and is 206 feet in depth. The drift deposits at this point are 100 feet in thickness. There are two veins of coal, the "upper" being about ten feet above the lower; the latter is on an average three and one-half feet in thickness; it is somewhat irregular, becoming in places considerably thicker and thinner than the measurement given; it is wanting at the base of the shaft, but it was encountered some ten rods distant towards the northeast by a lateral drift. The upper vein is somewhat thinner than the lower, but more uniform in thickness. There is also a third vein, said to be present about forty feet below the "lower vein." This third vein is not at present of economic importance at this point. About 200 yards to the northeastward is the Milford shaft which is located at the base of the bluff. It is 100 feet in depth, and also works in the "lower" vein, which here has a thickness of four feet. At the bottom of the shaft the layers shown are:



	FEET.
3. Shale, bituminous, with band of impure nodular iron-stone at base	5
2. Coal	6
1. Fire clay	4

FIG. 23. Bottom of shaft, Milford mine.

The upper seam is ten to twelve feet above this and is three feet in thickness. Several thin veins were passed through in sinking the shaft before the upper seam was reached. Half a mile southeast of Milford is the Boone Valley shaft which is seventy feet in depth. The coal is three and one-half feet in thickness. A second vein is eight feet higher but only the lower one is mined at the present time.

Directly to the east are several shafts known as the Marshall mines. They are all located on the river bottom and work coal from two and a half to four feet in thickness, presumably the lower vein.

On the opposite side of the Des Moines river a number of mines are in active operation, one of the most important being the Hunt slope (Tp. 84, N., R. XXVII W., Sec. 13, Ne. qr., Se. $\frac{1}{4}$). Half a mile to the southward is the Marshall slope, which like the preceding, mines the "upper vein."

BOONESBORO DISTRICT.

Occupying the amphitheater in the great bend on the Des Moines river is the Boonesboro area, which immediately adjoins the Milford region on the east and is only separated from it by the river.

The W. D. Johnson mine is located on the summit of the bluff (Tp. 84 N., R. XXVII W., Sec. 24, E. $\frac{1}{2}$). It is the oldest and

FIG. 24. Top works of the W. D. Johnson mine.

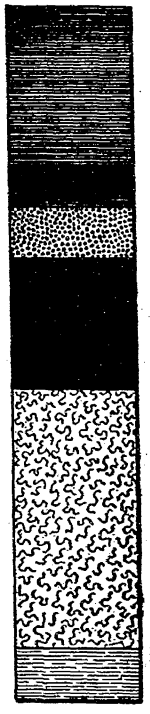
largest mine in the county. It has been operated continuously for more than thirty years. Finch & Company, of Des Moines, formerly operated it, but for more than a quarter of a century the mine has been under its present management. Two workable seams of coal are found, and both are worked by the longwall method. The following section of the shaft

was prepared from an examination of small samples obtained by the foreman at the time of sinking.

		FEET.
29.	Soil	5
28.	Clay, yellowish	20
27.	Clay, bluish; considerable grit present	40
26.	Clay, yellowish-brown	40
25.	Clay, massive, blue, jointed	9
24.	Sandstone, ash-colored, shaly, graduates into 23	9
23.	Shale, gray-blue	3
22.	Shale, with ironstone concretions	3
21.	Sandstone, fine-grained, friable	12
20.	Shale, bluish and drab; containing numerous oxidized iron concretions	6
19.	Sandstone, ash-colored	12
18.	Shale, compact, massive	7
17.	Shale, light colored ("soapstone" of the miners)	5
16.	Sandstone, whitish, argillaceo-calcareous	13
15.	Sandstone, more compact and coarser in texture, calciferous	8
14.	Shale, black, bituminous, fissile below	3
13.	Fire clay and light colored shale	9
12.	Shale, hard, blue-black	5
11.	Fire clay	1
10.	Shale, compact, brittle; highly bituminous and often fossiliferous	3
9.	Coal	½
8.	Shale, variegated, arenaceous, calcareous; a parting between 7 and 9	1
7.	Coal, "upper" vein	4
6.	Fire clay	3
5.	Shale, variegated, with numerous ironstone concretions and septarian nodules	4
4.	Coal, "lower" vein	4
3.	Fire clay	3
2.	Shale, light colored; graduating into the strata below	3
1.	Shale, dark, bituminous	2

The "lower" vein is quite variable in thickness, containing many pinches and swells and attaining a maximum measurement of five feet. A half mile to the southeastward is the Heap mine which is a shaft 208 feet in depth. Only the "upper" vein is mined here; the "lower" being absent. It appears to be the same as the "upper vein" in the Johnson

mine. The coal is from two to four feet in thickness. A little more than a mile to the southward is the McBirnie shaft 175 feet deep. The coal seam is from two and a half to three feet in thickness and has an excellent roof. The strata shown in connection with the coal at this point are as follows.



		FEET.	INCHES
7.	Shale, black, highly bituminous	3	
6.	Coal		7
5.	Shale, bituminous, argillaceous		2
4.	Limerock, impure, shaly, "caprock"	1	
3.	Coal, 2 to 4 feet, averaging	2	6
2.	Fire clay	5	
1.	Shale, exposed	1	

FIG. 25. Section in McBirnie shaft. Boonsborough.

The vein mined probably belongs to the same horizon as the upper vein in the preceding mines. The bipartite character of the seam confirms this view. Opened in the same vein are a number of other mines, though at present they are not in operation. Among these may be mentioned the Flock and Clark mines, and the McBirnie and Nelson shaft. Between the McBirnie shaft and the Johnson mines two or three mines have been opened recently.

The most important of these is a shaft operated by the Zimbleman Coal and Mining company. This shaft is located about one mile from Boonesboro (Tp. 84, R. XXVI W., Sec. 30). The plant is equipped with modern machinery and mining is carried on according to the most approved methods. The

seam worked and its including strata are essentially the same as at the Heap and McBirnie shafts.

FRASER DISTRICT.

About three miles north of the Milford area is the town of Fraser, which but recently has become the seat of considerable activity in coal mining. In 1893 the Boone Valley Coal & Railway company opened a mine (Tp. 85, N., R. XXVII W., Sec. 34, Sw. qr.). Several shafts have been sunk in the river bottom and mining operations are being vigorously pushed. The seam worked at this point has a thickness of from two to three feet and is probably the homologue of the "upper" vein represented farther down the river. This seam is popularly known among miners wherever it occurs as the "black jack" vein. This mine is provided with all modern improvements and finds convenient outlet for its products over a spur of the Minneapolis & St. Louis railroad. One mile north of Fraser on the right bank of the river are the Wilson and Zunkle mines (Tp. 85, N., R. XXVII W., Secs. 26 and 27). These are shafts 50 and 80 feet in depth respectively. They reach the same vein, which averages about three feet in thickness, and can probably be correlated safely with the "upper" vein of the Milford-Boonesboro area. The last two mines are only active during the winter months to supply fuel for the immediate vicinity. Although some prospecting has been done to the north of this, no mines have yet been opened within the limits of the county in that direction.

