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**THE CARBONIFEROUS SECTION OF  
SOUTHWESTERN IOWA**

BY

**GEORGE L. SMITH, M. D.**

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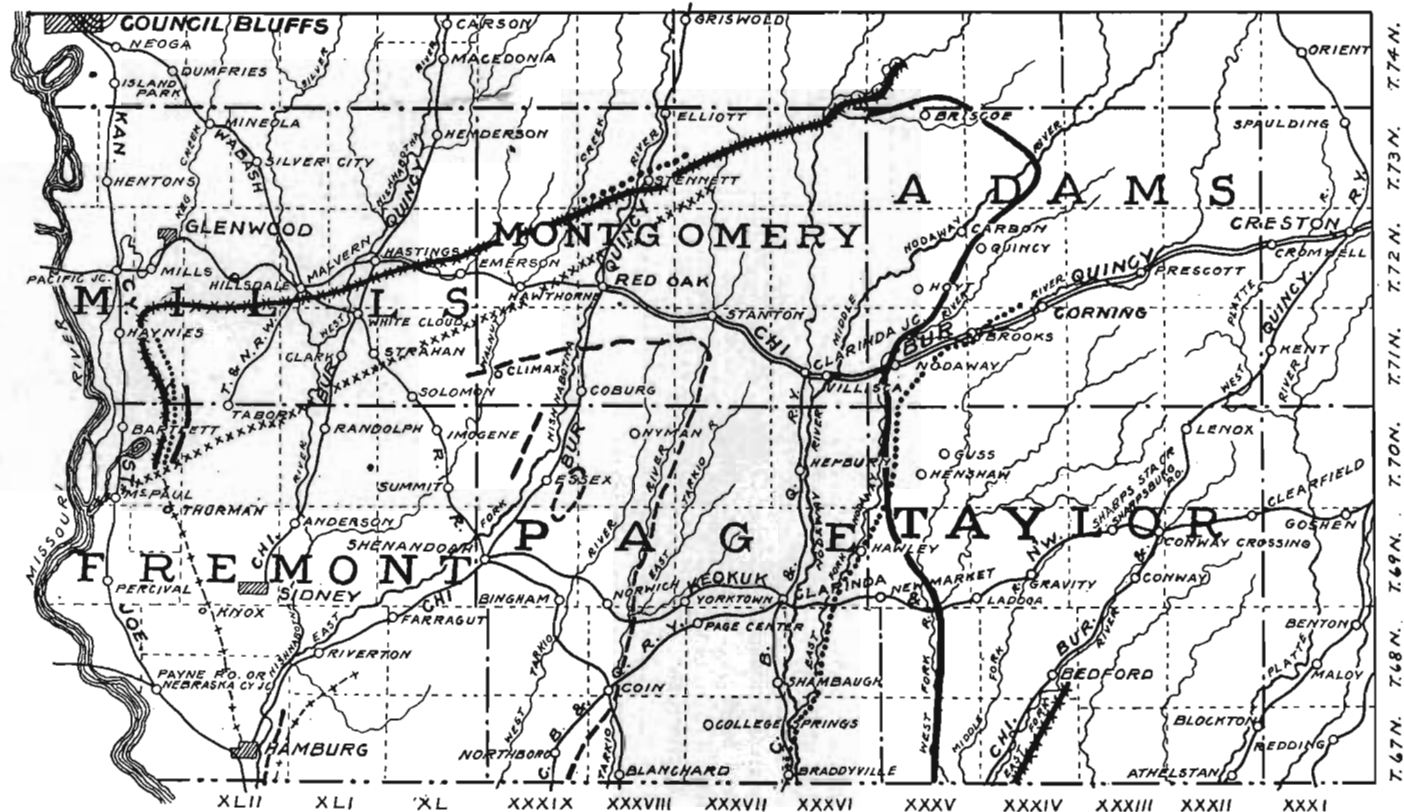


# The Carboniferous Section of Southwestern Iowa

BY GEORGE L. SMITH, M. D.

## CONTENTS

	Page
Introduction .....	609
Area .....	609
General relations of strata.....	610
Previous geological work.....	612
General character of the Missouri stage.....	613
Stratigraphy of the Missouri stage.....	621
One hundred and two river drainage.....	621
Nodaway river drainage.....	622
Tarkio river drainage.....	630
Nishnabotna river drainage.....	635
Missouri river bluffs.....	641
Coal seams.....	653
Altitude and thickness.....	654
Paleontology .....	655
Acknowledgments .....	657



+--+ Mc KISSICKS GROVE SHALES.

--- TARKIO LIMESTONES.

— NODAWAY COAL.

..... BRADYVILLE LIMESTONES.

\*\*\*\*\* FORBES LIMESTONE.

++++ LINE OF FAULT AT WILSON SECTION, PASSING INTO AN ANTICLINE TO THE NORTHEAST.

Map of southwestern Iowa showing outcrop of geological formations.

## CHAPTER V

### THE CARBONIFEROUS SECTION OF SOUTHWESTERN IOWA

#### INTRODUCTION

It is important from a scientific as well as an economic standpoint that an accurate and complete section of the Carboniferous of southwestern Iowa be made. Moreover recent investigation has shown that instead of being simple in its structure, deformations important and unusual for Iowa exist in this portion of the state.

Many prominent geologists have been workers in this field and have come to different conclusions as to the thickness and succession of the strata. There also has been in the last few years a great development of the coal mining industry and more than three hundred men are now employed in mines opened in the Nodaway coal seam in Adams, Page, and Taylor counties.

In the interest of this industry and for the guidance of prospectors in search of coal the stratigraphy and extent of this coal field should, as far as possible, be accurately worked out and published. To this end, in the preparation of this paper every effort has been made to avoid inaccuracies, and while minor changes may have to be made, it is believed that as a whole the results arrived at will be found to be substantially correct. All the critically important exposures have been examined in company with Professor Calvin, and the correlations arrived at by stratigraphy in nearly all instances have been confirmed by paleontological evidence.

#### AREA

The area covered by this report includes the six counties, Adams, Montgomery, Mills, Fremont, Page, and Taylor, situated in the southwestern corner of the state. It is bounded on

the south by the state of Missouri and on the west by the Missouri river. It extends east from the Missouri river an average of seventy-five miles and north of the south boundary of the state forty miles, and contains approximately 3,000 square miles. It is drained by several considerable streams flowing to the southwest, all being tributary to the Missouri river. Commencing at the eastern boundary of the area and proceeding to the west we have the East and West Forks of the One Hundred and Two river, the many different branches of the Nodaway river, the two Tarkio creeks, the East Nishnabotna river, the West Nishnabotna river with its branches Walnut and Silver creeks, and Keg creek. Outside of the level river bottom lands the surface is quite undulating, the river valleys being excavated to the depth of one or two hundred feet.

#### GENERAL RELATIONS OF STRATA

In only a few instances have the stratified rocks influenced the topography of the country, since the stream erosion has been wholly in the Pleistocene, which is of considerable thickness. In many places on the divides between the streams it reaches to the depth of 200 feet.

The superficial loess is only a few feet in thickness in the eastern portion of the district, but this increases to the west until it reaches over one hundred feet in the Missouri river bluffs. In fact, there are exposures of twice that thickness, a great part of which, however, is caused by landslides in the steep face of the bluffs. In the bluffs of the Missouri river exposures of the drift are rare, and are not more than two or three feet in thickness. This great thickness of the loess does not reach much east of the West Nishnabotna river, where it becomes much reduced. Eastward of this river the drift deposits are often one to two hundred feet thick on the divides between the streams and in many cases reach below the water level in the adjacent rivers.

In the field work the want of a topographic map has often been felt, as the correlation of different exposures but a few miles apart was rendered difficult by not knowing the exact elevation of each. This difficulty is further increased in places by the heavy dip and faulting of the strata.

Lying unconformably on the Carboniferous in the northeast corner of Mills, nearly the whole of Montgomery, and the northwestern part of Adams counties are outliers of Cretaceous sandstones and shales, some of which reach the thickness of at least one hundred feet. Being composed of soft and incoherent materials they do not usually modify the topography.

The Missouri of southwestern Iowa is composed of shales, limestones and limited amounts of sandstone. The shales, which comprise much the greater part of the strata, are generally calcareous, so much so that even those in immediate contact with the coals effervesce readily with acid. The limestones occur in layers from an inch or two in thickness to ledges twenty feet thick. Usually the limestones are highly fossiliferous. In all the Coal Measures exposures of Adams, Montgomery, Page, and Taylor counties not a single sandstone is to be found. Deep drillings also show a total absence of sandstone in the Missouri in these counties. The only sandstone known in the Missouri of Page county is in the Johnston coal mine shaft west of Clarinda, where there are in the shales eighty feet above the Nodaway coal two thin sandstones a few inches thick, divided by a foot of shale. In Fremont county at the summit of the Carboniferous of Iowa there is found a conspicuous sandstone that is of great service in correlation. In the Missouri a large amount of the strata is difficult to classify, as it is often hard to state whether a certain rock is a limestone or a shale. Different observers are much governed by the personal equation. By the older geologists strata of this description were called marls, by more recent observers impure limestones or calcareous shales. In nearly all instances in weathering they break down into clay and should be classified as calcareous shales. Likewise it is often difficult to state whether a rock is a shaly sandstone or a sandy shale. In Broadhead's sections many sandstones are given which the writer would without hesitation pronounce to be sandy shales. In the Missouri the different strata are very persistent, especially along the strike, for miles showing but little change, and hence correlations can be made with confidence. Natural outcrops are few and are confined to the vicinity of the streams. This requires that wide correlations be made and many local

dips complicate the situation. Paleontology affords much aid but the same fossils are found throughout the whole series of strata and the main dependence must be upon stratigraphy.

#### PREVIOUS GEOLOGICAL WORK

Nearly forty years ago C. A. White surveyed this part of Iowa and his Report of 1870 has been of much use in giving sections of outcrops that at the present time are much obscured. Reports have been published by the present Iowa Geological Survey on Montgomery county by E. H. Lonsdale, Page county by S. Calvin, and Mills and Fremont counties by J. A. Udden. These have been of much service and have been freely laid under contribution.

In considering the stratigraphy of a region it is indispensable that some standard classification be used and the General Section given by C. R. Keyes in his paper "Coal Measures of the Western Interior Basin," Volume 7, Proceedings Iowa Academy of Science, will be used with slight modifications. This section is believed to be the most accurate and satisfactory of any heretofore published on the Upper Coal Measure section from Kansas City to Omaha. The paper by J. E. Todd, "Some Variant Conclusions in Iowa Geology," Volume 13, Proceedings Iowa Academy of Science, describing the remarkable displacement of strata at Lake Wabonsie in Fremont county, is of great value in calling attention to an unusual feature of Iowa geology not found elsewhere in the state. Recent examinations of the exposures at Lake Wabonsie and in the vicinity of Thurman confirm the views of Todd and show that a short distance south of the Wilson section of White a fault of about 300 feet throw with an uplift to the north is present. In the same paper is given a general section of the Carboniferous as seen in natural outcrops in southwestern Iowa on the Missouri river, which agrees well with sections made from exposures examined farther east. This section of Todd's will be regarded as a type in the different correlations. Of the greatest aid and without which it would have been almost impossible to write this report has been the "Geology of Northwestern Missouri," in Part 2, Geological Survey of Missouri, "Iron Ores and Coal Fields," 1872, by G. C. Broad-



head. In this report the author gives a section of the Upper Carboniferous from Kansas City to City Bluffs, now Burlington Junction, following the Missouri and Nodaway rivers, also a section of the strata of Atchison county, Missouri. It has been possible from exposures in Iowa to connect the City Bluffs beds with the Atchison county group, and complete the Missouri section to the summit of the Carboniferous in that state. This section by Broadhead is one of the earliest published and should be given full recognition by succeeding geologists. Many references will be made to this section and wherever it can be made applicable his geographic names will be used. Broadhead's section goes into much detail and many beds given in it are probably of only local importance. It is also possible there is some duplication of strata. Like nearly all sections made from exposures of the strata it shows much excess in thickness over what is found in core drillings. Broadhead gives the total thickness of the Upper Coal Measures in northwestern Missouri as being 1,317 feet, while in Iowa within a few miles of the south line of the state core drillings and outcrops show a thickness of about 950 feet, the Iowa section reaching fully as high as the section in Missouri.

