

MINERAL RESOURCE
 RECORDS DIVISION
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 ILLINOIS STATE
 GEOLOGICAL SURVEY

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A REPORT ON THE GEOLOGY OF PARTS OF ST. CLAIR, MONROE,
AND RANDOLPH COUNTIES, ILLINOIS

Introduction

The Mississippian rocks in Illinois occupy three distinct areas along the western and southern borders of the state. The northernmost of these areas is the larger, and extends from southern Mercer County on the north, to northern Madison County on the south. Throughout this entire distance, except for an interval in Pike, Calhoun and Jersey Counties, where older rocks are exposed, the rock formations of the Mississippian series, constitute the Mississippi river bluffs. This area also includes the Mississippian strata which are exposed in the valley of the Illinois river as far north as Scott, Brown, and Schuyler Counties. Nowhere in this area do the higher formations of the series occur, the youngest formation exposed being the Ste. Genevieve limestone, in the summit of the bluffs at Alton.

The second of the three areas, occupies portions of St. Clair, Monroe, and Randolph Counties. This area includes about seventy miles of the Mississippi river bluffs, from a short distance below East St. Louis to about ten miles below the city of Chester, and at only one locality in this entire distance, at Valmeyer in Monroe County, are any formations older than the Mississippian exposed. The greatest width of this area is in Monroe County, where the formations under consideration form the surface rocks for a distance of about fifteen miles back from the river bluffs, before they pass beneath the Pennsylvanian strata. Within this area both the lower and upper Mississippian formations are present, and it includes the typical area of the Chester group, as these rocks were described by Hall and by Worthen, more than half a century ago.

The third area of the Mississippian rocks in Illinois is in the extreme southern portion of the state, where these formations constitute the surface rocks throughout a belt ranging from fifteen to thirty or more miles in width, from Union County on the west to Pope and Hardin Counties on the east. The greater portion of this area is occupied by the upper Mississippian rocks of Chester age, although the older formations occupy considerable areas in Union and Hardin Counties.

The present report is to deal with the second one of these areas. The field studies which are the basis for the report, have been prosecuted during three seasons, 1911, 1912, and 1913. The entire area has been examined in great detail, a detailed geological map has been made, careful studies of the structural and stratigraphic features have been prosecuted, as well as studies of the lithologic and paleontologic characters of the formations.

The whole of the area mapped is covered by a mantle of glacial drift and loess, and over considerable areas this mantle burys the underlying formations so deeply that no rock outcrops are exposed. In such portions of the area it has been necessary to generalize the mapping of the several formations on the basis of the actual exposures in the adjacent territory, the attitude of the strata, and the topography. It is of course recognized that the present topography, as modified by the drift mantle, may not conform with the topography of the underlying hard rock surface, and that in consequence the areal distribution of the formations in such regions is liable to inaccuracies directly proportional to the extent of the drift covered areas. An attempt has been made to differentiate between such generalized portions of the map and those portions which are established by actual outcrops, by indicating with a symbol the positions of the actual outcrops.

The rock outcrops within the territory mapped occur most commonly in the beds or in the banks of drainage channels. In some portions of the region, however, which are underlain by limestone, sink-holes are present in greater or less numbers, and not infrequently rock exposures are present in these depressions upon the uplands between the stream channels.

The present topography of the area, as modified by the drift and loess, does not conform closely, and is perhaps widely different from the preglacial topography. This lack in conformity of the present contour of the surface with that of the past is shown repeatedly in many of the stream beds, by the abrupt passage from a channel excavated from the hard rock, to a channel in which no rock outcrops are present, the banks and bed of the stream being entirely glacial drift. Fountain Creek, in Monroe County, perhaps exhibits such abrupt changes in the nature of its channel as well as any stream in the region, but scores of the smaller creeks and tributaries, as well as many of the larger streams, furnish examples of the same sort.

Structure

Dip and Strike. Throughout the greater portion of the area under consideration, the strata dip gently to the east with a strike of 10 to 15 degrees west of north. This dip is commonly less than one degree, too slight to be measured by clinometer except locally, and probably averages about 50 feet to the mile. This structure, however, is interrupted in several localities within the area by much more abrupt folding, and by some faulting.

Anticlines. Two anticlinal folds of importance are recognized within the area, besides other less conspicuous ones. The first of these may be designated as the Columbia Anticline, and the second as the Valmeyer Anticline.

The Columbia anticline extends from the Mississippi river bluffs just above Sugar Loaf School, at the extreme northern edge of our map, southwardly to a point a little beyond Waterloo. This anticline is asymmetrical, with a steeply dipping western limb, and very gently dipping eastern limb. The steepest dip recorded for the western limb is 55 degrees, at a point nearly opposite the plant of the Columbia Clay Works, about two miles south of Columbia, but dips of between 30 and 40 degrees are not infrequent. The dips of the eastern limb are rarely more than 2 degrees. The western limb is out off by a fault which continues from the river bluff at the north to within about two miles of Waterloo.

The Columbia anticline is naturally divided into two portions, the line of division being at about the south edge of the city of Columbia. North from Columbia the average strike of the beds, as determined from 42 observations, is between 19 and 20 degrees west of north, the strike becoming more westerly to the north where some of the readings are as much as 30 degrees west of north. South from Columbia the average strike of 48 observations is slightly over 12 degrees west of north, but when the southernmost 11 of these readings are disregarded the average strike is a little less than 10 degrees west of north. At the extreme southern end of the anticline the strike swings more westerly, the last observation being north 35 degrees west.

The northern portion of the anticline plunges to the south, while the southern portion is an elongate dome structure, plunging both to the north and to the south. At Columbia, and for about two miles north of the town, where the southerly and northerly plunging portions of the anticline meet, several more or less diagonal faults have been developed which cause the outcrops of the older formations exposed in the ravines which cut the axis of the fold, to be offset.