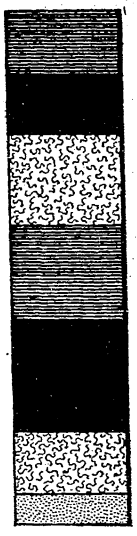
SQUAW CREEK VALLEY.

Considerable mining has been carried on in the vicinity of Zenorsville, in the eastern part of the county. The principal mines are three in number. The Hutchinson No. 1 (Tp. 84, N., R. XXV W., Sec. 12, Se. qr., Nw. $\frac{1}{4}$) is a shaft 125 feet deep with coal 28 inches in thickness. The section of the shaft is as follows.

		FEET.
11.	Soil, gray and sandy	1
10.	Clay, joint	40

		FEET.
9.	Shale, bluish	53
8.	Shale, light-colored	1
7.	Shale, bituminous; fissile below	2
6.	Coal	2
5.	Fire clay	3
4.	Sandstone, rather soft and friable	2
3.	Shale, lighter colored	4
2.	Shale, dark bituminous	3
1.	Coal	1

Hutchinson shaft No. 2 is located about 300 yards to the northward. It is on lower ground and is 105 feet in depth. The coal is nearly four feet in thickness. There is an upper vein present at this point about six feet above the lower, the latter only being mined. The section at the base of the shaft is shown in the annexed figure.



		FEET.
7.	Shale, bituminous fissile	3
6.	Coal, one to three feet, "upper vein"	2
5.	Fire clay	3
4.	Shale, bituminous	3
3.	Coal, "lower vein"	4
2.	Fire clay	2
1.	Sandstone, exposed	1

Figure 26. Coal bed in Hutchinson mine, near Squaw creek. Zenorsville.

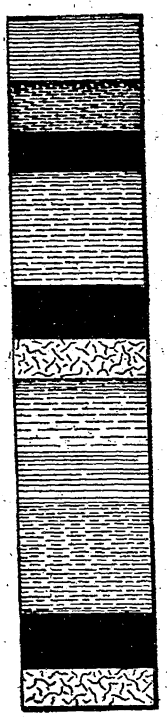
Northeast of the Hutchinson mine about a quarter of a mile are the York and the Clemens mines, which at the present time are not in operation.

ANGUS MINES.

In the extreme southwestern portion of Boone county is a region which a few years ago was one of the most important mining localities in the state. It forms a part of the district

which lies in portions of three counties; Boone, Dallas and Greene. The leading mines, however, were located in Boone. Altogether upwards of a score of shafts have been operated here. At the present time only a few are working, the principal ones running being the Angus and Dalby mines. Considerable confusion exists as to the exact correlation of the coal seams. There is one which is worked in the Angus mine and was formerly worked in the Craig, Ramsey and Panic shafts. Above this is a thinner seam which has also been worked to some extent in the Craig and the Hagger mines. This is the same vein which is said to crop out in the bluffs of the Raccoon river a few miles to the westward, but there is considerable doubt as to the correctness of the correlation. Lower down than the chief bed worked at the Angus mine is another seam which has been opened in the Dalby shaft. Beneath the first mentioned seam there has been reported a third coal bed, which, though not yet worked, has been encountered in borings. Other veins are also known to exist but none have yet been found thick enough for profitable working. The "third" seam is five and one-half feet in thickness according to the best information obtainable, and is located at a depth of ninety feet below the bed opened in the Keystone mine. All the mines are situated southwest of the Angus station. Drillings show that the seams extend beneath the town, but they are somewhat thinner and the roof is poor. A shaft put down east of the place was flooded after working but a short time.

The Angus mine, one of the largest now in operation, is located a short distance from Angus station (Tp. 82 N., R. XXVII W., Sec. 31, Nw. qr., Nw. ¼). It is a shaft fifty feet in depth, and is thought to be working in the "middle" seam. The coal is from three and one-half to five feet in thickness, with an average of about four feet. The section shows the following beds.



		FEET.
9.	Shale, light colored; exposed	5
8.	Shale, bituminous, indurated	4
7.	Coal	3
6.	Fire clay and shale	12
5.	Coal	4
4.	Fire clay	3
3.	Shale, bituminous below, light colored above	20
2.	Coal	5
1.	Fire clay	3

Figure 27. Section in shaft in Angus mine. Angus.

The seam is quite undulatory. A few faults have been met with and also several "horsebacks." Half a mile south of the Angus mine is the Dalby. This mine is a shaft 120 feet deep and works in the "lower" vein. The seam is from three to four and one-half feet in thickness; the roof is a hard, black shale and sandstone, but is in some places rather poor; the bed is somewhat undulatory, faults are rare. The bottom of the shaft shows the following beds:

		FEET.	INCHES.
5.	Sandstone, compact, massive; exposed	1	
4.	Shale, black, indurated, "black jack"		5
3.	Coal	3	5
2.	Shale, bituminous		2
1.	Fire clay, exposed	2	

Figure 28. Coal bed in Dalby shaft. Angus.

In several places a soft fire clay is found pressing up into the entry forming "creeps," one of which is represented in the accompanying figure 29.

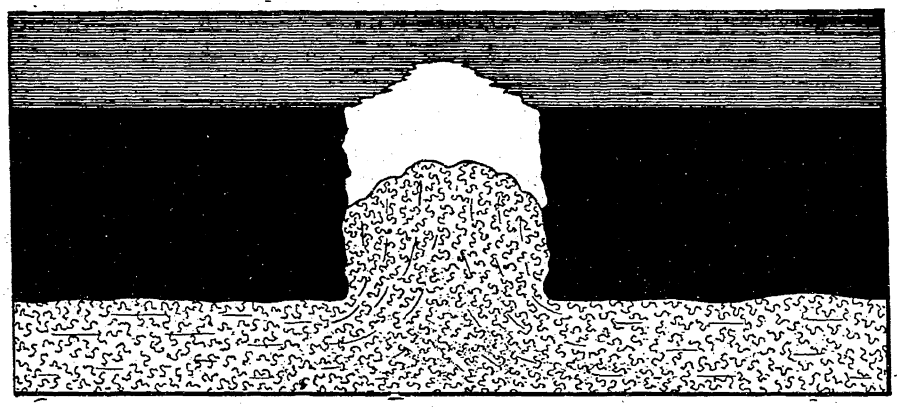


FIG. 29. "Creep" in Dalby mine. Angus

During the summer of 1883 several prospect holes were put down near the Boone county line in Greene county (Tp. 82 N., R. XXIX W., Secs. 10 and 11). The following composite section represents the sequence of strata.

