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The Middle Ordovician section in east central Missouri

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THE MIDDLE ORDOVICIAN SECTION IN EAST CENTRAL MISSOURI

BY

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A

T H E S I S

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INTRODUCTION

One of the most serious difficulties confronting anyone working on stratigraphic problems in the Ozark area is the lack of detailed faunal lists of the various formations. A great deal of general work has been done, but very few detailed faunal studies have ever been published, and correlation of the Missouri section with sections in adjoining states is often difficult.

In a recent paper[1], Dake has discussed the origin and correlation of the St. Peter sandstone. In this study he found considerable difficulty in correlating the various formations above the St. Peter, and at his suggestion, the present study was undertaken in the hope that additional data regarding the fauna and correlation of these forms would be obtained.

The area studied is located in the western part of St. Louis County. It is an irregular tract about twelve miles long and nine miles wide, and is bounded on the north by the Missouri River and on the south by the Meramec. The west boundary is the St. Peter-Joachim contact, which runs from Becker on the Missouri River to Pacific. On the western edge, the Ordovician rocks are

[1]Dake, C. L., The Problem of the St. Peter Sandstone, Bull. Sch. Mines & Met., Univ. Mo., Vol. 6, No. 1, 1921

overlapped by Mississippian along a line running approximately from Monarch Station on the Rock Island Railroad, south to Castlewood on the Missouri Pacific. The entire area lies in the northeast corner of the De Soto quadrangle and the southeast corner of the O'Fallon quadrangle.

The numerous railroad cuts, quarries, river bluffs and creeks in this area afford a great number of sections, which may readily be correlated with each other to form a complete section. The regional dip is to the northeast, and good exposures are rarely too far apart to be definitely correlated.

The field work was done in the fall of 1921. A large number of small sections were measured, and plotted graphically as measured. The positions of all fossil beds were plotted, and extensive collections were made. The various field sections were then fitted together; the net result being two complete sections of the middle Ordovician in this locality. One section lies along the Missouri Pacific and Frisco tracks, between Pacific and Cedar Hill. The other is taken along the tracks of the Rock Island railroad between Tavern Rock and Centaur. In the latter area,

a continuous section aggregating 475 feet of strata, was measured at Tavern Rock, but a portion of this was covered, or poorly exposed, and it was necessary to supplement this with additional sections at more favorable localities.

The writing of this report was divided as follows: The Introduction was written by the senior author. The junior author has written the description of the sections, has identified the collections and compiled the faunal lists. The identification of the fossils was done under the supervision of the senior author, and he assumes all responsibility for the correctness of these identifications. The junior author is also to be credited with the drafting of the various columnar sections. The sections dealing with correlation and conclusions are the work of both authors.

The writers desire to express their thanks and appreciation to Dr. C. L. Dake, of the School of Mines, for the interest he has displayed during the course of this investigation and for many valuable suggestions. They are also under great obligations to Dr. H. A. Buehler of the Missouri Bureau of Geology and Mines, for suggest-

ions and for access to various manuscripts in the possession of the Survey.

The Middle Ordovician of Missouri as recognized at present consists of the following formations:

Middle Ordovician - Mohawkian

Galena limestone			
Kimmswick limestone	0	-	100
Decorah formation	0	-	28
Plattin limestone	0	-	100
Joachim dolomite	0	-	100
St. Peter sandstone including Everton ss. and dolomite at base	0	-	150

The formations immediately below the St. Peter - i.e. Powell limestone, Cotter formation, Jefferson City formation, and Roubidoux sandstone - constitute the lower Ordovician, and are of Beekmantown age. Ulrich, however, wishes to consider them as belonging to a separate period, the Canadian, thus restricting the Ordovician to the formations listed above.

The Lower Ordovician formations form the great bulk of the Ozark uplift, while the Middle and Upper form a narrow belt along the eastern and northern side of the uplift. It is therefore much more convenient to treat the Middle Ordovician separately from the Lower. The Upper

Ordovician is not exposed in this area, but appears further south. The formations of the Middle Ordovician have each been given a number or names in various reports. These will be found under the description of the formations.

St. Peter Sandstone

(First sandstone of Swallow - Saccharoidal ss. - Pacific ss. - Roubidoux ss. in Nason - Crystal City ss. - Cap au Gres ss.)

The St. Peter ss. is well exposed at Pacific on the western boundary of the area, where numerous quarries have been opened into it. In one of these, three blocks northwest of the railroad station, over 100 feet of sandstone is exposed in a vertical bluff. The base is covered, so the exact thickness is not determined.

The fresh surface is pure white, and shows few bedding planes and practically no cross bedding. It is even grained, medium grained, extremely friable, and very pure. It constitutes an important economic output, and is extensively used in the manufacture of plate and optical glass.

No fossils have been found in the St. Peter in this area, and it is generally unfossiliferous. Sardeson has described a marine fauna from the St. Peter of Minnesota, but this is the only known instance. Inasmuch as the St. Peter has been well described in the report by Dake, little attention will be paid to it here.

It outcrops in a continuous belt from the Meramec River at Pacific to the Missouri River at Becker, and dips 2^{0} - 3^{0} northeast.

At Tavern Rock on the Missouri River, 4 miles northeast of Becker, 75 feet of St. Peter are exposed in the base of the section. On a small unnamed creek, 1 mile north and slightly west of Eureka, N.W. 1/4, Sec. 34, T. 44 N., R. 3 E., 15 feet of St. Peter are exposed in a creek bank, beside the Glencoe - Eureka Road. Small inliers of St. Peter are also exposed in the eastern portion, Sections 2 and 12, T. 43 N., R. 3 E., on each side of the Meramec River. These four inliers, and a few others to the southeast, indicate the presence of a broad low anticline, striking approximately N. 45^{0} W. In Section 1, T. 43 N., R. 3 E., the southwest limit of this anticline is cut by a strike fault which has a displacement of about 50 feet and which again brings up the St. Peter. On the southwest (up thrown) side of this fault, the dips are very steep, as much as 25^{0} S.W. having been recorded. These steep dips have been found as far north as the center of Section 3, T. 43 N., R. 3 E., where they appear to die out, and as far south as Bear Creek, near House Springs, Section 34, T. 43 N., R. 4 E. This indicates approximately a length of six miles for the fault.

THE JOACHIM FORMATION

Beds which were identified as belonging to this formation are exposed at Pacific, Sec. 24, T. 43 N., R. 2 E., at Nimms Station on the Missouri Pacific Railroad, S.E. 1/4, N.W. 1/4, Sec. 24, T. 44 N., R. 2 E., at Tavern Rock, Sec. 35, T. 45 N., R. 2 E., and at several other localities within the area at which the exposures are not sufficiently good for detailed study. The Joachim beds lie conformably upon the St. Peter, and are in turn overlain conformably by beds assigned to the Plattin. No break in either upper or lower contacts were observed at any of the localities mentioned. At Pacific, the section three blocks northwest of the Missouri Pacific Station just referred to is capped conformably by about one hundred feet of Joachim, the lower forty feet of which are exposed at the top of the St. Peter bluff. Other exposures occur at the reservoir site and in one or two small outcrops farther up the hill.

The rocks of this formation are composed here of a series of thin, gray to bluish-gray, dolomitic beds, separated at intervals by thin, green shale

layers from one to three inches in thickness. A shale parting one inch thick occurs at the base of the Joachim in this section, and separates it from the St. Peter. A graphic section of this exposure which, it must be remembered, represents only the lower forty or fifty feet of the formation, is given on another page.