In the northern portion of the anticline the oldest formation exposed in the axis of the fold, is the Keokuk shale, which, in this locality, may be as young as the Warsaw formation of the Iowa section. These beds are well exposed in the hollow east from Sugar Loaf School, below the old cement mine, and in the largest tributary of the same hollow from the north. The same formation is undoubtedly present in the lower portion of the Mississippi river bluff about a quarter of a mile above Sugar Loaf School, but it is entirely covered by the talus.

Southward from Sugar Loaf hollow, to Columbia, the only two outcropping formations involved in the anticline are the Salem and St. Louis limestones, the Salem being exposed as isolated areas, sometimes very small, in the ravines which cross the axis of the fold.

The southern portion of the Columbia anticline extends from just east of Columbia to a point one and one-half miles, more or less, south of Waterloo, the southern extremity of the fold being hidden by a heavy covering of drift; its length is approximately 10 miles. In this elongate, dome-like portion of the fold, the oldest exposed rocks are the Burlington cherts, whose resistant character is responsible for the high, nearly north and south ridge between Columbia and Waterloo. Excellent exposures of the chert are present in the hollow in the southern portion of sec. 26, T. 1 S., R. 10 W., about one-half mile east of the plant of the Columbia Clay Works. In the next three hollows south from the one mentioned, all situated in sec. 35 of the same township, other excellent exposures of the chert are present, but beyond this the hard rocks are more heavily drift covered, and only a few outcrops are exposed, the last one being in the southern part of sec. 11, T. 2 S., R. 10 W. Beyond this point the southerly plunge of the anticline carries the chert beneath the superjacent Keokuk formation. In the

more southern of these chert outcrops the rock exhibits an extreme degree of weathering, the condition being comparable to that in the non-glaciated portion of southern Missouri, where the same cherts occur and give origin to a conspicuous chert and red clay residuum. This much weathered condition is especially well exhibited in the hollow heading near the center of sec. 11, T. 2 S., R. 10 W., and running southwest.

Immediately east of Columbia, in the northwardly plunging portion of this anticline, the Keokuk is the oldest formation outcropping in the axes of the fold. Good exposures of these shale beds are to be seen in the hollow followed by the railroad spur, immediately east of Columbia, and in the large tributary of the same hollow entering from the north, this area being isolated and entirely surrounded by the Salem limestone. In the upper part of the valley of Wilson Creek and its tributaries, a half mile south of the last mentioned exposures, is another somewhat larger isolated area of Keokuk strata marking the axis of the anticline. Still a third, much smaller isolated Keokuk outcrop marks the axis of the fold in a small hollow in the extreme northeast corner of sec. 27, T. 1. S., R. 10 W. South of this locality the Keokuk is again well exposed in the hollow immediately west of Shoemaker School, and from here to Waterloo it forms a continuous band around the Burlington chert. The most southern occurrence of the Keokuk noted in this area, is in a well dug at the creamery at Waterloo. These Keokuk outcrops are entirely surrounded by the Salem limestone, and the Salem, in turn, is surrounded by the St. Louis limestone. Along the western limb, steeply dipping Ste. Genevieve and also lower Chester beds are involved in the anticlinal folding.

The Valmeyer anticline, the second of the two more important anticlinal folds in the region here described, extends from the Mississippi river bluffs at Salt Lick Point, just above Valmeyer, in a southeastwardly direction. Like

the Columbia anticline this is an asymmetrical fold, with steeply dipping beds in the southwestern limb, and very gently dipping beds to the northeast. At no point, however, do the beds dip so steeply as in the Columbia anticline, the steepest dip recorded being 33 degrees. Only rarely do the dips exceed 25 degrees, and in general they range between 15 and 25 degrees. Unlike the Columbia anticline, this fold is not limited by a fault along its steeply dipping face.

The strike of the Valmeyer anticline is much more westerly than that of the Columbia fold, the average of 82 readings being north, 48 degrees west. It plunges to the southeast and can be easily recognized in all the ravines crossing its axis to a point a little south of east from Mayestown, about eight miles from Salt Lick Point.

The oldest formations exposed in the area covered by our map, are present in the axis of the Valmeyer anticline in the bluff at Salt Lick Point. Three formations of Ordovician age, the Plattin limestone, the Kimmswick limestone, and the Maquoketa shale, outcrop at this locality. The Plattin is exposed at a single point, only its uppermost two or three feet can be seen for a few yards at the base of the bluff. Good exposures of the Kimmswick and Maquoketa occur in the face of the bluff, also in the hollow back of Salt Lick Point, and in Dennis hollow. In two of the ravines between Dennis hollow and Schaeffer hollow, the Maquoketa is again exposed in small isolated areas in the axis of the fold, and in the upper part of Schaeffer hollow there is exposed a small area of the red Fern Glen formation where the stream has cut into the axis of the anticline. From this point southeastwardly the plunging of the anticline causes isolated areas of the Burlington chert, the Keokuk formation, and the Salem limestone to be successively exposed in the ravines which cross the anticline, the whole being finally surrounded by the St. Louis limestone.

Minor anticlines. In a small hollow lying mostly in the n.w. $\frac{1}{4}$ of n.e. $\frac{1}{4}$ sec. 4, T. 1 S., R 9 W., one and one-half miles north of Millstadt, minor folding and perhaps faulting are exhibited. The formation involved is chiefly the Yankeetown, although the underlying Renault is also exposed. The deformation at this locality is very limited in its extent, and no evidence of it has been detected outside of a restricted area confined almost entirely to one 40 acre tract. Both limbs of a narrow anticlinal fold in the Yankeetown are exhibited, with a strike of 10 degrees east of north, and with dips as high as 60 degrees. About 600 feet west are other Yankeetown exposures with north and south strike, dipping 25 degrees to the west, and with the subjacent Renault sandstone exposed. If this more western outcrop is a part of a second narrow anticline, its eastern limb is not exposed. It is more probable, however, that a fault is present between the two exposures, and that the more western one exhibits an upthrown portion of the western limb of the same anticline which is exposed a little further east.