		FEET	INCHES
24.	Soil and yellow clay	14	
23.	Clay, blue	25	
22.	Soil and gravel	6	
21.	Clay, argillaceous, blue below	21	
20.	Sand, water-bearing	1	
19.	Shale, light colored	4	
18.	Shale, dark	5	6
17.	Shale, compact, brittle	8	
16.	Shale, gray, blue; bituminous below	3	6
15.	Coal (coal blossom of miners)		1
14.	Fire clay		2
13.	Shale, ash-colored	7	
12.	Shale, bituminous, fissile below	3	
11.	Coal, somewhat shaly above		6
10.	Fire clay and light colored shale	8	
9.	Shale, black	2	
8.	Shale, brittle, compact	1	6
7.	Coal		7
6.	Shale, strongly bituminous, hard	3	
5.	Sandstone	4	
4.	Shale, ash-colored	3	6
3.	Shale, black, bituminous	6	
2.	Coal	1	
1.	Fire clay	2	

Four seams of coal were penetrated in this area, yet none were of sufficient thickness to warrant the beginning of mining operations.

SUMMARY.

All of the coal beds now mined in the Des Moines valley in Boone county may be referred tentatively to three horizons. The first has an elevation of from fifty to seventy feet above the water in the Des Moines river, and is the bed operated at the Knox and Porter slopes in the southern portion of the county, and the drifts along Honey creek in the central area. This horizon is usually overlain by a "caprock" of hard, brittle, calcareous shale which contains in abundance the remains of a marine fauna—Rhynchonella, Discina and Productus are the more common genera represented.

The second horizon occurs some fifty feet below the first and is the most persistent seam in the county. It is currently known as the "upper vein," or "black jack." The former name is in contradistinction to a lower vein which sometimes accompanies it; the latter name is often applied to it on account of its semi-lustrous jet-black color and somewhat bony character. This seam is operated at the Blyth drift, and in the Moingona, Boonesboro, Milford and Fraser areas. It is usually provided with a good roof and carries its thickness well—two essentials to profitable mining. The roof shale often contains well preserved specimens of the genus Lingula.

The third horizon occurs from four to twelve feet below the second and is usually denominated the "lower vein." The distribution of coal in this seam is somewhat anomalous; the coal usually occurs in lens-shaped masses (pockets) of limited extent. The roof is fairly good, but often contains numerous septarian nodules and clay ironstone concretions, which render mining somewhat hazardous unless due precautions are observed. The product of this vein is much sought for furnace and domestic use and commands the highest market price. At the present time the production of this

coal is almost wholly limited to the Boonesboro–Milford area.

The regions away from the Des Moines afford but little data for their correlation with the central region. On lithological grounds, and because of the similarity in association of strata and of elevations, the seams worked in the Squaw creek basin may be referred with some degree of confidence to the second and third horizons in the Des Moines valley, probably being an eastward extension of that basin. Sufficient data are not at hand to attempt a correlation of the beds operated at Angus with those of the above regions.

CHEMICAL ANALYSES OF BOONE COUNTY COALS.

Experience has shown that it is impossible to formulate the criteria upon which the absolute value of a coal depends. Certain properties may not prove detrimental to the use of a coal for one purpose and yet seriously detract from its usefulness for another. Chemically, a coal usually is considered desirable if it contains high percentages of fixed carbon and of hydrocarbons, and low percentages of water, ash and sulphur. The subjoined analyses* may be considered representative of the principal Boone county coals.

	COAL.	H_2O.	Total comb	Ash.	Vol. comb.	F. carb.	Coke.	Sulp.	Sulphate.
1	Angus mine average	8.62	82.75	8.64	38.33	44.41	53.05	2.59	0.08
1a	Dalby mine average	2.84	88.36	8.12	43.08	45.29	54.08	4.33	0.14
2	Boonesboro average	12.37	81.90	5.87	48.24	43.72	49.41	------	------
3	Fraser	14.77	73.71	11.48	37 67	36.05	47.53	2.76	0.19

COAL LANDS.

To say that the entire region under consideration is underlain by the coal measures does not predicate that coal, in workable amounts, is universally distributed throughout Boone county. Sufficient data are not at hand to delimit the known

*Analyses—Nos. 1 and 2 were made by the survey and published in Vol. II, p. 505; No. 2 is taken from White's Report, Vol. II, pp. 390-391; No. 3 was made by the Department of Agricultural Chemistry of the Iowa Experiment Station.

coal basins, but certain it is that they have a much wider range than is suspected at the present time. Systematic prospecting has been confined almost wholly to the Des Moines valley in the north central portion of the county, although the strata have been explored over very limited areas in the vicinity of Angus and Zenorsville. Fully fifteen-sixteenths of the area of the county remains unexplored and offers an attractive field for the prospector. The diamond core drill would be found a valuable adjunct to the equipment of the progressive operator, and a judicious use of this instrument in the further development of the coal mining industry in Boone county would, undoubtedly, be rewarded with adequate returns.

The land now owned or leased by mining companies, and, therefore, properly considered as under development, are indicated on the map accompanying this report. The holdings of the different companies are indicated by numbers corresponding to those in the following list.

1. Boone Valley Coal & Railway Co.
2. Moingona Coal Co.
3. Clyde Coal & Mining Co.
4. Crow & Marshall Coal & Mining Co.
5. Milford Coal & Mining Co.
6. W. D. Johnson Coal & Mining Co.
7. Garden Hill Coal & Mining Co.
8. Zimbleman Coal & Mining Co.
9. James Wilson.
10. Mineral Ridge Coal Mining Co.
11. Joseph York.
12. Hutchinson Bros. & Son.
13. J. Clemmens.
14. W. Zenor.
15. Highland Chief Mine.
16. Riverside Coal Co.
17. W. D. Morgan.
18. Porter Bros.
19. Knox Bros.

1*a*. Excelsior Coal Co.
2*a*. Climax Coal Co.
3*a*. North Angus Town Lot & Coal Co.
4*a*. Angus Coal Co.
5*a*. Standard Coal Co.

BUILDING STONE.

But little has been done to develop the quarry industries of the county. As a rule the soft, incoherent character of the coal measure strata does not warrant the outlay of capital necessary in opening up quarries. At two or three points along the Des Moines river some quarrying has been done from time to time, the product being utilized in the rougher grades of masonry in the immediate vicinity. West of Madrid a calciferous sandstone has been quarried intermittently for more than a third of a century. Some of the stone used in the construction of the old court house in Des Moines is said to have been derived from this source (Section 11, No. 2).