In Iowa the area between the Westerville limestone, the uppermost of the Bethany limestones exposed on Grand river in Decatur county, and the Forbes limestone exposed on the East Fork river at Bedford is so deeply covered by the Pleistocene that it is almost devoid of exposures of the stratified rocks. On this account it would be impossible to make the connection between these two limestones without the aid of Broadhead's section and the records of deep core drillings.

#### GENERAL CHARACTER OF THE MISSOURI STAGE

In the six southwest counties of Iowa there is exposed in natural outcrop 400 feet of the Missouri, leaving 550 feet which is known only by deep core drilling. The Des Moines was penetrated 129 feet in the Clarinda drill hole, leaving an unknown amount beneath the bottom of the drilling. Deep core drill holes have been put down at Carbon, Clarinda, Coin, College Springs and Hamburg. The records of those at Clarinda, Coin, and College

Springs are available and will be correlated with the general section. At Glenwood two wells 2,000 feet deep have been drilled by the state of Iowa. This drilling was done by the cable rig method and the records of the two wells are not in agreement. Professor W. H. Norton gives the record of the first well in Volume VI, Iowa Geological Reports, and summarizes the formations as follows:

	THICKNESS IN FEET.
Pleistocene .....	175
Missouri .....	670
Des Moines .....	390
Mississippian .....	230
Devonian .....	135
Silurian .....	400

The first stratified rocks found beneath the Pleistocene at Glenwood are evidently the Plattsmouth limestones.

The general section of Keyes for the Missouri is as follows and will be correlated with Broadhead's section in parallel columns.

KEYES' GENERAL SECTION OF THE MISSOURI CORRELATED WITH BROADHEAD'S  
GENERAL SECTION FROM KANSAS CITY TO CITY BLUFFS, TOGETHER  
WITH THE ATCHISON COUNTY GROUP

KEYES.	THICKNESS IN FEET.	NUMBERS.	BROADHEAD.	THICKNESS IN FEET.
Atchison shales.....	500		Atchison county group.....	180
		224-216.	City Bluffs beds.....	105
		215.	Nodaway coal.....	
		214-187.	Limestones and shales.	67
Forbes limestone .....	30	186.	Forbes limestone.....	15
Platte shales .....	150	185-153.	Shales, thin limestones and sandstones.....	179
Plattsmouth limestones .....	30	152-150.	Limestone .....	38
Lawrence shales .....	300	149-122.	Shales, thin limestones and sandstones.....	235
		121.	Limestone .....	18
		120-109.	Shales and sandstones.	121
Stanton limestones .....	35	108.	Plattsburg limestone..	18
Parkville shales .....	100	107- 99.	Sandstone, thin lime- stones and shales...	83
Iola limestone .....	50	98.	Limestone .....	30
Thayer shales .....	75	97- 91.	Shales with two lime- stones .....	40
Bethany limestones .....	100	90- 74.	Limestones with inter- bedded shales.....	126
Total .....	1400	Total .....		1255

Broadhead was unable to make the connection between the City Bluffs beds and the Atchison county group and supposed there was an interval of fifty feet between them. Recent investigation in Iowa shows that the Atchison county group comes immediately on the City Bluffs beds with little if any hiatus. Keyes states that according to deep drilling north of St. Joseph the Iola limestone fails, bringing the Thayer and Parkville shales into contact with each other. The Clarinda drilling corroborates this and Broadhead's name "Parkville" will be used for the united shales. On the Missouri river the Lawrence shales are divided near the middle by an important limestone, Broadhead's number 121, to which Keyes has given the name "Iatan." The shale member beneath the limestone he has named "The Weston Shale" and the one above "The Andrew Shale." These names, often used by Broadhead, will be adopted here. Broadhead repeatedly speaks of the Plattsburg limestone and as it is the Missouri river section instead of the Kansas section under consideration his name will be used instead of "Stanton" as being the most appropriate.

Keyes' section modified to meet the conditions found in Iowa is as follows:

- Atchison shales.
- Forbes limestone.
- Platte shales.
- Plattsmouth limestones.
- Andrew shale.
- Iatan limestone.
- Weston shale.
- Plattsburg limestone.
- Parkville shale.
- Bethany limestones.

Todd's general section of the Carboniferous of southwestern Iowa as exposed on the Missouri river gives more detail and as it is believed to be accurate it will be given and correlated with Keyes' general section.

## TODD'S MISSOURI RIVER SECTION.

		THICKNESS IN FEET.
	16. Shales with two limestones two and four feet thick.....	19
	15. Micaceous sandstone.....	10
	14. Shales with a thin limestone.....	39
Atchison shales, 307 feet.....	13. Limestone .....	12
	12. Shales with five thin limestones and four sandstones.....	185
	11. Shales, limestones, and coal.....	12
	10. Shales with three limestones.....	30
Forbes limestone.....	9. Limestone .....	20
	8. Shales with two thin limestones....	12
Platte shales, 69 feet.....	7. Sandstone .....	12
	6. Shales with three or four limestones	45
	5. Limestone .....	20
	4. Shale .....	5
Plattsmouth limestone, 39 feet..	3. Sandstone .....	4
	2. Limestone .....	10
Andrew shales, 25 feet.....	1. Shale .....	25
	Total .....	460

The horizon of the Nyman coal is in the upper part of No. 14 and the coal in No. 11 is the Nodaway coal. The Platte shales contain a large amount of limestone and the deep drilling in Page county shows that these limestones amount to at least one-third of the total thickness of this member. One layer often rivals the Forbes limestone in magnitude. It will be noted that the Plattsmouth limestone is divided by sandstone and shale, and is thus a double limestone as is shown in all the deep drilling in Page county. It is equivalent to numbers 150-151-152 of Broadhead's section. Keyes suggests that eventually the Atchison shales may have possibly the same formational rank as the Des Moines.

Above the Nodaway coal in the Carboniferous of Iowa a great change in the character of the strata takes place. Below this coal, in the Missouri, nearly one-half of the section is composed of thick heavy limestone, which occurs in layers up to thirty feet in thickness. The shales, except those of the thick Andrew shales, are usually thin and calcareous. In the Clarinda drilling not a single sandstone was found in the Missouri. The Carboniferous above the Nodaway coal reaches a thickness of 300 feet but has less than fifteen feet of regular and persistent limestone

layers. The City Bluffs beds immediately overlying the cap rock of the Nodaway coal are at least 200 feet thick, but are composed wholly of shales. Even the Tarkio limestones are interbedded with shales that amount to three-fourths of their total thickness.

The Atchison shales of Keyes should be divided into subordinate formations for facility of description. The Braddyville limestones, City Bluffs beds, and Tarkio limestones are terms used in the Iowa and Missouri Geological Reports and these will be used here, their limits fixed and the terms definitely correlated with each other.

The following names will be used for the different formations of the Atchison shales.

	THICKNESS IN FEET.
McKissicks Grove shales .....	75
Tarkio limestones .....	25
City Bluffs shales .....	210
Braddyville limestones .....	50
	<hr/>
	360

Several years ago a core drilling was done at Clarinda in search of coal seams below the Nodaway coal, which is mined at that place. The core has been preserved and was examined and measured by A. G. Leonard and Geo. L. Smith and the record published in Volume XII, Iowa Geological Survey.

RECORD OF THE CLARINDA DIAMOND DRILL HOLE IN THE NORTHEAST  
PART OF TOWN CORRELATED WITH THE GENERAL SECTION  
(SE. ¼ OF SEC. 30, TWP. 69 N., R. XXXVI W.)

		THICKNESS FEET.	DEPTH FEET.	BROAD- HEAD'S NOS.
	109. Drift .....	43	43	
	108. Shale, blue .....	5	48	
	107. Limestone .....	4	52	
	106. Shale, black.....	1	53	
Nodaway coal.....	105. Coal .....	1¾	54¾	215
	104. Fire clay .....	2¼	57	
	103. Shale, gray, calcareous and fossiliferous...	17	74	
	102. Shale, dark.....	2	76	
Braddyville limestones, 42 feet.....	101. Limestone .....	2¾	78¾	
	100. Shale, calcareous....	1¾	80	
	99. Limestone .....	6	86	
	98. Shale, calcareous....	1 2-3	87 2-3	
	97. Limestone .....	3	90 2-3	
	96. Shale .....	6	96 2-3	
	95. Coal .....	1-3	97	
Forbes limestone, 18 feet..	94. Limestone .....	18	115	186
	93. Shale .....	2	117	
	92. Limestone .....	2	119	
	91. Shale, dark, calcareous	2	121	
	90. Limestone .....	2	123	
	89. Shale, calcareous....	15	138	
Platte shale, 86 feet.....	88. Limestone .....	4	142	
	87. Shale, dark blue....	36	178	
	86. Limestone .....	7	185	
	85. Shale, black.....	1	186	
	84. Limestone .....	3	189	
	83. Shale, black.....	12	201	
	82. Limestone .....	7	208	152
	81. Shale, blue.....	1	209	
Plattsmouth limestone, 40 feet .....	80. Limestone .....	2	211	
	79. Shale, dark blue....	8	219	
	78. Limestone, carrying fusulinas .....	22	241	150
	77. Shale, dark blue....	4	245	
	76. Shale, calcareous....	16	261	
	75. Limestone .....	6	267	
	74. Shale, calcareous....	11	278	
	73. Shale, red, green and blue .....	22	300	
Andrew shales, 172 feet...	72. Limestone .....	1	301	
	71. Shale, dark blue....	93	394	
	70. Limestone .....	4	398	
	69. Shale, dark blue, cal- careous in part....	15	413	
Iatan limestone, 16 feet...	68. Limestone .....	16	429	121

## GENERAL CHARACTER OF THE MISSOURI STAGE

619

		THICKNESS FEET.	DEPTH FEET.	BROAD- HEAD'S NOS.	
Weston shales, 76 feet....	67. Shale, black and green .....	13	442		
	66. Limestone .....	2	444		
	65. Shale, black.....	16	460		
	64. Limestone .....	1	461		
	63. Shale, black.....	1	462		
	62. Limestone .....	1	463		
	61. Shale, green and black	6	469		
	60. Coal .....	1½	469½		
	59. Shale, green and black	6½	476		
	58. Limestone, impure, argillaceous .....	6	482		
	57. Shale, black.....	13	495		
	56. Limestone .....	1	496		
	55. Shale, black.....	4	500		
	54. Limestone .....	2	502		
	53. Shale .....	3	505		
Plattsburg limestone, 19 feet .....	52. Limestone .....	19	524	108	
Parkville shales, 22 feet....	51. Shale, gray and black	4	528		
	50. Limestone .....	1	529		
	49. Shale .....	8	537		
	48. Limestone, argillaceous .....	4	541		
	47. Shale, green and black	5	546		
Bethany limestone, 165 feet	Westerville limestone.....	46. Limestone .....	10	556	90
		45. Shale, dark blue....	16	572	
		44. Limestone .....	4	576	
	De Kalb limestone..	43. Shale, dark blue....	2	578	
	Winterset limestone.....	42. Limestone .....	22	600	
		41. Shale, black and green	10	610	
		40. Limestone .....	31	641	
		39. Shale, black.....	8	649	
		38. Limestone .....	2	651	
		37. Shale .....	2	653	
	Earlham limestone..	36. Limestone .....	13	666	
		35. Shale, black .....	3	669	
		34. Coal .....	5-6	669 5-6	
		33. Fire clay.....	2 1-6	672	
		32. Limestone .....	9	681	
	Fragmental limestone.....	31. Shale .....	4	685	
		30. Limestone .....	5	690	
		29. Shale .....	13	703	
	28. Limestone .....	6	709	74	
	27. Shale .....	1	710		
	26. Limestone .....	1	711		

		THICKNESS FEET.	DEPTH FEET.	BROAD- HEAD'S NOS.
	25. Shale, gray.....	4	715	
	24. Sandstone, micaceous	7	722	
	23. Shale, sandy.....	25	747	
	22. Sandstone .....	1	748	
	21. Shale .....	5	753	
	20. Coal .....	1	754	
	19. Shale .....	1	755	
	18. Limestone, argilla- ceous .....	3	758	
	17. Shale .....	1	759	
	16. Sandstone .....	4	763	
	15. Shale, black.....	1	764	
	14. Sandstone, sandy shale, fine, micace- ous .....	19	783	
Des Moines, 129 feet.....	13. Shale .....	9	792	
	12. Limestone .....	1	793	
	11. Shale .....	4	797	
	10. Limestone .....	6	803	
	9. Shale .....	5	808	
	8. Limestone .....	2	810	
	7. Shale, black.....	3	813	
	6. Coal .....	1-3	813 1-3	
	5. Sandstone .....	7	820 1-3	
	4. Limestone .....	5 2-3	826	
	3. Shale .....	3	829	
	2. Limestone .....	2	831	
	1. Shale .....	9	840	

In this section the Bethany limestones with their interbedded shales reach a thickness of 165 feet. The same limestones in Decatur county, according to H. F. Bain, have a thickness of 171 feet. The coal No. 34 is also found beneath the Earlham limestone in both Madison and Decatur counties. The base of the Missouri is placed at No. 26, below which there is a change in the strata that can not be adequately described or shown in a published section. To the depth of 711 feet no sandstones or even arenaceous shales are shown, while in the lower part of the record they become an important part of it. The shales become arenaceous and bituminous and are different in appearance from those higher in the record. Much less limestone is shown and that which does occur is darker in color and more argillaceous than the upper limestones. Anyone conversant with the Carboniferous of Iowa would at once place all below No. 26 in the Des Moines.