Still another fold of minor importance is present north of Bremen in Randolph County, and may be designated as the Bremen anticline. The strike of this fold is north 70 degrees east, and the northwardly dipping strata of the northern limb are well exposed in the short ravine tributary to Little Marks River from the east, in the s.w. $\frac{1}{4}$ of sec. 22, T. 6 S., R. 6 W., about one and one-half miles northeast of the village of Bremen. The axis of this anticline is situated just south of the above mentioned ravine, the southerly dipping beds of the southern limb being exposed in the valley of the tributary to Little Marys River which enters the main stream from the east in n.e. $\frac{1}{4}$ sec. 28, T. 6 S., R. 6 W. This fold is somewhat asymmetrical, the northern limb exhibiting dips as high as 6 degrees, while the dip of the beds in the southern limb does not exceed 2 degrees.

The importance of the Bremen anticline in its eastern extension is not known, since the detailed mapping has not been extended in that direction, but to the westward the fold dies out probably within a mile.

The Pre-Pennsylvanian Unconformity

The lack of conformity between the Pennsylvanian and the underlying Mississippian formations, in the area which has been mapped, is exhibited by the overlap of the younger formation upon the successively older formations of the Chester Group in following the Pennsylvanian boundary from the south to the north; by the accumulation of conspicuous conglomerate beds in the basal portion of the Pennsylvanian in many localities; and by the uneven character of the Mississippian floor upon which the Pennsylvanian sediments have been deposited.

In those portions of the region where the Chester formation immediately underlying the Pennsylvanian is a limestone, it is comparatively easy to determine the position of the boundary line between the two formations, but where the Pennsylvanian sandstone rests directly upon a sandstone formation of Chester age, it is difficult, in many localities to determine the location of the boundary with entire satisfaction. The Chester sandstone strata which are most difficult to differentiate from the Pennsylvanian are found in the Palestine and Renault formations. Wherever the sandstone outcrops are extensive it is usually possible to differentiate the formations by means of their lithologic characters, but in small, isolated exposures it is sometimes impossible to determine whether a sandstone is Pennsylvanian or a member of one of the Chester formations.

Conglomerates are locally present at or near the base of the Pennsylvanian sandstones. They vary much in character and include pebbles derived from the Mississippian formations of the immediately adjacent region, as well as pebbles

from other sources. Good exhibitions of Pennsylvanian conglomerates may be seen in Breman township of Randolph County, in sections 15 and 22, T. 6 S., R. 6 W., and in the two sections immediately west of these. Again the basal portion of the Pennsylvanian, in its southwestward extension to the Mississippi river bluffs two miles below Fort Gage, is conspicuously conglomeratic at many points. Such conglomerates are well exposed in s.e. $\frac{1}{4}$ sec. 33, T. 6 S., R. 7 W., in the valley running northeast, tributary to one of the branches of Gravel creek. It is also exposed in the northern part of sec. 4, T. 7 S., R. 7 W., in the head of the ravine leading to Fort Gage; in the head of the ravine just north of Oak Ridge school, and in the heads of two ravines a little southwest of the same school, are other exposures.

Northward from the localities already mentioned, the conglomeratic facies of the base of the Pennsylvanian is inconspicuous in the outcrops, except very locally, until some of the tributaries of Prairie du Long creek are reached, in Monroe and St. Clair counties. Good exposures of the conglomerate may be seen in s.e. $\frac{1}{4}$, n.e. $\frac{1}{4}$ sec. 23, T. 3 S., R. 9 W., a little over one mile northeast of Poe Station. Other good exposures are present in s.e. $\frac{1}{4}$, n.e. $\frac{1}{4}$ sec. 1, T. 3 S., R. 9 W., in the little valley just west of Blackburn school. One of the best exposures of the Pennsylvanian conglomerate in the entire region is in the north half of s.w. $\frac{1}{4}$ sec. 11, T. 2 S., R. 9 W., in the bank of Prairie du Long creek one-half mile west of Floraville; at this locality most of the pebbles seem to have been derived from the Yankeetown formation. About two miles up the valley of Prairie du Long creek from the last locality, in n.w. $\frac{1}{4}$ s.w. $\frac{1}{4}$ sec. 3, T. 1 S., R. 9 W., are other good exposures of the same conglomerate.

The inlying areas of Mississippian strata, east of the Mississippian-Pennsylvanian boundary, which have been exposed by stream erosion through the superjacent Pennsylvanian strata, sufficiently demonstrate the uneven nature of the floor upon which the Pennsylvanian rocks were deposited. Such inliers are present at a number of points in the valleys of several of the streams in southwestern St. Clair County. The older strata exposed in this manner are all members of the Chester Group, although several formations are represented, and an observation of these isolated areas again shows the unconformities overlap of the Pennsylvanian, since in passing from west to east the formations exposed are successively younger members of the Chester Group.

The strong relief which must have existed in the pre-Pennsylvanian topography, at least locally, is shown by a well boring at Baldwin, in northern Randolph County. The Okaw limestone is well exposed in several of the tributaries of the Okaw river east of Baldwin, at an elevation of 400 feet above sea level. In Baldwin, scarcely one and one-half miles east of these outcrops, a well has penetrated 340 feet in the Pennsylvanian, a thin bed of coal being penetrated at 325 feet, and another much thicker bed at 300 feet. The difference of elevation between Baldwin and the outcrops west of town is not over 60 feet, so there must be a drop of at least 280 feet in the pre-Pennsylvanian surface in a distance less than one and one-half miles. Such an abrupt descent is of course suggestive of faulting, and such may be the explanation of it, although there is no confirmatory evidence.