In the central portion of the county the "Ledge" sandstone affords an abundance of constructional material which ought to receive more attention than has been accorded it heretofore. In the main it is a soft, buff to reddish sandstone or freestone, containing large concretions, which are highly refractory and some of which may be quarried advantageously. That even the matrix which holds these ferruginous or quartzitic concretions withstands weathering agencies is abundantly attested by the mural walls which have resisted the elements for thousands of years. This rock, when properly selected, will be found durable for above ground and above water structures, and its somewhat open texture will hold the mortar well.

Although the older strata furnish some valuable stone for constructional purposes, yet this is not the most important source. The great ice incursion made a generous contribution to the building materials of the region. Numerous boulders, some of which are of enormous size, are distributed over most of the county and are especially plentiful in the morainal area. The prevailing types are gray and red granites and red quartzites. An abundance of material suitable for foundations, roads, and monumental purposes is afforded. As a rule the economic importance of these stepping stones to wealth is not appreciated by the inhabitants and but feeble attempts have been made toward their utilization.

LIME AND CEMENT.

There are no limekilns or cement works within the borders of the county. Certain argillaceous limestones are present in the coal measures which might be made into a hydraulic cement of acceptable quality. Such deposits are of limited extent and not readily accessible.

CLAYS.

No county in the state is more bountifully supplied with clays of good quality, suitable for structural and ornamental purposes, than Boone. Clay shales and bituminous shales of the coal measures are abundantly exposed especially along the Des Moines river and its tributaries south and west of Boonesboro. To the southward they are cut by the "Ledge" sandstone, but they reappear farther down the river. The coal measures are overlain by a thick deposit of glacial debris, which is composed largely of calcareous clays. The upper drift, however, has been altered and the superficial covering, to a depth of from two to five feet, is now a siliceous, brown to grayish, somewhat alluvial-like soil.

Along the Des Moines the usual bottom land prevails. Near the stream the strictly alluvial character is noticed, but towards the slopes much of the slightly changed lime-bearing drift clay mixed with loamy material occurs a few feet beneath the alluvial surface.

At the present time the numerous clay-working factories in Boone county utilize the alluvium, the drift soil and the coal measure shales. The first of these has been adopted by several of the brick makers at and in the vicinity of Moingona. The drift soil is being extensively used at the yards west and southwest of Boone, and the shale clays at points east of the river in the same region. Only common structural brick are made of the unconsolidated clays, but the indurated beds are successfully manufactured into different grades of building brick, fire brick, tile and pottery.

BOONE CLAY WORKS.

The Boone clay works are located in the extreme southwest corner of Des Moines township, about two and one-half miles from the county seat. This factory was started during the latter part of the summer of 1889 by J. B. McHouse, present proprietor. A No. 2 kiln was used the first three years; at the end of this time the works were enlarged and a No. 1 put in. A dry pan made by the Des Moines Manufacturing Co. is used in pulverizing the raw material.

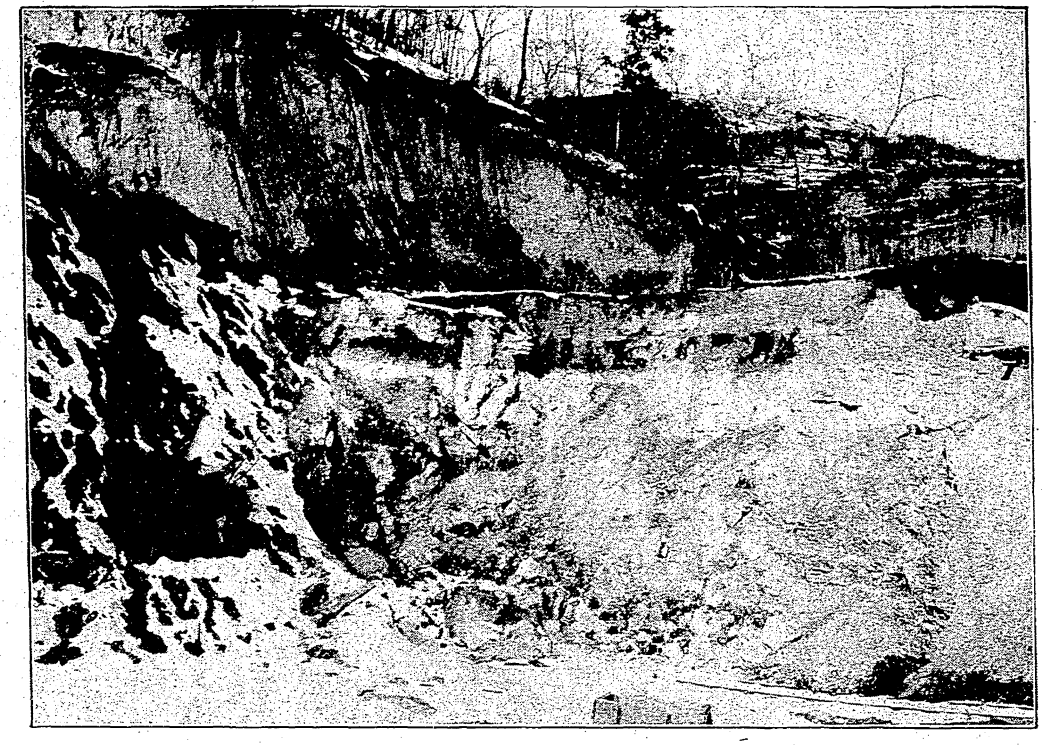


FIG. 30. Clay pit of Boone Clay Works.

The coal measure shales are developed here, and wrought into drain tile, sidewalk blocks, structural and fire brick. The following section is descriptive of the bank exposed.

		FEET.
9.	Drift	15+
8.	Potters clay	1½
7.	Clay shale, steel-colored	2
6.	Clay shale, gritty, ash-colored, iron-stained in the upper part	4

		FEET.
5.	Clay shale, colored red, blue and gray	12
4.	Shale, deep red, ochreous band	⅔
3.	Clay shale, similar to 2	2
2.	Fire clay	1½
1.	Shale, impure (exposed)	3

The above relations are shown in Fig. 30, taken from a photograph. The drift clay, which abounds in nodules of lime and hard pebbles, must be removed. Of the under clays, No. 3 is the principal clay used. It is of excellent quality and contains sufficient iron to give a good color to the finished products. The bottom clay is used in making fire brick. These command a fair price, and recently the output has been greatly increased. The entire bed is above the water level of the small branch which flows near by and is entirely available after the stripping is removed. Work at this point is carried on in a very expeditious manner. No loss is sustained through the ware checking as it becomes freed of its moisture. Drain tile is the principal product.