**STRATIGRAPHY OF THE MISSOURI STAGE**

No core drilling in southwestern Iowa has been deep enough to pass through the whole thickness of the Des Moines. The record shows a thickness of 129 feet, leaving an unknown amount beneath the bottom of the drill hole. As all of the outcrops of the Carboniferous in southwestern Iowa are confined to the immediate valleys of the streams the different exposures will be traced on each from the south boundary of the state northward, beginning in the eastern part of the territory under consideration. The different outcrops in each valley will be described and at least one representative section will be given and correlated with the general section.

**ONE HUNDRED AND TWO RIVER DRAINAGE.**

At Bedford on the East Fork of the One Hundred and Two river a twenty-foot ledge of limestone has been quarried, but at the present time the quarry is abandoned and the quarry pit is filled with water. Only a few of the upper layers can now be seen. In the opinion of Professor Calvin this limestone is to be referred to the Forbes limestone. It is in the line of strike of this limestone in the state of Missouri and without doubt may be correlated with it.

West of Hopkins, Missouri, the Nodaway coal has been mined on the One Hundred and Two river within a few miles of the Iowa state line. Broadhead states that in Missouri the One Hundred and Two river is the eastern limit of the Nodaway coal. In Iowa the West Fork river is probably the eastern limit of the coal to at least a short distance north of New Market.

Commencing one-half mile east of New Market and extending to a short distance east of the West Fork river is an important coal mining locality that for many years has done a large shipping trade in the well known New Market coal. This coal is mined from the Nodaway coal seam, the only coal bed in southwestern Iowa which is workable at the present time.

## NODAWAY COAL AT THE CAMPBELL MINES ONE MILE EAST OF NEW MARKET

	FEET.	INCHES.
7. Shale, light gray.....	80	
6. Limestone, light blue, in two layers.....	3	
5. Shale, gray, nonlaminated, with nodules of impure limestone .....	2	6
4. Coal .....		18
3. Shale, light gray, laminated.....	1	6
2. Limestone .....		8
1. Shale, light blue.....	12	
Total .....	101	2

In the roof and bottom shales of the coal the following fossils have been found: *Enteleles hemiplicata*, *Dielasma bovidens*, *Productus semireticulatus*, *Ambocelia planoconvexa*, *Derbya crassa*, *Allorisma granosum*, *Aviculopecten*, *Pinna*, and many plant remains.

No. 2 is called a sandstone by the miners but samples collected in the mines show it to be limestone. The dip of the strata at the New Market mines is to the southeast. The coal seam reaches a short distance east of the West Fork river and there ends beneath the superficial deposits. The Nodaway coal probably does not continue far north of New Market until its line of outcrop passes over to the valley of the East Nodaway river.

## NODAWAY RIVER DRAINAGE.

On the Nodaway river about ten miles south of the Iowa state line, near Burlington Junction, Missouri, is the exposure of the City Bluffs beds to which Broadhead often refers. This excellent outcrop of the shales between the Nodaway coal and the Tarkio limestones is the most extensive known and is the type locality of the City Bluffs shales. The following section is from Calvin.

## SECTION NEAR BURLINGTON JUNCTION, MISSOURI

	FEET.	INCHES.
20. Shale, blue .....	10	
19. Shale, yellowish green, calcareous.....		3
18. Shale, marly, concretionary.....	2	
17. Shale, bluish green, not calcareous.....	3	
16. Shale, yellowish, calcareous, concretionary.....	1	6
15. Shale, greenish blue.....	1	
14. Sandstone, calcareous, ferruginous.....		6

13. Shale, sandy, with septarian nodules in the upper part .....	10	
12. Limestone, impure, with obscure impressions of fossils .....		2
11. Shale, sandy .....	2	
10. Limestone, impure, in thin bands alternating with sandy shale which carries septarian nodules near the bottom; fossiliferous .....	5	
9. Shale, gray .....	3	
8. Thin layer showing cone-in-cone at top and bottom, structureless in the middle.....		7
7. Shale, gray, with occasional large septarian nodules .....	25	
6. Calcareous band, fossiliferous .....		4
5. Shale, dark, with some calcareous bands, fossiliferous near top; down to level of water in river..	25	
4. Shale below level of river.....	30	
3. Cap rock, limestone .....	2	
2. Shale .....	4	
1. Coal, Nodaway .....	1	6
Total .....	127	

On the Nodaway river at Braddyville, a short distance from the south boundary of the state, is an outcrop of a series of limestones and shales well known as the Braddyville limestones. Between the Forbes limestone and the Nodaway coal in the state of Missouri Broadhead gives a sequence of sixty-seven feet of limestones and shales. This interval is not well seen in the outcrop in Iowa but core drillings show a thickness of forty to sixty feet of these limestones with their interbedded shales. At the present time a large part of the outcrop is much obscured and Professor Calvin was unable to give as full a section as earlier observers. Broadhead gives a section that does not correspond with either White or Calvin, whose sections agree with each other except in some minor details. White's section giving layers both above and below that of Calvin's is used.

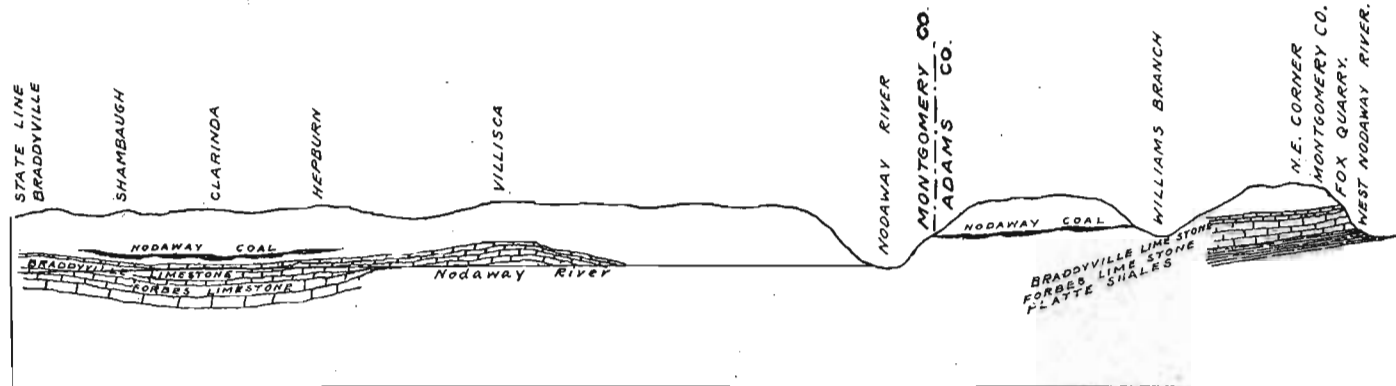
## WHITE'S BRADDYVILLE SECTION

	FEET.	INCHES.
7. Yellowish shaly marl with occasional layers of impure limestone .....	5	6
6. Layer of compact limestone.....		6
5. Dark-colored carbonaceous shale passing upward into light blue clayey shale.....	2	6
4. Layer of compact, bluish, impure limestone.....		6

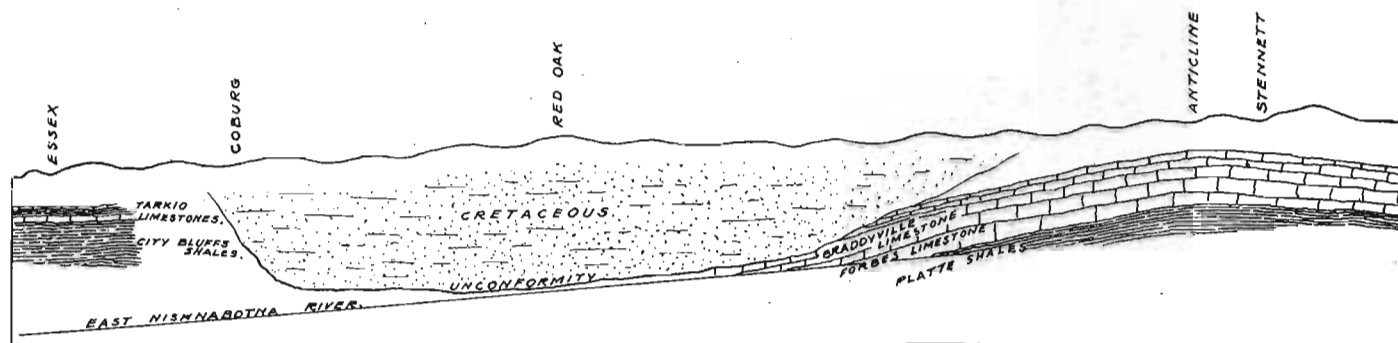
3. Bluish carbonaceous shale with thin calcareous seams .....	4	
2. Hard, bluish, impure limestone.....	2	6
1. Bluish concretionary and shaly limestone.....	1	6
Total .....	17	

This section is equivalent to numbers 99-103 of the Clarinda drill record. While the Braddyville section does not cover the whole interval between the Forbes limestone and the Nodaway coal, which at Clarinda is forty-two feet, at College Springs forty-five and one-half feet, and at Coin fifty-three feet, it is thought this series of limestones and shales should be raised to the rank of a formation. A complete exposure of these limestones and shales outcrops at Lake Wabonsie in Fremont county, but the term Wabonsie is preoccupied by the Wabaunsee of the Kansas geologists. It is therefore proposed that the limestones and shales between the Forbes limestone and the Nodaway coal be known by the name often used in the past, the Braddyville limestones.

The strata at Braddyville are at the crest of an anticline that has an amplitude of about twenty-five feet and cuts out the Nodaway coal at that place. The dip south into the state of Missouri is quite rapid and brings in the Nodaway coal within two miles of the state line. To the north the dip is but little more than the slope of the Nodaway river in the opposite direction so that the Nodaway coal appears low in the bank of the river at Shambaugh five miles north. The direction of this anticline is east of north and follows the course of the East Nodaway river. Exposures of the Braddyville limestone are found one mile north of Hawleyville and at Henshaw, where a dip of thirty-five feet in a quarter of a mile brings in the Nodaway coal at the same level as the limestone. This anticline is often spoken of as the Hawleyville anticline. Farther north in Adams county on the same stream the Nodaway coal is being mined northwest of the town of Nodaway. A short distance above this place the Braddyville limestone appears in the banks of the river and continues at intervals nearly to Corning above which place no outcrops are found on the East Nodaway river. At Shambaugh, five miles north of Braddyville, the Nodaway coal has been mined for many years. (Figure A, plate XX.)



A. Section, south to north from Braddyville to Fox quarry.



B. Section, south to north, Essex to Stennett.

One mile southeast of Clarinda in the east bank of the Nodaway river is an excellent exposure of the Nodaway coal which may be regarded as the type section of this coal.