The most complete section of the Joachim exposed within the area studied, occurs in the high bluff overlooking the Missouri River in the vicinity of Tavern Rock. The entire formation is exposed here, together with a considerable portion of the St. Peter and of the overlying Plattin and younger beds. The St. Peter - Joachim contact, occurring at an elevation of approximately ten feet above the railroad, is conformable and is marked by thin transitional beds of sand and arenaceous dolomite, passing gradually into the more massive Joachim dolomite. The Joachim - Plattin contact, also apparently conformable, is approximately 120 feet above the level of the railroad, and is marked at this point by a pronounced overhang of the Plattin beds. Analysis of the entire section exposed at this point, from the top of the bluff to the track level some 360 feet below, gave the

following formations :

Burlington	- - - - -	50 ft. +
Kinderhook	- - - - -	33 ft.
Kimswick	- - - - -	18 ft.
Decorah	- - - - -	23 ft.
Plattin	- - - - -	112 ft.
Joachim	- - - - -	110 ft.
St. Peter	- - - - -	10 ft.
	Total	356 ft. +

Below the level of the track, an additional sixty-three feet of St. Peter is shown by following a steep and rather obscure foot-path down the opposite embankment to the mouth of a cave of considerable dimensions within the sandstone.

The strike of the beds here is North 65° E., and a dip of from 3 to 5 degrees north-west is indicated. A section of the Joachim measured at Tavern Rock is as follows:

Plattin

Joachim

		ft.	in.
27.	Dolomite, pinkish-gray, mostly covered	8	0
26.	Unexposed section, probably same as above	3	0
25.	Dolomite, thin bedded, light to bluish-gray	0	6

		ft.	in.
24.	Dolomite, massive bedded, gray, somewhat pitted	2	0
23.	Unexposed section	10	0
22.	Dolomite, "Knotty", unevenly bedded, weathers to dull, dark gray, somewhat pitted	2	0
21.	Dolomite, thin, even bedded, fine grained, light to medium gray	3	0
20.	Dolomite, massive bedded, dark to bluish-gray	4	0
19.	Dolomite, fine, even-grained, gray to bluish gray, in beds 3 to 4 inches thick	2	0
18.	Dolomite, massive bedded, "knotty", somewhat pitted, medium to dark gray, forms prominent ledge	14	0
17.	Dolomite, massive, dark gray, in beds 5 inches to 1 ft. in thickness, with 4-inch green shale layer at base	12	0
16.	Dolomite, thin bedded, bluish-gray, with thin shale parting at base.	0	6
15.	Dolomite, massive, gray, in beds 5 to 10 inches thick	5	0
14.	Dolomite, thin bedded, light to medium gray, with occasional thin partings of shale.	11	6
13.	Dolomite, thin, even bedded, gray "knotty", irregularly bedded in places and with calcite nodules and thin shale partings	9	0
12.	Shale, greenish, clay shale, weathers to small chips	1	0
11.	Dolomite, massive, compact, light to medium gray	3	6

		ft.	in.
10.	Dolomite, thin, even bedded, light to medium gray, with thin shale partings. Top surface very noticeably wavy.	2	0
9.	Shale, reddish, as a thin parting at base of above dolomite bed.	0	2
8.	Dolomite, "knotty", irregularly bedded, light to medium gray, as a filling in shale hollows.	2	6
7.	Dolomite, "knotty", buff-colored, with thin shale partings 2 to 4 inches thick at top.	3	0
6.	Dolomite, compact, buff-colored, arenaceous	1	0
5.	Dolomite, thin bedded, wavy, with large calcite nodules	1	0
4.	Shale, thin greenish shale parting	0	1
3.	Dolomite, thin bedded, arenaceous, with large white sand grains at top	1	0
2.	Dolomite, "knotty", light to medium gray	3	0
1.	Dolomite, fine-grained, even bedded, gray, with 1-ft ss. layer in center	3	0

St. Peter sandstone ---------

In no locality were fossils found in any part of the Joachim at any of the places where the beds of this formation were examined. Particular interest was taken in this phase of the study, inasmuch as practically all previous reports to which access could be had failed to throw any light on a possible Joachim fauna for the

area under investigation. In fact, nearly all descriptions of these rocks, not only within this state, but in other areas as well, have been noticeably lacking in such information.

In Calhoun County, Illinois, the only area where Joachim rocks have been reported from that state, Weller reports[1] one or more species of ostracods and one of two species of trilobites.

[1] Weller, Stuart, Geology of Southern Calhoun County, Ill. Geol. Survey, Bull. No. 4, 1907, p. 222.

THE PLATTIN FORMATION

The Plattin is well represented throughout this area by beds averaging around a hundred feet in thickness, and good sections are exposed at various points. At Tavern Rock, the beds of this formation, as already shown, have a total thickness of 112 feet, a considerable portion of which, however, is covered or but poorly exposed. Sixty feet of Plattin are fully exposed in the bluff at Nimms Station, and opportunities at this place are particularly favorable for studying the lithology and fauna of the formation. Other good exposures are to be found along the river bluff at Bald Hill Ford, sec. 14, T. 43 N., R. 3 E., and a few rods west of the lower lime kiln at Glencoe, NE. 1/4 SE. 1/4, sec. 24, T. 44 N., R. 2 W. Ledges of varying thickness may also be observed in many of the highway cuts and ravines throughout the area.

The Plattin has been described as resting unconformably upon the Joachim throughout Missouri. Dake mentions this fact in a general statement in

Ledge of Plattin at Joachim-Plattin contact near Pacific, Mo.

his report on the St. Peter, and it has also been referred to by previous authors. The present writers made careful observations for the purpose of confirming this reported unconformity, but the evidence, if present in this area, is too inconclusive to admit of a definite statement at this time. About one half mile north of Pacific, in sec. 31, T. 43 N., R. 2 E., the Joachim-Plattin contact is exposed for several rods along the road. The basal Plattin is here represented by a ledge a foot or more in thickness, and lying apparently conformably upon the older formation. This ledge is also well exposed in the path above the reservoir, north of Pacific. It is a dark purplish gray limestone, weathering bluish white and carries the ostracod Leperditia sublaevis (Shumard).

Approximately 26 feet above the floor of the quarry at Nimms Station, one mile east of Glencoe, on the Missouri Pacific, the contact is again present, but without visible unconformity. While no break in the contact between these two formations has thus far been observed, the line of transition is marked by a distinct change in lithology and in the presence of fossils in the younger formation. The same is true of the contact in the Tavern Rock section.

'Chimneys' of Plattin limestone
near Port Royal, Mo.

Lithologically, the Plattin is a fine-grained, compact, dark gray or dove-colored limestone of more or less uniform texture. Some of the beds are so fine grained that they resemble lithographic stone, and in breaking show a distinct conchoidal fracture. The rock weathers to a light gray to grayish white, and may be distinguished from the underlying formation not only by the change in color, but also by the peculiar "wormy" or pitted appearance which usually characterizes the weathered surface of the Plattin. This very noticeable feature makes the formation one of the most easily recognized in the region. A similar result of weathering very often observed in the Kimmswick may at first lead to some difficulty in identifying these two formations. As mentioned farther one, however, a considerable difference in the general size of these solution cavities is to be noted between the two. Major solution cavities are not common, the effects of weathering being more pronounced along joint planes, which occur at fairly frequent intervals.