BOONE PAVING COMPANY.

The works of this company are located on the summit of the bluffs along the Des Moines river, near the extremity of the Shepardtown switch of the Chicago & Northwestern railway. Work was begun here several years ago, but through inadvertence rather than any other cause, the effort was not a success. During 1891 and 1892 the plant was idle. Since then the paving company has introduced new machinery, and at the present time is engaged in the manufacture of pavers of acceptable quality. The clay used belongs to the coal measures and is taken from a few feet above the river. It is raised on an incline to the works. The stripping necessitated is great. Over the clays desired there lies, perhaps, fifty feet of glacial debris, consisting mainly of sand and sandy clay abounding in lime concretions. It is impossible to mine the clay without removing the drift, since there is no adequate roof. However, the position of the bank renders stripping

possible with a minimum expenditure of labor. At the base of the drift the section is:

		FEET.
5.	Clay shale, gray, rather pure; bituminous	2½
4.	Clay shales, gray, rather pure; bituminous parting at the base	1
3.	Clay shales, upper part white, pure; lower part somewhat variegated	3
2.	Limestone, impure fossiliferous	⅔
1.	Clay shales, color light gray	5

All of the above beds, excepting No. 2, can be utilized in making various products, but at present are used exclusively in the manufacture of paving brick. The clay is first treated by a Des Moines dry pan, then it is transferred to a Frey-Sheckler machine. The product is burned in a Eudaly kiln, holding 125,000, or in one or two ordinary down draft kilns, with a capacity of 26,000 each. The brick have been used in paving some of the principal streets of the city of Boone.

THE N. W. GRIFFEE POTTERY WORKS.

This plant is located in West Boone. Pottery making was begun here nearly thirty years ago, and during the last quarter ter of a century the factory has been under the present management. The raw material is obtained from the east bank of Diamond Hollow, about one-third of a mile eastward from the Des Moines river. The bed worked is but two feet thick. The upper two or three inches are of a dark gray color, and of good quality; under this is a buff, siliceous clay, sandier in the lower portion. A mixture of the two grades affords the best results. Over the clay lies a limestone ledge, which serves as a roof, the clay being mined by drifting into the side of the hill. Under the clay a sandstone appears. One ordinary down draft rectangular potters' kiln is used for burning. The product consists of the ordinary vessels in various sizes and shapes, the extreme capacities being one quart to twenty gallons. In addition to the plain ware, fancy ornamental pieces and toys are made. A ready market is found for the finished product at various points along the

Chicago & Northwestern railway and branches, between Marshalltown and Council Bluffs.

Other pottery works have existed in this locality, but at present the plant just described is the only one in operation.

THE JACOB YEGGE BRICKYARD.

This yard is located on the level upland, about one mile southwest of Boonesboro. The material used is known as "white oak" clay. On the surface it appears to be a light colored soil, which becomes brownish below. It can be used to a depth of perhaps two feet. The deposit is followed by a yellow, jointed, somewhat gravelly clay, which contains numerous particles and concretions of lime. The brick, the only product made, are moulded by hand, dried on the yard and burned in cased kilns, the largest kiln holding 442,000 brick. Four days are required for weathering and about five to burn the brick properly.

In the vicinity of Boonesboro, F. Bowman, Dean & Bowman, S. Smiley, J. Benson and L. Stephens operate brickyards. At all of these yards the raw material is of the same character as that utilized at the Yegge works. The methods employed in preparing, drying and burning the product are essentially the same. Moreover, the bricks themselves are almost identical with those of the Yegge yard. It seems, therefore, unnecessary to give separate descriptions of each plant. The F. Wilcox yard, between Moingona and Ogden, may be classed in the same category. T. Franklin started a small brickyard on the east side of the river and may also make some pottery. The clay used is the same as at Griffee's.

THE SLATER YARD

Mr. Slater was the pioneer brickmaker at Moingona. He opened a plant in the southwestern part of town as early as 1866. Work has been prosecuted ever since, but, until six or seven years ago, only sand-rolled brick were made. Machinery was then introduced and used for several years, but at present the greater proportion of the product is made

by hand. The "white oak" clay for the hand-made brick is similar to that at Boonesboro, and is taken from the hilltop just south of the works. A few buff-colored bricks have been made from an almost white shale of good quality, which is exposed in a ravine near by. The dry-press brick were manufactured from a red shale. This shale outcrops near shaft No. 6 of the Moingona Coal company, and varies from three to six feet in thickness. This clay burns to a bright cherry-red color.

THE EVERETT YARD.

This comparatively new plant is located just southwest of the Chicago & Northwestern depot at Moingona. The raw material is taken from what might properly be called the "second bottom" deposit. The stratum utilized varies from one to five feet in thickness and is of a yellow to brown color. In texture it is somewhat sandy, yet rather strong, and grades upward into the surface soil, all of which is being utilized with good results.

There are three other manufacturers of clay products in this vicinity; two are near the station, the Erickson, and the McCloud & Carpenter, and a third is about a mile and a half southeast of town on the east side of the Des Moines. The last named factory is owned by S. Boles, who uses a clay essentially the same as that at the Everett bank. Both of those near the station use a loamy material. The Erickson clay belongs to a more recent deposit and is by no means strong. Attempts have been made to use the yellow under clay from the second bottom which lies below that used at the McCloud & Carpenter yard. All such attempts have proved futile on account of the excess of lime. The methods employed at these yards are similar. The brick, which are known as sand-rolled, are dried in the yard and burned in cased kilns. The color of the product is almost invariably good.

Small brick yards have been opened at several points along the river north of Moingona, but in material used, methods

pursued and the final product are essentially the same as in those just described.

G. ECKERT YARD.

In 1893 this small plant was established at Madrid and has been operated continuously since. It is located about three-fourths of a mile southwestward from the town. The material used is a rather sandy drift soil about two feet in thickness. The brick are hand-moulded and burned in temporary cased kilns. L. L. Wheeler also operates a small yard in this vicinity.

SOILS.

As has been said the drift completely mantles the county and hence the soil is a heterogeneous mixture of sand, clay and vegetable humus, and bears no relation to the country rock. Although the surface materials have an extraneous origin and are of a composite nature, yet several well marked types may be distinguished. The principal streams are flanked on either side by alluvium, varying from a few inches to several feet in depth. The soil contains a considerable percentage of sand and is a quick, warm soil often highly productive. The crests of the bluffs adjoining the Des Moines valley and an area extending some distance inland are capped with a gray, ash-colored soil (white oak soil). The timber limit is almost coincident with the distribution of this type. The upland region which comprises seven-eighths of the area of the county is covered with a thick layer of grayish-brown to black, sandy loam.