NODAWAY COAL ONE MILE SOUTHEAST OF CLARINDA

	FEET.	INCHES.
10. Yellow weathered shale.....	4	
9. Black shale .....	1	
8. Yellow shale .....	1	3
7. Yellowish impure limestone in one or two layers...	2	
6. Black shale .....		6
5. Gray shale, calcareous, nonlaminated and non-jointed; fossiliferous .....	2	
4. Black shale .....		6
3. Coal .....	1	6
2. Drab shale, laminated .....	1	6
1. Gray shale, down to water's edge.....	8	
Total .....	22	3

At the south end of the exposure the black shale No. 4 wedges out and the gray shale No. 5 immediately overlies the coal. The gray, nonlaminated and nonjointed shale No. 5 is universally present in the roof shales of the Nodaway coal and by it and the contained fossils this coal horizon may be recognized with certainty. In Volume 2, "Coal Report," Iowa Geological Survey, this shale is classified as an impure limestone. It frequently has imbedded in it thin discontinuous layers and nodules of impure limestone that are called cement rock by the miners. The dip at Clarinda is on the west limb of the Hawleyville anticline and is very heavy to the west, amounting to sixty-five feet within two miles west of the Nodaway river.

Two miles west of Clarinda the coal is mined at the Johnston mine at the depth of 180 feet. Several mines are being actively worked in the vicinity of Clarinda and a large amount of coal is annually placed on the market. From Clarinda to Villisca no exposures of stratified rocks are known. No development of the Nodaway coal has been attempted in this distance, although the coal has been found two miles southwest of Hepburn at a depth of 130 feet. There has been an uprise of the strata in the vicinity of Villisca causing the Nodaway coal to be eroded at that place. A few feet of limestones and shales outcrop one

mile east of the town, not sufficient for exact correlation, but without doubt they are to be referred to the Braddyville limestones. Eight miles north of Villisca the Nodaway coal sets in high in the hills along the Middle Nodaway river and continues on both sides of the valley nearly to Mount Etna above which place no exposures are known on this river.

At Carbon and in its vicinity a large mining industry has been in existence for nearly fifty years and the different openings in the coal are nearly innumerable. In an early day the coal was mined by drifts driven in from the outcrop, but at the present time shafts only are used. The coal seam at Carbon being the Nodaway coal differs from the type section near Clarinda only in having a bottom rock of limestone five feet in thickness.

## NODAWAY COAL AT CARBON

	FEET.	INCHES.
7. Shales .....	20	
6. Limestone, cap rock.....	2	
5. Shale, black, bituminous.....		6
4. Shale, gray .....	1	6
3. Coal .....	1	6
2. Shale, gray .....	2	6
1. Limestone .....	5	
Total .....	33	

No exposures are known on the West Nodaway river above its mouth until Grant is reached, where there is an outcrop of limestone that in the opinion of Professor Calvin is the Forbes limestone. Less than one-half mile north of the northeast corner of Montgomery county is a better exposure of this limestone at the Fox quarry.

## FOX QUARRY

	FEET.	INCHES.
12. Broken limestone, shales and residual clay.....	2	
11. Greenish shale .....	4	
10. Limestone, light gray to buff, two ledges.....	3	6
9. Calcareous shale .....	1	
8. Limestone, gray to brown.....	7	
7. Calcareous shale .....		5
6. Limestone, brown .....	1	
5. Shale, gray above, in lower portion bituminous....	1	6
4. Limestone, dark gray.....		9

## CARBONIFEROUS SECTION OF SOUTHWESTERN IOWA

3. Shale, gray .....	1	4
2. Shale, lower part carbonaceous.....	2	6
1. Limestone .....		
Total .....	25	

Numbers 6-10 are the Forbes limestone, and numbers 1-5 are to be correlated with the Platte shales. Along the river for several miles above this place the same limestones are exposed at intervals.

One mile south of the Fox quarry on Williams branch the Nodaway coal was mined many years ago. Three miles east of the last named locality the coal is now being mined by shafts at Briscoe.

Several years ago parties at College Springs had core drilling done near that place in search of coal. Through the courtesy of the driller, Jesse Stump of Coin, the record of the drilling was secured.

RECORD OF CORE DRILLING SOUTHEAST OF COLLEGE SPRINGS. SOUTHEAST  
CORNER OF SEC. 17, AMITY TP., PAGE COUNTY, IOWA

		FEET.	INCHES.
Pleistocene, 60 feet.....	63. Soil .....	5	
	62. White sand .....	2	
	61. Yellow sand .....	4	
	60. Clay and gravel.....	4	
	59. Blue clay .....	25	6
	58. Yellow clay .....	2	
	57. Boulders and gravel.....	7	
	56. Yellow clay .....	5	
	55. Blue clay.....	5	6
City Bluffs beds, 47 feet...	54. Limestone .....		8
	53. Shale .....	7	8
	52. Limestone .....		5
	51. Shale .....	3	
	50. Limestone .....		4
	49. Shale .....	3	2
	48. Calcareous shale .....	1	8
	47. Shale .....		9
	46. Limestone .....	1	4
Nodaway coal.....	45. Shale .....	28	
	44. Coal and shale in streaks.....	1	3



## STRATIGRAPHY OF THE MISSOURI STAGE

629

		FEET.	INCHES.
Braddyville limestones, 45½ feet.....	43. Shale .....	6	
	42. Limestone .....	2	9
	41. Shale .....		10
	40. Limestone .....	2	6
	39. Black shale .....	2	
	38. Limestone .....	7	4
	37. Shale .....	1	9
	36. Limestone with shale partings....	3	1
	35. Shale .....	9	3
	34. Limestone .....	1	6
	33. Shale .....	4	1
	32. Shaly limestone .....	1	
	31. Shale .....	3	4
Forbes limestone, 9 feet 2 inches.....	30. Limestone and flint.....	2	8
	29. Limestone .....	6	6
Platte shales, 73½ feet....	28. Shale .....	2	6
	27. Limestone .....	2	6
	26. Black shale .....	1	4
	25. Blue shale .....	1	6
	24. Limestone .....	1	8
	23. Shale .....	1	
	22. Limestone .....	3	4
	21. Shale .....	3	
	20. Green shale .....	2	
	19. Limestone .....	2	8
	18. Green shale .....	3	
	17. Limestone with shale partings....	3	6
	16. Green shale .....	3	
	15. Gray shale .....	37	4
	14. Limestone with shale partings....	4	4
Plattsmouth limestone, 26½ feet.....	13. Shale .....	1	
	12. Limestone .....	4	2
	11. Black shale .....		5
	10. Limestone .....	1	
	9. Black shale .....	4	3
	8. Limestone .....	4	7
	7. Black shale .....	1	4
	6. Blue limestone .....	4	2
	5. Shale .....		6
	4. Limestone .....	1	4
	3. Shale .....		8
	2. Limestone with shale partings....	2	9
	1. Brown shale .....	1	3
Total .....		260	

According to the record the limestone cap rock over the Nodaway coal is absent, which is unusual for this coal. Samples of the core from immediately above the coal prove it to be the gray calcareous non-laminated shale invariably found in the roof shales of the Nodaway coal. In this shale core were noted *Aviculopecten* and *Euomphalus rugosus*, usual fossils of this horizon. The bottom of the drilling evidently reaches into the Plattsmouth limestones.

## TARKIO RIVER DRAINAGE.

A short distance north of the Chicago, Burlington and Quincy railroad bridge over Tarkio creek at Coin the Tarkio limestones are exposed on the east side of the creek well above the water level in the stream. The outcrop is much weathered and is obscured by landslides so that the succession of the strata cannot be well made out at this place. On the creek one-fourth mile above this outcrop a core drilling was done by the Black Diamond Coal Co. of Coin. In the record the terminology of the driller is unchanged.

DRILL HOLE ONE MILE NORTHEAST OF COIN, ONE-FOURTH MILE UP THE CREEK ABOVE THE PALMER EXPOSURE OF TARKIO LIMESTONE

	FEET.	INCHES.
24. Clay .....	9	
23. Boulder .....	1	
22. Light shale .....	16	8
21. Gray shale .....	11	4
20. Gray limestone, impure, shaly.....	9	6
19. Gray shale .....	32	2
18. Limestone, impure, shaly.....	6	
17. Calcareous shale .....	2	
16. Light shale .....	3	8
15. Black shale .....	2	
14. Coal .....		6
13. Light shale .....	3	
12. Black shale .....	2	8
11. Gray limestone, impure, shaly.....	3	4
10. Gray shale .....	8	
9. Limestone, impure, shaly.....	2	
8. Green shale .....	16	9
7. Gray shale .....	37	3
6. Gray limestone .....	1	2
5. Gray shale .....	44	3
4. Cap rock, limestone .....	4	10
3. Black shale .....	4	
2. Coal .....		18
1. Light shale .....		10
Total .....	223	5

At the time of the survey of Page county by Professor Calvin it was impossible to make the connection between the Nodaway coal and the Tarkio limestones, but the putting down of core drill holes and the sinking of shafts attending the development

of the Nodaway coal at Coin renders it possible to fill the interval and complete the section. Number 22 in the drilling lies immediately below the lowest layer of the Tarkio limestones seen on the creek only a short distance away. The thick bed of shale that occupies the interval between the Nodaway coal and the Tarkio limestones reaches a thickness of 212 feet. This great body of shale, well known to the miners of southwestern Iowa as the "Big shale," should be raised to the rank of a formation and given a geographic name. Broadhead repeatedly speaks of the City Bluffs beds and gives a section of nearly one hundred feet of these shales near Burlington Junction, Missouri. Therefore it is proposed that the shale formation between the bottom shale of the Nodaway coal and the lowest layer of the Tarkio limestones be known by the old name of Broadhead's, the City Bluffs shale. It is evident that the Nodaway coal should be included in the overlying shales rather than in the Braddyville limestones. Two miles north of this locality a coal eight inches thick has been stripped low in the banks of the creek. This coal can be no other than number 14 in the drill record. It is also without doubt the same coal seam found in the Larrabee drilling northeast of Norwich. On a small creek just south of Coin a deep core drilling was carried to the depth of 450 feet in consequence of a rumor that a thick coal seam was to be found 150 feet below the Nodaway coal. The record is given below and correlated with the general section.

## CORE DRILLING IN SOUTH PART OF COIN

		FEET.	INCHES.
Pleistocene, 32½ feet.....	51. Surface clay .....	32	6
	50. Gray shale .....	3	6
	49. Yellow shale .....	2	
	48. Gray shale .....	14	8
	47. Yellow shale .....	11	9
	46. Gray shale .....	28	4
	45. Gray limestone .....	5	2
	44. Light shale .....	5	6
City Bluffs shales, 200 feet .....	43. Gray shale .....	1	6
	42. Black shale .....	7	2
	41. Light shale .....	29	5
	40. Soft gray shale.....	8	4
	39. Limestone .....		10
	38. Gray shale .....	76	3
	37. Gray limestone, cap rock.....	1	9
	36. Gray shale .....	4	1
	35. Coal .....		20

		FEET.	INCHES.
	34. Gray shale .....	10	8
	33. Gray limestone .....	7	5
	32. Black shale.....	2	
	31. Limestone .....	1	2
	30. Calcareous shale .....		6
	29. Limestone .....		6
Braddyville limestones,	28. Calcareous shale .....		10
53 feet.....	27. Soft limestone, shaly.....	4	6
	26. Light shale .....	4	
	25. Soft limestone, shaly.....	5	10
	24. Gray shale .....	10	4
	23. Limestone .....	1	4
	22. Light gray shale.....	4	
Forbes limestones, 13½			
feet .....	21. Limestone .....	13	5
	20. Black shale .....	5	2
	19. Limestone .....	3	4
	18. Gray shale .....	3	
	17. Light shale .....	13	2
	16. Limestone .....	4	1
	15. Gray shale .....	26	10
Platte shales, 84½ feet....	14. Gray limestone .....	12	6
	13. White limestone .....	6	11
	12. Black shale .....		4
	11. Gray shale .....	1	6
	10. White limestone .....	1	5
	9. Black shale .....	2	8
	8. Blue-black shale .....	3	6
Plattsmouth limestones,	7. Limestone .....	12	11
38 feet.....	6. Calcareous shale .....	4	6
	5. Gray shale .....	10	7
	4. Limestone .....	9	11
Andrew shales, 27½ feet...	3. Gray shale .....	22	2
	2. Black shale .....	4	4
	1. Limestone .....	1	
	Total .....	450	7

Since the discovery of coal at Coin several years ago a couple of shafts have been sunk and an important local trade supplied. The shafts are 230 feet deep and the coal is of much better thickness and quality than at its nearest outcrop at Shambaugh ten miles east.