STRATIGRAPHY

The hard rocks which underly the almost universal mantle of glacial drift and loess in the region under consideration, consist of sedimentary limestones, sandstones, and shales, of various textures and lithologic characters, and for the most part marine in origin. The actual surface outcrops of the strata are confined almost entirely to the Mississippi river bluffs, and to the beds and banks of many of the streams in the area, which have cut their channels through the covering of mantle rock to the hard rocks beneath. These hard rocks were deposited in three distinct geological periods, separated from each other by long time intervals, during which our area was above sea level in such a position that no deposition of sedimentary rocks was possible, and during which the rocks already formed were subjected to erosive agencies. The three geologic periods represented are the Ordovician, the Mississippian, and the Pennsylvanian.

Ordovician System

The rocks of the Ordovician System, deposited during the Ordovician time period, have a very limited geographic distribution, near Valmeyer, occupying less than one square mile, and being confined chiefly to sec. 3, T. 2 S., R. 11 W. These older rocks have been elevated at this point in the axis of the Valmeyer anticline, and have become exposed at the surface because of the deep erosion of the Mississippi River valley, and some of its tributary ravines, notably Dennis hollow and another short ravine between Dennis hollow and Salt Lick Point. If the Columbia anticline, between Columbia and Waterloo had been penetrated as deeply by stream erosion as the Valmeyer anticline has been in Dennis hollow, the same formations, and perhaps even others lower in the stratigraphic series, would be exposed.

The Ordovician rocks, as exposed, have a total thickness of about 195 feet. They fall into four distinct formations, the Plattin limestone, the Kimmswick limestone, the Fernvale limestone, and the Maquoketa shale, all of which are well exposed in and above the old railroad quarry, in the point of the bluff near Valmeyer. The section exhibited at this locality is as follows:

- 5. Limestone, red, argillaceous, with chert bands.
 Fern Glen limestone of Mississippian age 23 feet
- 4. Shale, buff and greenish in color, with nodular
 bands. Largely talus covered. Maquoketa shale 80 "
- 3. Limestone, cherty and impure, brown to nearly
 white in color. Fernvale limestone 4 "
- 2. Limestone, white, crystalline, heavy bedded, generally
 free from chert. Kimmswick limestone 110 "
- 1. Limestone, dark gray in color, close textured.
 Plattin limestone, exposed,..... 2-3 "

Plattin limestone. Only the top-most portion of this formation is exposed in the base of the bluff just above the Valmeyer quarry. The outcrop can be seen only for a few yards, and even this exposure can be easily overlooked because of the growth of vegetation. The formation has a much greater extent west of the Mississippi river in Missouri, it having been named from typical exposures along Plattin creek, in Jefferson County, Missouri. No fossils have been secured

Ulrich, Mo. Bureau Geol. and Mines, vol. 2, 2nd ser., p. 111.

from the single exposure near Valmeyer, although the formation is abundantly

fossiliferous at many localities in Missouri, but its lithologic characters are so different from the overlying Kimmswick limestone that it can be easily distinguished.

Kimmswick limestone. The Kimmswick limestone is the quarry rock in the Valmeyer quarry, where a little over 100 feet are exposed. The exposure continues northeastwardly in the bluff for about three-fourths of a mile, at which point the gentle northeasterly dip carries the formation beneath the surface. Good exposures are also present in the ravines lying back of the ridge in whose western face the Valmeyer quarry has been opened, and again in Dennis hollow nearly east of Valmeyer.

This limestone was named by Ulrich from the typical exposures in the neighbor-

Mo. Bureau Geol. and Mines, vol. 2, 2nd ser., p. 111.

hood of Kimmswick, Jefferson County, Missouri. The formation has a wide distribution in the Mississippi valley, there being more or less extensive exposures in Ralls, Pike, Lincoln, St. Louis, Jefferson, Ste. Genevieve, Perry and Cape Girardeau counties, Missouri. Its exposures east of the Mississippi are much more limited, being restricted to Calhoun, Monroe, and Alexander Counties, Illinois, all of which are much less in extent than the exposures in the Missouri localities.

Throughout the entire extent of its outcrops in Missouri and Illinois, the Kimmswick limestone is very uniform in its lithologic characters, the exposures near Valmeyer being no exception. It is a very pure, light colored, often nearly white, sometimes flesh-colored, crystalline limestone, usually nearly or quite free from chert. The quarry at Valmeyer a single band only, about three feet in thickness, above the middle of the quarry face, contains concretionary bands of chert. At no other locality observed is there as much chert, even, as that noted in the Valmeyer quarry. At several localities in Missouri, notably at Glen Park,

Jefferson County, and Glencoe, St. Louis County, the Kimmswick limestone is extensively utilized for the manufacture of lime, for which purpose it is well adapted.

The fossil fauna of the Kimmswick limestone is large, varied, and highly interesting, although it has never yet been thoroughly studied, and contains many undescribed species. No attempt has been made to secure a full collection of the fossils from Valmeyer, but the following species have been recognized in a collection from the lime quarries at Glen Park, Missouri.

One of the most notable members of the fauna is Receptaculites oweni, which is almost always present in abundance in the upper portion of the formation. Indeed, this species is so conspicuous a fossil in the Kimmswick limestone that Shumard used the name Receptaculite limestone to designate the formation, in his

Rep. Geol. Surv. Mo., 1855-1871, pp. 265, 282, 297, 306.

reports upon Jefferson, Ste. Genevieve, Perry, and Cape Girardeau counties, Missouri. This fossil, sometimes called the "sun-flower coral," attains a diameter of six or eight inches in large specimens. Many examples of it may be seen in the upper portion of the Valmeyer quarry, and also in the road through Dennis hollow.