In many cases, especially in the western half of the county, the soil is so heavily charged with humus it attains a jet black color and is extremely close-textured. On account of its great retentive power as regards water, it is often imperfectly drained and is not considered arable. Nearly one-fourth of the superficial area of the county remains untilled because of imperfect ventilation and drainage. To show that such soil does not lack the proper chemical constituents,

but that its apparent worthlessness is due to physical conditions, the following analyses are appended.*

	PHOSPHORIC ACID P_2O_5		POTASH.		NITROGEN.	
	Soluble in H Cl.	Soluble in Citric acid.	Soluble in H Cl.	Soluble in Citric acid	Total.	Soluble in Citric acid
1. Upland, well drained..	0.20	0.0118	0.27	0.0039	0.179	0.0032
2. Upland, poorly drained-	0.15	0.00235	0.33	0.0060	0.301	0.0150

The analyses require but little comment; the relative value of the two soils represented by the samples considered, measured in terms of available plant food is plainly evident, yet sample 2, was taken from supposedly the poorest land in the region.

Whitney has shown that the productiveness of a soil depends even in a greater degree upon its texture and physical constitution than upon its chemical composition. The apparent need of a considerable area of the county is the introduction of tile drains. By such means thousands of acres might easily be rendered tractable, and would soon become the most productive land in the region. Tile could readily be produced in the immediate vicinity, for no county possesses a greater amount of clay suitable for the purpose.

ROAD MATERIALS.

Sand and gravel knolls are not uncommon over the county, and these taken in conjunction with the stream sands and gravels afford an abundance of road material. The above sources also furnish an adequate supply of sand suitable for building purposes.

ARTESIAN WATERS.

The deep well in the city of Boone demonstrates the improbability of being able to obtain a flow from the great

* The above analyses were taken from a paper entitled The Chemical Analyses of Soils, by Prof. G. E Patrick, Iowa Acad. Sci., vol. II, p. 65. Des Moines, 1895. The samples were taken in Pocahontas county where the relations are similar to those in Boone.

sandstone formations of the lower Paleozoic. Of the drift wells, there are two well marked artesian basins represented in the county; the Beaver creek basin and the area drained by Squaw creek. All of the wells in these two areas afford but weak flows, yet the amount of water is sufficient for local consumption. The water is usually highly tinctured with salts of iron, but not in sufficient quantities to seriously interfere with its use for domestic purposes, and it seems to have no deleterious effects on stock. These wells range from 50 to 150 feet in depth. In other portions of the county good water is generally obtained at a depth of from 20 to 150 feet.

MINERALS.

Pyrite.—The coal measure shales afford an abundance of pyrite crystals, some of which reach a high degree of perfection. They usually occur as parallel growths and often form masses of considerable size composed of sub-individuals. The pyritohedron is the prevailing type.

Gypsum.—Good crystals of selenite are often encountered in the lower members of the drift. They usually occur in seams one or two inches in width, composed largely of "swallow tailed" twins. Gypsum is also not uncommon in the coal measures, filling interstices in shale, and it often appears as thin, white, semi-translucent partings in the coal itself.

Calcite.—This mineral in the crystalline form is rarely found in this locality. It enters largely into the formation of partitions in the septarian nodules and often occurs in small amounts in certain sandstones and shales. One of the most interesting forms assumed by calcium carbonate is that popularly known as cone-in-cone. Beautiful examples of this structure are found in the argillaceous shales along the Des Moines river near Madrid. This occurrence was noted by Owen* during his ascent of the Des Moines river in 1849. He describes it as "a band of translucent calcareous spar, having the prismatic structure of aragonite, and the fibrous prisms

*Geol. of Wis., Ia. and Minn., p. 123.

collected, however, into perfect conical bundles, with the apex of the cone turned either directly downward, or sometimes upwards, the external surface of the cones crimped, possessing in fact, at the same time, the most perfect *tutenmergel* structure, as if produced by some combined process of stalactitic infiltration and simultaneous crystallization." The cone-in-cone seam occurs some twenty feet above low water and varies from one and a half to three inches in thickness. It is practically parallel to the enclosing strata and gradually thins out and disappears laterally. A chemical examination by Prof.

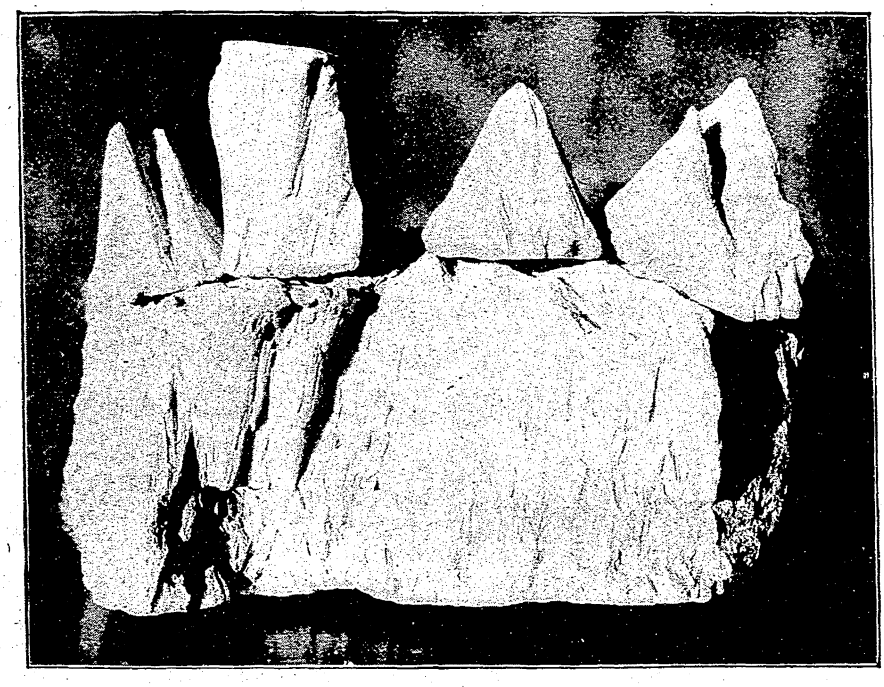


FIG. 31. Undisturbed cones in the lower portion with several detached cones above.

G. E. Patrick proves the substance to be essentially calcium carbonate (C_a CO_3 —83. 12 per cent.) contrary to the opinion of Dr. Owen who believed it to be the sulphate.

ACKNOWLEDGMENTS.