During the past summer a new air shaft has been sunk at one of the mines and the excavated material from the shaft affords an excellent opportunity for the study of the paleontology of the City Bluffs shale. In the shales above the cap rock of the coal the most conspicuous feature is the great profusion of Bryozoa in the more calcareous shales. *Rhombopora lepidodendroides*, and the fan bryozoa *Septopora biserialis*, and *Polypora*

*crassa*, are especially numerous. *Aviculopectens* are frequent throughout the whole thickness of the shales. Among the other fossils noted were *Productus semireticulatus*, *P. cora*, *P. costatus*, *P. nebrascensis*, *Chonetes granulifera*, *Athyris subtilita*, *Ambocelia planoconvexa*, *Derbya crassa*, *Spiriferina kentuckiensis*, *Enteletes hemiplicata*, *Dielasma bovidens*, *Allorisma subcuneatum*, *Nucula ventricosa*, *Pleurotomaria perhumerosa*, *P. tabulata*, *Bellerophon carbonarius*, *B. nodocarinatus*, *B. percarinatus*, *B. montfortianus*, *Euomphalus rugosus*, *Soleniscus brevis*, *Lophophyllum proliferum*, *Fistulipora nodulifera* and a small trilobite. The roof and bottom shales of the coal contain great numbers of plant remains, stems and leaves being abundant. Among the plants seen were *Neuropteris*, very common, *Calamites*, common and *Pecopteris*. In the roof shales were found *Derbya crassa*, *Ambocelia planoconvexa*, *Allorisma subcuneatum*, *Aviculopectens* and a *Pinna*, *Bellerophon carbonarius* and *Euomphalus rugosus*. In the Tarkio limestones at the old Palmer quarry were found *Productus semireticulatus*, *P. cora*, *P. pertenuis*, *P. longispinus*, *Athyris subtilita*, *Enteletes hemiplicata*, *Chonetes glabra*, *Derbya crassa*, *Myalina subquadrata*, *M. swallowi*, *M. perattenuata*, *Naticopsis altonensis*. The gray shales above the cap rock of the coal contain a great number of large septaria. One bed six feet thick was passed through in sinking the shafts at Coin. Probably some of the limestone layers in the drill records are of this character. The soft impure limestones are calcareous shales as is well shown in the outcrops of this shale bed. It will be noted that no sandstones are found in the City Bluffs shale at Coin.

## NODAWAY COAL AT COIN

	FEET.	INCHES.
Limestone, cap rock, very hard, pinkish and crystalline	1	6
Shale, yellow .....	1	
Shale, gray, nonlaminated.....	2	6
Shale, black, bituminous, laminated.....		8
Coal .....		20
Shale, gray .....	10	
<hr/>		<hr/>
Total .....	17	4

Deep drilling south of Coin shows a rise of strata and the Tarkio limestones are absent in that direction. North of Coin

the strata rise and the Tarkio limestones are frequently exposed in the hillsides of the creek.

Two miles northeast of Norwich many quarries in the limestones have been worked in past years. The following composite section by Professor Calvin of the different exposures in this vicinity may be taken as the type section of the Tarkio limestones.

## TARKIO LIMESTONES NORTHEAST OF NORWICH

	FEET.	INCHES.
8. Fusulina limestone .....	1	
7. Shale .....	3 to 5	
6. Limestone, soft .....		8
5. Limestone, blue, hard and fine-grained.....	1	4
4. Shale .....	12	
3. Limestone, soft .....	1	6
2. Shale .....	3	6
1. Limestone, soft .....	2	
Total .....	27	

The following fossils have been noted in the Tarkio limestones northeast of Norwich: *Fusulina cylindrica*, *Rhombopora lepidodendroides*, *Productus semireticulatus*, *P. cora*, *Enteleles hemiplicata*, *Chonetes granulifera*, *Athyris subtilita*, *Allorisma subcuneatum*, *Myalina subquadrata*, and a *Pleurotomaria*. The two lower soft impure limestones are not constant, as they often pass into a very calcareous shale. The layers do not wedge out but gradually grade into a shale. In this vicinity an upper thin coal seam has been worked by stripping, but its relation to the underlying limestone is not well shown. Two miles southeast of Nyman at the old Linquist mine both coal and limestone are well exposed in the same hillside.

## COAL AT LINQUIST MINE

	FEET.	INCHES.
8. Limestone, cap rock .....	3	
7. Coal .....		10 to 15
6. Shale .....	30	
5. Fusulina limestone .....	1	
4. Shale .....	3	
3. Limestone, soft .....		8
2. Limestone, blue .....		16
1. Shale .....	6	
Total .....	46	

In the cap rock, No. 8, *Spirifer cameratus* is abundant. The previous reports of the Iowa Geological Survey have named the coal, No. 7, the Linquist coal. This coal, the highest in the Carboniferous of Iowa, should be given a geographic name. In this locality the coal is generally known as the Nyman coal, which is believed to be the most appropriate name for it.

The extent of the Nyman coal on Tarkio creek is from east of Norwich thence north twelve miles to a short distance into Montgomery county. The Tarkio limestones are exposed at frequent intervals in the valley of Tarkio creek until within two miles of Stanton where they disappear high in the hillsides.

#### NISHNABOTNA RIVER DRAINAGE

No exposures of stratified rocks are known on the East Nishnabotna river above its mouth until the vicinity of Essex is reached. Two miles southeast of this place on Rocky branch is an excellent exposure of the Tarkio limestones. (Figure B, plate XX.)

#### TARKIO LIMESTONES NEAR ESSEX

	FEET.	INCHES.
7. Fusulina limestone .....	1	
6. Shale .....	3	
5. Limestone, soft .....		8
4. Shale .....		6
3. Limestone, blue .....	1	4
2. Shale, calcareous .....	7	
1. Limestone, shaly, soft, impure.....	1	6
Total .....	15	

The dip at this place is very heavy to the west.

Two miles north of Essex, in the hills on the west side of the East Nishnabotna river, the Tarkio limestones have been quarried on an extensive scale years ago. The face of the old quarry extends for upwards of one-half mile. At the present time the outcrop is much obscured and no detailed section can be given. From this last locality north to the northern boundary of Page county several outcrops of the limestone are to be found in the hills on the west side of the river. One mile south of the north county line at Franklin Grove the Nyman coal has been discovered in digging wells. The coal, however, is less than six inches in thickness.

From Coburg to Stennett the Carboniferous is deeply covered by the Cretaceous, which in places reaches a thickness of nearly one hundred feet. Carboniferous strata consisting of only single layers of limestone a foot or two thick, insufficient for correlation, are found at Coburg and one mile south of Red Oak.

The Forbes limestone and the basal portion of the Braddyville limestones with a few feet of the Platte shales are well exposed on both sides of the East Nishnabotna river at Stennett.

## LIMESTONES AND SHALES AT STENNETT

	FEET.	INCHES.
13. Limestone, residual .....	5	6
12. Shale, calcareous .....		6
11. Limestone, gray, fine-textured.....	1	8
10. Shale, buff to gray, argillaceous.....	3	6
9. Limestone, variable, earthy below.....	5	
8. Shale, buff .....	1	
7. Limestone, blue above, cherty.....	6	
6. Shale parting .....		2
5. Limestone, variable .....	5	
4. Shale, argillaceous .....	1	6
3. Shale, black, bituminous.....	3	
2. Limestone, shaly .....	2	
1. Limestone .....	3	
Total .....	37	10

Numbers 1-4 belong with the Platte shales, numbers 5-9 are the Forbes limestones; above No. 9 is the lower part of the Braddyville limestones. A drift has been driven in the black shale No. 3 in search of coal, but without results. The different outcrops near Stennett for a distance of two miles have a heavy dip to the north. The line of disturbance if extended in a direction north of east through Jones Point on the Missouri river in Nebraska and south of the Wilson section at Lake Wabonsie in Fremont county would pass a short distance south of Stennett. The fault near Lake Wabonsie has, probably, in its eastward extension, become an anticline and the dip to the north at Stennett would indicate that the line of disturbance lies not far to the south of this place. The following fossils have been noted in the limestones at Stennett: *Fusulina cylindrica* in great profusion, *Fenestella*, plates and spines of *Archæocidaris*, *Spirifer cameratus*, *Meekella striatocostata*, *Orthis pecosi*, *Chonetes ver-*



*newiliana*, *C. granulifera*, *Athyris subtilita*, *Productus semireticulatus*, *P. cora*, *P. costatus*, *Derbya crassa*, *Enteleles hemipliata*, *Reticularia perplexa*, *Allorisma subcuneatum*, *Chaenomya minnehaha*, *Macrodon tenuistriatus*, *Bellerophon carbonarius*, *B. percarinatus* and a *Pleurotomaria*.

No exposures of the Carboniferous are known on either Walnut creek or the West Nishnabotna river in Fremont county. The eastern half of this county is probably underlain immediately below heavy deposits of the Pleistocene by the City Bluffs shale, which being composed of soft and easily eroded material does not show in outcrops.

In the southwest corner of Montgomery county on Walnut creek at Climax is an exposure of limestones and shales much obscured at the present time. The following section is from Lonsdale.

## LIMESTONES AND SHALES AT CLIMAX

	FEET.	INCHES.
6. Limestone, hard, drab, fine-textured.....	1	
5. Limestone and shale, marly.....	3	
4. Shale, argillaceous, gray.....	2	
3. Limestone, bluish, dull, earthy.....	1	
2. Shale, argillaceous, gray.....	1	
1. Limestone, blue, hard, dimension stone.....	1	6
Total .....	9	6

These limestones and shales can be referred to the Tarkio limestones, as they are in the line of strike of that formation and are only four miles distant from the exposures of these limestones on the East Nishnabotna river north of Essex. On Walnut creek five miles southwest of Stennett and in a line with the exposures at Grant, Stennett, and the Wilson section is an exposure of a nine-foot ledge of a very cherty limestone that without doubt is to be referred to the Forbes limestone. One mile south of Malvern on Silver creek the Forbes limestone is found as shown by the following section from Udden.

## FORBES LIMESTONE ONE MILE SOUTH OF MALVERN

	FEET.	INCHES.
6. Shale, marly .....		6
5. Limestone, grayish yellow, cherty.....	6	
4. Limestone, grayish blue, compact.....		9
3. Talus slope .....	2	
2. Limestone, yellow, fragmental.....	2	
1. Limestone, below water level of creek.....	3	
Total .....	14	3

This outcrop is now much obscured, only number 5 being visible. Udden correctly correlates these limestones with the lower main limestone at the Wilson section.

Two miles south of Riverton on Mill creek is a critical exposure, as it is thought to be at the very summit of the Carboniferous in Iowa.

## McKISSICKS GROVE SHALES ON MILL CREEK

	FEET.
6. Shale, weathered, gray.....	10
5. Limestone in five layers with shale partings. The upper layer, six inches thick, is a white and very hard limestone composed of fragments of shells and crinoid plates arranged in a horizontal position. The two lower layers, ten and four inches in thickness, are very dark, almost black limestones. They contain numerous round lumps of calcareous matter one-fourth inch in diameter.....	3
4. Shale, calcareous, weathered yellow.....	3
3. Shale, blue, contains several thin bands of sandstone; not well exposed .....	9
2. Sandstone, blue, indurated, micaceous.....	2
1. Shale, blue .....	8
Total .....	35

Parties long resident in this vicinity report a seam of coal twenty feet below the sandstone. The following fossils were found in the limestone: *Fusulina cylindrica*, *Productus cora*, *Spirifer cameratus*, *Chonetes granulifera*, *C. glabra*, *Aviculopecten providencensis*, *Myalina swallovi* and *Bellerophon marcouanus*.