Along the river bluffs, the Plattin beds may very often be seen standing out as prominent chimneys, in sharp contrast to the other rocks of the vicinity. (see illustration)

Fauna - The Plattin was found to be highly fossiliferous at certain horizons, the fossils very often occurring in thin, closely compact lenses. The forms here listed were taken largely from the quarry and bluffs at Nimms Station, opportunities for collecting there being exceptionally good. Twenty-six feet above the floor of the quarry, the writers observed a thin dark gray highly crystalline bed, four to six inches thick, and carrying bryozoans in great abundance. This is here taken as the basal bed of the Plattin. It is not exactly similar to the basal beds observed near Pacific, but seems to lie within a few feet of them. The layer with ostracods was not found here, but rock specimens taken immediately below this bryozoan layer appear to be typical Joachim dolomite, while those coming from above it are as characteristically Plattin. Due to the fact that the contact is exposed in a quarry face, the lithologic change is not as sharp as it is along a weathered hillside. The floor of the quarry is certainly in the Joachim, and it is quite possible that the ostracod layers, above noted, are really a part of the Joachim. The same condition obtains in the section along the Frisco tracks about

1/2 mile west of Allenton, Mo. At this point the bryozoan layer is about 30 above the creek, and three feet above track level at the west end of the cut. It dips 2 - 30° Northeast and is soon carried below the level of the tracks.

In the section at Nimms Station this bed, and the beds immediately overlying it, also carry Rhynchotrema minnesotense (Sardeson), Pianodema subaequata conradi (N. H. Winchell), Dalmanella testudinaria (?) (Dalman), and Cornulites flexuosus (Hall).

About twenty feet above this layer, at the top of the quarry, is a second fossil bed, which may be called the Rhynchotrema minnesotense horizon. Fossils are abundant in this layer, but are badly weathered and poorly preserved. They are contained in a thin seam of rather coarsely crystalline limestone. In addition to Rhynchotrema minnesotense (Sardeson) the following forms were identified from this layer. Zygospira recurvirostris (Hall); Strophomena incurvata (Shepard); Streptelasma profundum (Conrad); Orthoceras multicameratum, Hall; Schizocrinus nodosus (?) Hall. Exposures are poor for the next twenty-seven feet, but near the top of this interval are several thin fossil beds. Rafinesquina minnesotensis (N. H. Winchell)

and Phragmolites fimbriatus (?) (U. & S.) were obtained here.

About eighteen feet above this zone is another well defined fossil zone carrying Liospira vitruvia (Billings); Schizocrinus nodosus, Hall; Orthis tricenaria, Conrad; and Leperditia Sp.

The most important fossil zone of the Plattin occurs thirty-eight feet above this zone. It is characterized by Orthis tricenaria, Conrad, and Pianodema subaequata conradi, N. H. Winchell, in great abundance. It is the most abundantly fossiliferous zone of the Plattin in this section, and in addition to the above contains the following species: Liospira vitruvia (Billings), Streptelasma profundum (Conrad), Strophomena incurvata (Shepard), Trochonema umbilicatum (Hall), Maclurites bigsbyi (?), (Hall), Orthoceras multicameratum, Hall, Salpingostoma buelli, (Whitfield), Helicotoma cf planatuloides, Ulrich, Rhinidictya Sp., Pachydictya (?) Sp. and Grania Sp.

A few feet above this zone, is another fairly well marked horizon from which the following fossils were obtained: - Pianodema subaequata conradi, N. H. Winchell, Rafinesquina minnesotense, N. H. Winchell, Streptelasma profundum (Conrad), Orthoceras junceum, Hall, and Rhinidictya Sp., Leperditia Sp.

In the course of this work no other section of the Plattin was measured which is anywhere as nearly complete as the one just given. However, it was found quite easy to recognize certain well marked fossil horizons in various sections. These are:- (1) the bryozoan bed at the base, (2) the Rhynchotrema minnesotense - Strophomena incurvata zone about twenty feet above the base, and (3) the Orthis tricenaria zone within ten feet of the top of the formation. These zones appear to hold over most of the territory.

In other sections additional fossils were found, some of which are very interesting. South of the Meramec River, in the S.E. 1/4, S.E. 1/4, Sec. 16, T. 43 N., R. 4 E., the senior author found a large specimen of Tetradium cellulosum (Hall) It was found in a float boulder, within twenty feet of the top of the formation. The lithology of the boulder suggests the Plattin, and it is believed to have come from one of the two upper fossil zones. Since this form is characteristic of the Lowville of New York and Tennessee, it and the many other species occurring in the Plattin which range down into the Lowville are strongly indicative of the Lowville age of the Plattin. The identification was confirmed by Dr. R. S. Bassler of the U. S. National Museum, to whom a portion of the specimen

was sent. The species appears to be rather rare in this area, but a second specimen was found in the Tavern Rock section. Here it was either in the very top of the Plattin or the base of the Decorah.

Near House Springs, on the dip of the hill in the N.W. 1/4, N.W. 1/4, Sec. 3, T. 42 N., R. 4 E., the upper beds of the Plattin are well exposed. The following section was measured by the senior author -

Kimmswick limestone	6 - 8	ft.
Decorah formation mostly covered	18±	"
Plattin limestone	40	"
Level of road in Heads branch		

About thirty feet below the top of the Plattin, and about twenty feet below the Orthis tricenaria zone, which is sparingly exposed here, a large specimen of Columnaria halli, Nicholson, was found. A record specimen was found in the stream gravels of Bear Creek, about three fourths of a mile northeast of House Springs.

About twenty feet below the top of the formation is a zone which carries Actinoceras bigsbyi (Bronn) in considerable numbers. This zone has also been noted near Pacific. The same horizon also carries Monotrypa magna, Ulrich. Monotrypa magna

was also found near the top of the Plattin in the East 1/2, sec. 23, T. 44 N., R. 2 E., in a small gully west of the Pacific-St. Albans road, where it is associated with Orthis tricenaria and limestone.

Table I

FAUNA OF THE PLATTIN LIMESTONE

		Allentown	Nimms Station	St. Albans	High Ridge	House Springs	Pacific		Herculaneum		Top of Plattin Missouri	Oklahoma U. Simpson	Oklahoma L. Viola	Platteville-Decorah Ill.	Platteville Iowa	Platteville Minnesota	Platteville Wisconsin
Coelenterata																	
Columnaria halli - Nicholson	(r)					x											
Streptelasma profundum (Conrad)	(c)		x										x			x	x
Tetradium cellulosum (Hall)	(r)				x												
Echinodermata																	
Schizocrinus nodosus (?) Hall	(c)		x						x								x
Unidentified Cystoid (?) plates	(r)			x													
Vermes																	
Cornulites flexuosus (Hall)			x														x
Molluscoidea																	
Monotrypa magna - Ulrich	(c)			x		x											x
Pachydictya (?) sp.			x														
Rhinidictya mutabilis - Ulrich	(c)		x										x			x	
many unidentified forms		x	x						x								
Crania sp.	(c)		x														
Hebertella bellarugosa (Conrad)	(r)								x			x				x	
Orthis tricenaria (Conrad)	(a)		x		x	x					x	x		x	x	x	x
Pianodema subaequata (Conrad)	(r)		x									x		x	x	x	x
Pianodema subaequata N. H. Winchell	(a)		x	x	x	x											
Rafinesquina alernata (Conrad)	(c)										x			x	x		x
Rafinesquina minnesotensis (N. H. Winchell)	(r)		x		x				x						x		x
Rhynchotrema minnesotense (Sardeson)	(a)	x	x			x					x					x	x
Strophomena incurvata (Shepard)			x			x					x	x	x			x	x
Zygospira recurvirostris - Hall		x							x				x	x		x	
Mollusca																	
Phragmolites fimbriatus - U. & S.	(r)		x								x						
Helicotoma plaunlatoides (?) Ulrich	(r)		x														
Liospira vitruvia (Billings)	(a)		x			x									x		
Maclurites bigsbyi (?) (Hall)	(r)		x			x					x					x	x
Salpingostoma buelli (Whitfield)	(r)		x														x
Trochonema umbilicatum (Hall)	(c)								x						x	x	x
Actinoceras bigsbyi (Bronn)	(c)	x			x	x	x										
Cycloceras olorus (Hall)	(r)								x								x
Endoceras proetiforme - Hall		x				x											x
Endoceras or Vaginoceras sp.		x							x								
Orthoceras junceum - Hall		x															x
Orthoceras multicameratum - Emmons	(c)		x		x				x								
Arthropoda																	
Illaenus sp.																	
Leperditia fabulites (Conrad)	(c)		x			x								x		x	x
Leperditia sublaevis (Shumard)	(c)						x										