In the preparation of the present report the writer has received much valuable information from the officials of the various mining companies and clay industries. The officers of the W. D. Johnson Coal & Mining Co., the Boone Clay

works and the Boone Paving Brick Co., especially, have been courteous in co-operating with the representative of the survey. Mr. E. E. Chandler and Mr. E. D. Roberts of the city of Boone, have rendered generous assistance in placing at the disposal of the survey, the records of numerous shafts and wells in the vicinity. To them and to many others who have facilitated the work in many ways, the writer's best thanks are due.

CHARACTER AND DISTRIBUTION OF FOREST TREES AND SHRUBS IN BOONE COUNTY.

BY PROF. L. H. PAMMEL.

Central Iowa is not covered extensively with forest growth, and Boone county forms no exception to the rule. Its timbered area is, however, greater than that along the Skunk river in Story county, but fourteen miles distant. The timbered portion of Boone county covers an area varying from three to six miles in width. It is confined to the Des Moines river and its tributaries.

Two features are especially noteworthy: first, the timbered area of the alluvial and sandy flood plain of the Des Moines river and its larger tributaries; second, the timber occupying the hilly country, which consists of numerous valleys, elevated ridges and hills. There is usually a sharp demarkation of the species of the alluvial flood plain and the hilly country. The first area is occupied almost exclusively by the white elm (*Ulmus americana*) and the common cork elm (*U. racemosa*), soft maple (*Acer dasycarpum*), box elder (*A. negundo*), cottonwood (*Populus monilifera*), black walnut (*Juglans nigra*), willow (*Salix sps.*), and green ash (*Fraxinus viridis*, *F. sambucifolia*).

Among the hills the dominant trees are red oak (*Quercus rubra*), bur oak (*Q. macrocarpa*), white oak (*Q. alba*), chestnut oak (*Q. muhlenbergii*), green ash and white elm less commonly than along the river, butternut (*Juglans cinerea*), shell-bark hickory (*Carya alba*) and bitternut (*C. amara*).

On steep hillsides facing the river, ironwood (*Carpinus caroliniana*) and hop hornbeam (*Ostrya virginica*) occur. Slippery elm (*Ulmus fulva*) is abundant. In thickets, *Prunus americana*, *P. virginiana*, *Pyrus coronaria*, *Cratægus mollis*, *C. punctata*, *Cornus alternifolia* and *Viburnum pubescens* are also common to the bluffs.

Without doubt the soil bears an important relation to the kind of tree or shrub produced, and, to a certain extent, the soil and geological formation is an index to plant life. Most collectors in North America have given this subject very little attention.

The appended list of shrubs and trees found in Boone county, is in part represented by specimens in the Agricultural college herbarium. The remaining plants on the the list are inserted from observations by the writer, Dr. S. W. Beyer, or Messrs. Sirrine and Carver. In arrangement and synonomy Gray's Manual, sixth edition, has generally been followed.

ANGIOSPERMS DICOTYLEDONÆ.

TILIACEÆ.

Tilia americana L.

Hills and second bottoms; abundant.

RUTACEÆ.

Xanthoxylum americanum Mill.

Abundant in hilly woods.

CELASTRACEÆ.

Celastrus scandens L.

Upland woods, frequently climbing over small trees and shrubs; highly ornamental.

Euonymus atropurpureus Jacq.

Common in woods and on second bottom.

RHAMNACEÆ.

Rhamnus lanceolata Pursh.

Local, in upland woods. (Carver.)

Ceanothus americanus L.

Dry woodlands and along railroads on the prairies; abundant.

C. ovatus Desf.

Probably occurs on very dry drift soils; occurs in Story county.

VITACEÆ.

Vitis riparia Michx.

Abundant in upland woods and bottoms, climbing over shrubs and large trees.

Ampelopsis quinquefolia Michx.

Abundant in woods, first and second bottoms and uplands.

SAPINDACEÆ.

Aesculus glabra Willd.

On second bottoms and hillsides; not uncommon.

Acer dasycarpum Ehrh.

Low grounds and alluvial bottoms; abundant.

A. nigrum Torr. and Gray.

Hills; abundant.

Negundo aceroides Moench.

Low, rich grounds; abundant.

Staphylea trifolia L.

Upland woods and high banks.

ANACARDIACEÆ.

Rhus glabra L.

Abundant along the border of the woods and dry, sterile grounds.

R. toxicodendron L.

Low grounds and dry soil; abundant.

LEGUMINOSÆ.

Amorpha canescens Nutt.
Dry, sterile hills; abundant.

A. fruticosa L.
Common on low grounds and along streams.

Robinia pseudacacia L.
Introduced in places.

Gymnocladus canadensis Lam.
Common along streams.

Gleditschia triacanthos L.
Common along streams and on low grounds.

ROSACEÆ.

Prunus americana Marshall.
Forming thickets; abundant.

P. pennsylvanica L.
Valleys and rich woods; infrequent.

P. virginiana L.
Upland woods and steep banks; common.

P. serotina Ehrb.
Infrequent in upland woods.

Rubus occidentalis L.
Dry hillsides and upland woods; common.

R. villosus Ait.
Upland prairies; abundant.

Rosa arkansana. Porter.
Borders of woods and open prairies; abundant.

Pyrus coronaria L.
Common in the bottoms of all the smaller streams, forming large thickets.

Crataegus mollis Torr. and Gray.
Woods; frequent.

C. tomentosa L.
Frequent in upland woods.

C. punctata Jacq.
Thickets, borders of woods and second bottom.

Amelenchier canadensis Torr. and Gray.
Upland woods; frequent.

SAXIFRAGACEÆ.

Ribes cynosbati L.
In woods; not uncommon.
R. gracile Michx.
Low grounds in woods and open places; abundant.
R. floridum L'Her.
Low grounds, second bottoms and moist places in upland woods; frequent.

CORNACEÆ.

Cornus paniculata L'Her.
In upland woods; frequent.
C. alternifolia L.
Rocky woods; abundant near the "Ledges."

CAPRIFOLIACEÆ.

Sambucus canadensis L.
Bottoms; abundant.
Viburnum pubescens Pursh.
Rocky woods and declivities; abundant near the "Ledges."
V. lentago L.
Not uncommon in woods.
Symphoricarpus occidentalis Hook.
Rocky woods; common.
Lonicera glauca Hill.
Common in upland, moist woods.

RUBIACEÆ.

Cephalanthus occidentalis L.
Bottoms and sloughs; abundant.

OLEACEÆ.

Fraxinus viridis Michx.
Alluvial bottoms and upland woods; abundant.
F. sambucifolia Lam.
First and second bottoms; common.

URTICACEÆ.

Ulmus fulva Michx.

Abundant in upland woods.

U. americana L.

Valleys of upland woods and low bottoms; abundant.

U. racemosa Thomas.

This beautiful tree was only observed on the second bottom, near the "Ledges."