In the earliest attempt at the correlation of the Kimmswick limestone, by Shumard in 1855, the formation was said to probably "represent the "lead bearing"

1st and 2nd Repts., Geol. Surv. Mo., pt. 2, p. 142.

or Galena limestone of Iowa, Wisconsin and Illinois, although the mass in the two districts differs essentially in lithologic appearance." The basis for this correlation was "the occurrence of the same species of Receptaculites" in the two formations. Both of these formations was further correlated with the Trenton

of the New York section. He says "while there is a marked lithological difference in Iowa and Wisconsin, as well as in Missouri, between the rocks of recognized Trenton age and the so-called Galena Limestone, we have, as yet, but little paleontological evidence for separating them into distinct groups." After some further discussion of the evidence, the same author continues "For these reasons I have thought it best, for the present, to include our Receptaculite beds in the Trenton limestone."

In a later report, Shumard expresses a change of opinion concerning the

Rep. Geol. Surv. Mo., 1855-1871, p. 266.

correlation of the Receptaculite limestone, and places it in the "Hudson River Group." "This view is based upon the fact that its most characteristic fossils are Hudson River species." It is altogether probable that one reason for this correlation with Ordovician strata in the New York section younger than the Trenton was that the Fernvale limestone was not differentiated from the subjacent limestone, to which alone, the name Kimmswick is now applied.

The latest statement concerning the correlation of the Kimmswick limestone is by Ulrich, who places it, in a correlation table of the Ordovician formations

Bull. Geol. Soc. Amer., vol. 22, pl. 27, facing p. 608.

of North America, below the Trenton, at the top of the Black River stage, and this correlation is doubtless the best that can be arrived at with our present knowledge of the fauna and its geographic distribution.

Fernvale limestone. Resting upon the Kimmswick limestone in the Valmeyer quarry, is a thin bed of impure, more or less cherty, limestone, usually brownish in color, which was never separated from the underlying rock by the earlier geologists. In his definition of the Kimmswick limestone, however, Ulrich

Mo. Bur. Geol. and Mines, vol. 2, ser. 2, p. 111.

especially excludes this bed from the formation, noting the fact that it is characterized by the Fernvale fauna of the Richmond or uppermost division of the Ordovician, which is considered by some authors to be even Silurian in age.

Ulrich, Bull. Geol. Soc. Amer., vol. 22, pl. 28, facing p. 608.

Bassler, Bull. U. S. Nat. Mus., No. 77, p. 25.

The total thickness of the Fernvale bed in the Valmeyer quarry section is only about one foot, and it rarely exceeds two or three feet anywhere in the Mississippi valley, and is locally even less than one foot. The formation is so thin that it is commonly obscured by the wash from the soft overlying Maquoketa shale, except in especially favorable situations. The Valmeyer quarry is the only locality in our area where the formation has been seen, although it may be looked for in Dennis hollow and in the hollows between Dennis and Salt Lick Point, anywhere that the basal contact of the Maquoketa is met with.

As in the case of the Kimmswick limestone, this Fernvale bed has a much wider distribution west of the Mississippi river in Missouri, than in Illinois. It has not been observed by the writer, however, north of Jefferson County, Missouri, although it is probably present in St. Louis County. In Calhoun County Illinois, the formation seems to be absent, the Maquoketa shale resting directly upon the Kimmswick limestone. The presence or absence of the formation in the more northern Missouri localities, in Pike and Ralls Counties, is not known. The formation is known to occur in Jefferson, Ste. Genevieve, and Cape Girardeau Counties, and is probably present also in Perry County, Missouri. It is probably coextensive with the Kimmswick limestone throughout this area, although it is commonly hidden except where the actual contact at the base of the Maquoketa can be seen.

In its relations with the Kimmswick limestone the Fernvale is unconformable although this lack of conformity is obscure when observed in isolated sections, and was entirely overlooked by Shumard in his early studies in Missouri. When careful observations are made at different localities, however, it is seen that the Fernvale bed does not always rest upon the same member of the Kimmswick limestone. This relation is especially well exhibited in a series of sections in Jefferson County, Missouri, from just below Kimmswick, southward to beyond Glen Park. Towards Kimmswick the higher beds of the Kimmswick limestone are wanting and the Fernvale rests upon beds which are stratigraphically older than the conspicuous Receptaculites zone at the top of the formation. Higher and higher Kimmswick limestone beds are present in the section as it is followed southward until, at a locality a short distance beyond Glen Park, the Receptaculites zone is fully developed.

This Kimmswick-Fernvale unconformity indicates that dry land conditions prevailed in our area for a long period of time subsequent to the deposition of the Kimmswick limestone, during which period the greater portion of the middle Ordovician and most or all of the upper Ordovician rocks were deposited in the eastern part of North America. In fact the presence of this unconformity, which is widespread in its distribution, is one of the reasons advanced for the separation of the Fernvale, Maquoketa, and other Richmond formations from the Ordovician, and for their inclusion in the Silurian period.

Jour. Geol., vol. 15, pp. 519-525.

The Fauna of the Fernvale is totally different from that of the Kimmswick limestone, the most characteristic index fossil being Rhynchotrema capax. A list of the species which have been collected from the formation at the Valmeyer

quarry, is as follows:-

The Fernvale formation was originally described by Hayes and Ulrich from the Columbia quadrangle of Tennessee, where it includes shale and limestone strata.

Geol. Atlas of U. S., Columbia Folio, p. 2.

Its thickness in that region is said by these authors to range from nothing to 40 feet, the average being less than 20 feet. The correlation of the formation in the Mississippi valley was first made by Ulrich.

Mo. Bureau Geol. and Mines, vol. 2, ser. 2, p. 111.

Maquoketa shale. On the face of the Mississippi river bluff extending north-east from the Valmeyer quarry, there is a conspicuous slope covered with vegetation, lying between the nearly vertical escarpment of Kimmswick limestone below and the still more conspicuous escarpment of Mississippian rocks above. This slope is underlain by the Maquoketa shale, and the topographic expression is what it is because of the presence of this soft stratum between the two resistant formations. The thickness of the formation at this locality is approximately 80 feet, and it probably does not vary much from this thickness throughout the area of its outcrop in Monroe County.