On a small creek in McKissicks Grove two miles northeast of Hamburg and about the same distance north of the south boundary of the state is one of the most extensive and important

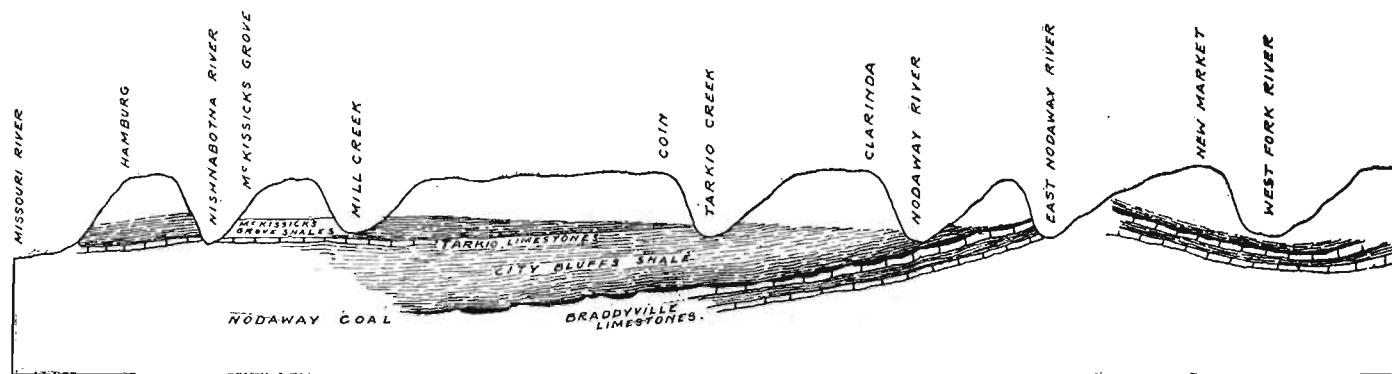
exposures in southwestern Iowa, showing the succession of strata above the Tarkio limestones to the last of the Carboniferous in Iowa. The different outcrops are seen on following the creek from the lower bridge on the bottom land to the forks of the creek and then up the north branch of the creek. The cap rock of the coal is also exposed under an old bridge on the south branch of the creek.

## LIMESTONES AND SHALES AT MCKISSICKS GROVE

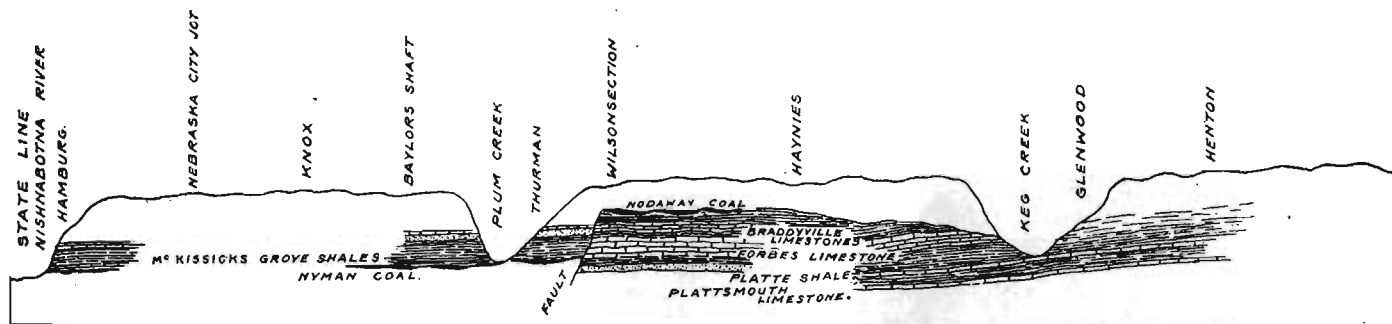
	FEET.	INCHES.
17. Shale, gray .....	7	
16. Limestone, weathered .....	1	
15. Limestone, very dark, containing nodules about one-half inch in diameter.....	1	
14. Shale, blue, sandy and micaceous, with several thin bands of sandstone.....	7	
13. Sandstone, micaceous, blue weathering to yellow...	3	
12. Shale, gray .....	15	
11. Limestone, compact, gray, with many specimens of <i>Productus semireticulatus</i> .....	1	
10. Limestone, impure .....	1	
9. Coal .....		9
8. Shale .....	20	
7. Limestone .....		6
6. Shale, dark .....	3	6
5. Limestone .....		6
4. Shale, blue, weathering to yellow.....	8	
3. Limestone in two or three heavy ledges crowded with very large specimens of <i>Fusulina cylindrica</i> , no other fossils recognized.....	4	
2. Shale with occasional individuals of <i>Productus</i> <i>semireticulatus</i> .....	12	
1. Limestone, dark gray .....	1	
Total .....	86	3

Numbers 1-7 represent the Tarkio limestone, No. 9 is the Nyman coal and the upper part of the section is equivalent to the Mill creek section.

McKissicks Grove is a locality well known in southwestern Iowa and northwestern Missouri and has had much of historical interest in the early settlement of the country and during the civil war. The term Atchison could well be applied to the strata above the Tarkio limestones, but Broadhead's Atchison county group extends eighty feet below these limestones. Besides,



A. Section, west to east, from Hamburg to West Fork river.



B. Section, south to north, along the Missouri river bluffs.

Keyes has used the name Atchison to include all of the Missouri above the Forbes limestone to the Cottonwood limestone. The term McKissicks Grove shales can well be applied to the beds of the Missouri above the Tarkio limestones to the close of the Carboniferous as found in Iowa.

## SANDSTONE AND SHALE ON SCHOOL GROUNDS AT HAMBURG

	FEET.
2. Sandstone .....	3
1. Shale, divided near the middle by a hard band three inches thick .....	20
Total .....	23

The sandstone does not resemble the sandstone at McKissicks Grove, as it is of much coarser grain and contains but little mica. The underlying shale carries nodules of pyrite and many broken fragments of *Aviculopectens*, and has the appearance of some portions of the City Bluffs shale.

Nearly twenty years ago a core drilling one thousand feet deep was done a short distance north of Hamburg on the west side of the Nishnabotna river. The core has been lost and no record of the drilling has been preserved, but parties who were interested in the drilling state that the superficial deposits were seventy feet deep, and at ninety feet a seam of coal one foot thick was found. Udden gives the elevation of the surface where the drilling began at 998 feet A. T. The elevation of the base of the shales at the school grounds is approximately 935 feet, and the dip at this point, being strong to the north, would bring the shale down on the coal. The sandstone and shale at Hamburg can be correlated with the sandstone and shale at McKissicks Grove. According to the best information no other coal seams were found in this drilling.

## MISSOURI RIVER BLUFFS.

Broadhead's Atchison county group will be given and correlated with the section found in Iowa. It will be noted Broadhead numbers the section from above downwards.

	FEET.	INCHES.
1. Bluff .....	250	
2. Drift, thickness unknown beneath the bluff.....		
3. Red shales .....	5	
4. Sandstone and shales. Sandstone at top, upper three feet irregularly bedded and micaceous, green; below eight or ten feet, soft, brown; then thirty-five feet of shales and sandstone; red shales in upper part, thick bedded shales at bottom....	47	
5. Drab limestone, weathers brown.....		10
6. Shaly limestone, contains fossils.....	3	2
7. Blue concretionary limestone traversed by calc-spar veins .....	1	4
8. Sandy shales or dark brown clay.....		2
9. Impure coal and shales.....		2
10. Ochery sandy shale.....		
11. Sandy shales .....	22	
12. Dark blue shaly limestone.....	1	6
13. Red and green shales with nodules of limestone....	1	6
14. Limestone, upper part nodular, weathers brown, abounds in Fusulina .....	4	
15. Blue and drab argillaceous shale.....	28	
16. Bluish drab limestone.....	2	
17. Blue fossiliferous shale.....		10
18. Hard sandstone .....	2	6
19. Soft sandstone .....	3	
20. Calcareous sandstone .....		10
21. Blue argillaceous shale, 6 to 13 feet.....	6	
22. Fine-grained blue limestone.....	1	
23. Shale .....	1	3
24. Buff ochery decomposing limestone.....		10
25. Buff and olive shale.....	2	
26. Red shale .....	2	
27. Clay and sandy shales.....	30	
28. Shaly limestone .....		
Total .....	417	

Below No. 14, which is the base of the Tarkio limestone, the section has a thickness of eighty feet. This added to one hundred and twenty-five feet of City Bluffs shale, exposed near Burlington Junction, gives a thickness of two hundred and five feet, about the normal thickness of this shale formation.

In this section Broadhead gives fifty feet of sandstones and shales above the Nyman coal No. 9 without any limestones corresponding to numbers 15 and 16 of the McKissicks Grove section. He gives a section at Halls bridge on the Nishnabotna

river only a few miles south of the Iowa state line showing two limestones that are equivalent to these limestones.

## SECTION AT HALLS BRIDGE, MISSOURI.

	FEET.
1. Bluff .....	
2. Hard silico-ferruginous limestone, weathers brown.....	1
3. Sandstone, greenish drab, fine grained, slightly micaceous..	3
4. Coarse grained, brown and green silico-micaceous limestone	1
5. Soft brown and buff sandstone.....	4
6. Shales, the upper half sandy, the lower argillaceous.....	16
7. Shales with nodules of brown and ferruginous limestone.	
No. 7 of general section.....	2
Total .....	27

Broadhead also gives a section in the Missouri river bluffs at the state line:

	FEET.	INCHES.
1. Ochery and blue banded clay shales in thin laminae. No. 5 of general section.....	2	
2. Dark limestone, weathers brown.....		10
3. Shaly limestone .....	2	
4. Dark brown clay .....		2
5. Coal .....		3
6. Ochery sandy shales. No. 10 of general section....	2	
7. Ochery and blue sandy shales.....	17	
Total .....	24	3

In the Missouri river bluffs north of Hamburg but few outcrops of stratified rocks are seen until within a couple of miles of Thurman. Three miles east of Nebraska City Junction is an exposure of sandstone above a few feet of shale, and a short distance south of Knox on a small stream that comes down out of the bluffs at this place is an outcrop of a three-foot ledge of limestone underlain by a sandstone that is not well exposed. Commencing two miles south of Thurman and extending north to the Mills county line is a series of exposures, the most important in southwestern Iowa, and one that affords a solution of the seeming inconsistencies found in the structure of the Carboniferous in this part of the state. Udden gives a composite section of the different exposures found two miles south of Thurman.

## SECTION IN THE BLUFFS TWO MILES SOUTH OF THURMAN

	FEET.
6. Bluish gray sandstone of fine texture.....	1½
5. Gray shale .....	10
4. Dark gray limestone cut by straight and vertical joints into large blocks and containing numerous spheroidal cal- careous lumps about one-fourth inch in diameter.....	3
3. Soft bluish gray shale.....	2
2. Grayish blue sandstone of fine texture, in straight layers below and ripple marked above.....	3
1. Shale .....	
Total .....	18½

This section in the opinion of Professor Calvin is at the very close of the Carboniferous in Iowa, nothing similar to it being found in the Missouri in the rest of the state. All the other strata of the Missouri in Iowa were deposited under deep sea conditions, while these are shore deposits, unfossiliferous, ripple marked. The limestone is composed of an aggregation of rounded nodules of calcareous matter, which indicates a shallowing of the Carboniferous sea together with the prevalence of beach conditions. The limestone is similar in structure to the upper limestone at McKissicks Grove in containing nodules of calcareous matter, and they, without doubt, are equivalent to each other. The limestone and sandstone in this section are exposed at intervals along the bluff road to within a half mile of Thurman. One-fourth mile east of the town on Plum creek is an exposure which shows:

	FEET.
4. Shale, thickness undetermined, the slope above being sodded over .....	
3. Impure limestone, broken into blocks.....	½
2. Carbonaceous streak .....	
1. Shale .....	10
Total .....	10½

At this place all the beds are dipping strongly to the north-west. On the slope above the exposure are loose blocks of sandstone from some higher ledges. These beds belong immediately below the limestone and sandstone found on the bluff road less than one-half mile away. It is believed the limestone and sand-



stone south of Thurman belong to the close of the Carboniferous in Iowa, and are equivalent to the exposure on Mill creek, and the upper part of the McKissicks Grove section. In addition there is the further evidence of the finding of a coal seam fourteen inches thick in a shaft sunk on the farm of R. Baylor. The coal is about twenty feet below the outcrop near by and ten feet below the bluff road.