Celtis occidentalis L.

Low alluvial bottoms; Des Moines river.

Morus rubra L.

Local; Des Moines river bottom; not common.

PLATANACEÆ.

Platanus occidentalis L.

Bottoms along Des Moines river; not uncommon.

JUGLANDACEÆ.

Juglans cinerea L.

Second bottom and upland woods; abundant.

J. nigra L.

Common; rich soil; second bottom and alluvial bottoms of the larger streams.

Carya alba Nutt.

Upland woods; common.

C. amara Nutt.

Common; upland woods; especially in valleys and second bottoms.

CUPULIFERÆ.

Corylus americana Walt.

Upland woods; abundant.

Ostrya virginica Willd.

Abundant on exposed hills; "Ledges" and Moingona.

Carpinus caroliniana Walt.

Upland woods; rare. (Carver.)

Quercus alba L.

Hills and ridges; common.

Q. macrocarpa Michx.

Hills and ridges; common.

Q. muhlenbergii Engelm.

In valleys; fine, large trees; common.

Q. rubra L.

In valleys, second bottoms and on ridges; abundant.

Other species of Quercus undoubtedly occur in the county, as they have been observed near Des Moines and Webster City. At the latter point *Quercus texana* Buckley has been collected. It is not improbable that this species and *Q. coccinea* Wang occur in Boone county.

SALICACEÆ.

Salix nigra Marsh.

River banks and alluvial bottoms; abundant.

S. longifolia Muhl.

Sandy banks of the Des Moines river; abundant.

S. humilis Marsh.

Hills, prairies; frequent.

S. cordata Muhl.

Probably occurs in swampy ground. Reported from Story county by Hitchcock. (Catalogue Anthophyta and Pteridophyta of Ames, Iowa.)

Populus tremuloides Michx.

Upland woods; frequent.

P. grandidentata Michx.

Record has not been made of the occurrence of this species in the county, but I believe it occurs.

P. monilifera Ait.

Abundant on alluvial and second bottoms; also near coal mines and on talus slopes.

MONOCOTYLEDONÆ.

LILIACEÆ.

Smilax hispida Muhl.

In rich, upland woods; infrequent.

GYMNOSPERMÆ.

CONIFERÆ.

Juniperus virginiana L.

High bluffs; local; occasionally a tree on the most exposed salients. Perhaps it was once more common than now. The only Conifer native to the county.

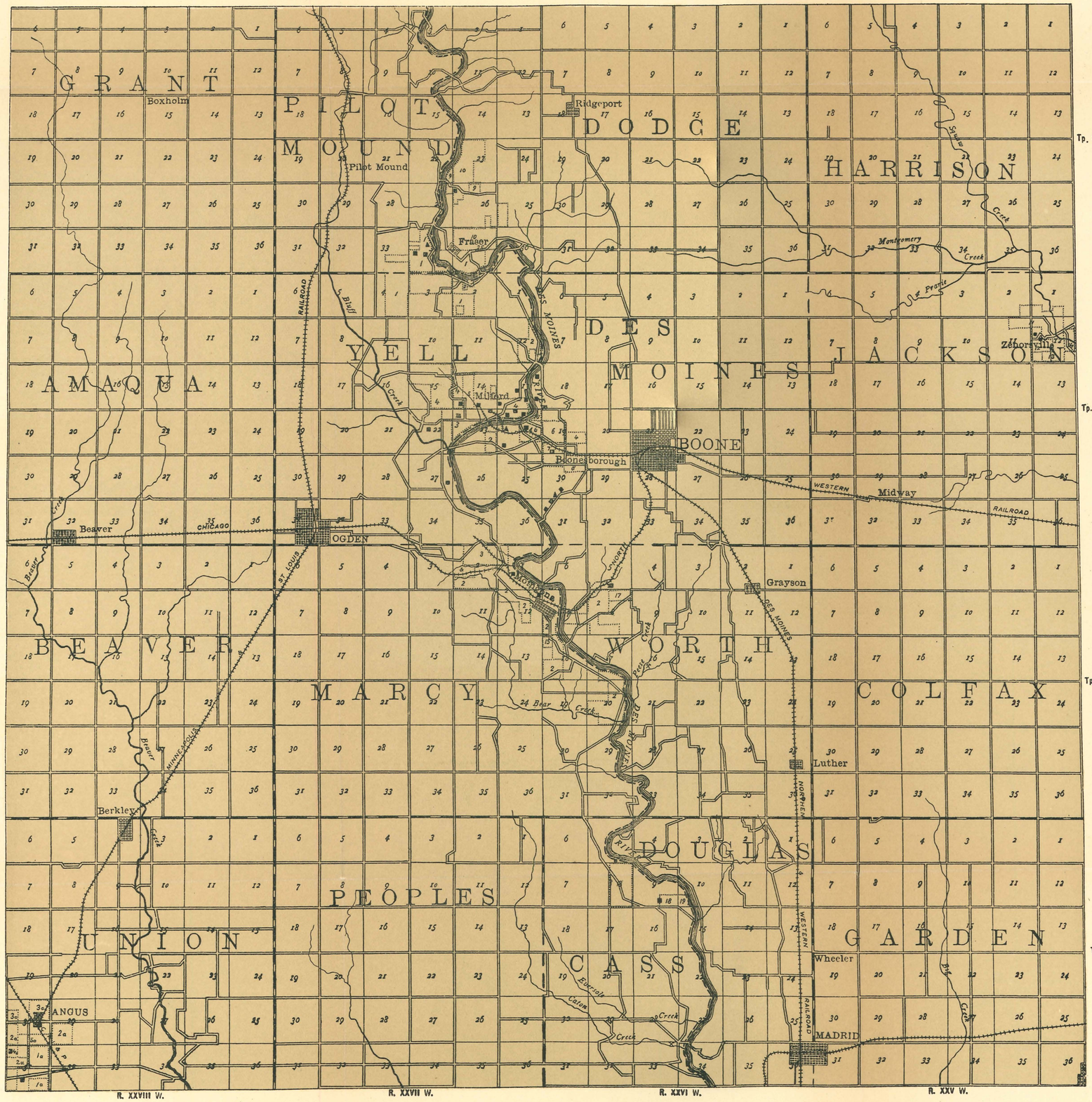
IOWA GEOLOGICAL SURVEY

GEOLOGICAL MAP OF BOONE COUNTY, IOWA.

BY

S. W. BEYER

1896.



LEGEND

GEOLOGICAL FORMATIONS

DES MOINES (Coal Measures)

INDUSTRIES

COAL MINES

CLAY WORKS

QUARRIES

IOWA PRINTING CO. DES MOINES, IA.

DRAWN BY F. C. TATE