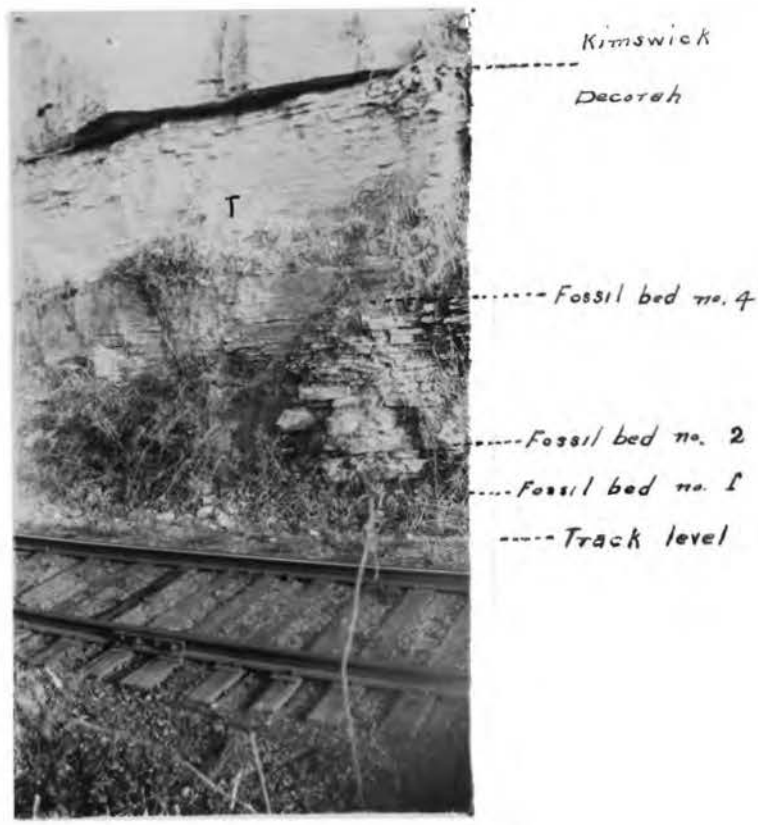
(r = rare c = common a = abundant)

THE DECORAH FORMATION

(Green shale - Upper Buff limestone - Auburn residual chert)

Resting conformably upon the Plattin and overlain conformably by the Kimmswick, are some 24 to 27 feet of strata referred to the Decorah. A good section of this formation is to be found in sec. 24, T. 45 N., R. 2 E., in a railroad cut on the Rock Island, approximately 200 feet east of Port Royal Station. Other sections were also examined at Nimms Station, on the Missouri Pacific, S.E. 1/4, NW. 1/4, sec. 24, T. 44 N., R. 2 E., and at Tavern Rock. At Nimms Station, the upper nine or ten feet of the Decorah is fully exposed, and six to seven feet more of it are indirectly traceable down the slope. The contact between it and the Kimmswick is sharply defined and may be traced for several yards along the bluff. Opportunities for collecting are good at this point, an abundance of Pianodema subaequata, Rafinesquina minnesotensis, and other characteristic forms being obtainable from the loose arenaceous, easily weathered, upper beds of the formation.

At Tavern Rock, approximately 23 feet of Decorah are present near the top of the bluff. Only the top and bottom of the formation, however, are



Decorah at Port Royal, Mo.
(note geologists' pick in upper center.)

exposed here, computation of the total thickness being based upon measurements between the two outcrops. Little opportunity for collecting was found at this point.

The Port Royal section occurs at the base of the bluff, and at the level of the Rock Island railroad. Approximately fifteen feet of the formation are exposed here. Its contact with the more massive and resistant Kimmswick beds is rendered conspicuous by the pronounced overhang of the latter. The beds dip perceptibly in a northeast direction and disappear at a low angle beneath the track. The Decorah-Plattin contact may be picked up, however, a few rods southwest of this point, and by noting the approximate angle of dip, it is evident that not more than five or six feet of Decorah remain unexposed below the cut.

The senior author reports the Decorah as being exposed for a considerable distance along Wildhorse Creek, between sections 29 and 30, T. 45 N., R. 3 E., The exact location of this outcrop is given as about 100 yards north of the junction of the Wildhorse Creek road and that running northwest from Fox Creek. Approximately 27 feet of the formation are present here,

the maximum thickness thus far observed within this area. The occurrence was noted in the course of a rapid reconnaissance and no time was available for detailed study.

While the number of measurements made of the Decorah throughout this area have been too few to admit of a more definite statement at this time, it may be mentioned that, in general, there seems to be a tendency for the formation to thicken toward the east.

Allowing 24 to 27 feet of total thickness for the Decorah in this part of the State, it may perhaps be worth noting by way of comparison the thickness which this formation attains in other areas. In Ste. Genevieve County, Weller reports[0] the Decorah as ranging from 0 to 3 feet in thickness. In Illinois, the Decorah is described[1] as rarely exceeding ten feet in thickness. In Iowa[2], it ranges from ten to forty feet, while a maximum thickness of sixty feet is recorded from Minnesota[3]. From available data, it is evident that the Decorah of Wisconsin,

[0] Weller, Stuart, unpublished mss. Ste. Genevieve Co., Mo. Bureau of Geology and Mines.
[1] Shaw, E.W. and Trowbridge, A.C., Geology and Geography of the Galena and Elizabeth Quadrangles; Ill. Geol. Survey, Bull. No. 26, 1916.
[2] Dake, C. L., Problem of the St. Peter Sandstone, p.76
[3] Local cit., p. 104

or at least such members of the Upper Ordovician of that state as may reasonably be referred to this formation, are well under twenty feet in total thickness. The Decorah probably is not reported as a distinct and recognizable formation in Arkansas. Information, at least, is lacking in this regard, and no figures as to possible thickness there can be given.