## SHAFT ON BAYLOR FARM TWO MILES SOUTH OF THURMAN

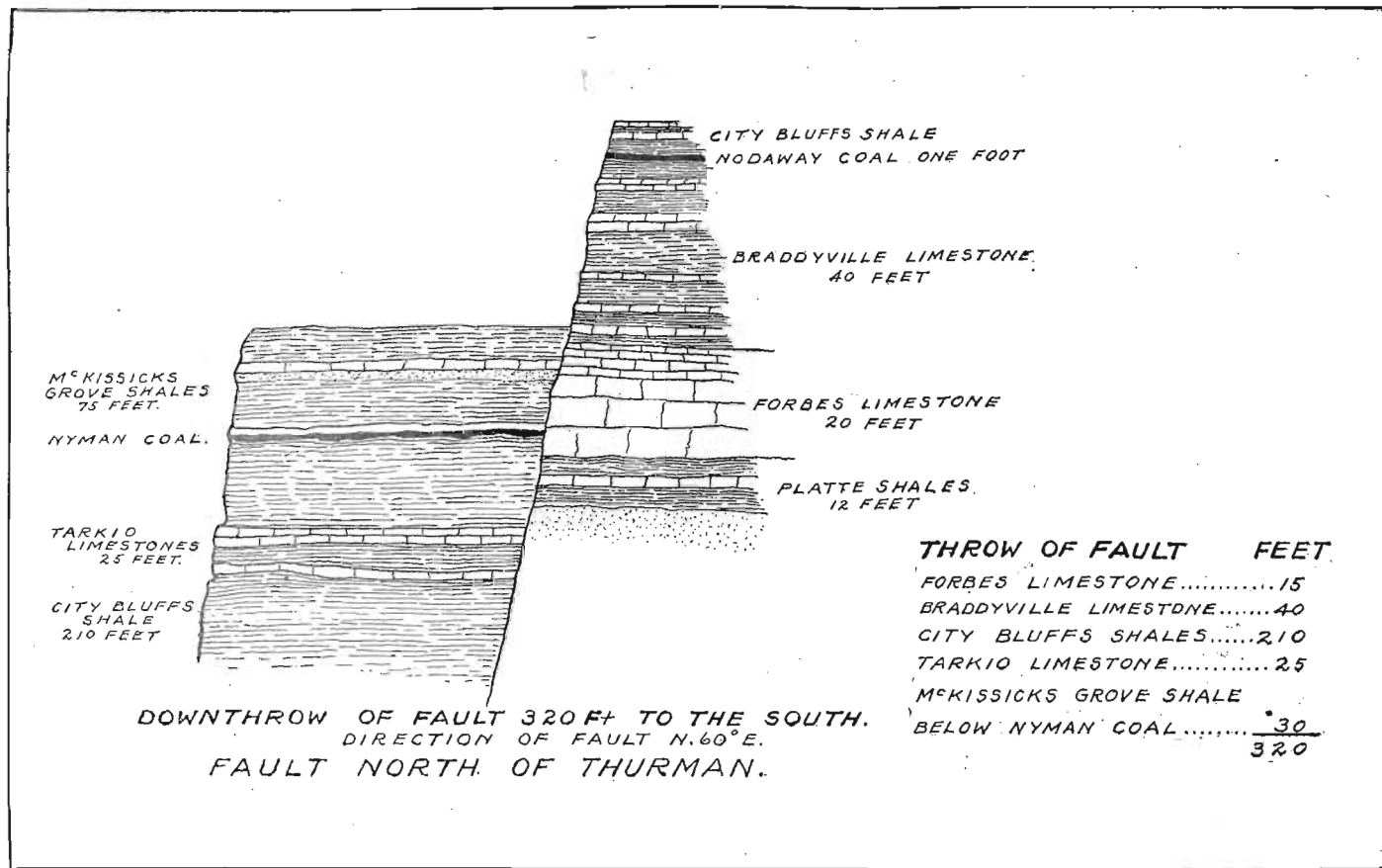
	FEET.	INCHES.
7. Surface material .....		
6. Blue limestone .....	3	
5. Sandstone .....	5	
4. Shale .....	20	
3. Limestone, cap rock.....		6
2. Coal .....		14
1. Shale and sandstone.....		
Total .....	29	8

West of the bluff road a point well was driven eighty feet deep without encountering rock of any kind.

This coal is without doubt the Nyman coal and the correlation becomes very positive. In the exposure near Thurman on Plum creek the coal is represented by the carbonaceous streak under the limestone.

Along the foot of the bluffs north of Thurman before reaching the Wilson section of White are two old quarries about one-half mile distant from each other. At the present time both are so covered by wash from the bluff above that not a single undisturbed layer can be seen. In the quarry farther north the rubbish shows slabs of a rough irregularly bedded blue limestone containing many specimens of *Productus cora*.

The following fossils have been observed in the McKissicks Grove shales at McKissicks Grove and Thurman: *Fusulina cylindrica*, *Rhombopora lepidodendroides*, *Fenestella*, plates and stems of crinoids, *Productus cora*, *P. longispinus*, *P. semireticulatus*, *Chonetes granulifera*, *C. glabra*, *Athyris subtilita*, *Pugnax uta*, *Hustedia mormoni*, *Allorisma subcuneatum*, *Edmondia nebrascensis*, *Myalina swallowi*, *Aviculopectens* and *Bellerophon carbonarius*.



On the bluff road two miles north of Thurman is the Wilson section of White where a situation is met which is unparalleled by any similar condition to be found in the state of Iowa. A displacement in the strata has taken place between this point and Thurman with the uplift to the north of an amount of at least 300 feet. White and Udden have both given sections of the Wilson exposure, but the base of the outcrop at present is covered by talus, and as White's section includes several numbers that now are not visible it will be used.

## WILSON SECTION OF WHITE

	FEET.	INCHES.
29. Yellowish gray, impure limestone in thin layers....	2	
28. Limestone in two layers with a three inch parting..	2	6
27. Yellowish shaly marl.....	1	3
26. Black carbonaceous shale .....	1	9
25. Bluish clayey shale .....	1	3
24. Black carbonaceous shale.....	1	
23. Bluish marly shale with numerous fossils.....	1	6
22. Coal .....		10
21. Light bluish, fossiliferous, shaly clay.....	2	
20. Compact bluish limestone, with shaly partings.....	4	
19. Marly clay with calcareous concretions.....	6	
18. Light gray limestone .....	4	
17. Light yellowish, indurated marl.....	6	
16. Compact limestone .....	1	6
15. Light yellowish, indurated marl.....	4	
14. Yellowish siliceous limestone with flinty concretions	2	6
13. Yellowish marly shale with concretions of impure limestone .....	3	
12. Compact limestone .....	1	
11. Yellowish marly shale.....	2	
10. Gray limestone in thick layers.....	3	
9. Bluish clayey shale .....		6
8. Yellowish siliceous limestone.....	1	6
7. Compact gray limestone with marly partings.....	16	
6. Bluish shaly clay .....	2	6
5. Compact layer of limestone.....		9
4. Bluish shaly clay .....	2	6
3. Compact bluish limestone.....	2	
2. Bluish clayey shale.....	4	
1. Fine grained, micaceous sandstone.....	1	
Total .....	81	10

Numbers 1-6 belong with the Platte shale; numbers 7-10 are the Forbes limestone; numbers 11-21 are equivalent to the Braddyville limestones and the coal No. 22 is the Nodaway coal.

One mile north of the Wilson section on Indian creek a drift has been driven in on the coal in hopes that it might prove workable, but the enterprise has been abandoned.

#### NODAWAY COAL IN INDIAN CREEK

	FEET.	INCHES.
10. Black laminated shale .....	1	
9. Yellow limestone .....		8
8. Gray shale .....		8
7. Yellow limestone .....	1	6
6. Yellow shale .....	1	
5. Black shale .....	2	
4. Gray nonlaminated, nonjointed shale.....	1	4
3. Black shale .....	1	
2. Gray shale, similar to No. 4.....	1	6
1. Coal .....	1	
Total .....	11	8

The dull gray nonlaminated shale invariably found in the roof shales of the Nodaway coal is here divided by the black shale No. 3, and according to Professor Calvin bears the same fossils that are found in the shales over that coal. The correlation of White is accepted and no doubt is entertained that the coal in the Wilson section is identical with the Nodaway coal.

To Todd is due the credit of calling attention to the deformation of the Carboniferous strata that takes place between the Wilson section and Thurman, and causes the Forbes limestone at the Wilson section and the limestone and sandstone in the upper part of the McKissicks Grove shales at Thurman, to appear at the same elevation above the bottom lands of the Missouri river. The strata in the vicinity of Thurman as far north as Plum creek all have a slight dip to the north. As far as can be seen there is no disturbance or heavy dip of strata in the abandoned and wash covered quarries between Thurman and the Wilson section, which leads to the conclusion that the displacement of strata of about 300 feet with the uplift to the north takes place just south of the Wilson section and is due to a fault of

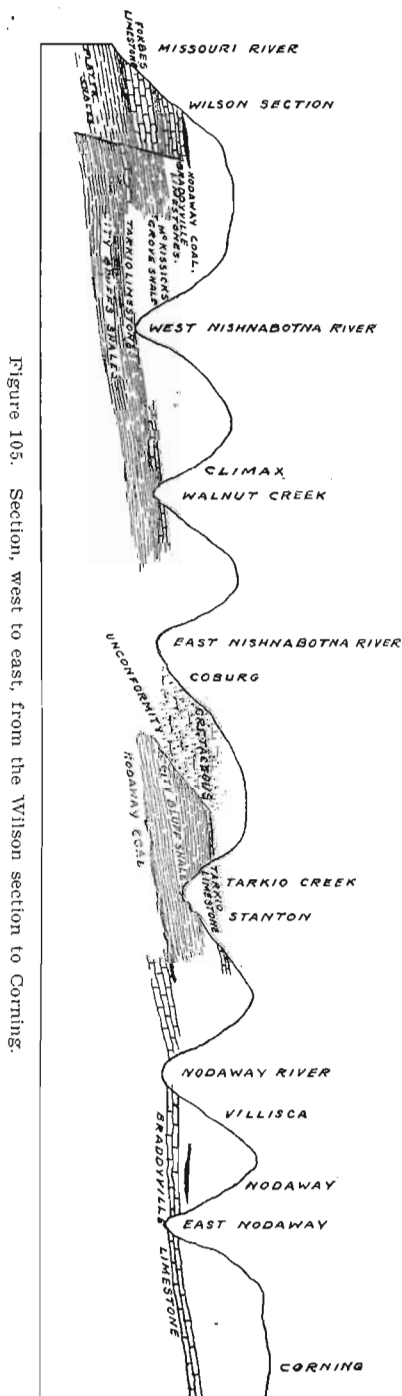


Figure 105. Section, west to east, from the Wilson section to Corning.

that amount with downthrow to the south. According to Todd, at Jones Point on the west side of the Missouri river in Nebraska, seven miles southwest of and in plain view of the Wilson section, is found a very heavy dip to the south of the Carboniferous series in which over 100 feet of strata disappear beneath the Missouri river in less than one mile. A continuation of the line of displacement from Jones Point to the Wilson section would pass south of the exposures of the Forbes limestone at Malvern, Stennett and Grant, and would thus give an explanation of the appearance of the limestone at those places.

To the north of Wabonsie creek the lower limestones of the Wilson section are exposed at frequent intervals in the foot of the bluffs to the old abandoned quarries east of Haynies.

Udden's Section No. 4 may be correlated with the lower part of the Wilson section as given by White. At both localities these strata represent the upper members of the Platte shales.

## CARBONIFEROUS SECTION OF SOUTHWESTERN IOWA

## PLATTE SHALES ONE MILE SOUTHEAST OF HAYNIES

	FEET.	INCHES.
7. Bluish gray shale .....	2	
6. Dark limestone .....		3
5. Blue shale .....		6
4. Blue limestone .....	1	6
3. Arenaceous and micaceous silt, yellow above and bluish green below .....	6	
2. Greenish or bluish gray limestone.....	2	
1. Yellow shale .....	3	
Total .....	15	3

The sandstone No. 1 of the Wilson section is equivalent to No. 3 of the above.