Because of its lithologic character, good exposures of the Maquoketa are rarely met with, but as usually seen in its upper portion, it is a fine, olive green, argillaceous shale, nearly or quite free from grit of any sort. Good exposures near the summit of the formation occur at about the mid-length of Dennis hollow, on the road from Waterloo to Valmeyer. The basal portion of the formation, just above its contact with the Fernvale, is exposed in the bluff a few rods above the Valmeyer quarry. At this locality the formation is yellow or buff in color, and is a more or less granular, shaly dolomite rather than an argillaceous shale,

some of the beds, for two or three inches or more in thickness, being quite dense and hard.

The characteristic basal Maquoketa fauna, which has been recorded from many localities in northwestern Illinois and the adjacent portions of Wisconsin and Iowa, consisting mostly of diminutive pelecypods, is well developed at the locality above the Valmeyer quarry. The shells are found washed out on the bank and are also in place in a bed a few inches thick, about one foot above the Fernvale limestone contact. This bed contains, besides the little shells, numerous irregular nodules, brownish in color, from a quarter of an inch in diameter down, which are apparently phosphatic in character. The fossil species which have been collected from this locality are as follows:-

Schizocrania sp.

Plactambonites cf. sericea (Sow.)

Zygospira ? sp.

Ctenodonta sp.

Cleidophorus neglectus Hall.

Archinacella sp.

Scenella sp.

Lophospira sp.

Liospira micula (Hall).

Hormotoma ? sp.

Holopea sp.

Orthoceras sp.

Aside from the Mississippi river bluff, Dennis Hollow, and the hollows between Dennis and Salt Lick Point, where the Maquoketa occurs in association with the underlying Fernvale and Kimmswick limestones, the formation outcrops in the first hollow intersecting the bluff above Salt Lick Point, whose mouth is in the S.W.

1/4 of sec. 35, T. 2 S., R. 11 W. At this locality none of the lower formations are exposed, the dip of the strata having carried them below the surface, but a good exposure of the Maquoketa may be seen in the bank of the stream a short distance from the mouth of the ravine. The total thickness of beds exposed at this point is about ten or twelve feet. The lower half of the exposure consists of ashen gray, soft shales, with conspicuous nodular bands. The nodules in these bands are probably dolomitic in character, they are flattened or more or less lenticular in form, usually two or three inches in thickness, and may be a foot or more in width, they occur along the bedding planes with shale intervals between of a few inches to a foot in thickness. Above these nodular layers the formation consists of yellow or greenish shale without the nodules. Along the horizon separating these two layers fossils are somewhat common, they occur through about two or three feet of strata including the summit of the nodular layer and the basal portion of the upper bed. Fragments of bryozoa are the most common, but several branchiopods are also present. A list of the species which have identified from this locality is as follows:-

Dalmanella cf. testudinaria

Dinorthis subquadrata

Strophomena sp. undet. (small transverse form.)

Strophomena sp. undet. (large form.)

Rafinesquina sp. undet. cf. R. unicostata

Scenidium sp. undet.

Parastrophia divergens Halland Clarke.

Rhynchotrema capax (Conrad.)

Corynotrypa inflata (Hall.)

Ceramopora granulosa Ulrich.

Prasopora n. sp.

Prasopora n. sp.

Aspidopora ? sp.

Bythopora n. sp.

Hemiphragma imperfectum

Diplotrypa n. sp. ?

Anaphragma mirabile Ulrich and Bassler.

Two other outcrops of the Maquoketa occur within our area. The first of these is in the long ravine next south of Dennis Hollow, a little less than one mile from its mouth. This exposure is less than one-fourth of a mile in length where the erosion of the ravine has cut through the higher formations in the axis of the Valmeyer anticline. Not more than about four feet of shales are exposed at any one point in the creek bank, although there must be present about thirty feet altogether beneath the base of the overlying Mississippian. At one point in the creek bank, at this locality, a thin bed of brown sandstone is present, one or two inches in thickness, which is filled with irregular, brownish nodules, probably phosphatic in composition. Most of the shales, where well exposed here, are very thin and evenly bedded, graptolites are abundant in some horizons, some of the beds being so filled with them as to be almost black. The only species which has been identified is Diplograptus peosta (Hall).

The last Maquoketa locality is in the north branch of Schaeffer Hollow, about one mile from the river bluff. The area of outcrop at this locality is even smaller than the last, and like that one, it is uncovered by the erosion of the ravine across the axis of the Valmeyer anticline. No clean-cut exposures of the shale are present, although the characteristic greenish mud, due to the

disintegration of this formation, is clearly exhibited at one point in the creek bank. Not over ten feet in thickness of the shale can be present in this ravine beneath the base of the overlying Mississippian.

MISSISSIPPIAN

Pre-Mississippian Unconformity. The basal contact of the Mississippian upon the older rocks is exposed within the area under consideration, only in the Valmeyer anticline, and in this region the only formation with which the Mississippian comes in contact, is the Maquoketa shale of the Ordovician, the entire series of Silurian and Devonian formations being absent. This hiatus represents an enormously long period of time, probably equivalent to from one-fifth to one-third of the whole of the Paleozoic, during which the area was above sea level, or at least in such an attitude that no sediments could be deposited, or it received sediments during a portion of the time which were later raised above sea level and removed by erosion before the beginning of Mississippian time. During this enormously long lapse of time the older rocks were subjected to no notable deformation, since the stratification of the younger rocks is essentially parallel with that of the older sediments, the deformation which is recognized in the area being of much younger age, involving as it does, both the older and the younger formations equally.

Although the surface outcrops do not indicate that any rocks of Silurian or Devonian age were ever present in the region, there is some indication of strata lying between the Mississippian and the Ordovician in certain deep well sections. In the Gilster well at Chester the base of the Mississippian can be certainly recognized in the 29 feet of red Fern Glen rock, at a depth of from 1656 to 1685 feet. Beneath this horizon there are 390 feet of variously colored limestones before a conspicuous shale stratum, 95 feet in thickness, is reached

This shale is believed to be the Maquoketa, in which case the 390 feet of limestone must represent either or both the Silurian and Devonian.