Detailed study was made of the Decorah at Port Royal and a description of this section is given herewith:

Kimmswick limestone ----

Decorah		ft.	in.
19.	Shale, light brown to buff, non-calcareous, somewhat arenaceous, weathers to small fragments, no fossils	0	4
18.	Shale, light, bluish gray, very slightly calcareous, forms thin lense	0	2
17.	Limestone, medium to dark gray, buff and shaly in upper part. Fossils: Pianodema subaequata, Rafinesquina minnesotensis, Sinuites cancellatus, Zygospira recurvirostris	0	2
16.	Limestone, light brown to buff, arenaceous, forms thin lense. Fossils: Pianodema subaequata, Rafinesquina minnesotensis	0	1
15.	Limestone, medium to dark gray, arenaceous in upper part. Fossils: Pianodema subaequata, Rafinesquina minnesotensis, Zygospira recurvirostris, Cyrtodonta janesvillensis	0	1

14.	Shale, light bluish gray, forms thin lense	0	1
13.	Limestone, medium to dark gray, "knotty" in lower part, somewhat arenaceous. Fossils: Stictoporella angularis, Rhindictya mutabilis, Pianodema subaequata, Rafinesquina minnesotensis, Ctenodonta nasuta, Liospira vitruvia, Hormotoma gracilis, Sinuites rectangularis, Cyrtolites sp.	0	7
12.	Limestone, medium to dark gray, with thin, compact fossil lense. Fossils: Pianodema subaequata, Rafinesquina minnesotensis	0	3
11.	Limestone, light brown to buff, very arenaceous, "knotty". No fossils	0	7
10.	Limestone, light brown to buff, arenaceous, with fossils occurring in thin compact lenses. Fossils: Stictoporella angularis, Plectambonites sericeus, Liospira vitruvia, Trochonema umbilicatum	0	3
9.	Limestone, light brown, arenaceous, fossils occurring generally throughout. Fossils: Pianodema subaequata, Hormotoma gracilis	0	10
8.	Limestone, light brown to buff, arenaceous. A thin fossil lense, Fossils: Stictoporella angularis, Pianodema subaequata, Hormotoma gracilis	0	1
7.	Limestone, same color as above, arenaceous, with thin, irregular fossil lenses, 1/4 to 2 inches in thickness. Fossils: Pianodema subaequata, Rafinesquina minnesotensis, Zygospira recurvirostris	2	10

6.	Limestone, thin, compact, gray to buff, somewhat arenaceous in lower part. Fossils: Rhindictya mutabilis, Pianodema subaequata, Zygospira recurvirostris, Pterygometopus intermedius	0	4
5.	Limestone, light brown to buff, very arenaceous, with thin, dark gray, highly fossiliferous lenses, and calcite nodules in places. Fossils: Rhinidictya mutabilis, Stictoporella angularis, Pianodema subaequata, Zygospira recurvirostris, Orthis tricenaria	1	3
4.	Limestone, compact, massive, dark gray, weathering to buff, with highly fossiliferous lenses in lower part. This bed forms a more or less solid, compact layer, weathering less easily than the beds immediately above or below. Fossils: Rhinidictya mutabilis, Pianodema subaequata, Rafinesquina minnesotensis, Zygospira recurvirostris.	1	8
3.	Limestone, medium to dark gray, arenaceous and buff-colored in places, especially on weathered surface. Fossils occurring in thin, highly calcareous lenses. Fossils: Pianodema subaequata, Rafinesquina minnesotensis, Zygospira recurvirostris, Cyrtolites sp., Hormotoma gracilis, Pterygometopus intermedius.	2	3
2.	Limestone, medium to light gray, compact, massive, somewhat arenaceous in places, especially in upper part. Fossils occurring in thin, compact lenses. Fossils: Stictoporella angularis, Rhinidictya mutabilis, Pianodema subaequata, Zygospira recurvirostris, Rafinesquina alternata, Orthis tricenaria, Hormotoma gracilis	1	6

1.	Limestone, light brown to buff, very arenaceous in places, with thin, compact, highly fossiliferous lenses throughout. Fossils: Rhinidictya mutabilis, Stictoporella angularis, Pianodema subaequata, Rafinesquina minnesotensis, Zygospira recurvirostris, Orthis tricenaria, Cyrtodonta janesvillensis, Hormotoma gracilis, Cyrtolites sp., Pterygometopus intermedius	1	7
	Total	15	1

As indicated in the description already given, it is seen that the Decorah at Port Royal is represented by a series of thin bedded, gray to buff limestones, with thin, clay shale partings near the top. The beds are highly arenaceous in places, especially in the upper two-thirds of the section. Numerous thin, dark gray, highly calcareous fossil lenses occur throughout, these being particularly abundant in the lower half of the formation. This part of the Decorah is generally more massive and compact, and shows to a lesser degree the results of weathering. A thin, somewhat arenaceous, light brown clay shale, 4 to 5 inches in thickness occurs at the top of the formation in contact with the overlying Kimmswick. The effects of weathering in this friable shale bed make the Decorah Kimmswick contact at this point conspicuous, even from a distance.

Altogether, not more than eight to ten inches, total thickness, of shale are present in the section at Port Royal. It occurs in three thin fairly well defined beds within the upper two feet of the formation. The uppermost shale is practically non-calcareous, the other two are but slightly so. No fossils were found in any of these beds. The presence of thin shale partings at the top of the Decorah was also observed at Nimms Station and at Tavern Rock, though exact correlation of these beds with those at Port Royal could not be made. A thin, gray to buff clay shale, not exceeding three or four inches in thickness, marks the Decorah-Kimmswick contact at Nimms Station, and a pronounced overhang of the Kimmswick is again conspicuous at this point. The occurrence of a small amount of shale in the upper part of the Decorah at the above-mentioned localities, seems to indicate that within this area, at least, it is a fairly constant, though relatively unimportant part of the formation. Its presence may be considered of some value, however, in denoting the Decorah-Kimmswick contact.

In connection with the marked predominance of limestone over shale in the Decorah of this region, mention may be made here concerning the lithological character of this formation elsewhere. In Illinois,[1] it is described as being composed of very thin bedded limestones, with considerable shale. In the Waukon District, northeastern Iowa, it is represented by a "light, gray-green, calcareous, soft, fissile shale, - 15 to 28 feet in thickness, and with interbedded limestone layers, and with frequent bands of calcareous nodules and lenses of shaly limestone.[2] Farther north, in Minnesota, the Decorah is described as being over 60 feet in thickness, one-fifth of which consists of occasional thin limestone beds, in a typical clay shale.[3] Little information can be had regarding the Decorah of Wisconsin. In his report on the St. Peter, Dake comments upon the absence of any recognized Decorah in the Ordovician of that state.[4] He believes, however, that this formation is "quite

[1] Shaw, E. W. and Trowbridge, A.C., Galena-Elizabeth Quadrangles.

[2] Annual Report, Iowa Geol. Survey, vol. 15, 1914, p. 48.

[3] Minneapolis - St. Paul Folio, No. 201

[4] The Problem of the St. Peter Sandstone, p. 118.

probably included in the "Lower Blue" of older geologists." Also, the "Upper Bluffs", though apparently belonging with the "Upper Blue" to the Galena, "may in places include Decorah." The "Lower Blue" lime in the vicinity of Beloit, Wis., is described by T. C. Chamberlain as a "thin-bedded" impure limestone, of varying earthy and crystalline texture, interleaved with shaly partings." [1] The thickness of the stratum is given as 23 feet, and the reported great abundance in it of (Murchisonia) Hormotoma gracilis and of Sinuites cancellatus (Bellerophon bilobatus), seems to strengthen the supposition that these beds may, in part at least, be equivalent to the Decorah of other localities. The above forms are particularly abundant in the sections examined by the writer at Port Royal and at Nimms Station. They are also reported from the Decorah of other localities. If these beds are, indeed, representative of the Wisconsin Decorah, it is evident that the shaly facies of the formation are again considerably reduced in importance in this area.