On Keg creek near Glenwood and at Henton in the Missouri river bluffs are limited exposures of limestones and shales difficult of correlation, but their horizon is probably in the Platte shales. In the face of the bluff one-fourth of a mile south of the railroad bridge over the Missouri river at Nebraska City, Nebraska, less than one-half mile from the Iowa side of the river, is an exposure often referred to by geologists since the first observations of Meek and Hayden, and of Marcou, fifty years ago.

## SECTION OF BLUFF AT NEBRASKA CITY

	FEET.
12. Thin bedded limestone, impure, with shaly partings, some crinoid stems .....	4
11. Yellow, very arenaceous shale .....	4
10. Blue shale .....	5
9. Heavy layer of limestone .....	2
8. Thin seam of very carbonaceous matter, with plant impres- sions .....	$\frac{1}{4}$
7. Blue laminated and nonlaminated shale, micaceous and arenaceous in places. In part of the exposure divided by a thin band of more indurated shale, yellowish in color. Ten feet above the base of the shale is a thin band of limestone .....	40
6. Limestone with <i>Pugnax uta</i> .....	2
5. Shale .....	6
4. Crinoidal limestone .....	1
3. Shale .....	1
2. Limestone, in two layers.....	1
1. Shale, exposed in bed of small intermittent creek.....	
Total .....	66 $\frac{1}{4}$

The lower part of the thick shale No. 7 is covered by a railroad embankment, but is known to occur as stated. Numbers 1-6 are exposed in the creek bed near the brick yard office.

This section corresponds very closely to that at McKissicks Grove, twelve miles southeast of this place, and without doubt they are equivalent. The lower limestones are fossiliferous, but the beds above them are very different from the same strata found in Iowa. In the shale pit Professor Calvin was unable to find a single marine fossil. The thick shale No. 7 throughout its whole thickness contains many plant remains. Some of the layers are well laminated, with vertical joints, while other portions seems to be but a mass of slickensided shale. Many of the layers are ripple marked and all of the beds above the lower limestones have been formed under shallow water conditions. The whole exposure resembles the Des Moines in many features.

A deep boring at the brick yard office began with No. 6 of the section and extended to the depth of 863 feet. The record of the drilling was furnished by C. A. Ingersoll, the driller. Drilling was done by the cable rig method. The terminology of the driller is unchanged.

## RECORD OF NEBRASKA CITY DRILLING

	FEET.	TOTAL.
Soil .....	4	4
Lime .....	4	8
Shale .....	25	33
Lime .....	2	35
Red shale .....	5	40
Blue shale .....	15	55
Red shale .....	5	60
Blue shale .....	22	82
Lime .....	5	87
Blue shale .....	32	119
Red rock .....	6	125
Sand stone .....	2	127
Blue shale .....	73	200
Lime .....	9	209
Black shale .....	6	215
Lime—blue .....	5	
white .....	30	
blue .....	15—50	265
Black shale with oil .....	2	267
White lime .....	15	282
Blue shale .....	8	290

	FEET.	TOTAL.
White lime .....	45	335
Blue shale .....	2	337
Lime .....	17	354
Blue shale .....	2	356
Black shale .....	9	365
Lime .....	15	380
Sand rock with mineral water, artesian.....	35	415
Blue shale .....	20	435
White lime .....	20	455
Red rock .....	3	458
Black shale .....	10	468
Lime .....	25	493
Blue shale .....	15	508
Sand stone with artesian mineral water.....	12	520
Black shale .....	10	530
White lime .....	40	570
Red rock .....	5	575
Lime, bottom sandy with water.....	40	615
Blue shale .....	2	617
White lime .....	60	677
Shale and lime.....	5	682
Shale .....	3	685
Limey shale .....	5	690
Lime .....	10	700
Black shale .....	10	710
Limey sand .....	15	725
Lime .....	25	750
Blue lime .....	10	760
Limey shale .....	25	785
Sand rock, very hard .....	8	793
Lime .....	20	813
Sand rock, very hard.....	5	818
Lime .....	5	823
Shale .....	10	833
Lime .....	10	843
Shale, blue .....	20	863

The limestone and black shale at the depth of 215 feet probably represent the cap rock and horizon of the Nodaway coal. The heavy bed of shale above 200 feet is the City Bluffs shale. No further attempts at correlation will be made, although it is evident the bottom of the drilling must be near the base of the Missouri.



## COAL SEAMS.

Some practical conclusions on the area and availability of the coal seams of southwestern Iowa are of importance to miners and prospectors in the future development of the mining industry in this part of the state. The Nyman coal at the old Linquist mine has a thickness of ten to fifteen inches, and was of very good quality but difficulties attending a large amount of water and a bad roof caused its abandonment several years ago. At McKissicks Grove Udden reports a thickness of fourteen inches, which is greater than the average; the outcroppings usually show a thickness of six or eight inches. The drilling at Hamburg gives a thickness of one foot. In the bluff at Nebraska City it is but a mere carbonaceous streak. From Hamburg to Thurman, if correlations are correct, it should be found in the bluffs at a level not far different from the bluff road. In Baylor's shaft south of Thurman it is fourteen inches thick. On Plum creek near Thurman it is reduced to a mere streak hardly recognizable. Over most of its area the Nyman coal has been eroded in the valleys of the streams and will be found only in patches of limited extent. Although the Nyman coal is a well defined horizon in the Carboniferous of southwestern Iowa, its average thickness will probably not exceed six inches and with the exception of local basins of greater thickness it cannot be regarded as workable. It is believed that at the present time attempts to develop it will prove unsuccessful.

All the coal mines in this part of the state are now working in the Nodaway coal, the areal extent of which exceeds that of any other coal seam in Iowa. According to Broadhead it becomes thinner to the south in the state of Missouri and in places is much damaged by clay seams, as it is at Shambaugh, Iowa. The Nodaway coal is not of very high grade as it carries a large percentage of ash. It does not generally show much pyrite, and usually burns without clinker. The quality improves from the south toward the north, and the coal in Adams county is of superior quality to that in Taylor and Page counties. It is not in much request as a domestic coal, but is regarded as being a good steam coal. The coal is firm and hard and, always being mined by the longwall method, is free from slack; it stocks well

and does not disintegrate on exposure to the weather. The coal varies in thickness from a minimum of six inches to a maximum of three feet. Its usual and average thickness is about sixteen inches, and it is rarely altogether absent from its horizon. The Nodaway coal is exceptional in not having an under bed of fire clay. It is, however, usually underlain by a gray shale, that often causes the mining of the coal to be attended with considerable difficulty. The coal seam holds its thickness well in passing west of its outcrops on the Nodaway river and is of greater thickness at Coin than at its nearest outcrop, ten miles away, at Shambaugh. Many years ago a drilling was done at Riverton on the hill and it is reported that a coal seam one foot thick was penetrated at the depth of 400 feet. The surface where the drilling started is at least 100 feet higher than the McKissicks Grove shales on Mill creek two miles south of Riverton. The horizon of the Nodaway coal is about 300 feet lower than the outcrop on Mill creek and the coal of the Riverton drilling is probably the Nodaway seam. If the records are correct the Nodaway coal is absent in the drillings at Hamburg and Nebraska City. From Hamburg to Thurman the coal is upwards of 300 feet deep and is probably too thin to be workable. North of the fault at the Wilson section it is too poor and thin to be available. Drilling at Tabor has found the coal at the depth of 260 feet, but it is not of workable thickness.

The mine at Coin is only seven miles east of the west line of Page county and it is thought the coal will be of sufficient thickness to be workable that far west. In Montgomery county the northern limit of the coal is south of the line of disturbance passing northeast from the Wilson section. The area east of these boundaries to the eastern outcrop of the coal in Adams and Taylor counties is believed to be underlain by the Nodaway coal, which in the valleys can be reached by shafts less than 300 feet deep.

#### ALTITUDE AND THICKNESS.

The altitude of the Nodaway coal at New Market is 980 feet A. T., or fifteen feet higher than the same coal at Clarinda. The altitude of the Nodaway coal at Clarinda is 965 feet A. T., at

Shambaugh 950 feet A. T. and at Coin 790 feet A. T. The dip of the coal from Shambaugh west to Coin, ten miles, is at the rate of sixteen feet to the mile. The dip from Clarinda southwest to Coin, thirteen miles, is thirteen and one-half feet to the mile. The altitude of the Tarkio limestones at Coin is 1,025 feet A. T., and at McKissicks Grove the same limestones have an elevation of 920 feet A. T. The dip west from Coin to McKissicks Grove, twenty miles, is about five feet to the mile. The altitude of the sandstone in the bluff at Hamburg is approximately 960 feet A. T. Near Thurman the same sandstone is at an elevation of about 970 feet A. T. At Nebraska City the sandy shale in the bluff is at an elevation of 960 feet A. T., making the sandstone practically horizontal for a distance of sixteen miles.

## GENERAL SECTION OF THE CARBONIFEROUS IN SOUTHWESTERN IOWA

	FEET.
McKissicks Grove shales.....	75
Tarkio limestones .....	25
City Bluffs shale.....	210
Braddyville limestones .....	45
Forbes limestone .....	18
Platte shales .....	86
Plattsmouth limestones .....	40
Andrew shales .....	172
Iatan limestone .....	16
Weston shales .....	76
Plattsburg limestone .....	19
Parkville shales .....	22
Bethany limestones .....	165
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Thickness of Missouri in Iowa.....	969
Des Moines in Clarinda drilling.....	129
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Total .....	1,098

In round numbers 1,100 feet.

## PALEONTOLOGY.

In the study of the paleontology of southwestern Iowa certain features in the distribution of the different species become apparent. While the greater number of forms range throughout the whole of the section, certain horizons are characterized by a fauna that is of value in correlation.

*Fusulina cylindrica* is common in all the limestones of the Missouri, and in the Forbes limestone and upper layer of the Tarkio limestones becomes especially abundant. There seem to be at least three different varietal forms of *Fusulina*. In the Forbes limestone a large portion of the *Fusulinas* are of a different form from the usual type, being of a robust, nearly globular variety. In the Tarkio limestones in Page county none of the globular variety are seen, and only the forms usually figured are found. In the Tarkio limestones at McKissicks Grove the prevailing forms are of a much elongated and curved variety. The different Bryozoa are abundant throughout the section in the calcareous shales. It is probable careful study would show that certain species are confined to particular horizons. Crinoidal remains are frequent in all the different strata. Disjointed stems and plates are all that have been found. A careful search has failed to discover a single perfect calyx. The spines and plates of *Archaeocidaris* are rather frequent in the Forbes limestone. The different species of *Productus* do not seem to be good horizon markers. Of the three species of *Chonetes* *C. verneuili-ana* has been found only in the Forbes limestone where it is a long eared form with deep mesial sinus. *C. granulifera* and *C. glabra* range in abundance through the whole section. *Spirifer cameratus* is abundant in the cap rock of the Nyman coal and in the limestone in the upper part of the McKissicks Grove shales. It is frequently of the elongate eared form. *Meekella striatocostata* has been seen only in the Forbes limestone. *Ambocelia planoconvexa* is quite abundant in any of the weathered shales. *Athyris subtilita*, *Derbya crassa* and *Dielasma bovidens* range throughout the section and are valueless for correlation. *Orthis pecosi* and *Reticularia perplexa* seem to be confined to the Forbes limestone and Platte shales. *Spiriferina kentuckiensis* and *Productus nebrascensis* have been noticed only in the City Bluffs shale. *P. pertenuis* has been found only in the Tarkio limestones. *Euomphalus rugosus* has a great vertical range and is very abundant in the roof shales of the Nodaway coal. *Bellerophon carbonarius* ranges through all the section. The City Bluffs shale contains numerous specimens of at least four species of *Bellerophon*. The only horizon in which *Naticopsis altonensis*

has been noted is the blue ledge of the Tarkio limestones. *Pleurotomaria perhumerosa* is very abundant in the City Bluffs shale. A single specimen of *P. tabulata* was found in these shales. In Page county the lower layers of the Tarkio limestone seem to be an important Myalina horizon as at least three, perhaps four different species are found in abundance.

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