In the Hergenroder well No. 1, sunk about two miles east of Waterloo, 70 feet of white limestone is present beneath the red Fern Glen, separating it from 105 feet of light colored shale which is doubtless the Maquoketa. This white limestone can only be Silurian or Devonian.

From these records it would appear that either Silurian or Devonian formations, or perhaps both, may have been deposited throughout the region, which were later entirely eroded in a part of the area before the beginning of Mississippian time.

The Maquoketa shale which lies immediately beneath the Mississippian where this contact is exposed in surface outcrop, is so soft and nonresistant, that it could scarcely have remained as nearly unchanged as it seems to be, during the enormous interval from the time of its deposition to the beginning of the Mississippian, under any conditions which are conceivable. This unchanged condition of the Maquoketa shale, therefore, would suggest that it had been buried beneath younger formations during the greater portion of the interval represented by the great pre-Mississippian unconformity, and that it had been exposed for only a comparatively short time immediately preceding the initial Mississippian sedimentation.

Subdivisions of the Mississippian. The total thickness of the Mississippian rocks in the region, is approximately 1650 feet, as shown in the Gilster well at Chester, which starts in the uppermost formation of the series and penetrates 2737 feet, into formations much older than the Mississippian, the base of the Mississippian being at the depth of 1685 feet. In this total 1650 feet, many

distinct formations are recognized, having different lithologic characters, some of them being conformable one upon the other, and others being separated by unconformities of greater or less importance. In general the lower half, or somewhat more than half, is made up of limestones of varying characters, sometimes with large amounts of chert. The upper division includes sandstones, limestones and shales, and is much less uniform in its lithologic character than the lower division. No distinctive name for the combined formations of the lower division has ever been used, but the upper division commonly has been known for many years as the Chester group.

The several formations of the Mississippian which have been mapped in the Randolph-Monroe County area, and the grouping of these formations in the manner which seems to best facilitate their interpretations, are shown in the following table.

Kinkaid
Degonia
Clore formation.
Palestine formation.
Menard formation.
Okaw formation,
Chester
Group Cypress formation.
 Paint Creek formation
 Yankeetown formation,
 Ranault formation.
 Aux Vases sandstone.

Ste. Genevieve limestone.

Meramec St. Louis limestone.
Group Salem limestone

Osage Warsaw formation.
Group Keokuk limestone
 Burlington limestone.

Kinderhook Fern Glen formation.
Group

KINDERHOOK GROUP

Fern Glen formation.- The basal formation in the Mississippian system in our region, is the Fern Glen, This formation is largely limestone, although in many localities it is more or less argillaceous, and in its upper portion it includes much chert in regular horizontal bands, which are either more or less detached concretionary masses, lenticular in form, or solid continuous bands varying in thickness up to ten or twelve inches. A characteristic feature of the formation in its type locality, Fern Glen, St. Louis County, Missouri, and also in the Monroe County, Illinois, localities, is its deep red color, which grades upward in most localities, into greenish beds. This coloration of the formation is clearly primary, that is it is not due to the effects of weathering at or near the surface, since the same characteristic red color is present when the formation is encountered in deep well drilling. In the Gilster well at Chester red limestone and shale, undoubtedly the Fern Glen, occurs at a depth of 1656 feet and continues for 29 feet. In the Hergenroder well, two miles east of Waterloo, the red Fern Glen is first recognized at a depth of 795 feet, and apparently continues for 60 feet.

The thickness of the Fern Glen, as exposed in its surface outcrops, is usually about thirty feet, but because of the absence of any sharp line of demarkation between it and the superjacent formation, it is not always easy to locate its upper limit. In the deep well at Chester 29 feet of the red shale and limestone are reported, but in the Hergenroder well east of Waterloo, 60 feet are recorded.

The surface exposures of the Fern Glen are entirely limited to the Valmeyer anticline. Except where covered with talus, a continuous outcrop of the formation is present, in all the ravines and in the face of the bluff, from the south side

of Dennis Hollow east of Valmeyer. At the latter point the dip of the strata carries the formation beneath the level of the flood plane of the Mississippi river. Only three other isolated outcrops of the formation occur within our area. These are along the axis of the Valmeyer anticline, where erosion in three of the ravines southeast of Dennis Hollow has cut entirely through the overlying formations. The largest of these exposures lies mostly in n.w. 1/4 of s.w. 1/4 sec. 11, T. 3 S., R. 11 W., extending for a short distance to the west into the adjacent section 10. This outcrop is present in both banks of the ravine and has an extreme length of about one-fourth of a mile, entirely surrounding a small area of Maquoketa shale which marks the crest of the anticline. In the next ravine, a tributary of Schaeffer Hollow, to the south-east, and for most part limited to the s.e. 1/4 of s.w. 1/4, sec. 11, T. 3 S., R. 11 W., a similar but smaller outcrop of Fern Glen occurs, which also surrounds a small area of Maquoketa. The last exposure of the formation occurs in the upper part of Schaeffer Hollow, in the n.e. 1/4 of n.e. 1/4 sec. 14, T. 3 S., R. 11 W. This outcrop is a very small one, about one-eighth of a mile in length and since the erosion in this ravine has not progressed far enough to uncover the underlying Maquoketa, it is the oldest rock exposed in the axis of the anticline.

The recognition of the Fern Glen in the deep well sections at Chester and again east of Waterloo, indicates that in all probability the formation is present throughout the entire area of our map, beneath the younger formations.