[1] Geology of Wisconsin, Vol. 2, 1873-77, p. 297

FAUNA OF THE DECORAH FORMATION

		Port Royal	Tavern Rock	Allenton	Bald Hill Ford	Nimms Station	Fox Creek		Iowa Decorah	NW. Illinois Platteville Decorah	S. Illinois Decorah	Minnesota Decorah	Wisconsin Platteville	Wisconsin L. Buff	Wisconsin L. Blue	Wisconsin U. Buff
Coelenterata																
Streptelasma profundum - (Conrad)	(c)			x		x	x			x			x			
[1]Tetradium cellulosum - (Hall)	(r)	x														
Echinodermata																
Schizocrinus nodosus - Hall	(c)		x		x	x									x	x
Vermes																
Cornulites flexuosus - (Hall)	(r)	x														
Molluscoidea																
Actactoporella insueta - Ulrich	(c)	x														
Rhinidictya mutabilis - Ulrich	(a)	x	x	x	x	x						x				
Stictoporella angularis - Ulrich	(a)	x	x	x	x	x				x						
Crania setigera ? - Hall	(c)	x										x				
Dinorthis deflecta - (Conrad)	(r)						x		x	x			x	x	x	x
Orthis tricenaria - Conrad	(a)	x					x					x		x	x	x
Pianodema subaequata - (Conrad)	(a)	x	x	x	x	x	x		x	x	x		x			
Pianodema subaequata v. conradi, Winchell	(c)	x				x										
Plectambonites minnesotensis, (Sardeson)	(c)	x	x	x	x	x						x				
Rafinesquina minnesotensis, (Winchell)	(a)	x			x				x			x	x	x		
Rhynchotrema ainsliei - Winchell	(r)	x										x				
Rhynchotrema minnesotense - (Sardeson)	(r)						x					x	x			
Strophomena trentonensis - (W. & S.)	(r)	x														
Zygospira recurvirostris - Hall	(a)	x				x				x		x				
Mollusca																
Clionychia lamellosa - (Hall)	(r)	x											x		x	x
Ctenodonta nasuta - (Hall)	(r)	x												x		
Cyrtodonta janesvillensis - Ulrich	(r)	x														
Hormotoma gracilis - (Hall)	(a)	x										x			x	x
Liospira vitruvia - (Billings)	(c)	x							x			x				x
Lophospira perangulata ? - (Hall)	(c)	x														
Phragmolites fimbriatus - (U. & S.)	(c)	x														
Sinuites cancellatus ? - (Hall)	(c)	x										x				x
Sinuites rectangularis - (U. & S.)	(c)	x											x			
Subulites elongatus - Conrad	(r)	x										x		x	x	x
Trochonema umbilicatum ? -)Hall)	(c)	x										x		x	x	x
Orthoceras junceum - Hall	(r)	x												x	x	x
Arthropoda																
Ceraurus pleurexanthemus ? - Green	(r)	x							x					x	x	x
Pterygometopus intermedius - (Walcott)	(a)	x														

r = rare, c = common, a = abundant

[1]this form may be from the top of the Plattin, for the exact base was not determined at this locality

The significance of this increasing prevalance of shale facies to the north and west, is referred to by Dake as indicating, in part, the probable direction of origin of the sediments laid down in the central Ozark region during early and middle Ordovician times.

Fauna - Reference has already been made to the abundant distribution of fossils in the Decorah of this area. They occur more or less abundantly throughout most of the formation, the only portions of which proved barren of organic remains being the shale layers and one thin limestone lense near the top. Certain limestone beds, particularly in the lower two-thirds of the formation, are literally packed with the well preserved remains of Pianodema subaequata, Rafinesquina minnesotensis, and the branching bryozoans - Stictoporella angularis, and Rhinidictya mutabilis. In fact, several of these lenses are little more than compact masses of the remains of these forms. In the section at Tavern Rock, a stratum two or three inches thick, closely packed with stems and calyces of Schizocrinus nodosus, was observed within a foot of the Decorah-Kimmswick contact. In general, it may be said that, as far as the writers' observations have gone, the

Decorah fauna of this area is closely similar to that reported from other localities, this fact being shown in the table below.

THE KIMMSWICK LIMESTONE

(Trenton limestone - McCune limestone - Receptaculite ls.)

Fairly good exposures of this formation occur at several places within the area studied, and little difficulty is to be encountered in recognizing, on the basis of its lithology and fauna, the so-called Receptaculite limestone.

The Kimmswick is a light gray to nearly white, more or less uniformly textured, coarse and highly crystalline limestone. The beds are usually massive, compact, and do not yield readily to the processes of weathering. Partly because of this fact, and also for the reason that the Kimmswick is in contact both above and below with essentially different types of rock, the formation is often easily and unmistakably discernable even at a distance from the younger and older beds. Reference already has been made to the nature of the Kimmswick-Decorah contact. A less marked, though usually apparent contrast in the lithology of the Kimmswick and younger formations is also to be noted. In favorable exposures, the lower portion of the formation frequently may be observed as a compact, projecting ledge, 12 to 18 or more feet in thickness.

The weathered surface is usually of a dull gray or buff color. Joint planes, while present and well developed, commonly occur at infrequent and widely-spaced intervals. Major solution cavities are not common, and occur for the most part along bedding or joint planes. In the process of weathering, it is frequently to be observed that the rock is subject to a peculiar chipping or flaking effect, and the base of a Kimmswick bluff often strewn with large, thin slabs of weathered limestone - a more readily worked source of fossils. Another characteristic feature of this rock, a peculiarity already noted in connection with the Plattin limestone, is the pitted or "wormy" effect observed on weathered surfaces. As in the case of the Plattin, this is due to innumerable small, irregular solution cavities. It is notable, however, that in the case of the Kimmswick, these cavities are in general considerably larger than those of the Plattin, the importance of this fact in aiding in the identification of the formations being readily appreciated.

Owing to its highly crystalline character and relative purity, this limestone commands a ready

market as a source of lime. Numerous small quarries have been opened up throughout this area, and the history of the lime-quarrying industry here dates back for considerably over half a century. Good collecting and opportunities for examining carefully the lithological character of the rock is to be found in many of these quarries. At Fox Creek, sec. 27, T. 44 N., R. 3 E., five quarries have been opened up within a short distance of one another. Facilities for studying the beds are good here, and sections of the Kimmswick are exposed which range from 50 to 60 feet. Another quarry site is to be found at Centaur Station, sec. , T. 45 N., R. 3 E. Approximately 30 feet of Kimmswick are exposed here, the lower portion of which, however, is below the level of the quarry floor. The top is capped by a glacial terrace.

The Kimmswick thins rapidly to the west, and marked fluctuations in thickness were observed at various points. Altogether a difference of around 40 feet between maximum and minimum thicknesses occurs within this area. This may largely be accounted

for by one or more post-Kimmswick - pre-Mississippian erosion intervals. A very striking and unmistakable erosion surface overlain by a basal conglomerate marks the Kimmswick-Kinderhook contact at Tavern Rock. On a hill between Glencoe and Eureka, NW. 1/4, sec. 12, T. 44 N., R. 3 E., approximately 10 feet of Kimmswick are present, capped by Kinderhook sandstone. In the upper quarry at Fox Creek, the top of the Kimmswick appears somewhat eroded and is overlain by a thin, bluish-green shale, and nodular limestone, 4 to 5 inches in thickness, which is probably Chouteau. South of Kimmswick, Mo., in the bluffs along the Mississippi river, 16 miles southeast of this area, the Kimmswick is thicker, and is overlain unconformably by the Fernvale limestone, and the Maquoketa shales, which in turn are overlain by the Kinderhook. This is overlain by the red limestones of the Fern Glen. At one or two other localities visited, evidence of a similar though less obvious nature was observed.

The presence of such a break in the contact between the Kimmswick and younger beds has not, of course, been unknown to previous investigators in the eastern Ozark area. Ulrich, in mentioning the evidence for a later Ordovician erosion interval, calls attention to it in his "Revision of the Pal-

eozoic Systems." [1] Dake also suggests the possibility of a post-Galena (Kimmswick) and pre-Maquoketa erosion period in Wisconsin, where the Galena is reported to vary from 150 to 250 feet in thickness. A similar variation in the thickness of the Maquoketa beds as reported from Iowa, might also suggest a relationship to the established hiatus in Missouri. It seems evident, at least, that the conditions which gave rise to this break in the continuity of beds were not local. The period of emergence and erosion which, in eastern Missouri is clearly indicated in the upper Kimmswick, in all probability prevailed over a much wider area, as suggested by the evidence already referred to.

Fauna - The Kimmswick of this area is in places highly fossiliferous, and opportunities for collecting are good, as already suggested, at the various quarry sites and along the river bluffs at Tavern Rock and Nimms Station. The list of Kimmswick fauna as given herewith was collected by the authors from several localities, and may be taken as representative of a complete section of this formation within this area.

[1] Bull. Geol. Soc. America, vol. 22, 1911, p. 309.

In general, two fairly well-defined faunal zones seem to be present in the Kimmswick. The lower 18 or 20 feet is marked particularly by the presence of Receptaculites owena and Endoceras proetiforme together with one or two species of Orthoceras and the gasteropods, Hormotoma trentonensis and Trochonema umbilicatum. A rather noticeable change in lithology between this and higher beds is also to be observed. The Receptaculite beds are brownish-gray to buff and distinctly less crystalline and more arenaceous than the middle and upper portions. Above the Receptaculite zone is a zone of varying thickness which, so far as the writers could discover, is practically or nearly barren of organic remains. The exact line of transition between this and the lower zone was not observed, but it is believed that the change is a gradual one. The lithology of this portion of the formation is essentially of the same light gray, highly crystalline character as the upper faunal zone. The upper 20 to 30 feet carries in considerable abundance the remains of Rafinesquina deltoidea, Rafinesquina minnesotensis, Cerarus pleurexanthemus, Isotelus gigas, Goldius lunatus, Bumastus milleri, and other forms of less characteristic occurrence. Receptaculites oweni and the cephalopods which are so abundant in the lower 20 feet of this

FAUNA OF THE KIMMSWICK LIMESTONE

		Cedar Bluff	Nimms Station	Fox Creek	Tavern Rock	Port Royal	Allenton	Between Eureka and Glencoe	Jeadburg	Wallace	Centaur	Monarch	Pike Co, Mo. (Hawley)	Ralls Co, Mo (Fearsite)	Arkansas Polk Bayou	Oklahoma Lower Viola	Middle Viola	Iowa Galena Is.	S. Illinois Kimmswick	NW. Illinois Basal Galena	Upper Galena	Minnesota Decorah	Galena	Wisconsin Basal Galena	Upper Bluff	Upper Blue
Porifera																										
Receptaculites oweni - Hall	(c)	x	x		x	x	x	x					x	x				x	x		x	x		x		
Coelenterata																										
Streptelasma corniculum - Hall	(c)		x			x							x	x				x							x	
Echinodermata																										
Schizocrinus nodosus - Hall	(r)								x																x	
Molluscoidea																										
Cyphotrypa Sp.	(c)			x	x				x																	
Eridotrypa aedilis - (Eichwald)	(c)			x																						
Hallopora goodhuensis - (Ulrich)	(c)			x																						
Chasmatopora sublaxa - Ulrich	(r)			x																						
Rhinidictya mutabilis - Ulrich	(c)			x										x		x						x				
Dalmanella rogata - (Sardeson)	(c)			x	?									x					x			x	x			
Dinorthis meedsi - W. & S.	(r)			x										x								x				
Dinorthis pectinella - (Emmons)	(r)			x	x								x	x	x	x			x	x		x		x	x	x
Platystrophia praecedens - McEwan	(r)								x																	
Plectambonites minnesotensis, Winchell	(a)		x	x	x		x							x					x			x	x			
Rafinesquina alternata - (Conrad)	(c)			x									x	x	x			x	x	x		x	x	x	x	x
Rafinesquina deltoidea - (Conrad)	(c)			x						x		x	x	x	x	x	x	x					x		x	
Rafinesquina minnesotensis - Winchell	(c)			x					x		x							x	x							
Strophomena incurvata - Shepard	(r)			x							x	x	x	x		x		x		x		x		x		
Rhynchotrema minnesotensis - Sardeson	(c)			x																		x	x			
Zygospira recurvirostris - Hall	(c)			x												x			x							
Mollusca																										
Hormotoma trentonensis - Ulrich	(r)					x																				
Trochonema umbilicatum - Hall	(r)				x								x	x				x				x			x	
Endoceras proetiforme - Hall	(a)		x				x	x						x											x	
Arthropoda																										
Bumastus billingsi - R. & N.	(c)			x							x			x					x							
Bumastus milleri - Billings	(r)			x															x							
Ceraurus Sp.	(r)			x															x							
Goldius lunatus - (Billings)	(r)			x																						
Isotelus gigas ? - DeKay	(c)			x							x				x		cf									
Pterygometopus callicephalus - (Hall)	(r)			x										x												
Thaleops ovatus ? - (Conrad)	(r)			x															cf						x	
Leperditia fabulites - Hall	(r)		x	x																					x	

formation, are rarely met with in this division. Other authors note an upper Receptaculite zone at the top of the Kimmswick, but this has been removed by erosion in this area.

Correlation : - The Kimmswick limestone was commonly correlated with the Galena of Illinois, and referred to Upper Trenton by older authors. This correlation was based mainly upon the abundant presence of Receptaculites oweni in both formations. Ulrich, who gave the name Kimmswick to the formation, is inclined to place it in the late Black River, mainly on the basis of two species of Camarocystites and one species of Echinosphaerites which occur in the Kimmswick in Missouri, and which are believed to be characteristic of Black River. Thirty four species are listed from the Kimmswick in Bassler s "Bibliography of the Ordovician and Silurian".

Very few detailed faunal lists have been published from the Kimmswick. Savage has given us a list from Illinois; Rowley has given us a combined Plattin-Kimmswick list from Pike County; and more recently Foerste has published a list from Ralls County.

The fauna from St. Louis County contains 12 of

the 47 species listed by Savage, 7 of those listed by Rowley, and 14 of the 45 listed by Foerste. Only 3 forms (R. oweni, D. pectonella, R. alternata) are common to all four faunas. Comparing the forms found in St. Louis County with range recorded for these forms elsewhere, we find that in the fauna of 30 species , 2 are ganeric only and two are too generally distributed to be of much value. Of the remaining 26, six are recorded as Black River or older, nine as common to Black River and Trenton, and eleven as Trenton or younger. Of the nine common to the Black River and Trenton, one does not go above the Prosser horizon; and of the eleven, which are Trenton or younger, three are restricted to the Prosser and one to the Audsville.

There is in this fauna a notable absence of such characteristic upper Trenton forms as Hormotoma major, Fusispira nobilis, etc., which characterize the Trenton of Pike and Ralls Counties. Ulrich claims that here the Trenton rests unconformably upon the Kimmswick, and Weller agrees with this. Ulrich is inclined to make the entire Kimmswick of Black River age, but in view of the many lower Trenton forms found in this fauna, it would seem as though a portion of the lower Trenton

(Curdsville and Prosser) should be included in it. No evidence of unconformity within the Kimmswick was noted by the writers in this area, and the formation may be traced almost continuously to the type locality at Kimmswick, 18 miles southeast. Such evidence as we have obtained seems to support the idea advanced by Dake, that the Kimmswick includes both Black River and Trenton, but we could not make it include all of the Trenton as he has done.[1] Apparently there is no formation south of the Missouri River that is the exact equivalent of the Upper Trenton of Pike County and elsewhere.

[1] Dake, C. L., op. cit. pp. 33 - 35, Pl. I

THE CINCINNATIAN SERIES

In this area, no rocks belonging to the Cincinnatian series were found. The Maquoketa-Thebes and Fernvale, though, if present to the Southeast, have been completely removed by the pre-Mississippian erosion periods.

POST ORDOVICIAN ROCKS

While it is not the purpose of this paper to enter into a detailed description of rocks of post-Ordovician age, it is believed that a brief note or two concerning them will not be out of place here.

MISSISSIPPIAN

Kinderhook --- In most instances, the Kimmswick is overlain by white to brownish sandstone about ten feet thick. This is rarely exposed except in vertical bluffs. In the Tavern Rock section, the lowermost two or three feet are conglomeritic, the pebbles of this conglomerate being largely limestone, and of a character quite unlike any of the previously described rocks. They are commonly less than a quarter of an inch in diameter, dark and well polished on the outer

surface. Overlying this sandstone are about three feet of bluish-gray, nodular, shaly limestone, and this in turn is followed by not less than twenty feet of yellowish brown, coarsely crystalline limestone. These beds are sparingly fossiliferous, but a few undoubted Mississippian forms occur in them. From their position beneath the Fern Glen and Burlington formations, they are assigned to the Kinderhook and probably represent the Sulphur Springs formation in this area.

Osage Group -- The Fern Glen formation is well exposed at its type locality, Fern Glen, on the Meramec River, in S.W. 1/4 sec. 15, T. 44 N., R. 4 E. It is not commonly exposed throughout this area, but in S.W. 1/4 of sec. 12, T. 44 N., R. 3 E., on the west side of the road running south from Grover, near the south line of the section, the characteristic red shale of this formation is well exposed. Beneath it are about 10 feet of pale pinkish limestone, which is doubtless the equivalent of the red limestone at the type locality. Very few fossils were found at this place. The Fern Glen is doubtless present wherever the succeeding Burlington is found, but is usually covered by the abundant chert float of the

overlying formation.

Good exposures of the Burlington limestone are rare, but its presence is indicated on all the higher hills by the great masses of highly fossiliferous, residual white chert. The Burlington (together with the Keokuk, which here is lithologically separate), is the most persistent and easily recognized Mississippian formation in this area. It is well over a hundred feet in thickness and is made up of a great series of limestone beds, which are packed with layers of white chert. The best exposures are along the Meramec River between Castlewood and Fern Glen. To the west, it overlaps with the Fern Glen, the Sulphur Springs formation, and rests on the Kimmswick and Decorah in the vicinity of Eureka, and on the Plattin and Joachim in the vicinity of Pacific. Farther west, small patches of it are found on even older formations.[1]

Mississippian rocks of younger age doubtless occur in this area, but have not been recognized. They are much better exposed farther east, and have been described by Fenneman.[2]

[1] Bridge, J., A Study of the Faunas of the Residual Mississippian Cherts of Phelps County (Central Ozark Region), Mo., Journal of Geology, vol. 25, no. 6, 1917.

[2] Fenneman, N. M., Geology and Mineral Resources of the St. Louis quadrangle, Bull. 438, U.S.G.S., 1911

PENNSYLVANIAN

A great portion of the high divide between the Meramec and Missouri rivers was found to be capped by the red Cherokee shales, the basal formation of the Pennsylvanian. These shales are rarely exposed at the surface, but may frequently be seen in clay pits, road cuts, etc. On the Manchester road, at the head of Fox Creek, a clay pit exposes about 60 feet of this formation. These shales are for the most part, a dark purplish red in color, and associated with them are occasional thin stringers of sandstone. They rest unconformably upon the Burlington.

TERTIARY

Overlying these Pennsylvanian shales in the area just mentioned, and capping several other high points on the divide, is a bed of gravel from 15 to 30 feet thick. The pebbles are of various sizes up to two and three inches in diameter, well rounded and polished, and representing many kinds of rock,

In one of these deposits, a piece of silicified wood, belonging to a tree closely allied to the oaks, was found. From this fact, and from their position on the hilltops, these gravel beds are referred to the Lafayette.

PLEISTOCENE

The Pleistocene ice invasion did not cross the Missouri River at this point, or, if it did, it retreated again and left but slight trace of itself. However, it did have ponding effect on the streams flowing northward, and along the lower courses of these can be seen terraces of silt which represent the filling of these ice-dammed waters. They are particularly noticeable in the valleys of Wildhorse and Big Tavern creeks.

REGISTER OF LOCALITIES

(see map in pocket)

1. Bluff on southeast side of Frisco tracks at bridge over Fox Creek, about 1 mile southwest of Allenton.

2. Cliff on east side of road at north end of bridge across Meramec River at Bald Hill Ford, sec. 12, T. 43 N., R. 3 E.

3. Divide on road between Eureka and Glencoe, NW. 1/4, sec. 25, T. 44 N., R. 3 E.

4. Nimms Station, Missouri Pacific Railroad, NW. 1/4, sec. 17, T. 44 N., R. 4 E. Quarry and bluff on east side of ravine.

5. Numerous quarries on creek in sec. 10, T. 44 N., R. 3 E.

6. Bluff at Tavern Rock, NE. 1/4, sec. 35, T. 45 N., R. 2 E.

7. In the railroad cuts immediately northeast and southwest of the station platform at Port Royal, center sec. 24, T. 45 N., R. 2 E.

8. Quarry southwest of depot at Centaur.

9. Railroad cut east of depot at Monarch.

10. Ledge at top of hill, 1 mile north of Pacific, near center sec. 1, T. 43 N., R. 2 E.

11. On west side of road and north side of Little Fox creek, near center sec. 36, T. 44 N., R. 2 E.

12. Head of a ravine, east half NE. 1/4, sec. 23, T. 44 N., R. 2 E.

13. On ridge top at road forks, and along hillside to the northwest, SE 1/4, sec. 16, T. 43 N., R. 4 E.

14. On southeast side of Bear Creek, near center sec. 34, T. 43 N., R. 4 E.

15. On northeast side of Heads Creek, about 1/4 mile southeast of House Springs, sec. 3, T. 42 N., R. 4 E.

16. On hillside on northeast side of first ravine, east of creek flowing through Pacific, Mo., not sectionalized, but about on center of what would be the line between sections 6 and 7, T. 43 N., R. 3 E.

17. Bluff at Castlewood, sec. 16, T. 44 N., R. 4 E.