Paleontology.— The fauna of the Fern Glen has been fully described in another place¹, and although more recent studies have added little new to the

¹ Bull. Geol. Soc. Amer., vol. 20, pp. 265-332, plates 10-15 (1909)

fauna, the identification of several of the species has been modified. This original study of the fauna was based upon material which was for the most part collected at Fern Glen and near Kimmswick, Missouri, localities outside of the area under immediate consideration here, although a collection from outcrops at Salt Lick Point, above the Valmeyer quarry, and also at hand at the same time. None of the Monroe outcrops are abundantly fossiliferous, the best locality being that at Salt Lick Point, but a few species can be found at nearly every locality. The complete fauna of the Fern Glen, as it is now known both from the Missouri localities and those in Monroe County, is as follows:

Cyathaxonia arcuata Weller.

C. minor Weller.

Amplexus rugosus Weller.

A. brevis Weller.

Zaphrentis cliffordana Milne-Edwards and Haime.

Z. wortheni Weller.

Beaumontia americana Weller.

Favosites valmeyerensis Weller.

Cladoconchus americanus Weller.

Monilopora crassa (McCoy).

Palaeacis depressus (Meek and Worthen).

P. bifidus Weller.

Synbathocrinus dentatus Owen and Shumard.

Poteriocrinus macropleurus (Hall).

Poteriocrinus sp.

Barycrinus sp.

Coeliocrinus sp.

Graphiocrinus sampsoni Weller.

Platycrinus stellatus Weller.

P. springeri Weller.

Rhodocrinus punctatus Weller.

Agaricocrinus praecurosor Rowley.

Lobocrinus pistilliformis (Meek and Worthen).

Actinocrinus rubra Weller.

Physetocrinus smalleyi Weller.

Mespilocrinus sp.

Metichthyocrinus sp.

Pentremites decussatus Shumard.

Fistulipora fernglenensis Weller.

Chilotrypa americana (Miller).

Cystodictya lineata Ulrich.

Evactinopora sexradiata Meek and Worthen/

Crania missouriensis Weller.

Leptaena analoga (Phillips)/

Schuchertella rubra Weller.

S. fernglenensis Weller.

Rhipidomella jerseyensis Weller.

R. sp.

Schizophoria poststriatula Weller.

Chonetes multicosta Winchell.

C. logani Norwood and Pratten.

Productus fernglenensis Weller.

P. sampsoni Weller.

Camarophoria bisinuata (Rowley)

Rhynchopora persinuata (Winchell).

Spirifer vernonensis Swallow.

S. rowleyi Weller.

S. chouteauensis Weller.

S. fernglenensis Weller.

Spirifereilla plenus (Hall).

Delthyris novamexicanus (Miller).

Spiriferina subtexta White.

Cyrtina burlingtenensis Rowley.

Pseudosyrinx sampsoni Weller.

Athyris lamellosa (L'evaille).

Cliothyridina obmaxima (McChesney).

C. fernglenensis Weller.

C. prouti (Swallow).

Ptychospira sexplicata (White and Whitfield).

Hustedia circularis (Miller).

Dielasma fernglenensis Weller.

Deltopecten fernglenensis Weller.

Conocardium sp.

Platyceras paralius White and whitfield.

Orthoceras sp.

Cyrtoceras sp.

Proetus fernglenensis Weller.

BURLINGTON LIMESTONE.

The characteristically red Fern Glen formation passes into the superjacent Burlington with no sharp line of demarkation. The red color disappears and the chert layers begin at about the same horizon, but whether the basal line of the Burlington should be placed beneath the lowermost chert, or whether some portion of the cherty beds should be included in the Fern Glen is an open question. In the mapping of the formations the basal line of the Burlington has been uniformly placed about 30 feet above the base of the Mississippian.

In the southeastern Iowa, where the Burlington limestone has its typical development, a maximum thickness of about 150 feet has been recorded,¹ the upper

Keys, Iowa Geol. Surv., vol. 3, pl. 28, opposite p. 330 (1895).

most 30 to 50 feet being conspicuously cherty in character, and forming the resistant beds which have been the cause of the development of rapids in the Mississippi river above Keokuk. In the southern extension of the Burlington limestone the chert inclusions become a more and more conspicuous feature of the formation, until in Monroe County, Illinois, it is made up of chert in very large part. Excellent exposures of the formation may be seen in Dennis Hollow where the thickness of the chert beds is approximately 100 feet. The chert occurs in exceedingly irregular and knotty layers, parallel with the bedding planes of the formation and varying in thickness up to 10 or 12 inches. Sandwiched between the chert beds are layers of limestone, the proportional amounts of limestone and chert varying somewhat from place to place, the limestone rarely or never making up more than 50%, and in places probably constituting as little as 20% of the entire mass of the formation. In the weathered outcrops of this formation, the limestone constituent has been more or less completely removed by solution, and the chert has broken down in angular fragments which cover the hill

slopes. The limestone layers of the formation are commonly very pure, light colored calcium carbonate, often nearly white. The texture of the limestone layers varies from dense to somewhat coarsely crystalline, the more crystalline beds being made up more or less entirely of the fragmentary remains of crinoids. The chert layers are most commonly light gray in color, becoming nearly white in places. Their texture is dense, and at no locality has the porous chert filled with cavities from which fossils have been dissolved, such as occurs in many other localities in the Mississippi valley, been observed in Monroe County.

Origin of the Chert. The limestones constituting the Osage group are always conspicuously cherty, wherever they occur throughout the entire Mississippi valley region, extending into northern Arkansas and to Alabama. In Arkansas these beds have been named the Boone Chert¹, and the name Boone has been very extensively

1

used in Arkansas, southwestern Missouri and Oklahoma. In Tennessee and Alabama the name Fort Payne Chert has been used for beds of approximately the same age. The origin of the vast amount of silica which has entered into the composition of these cherts, is a question which seems never to have been satisfactorily solved. Appeal has been made to the agency of silica secreting organisms, such as sponges, but if sponges had been present in these ancient seas in the enormous numbers requisite for the secretion of this vast amount of silica, it is only reasonable to suppose that they would have left some evidence of their existence, as fossils, but not a single fossil sponge is known to the writer from these beds. That the silica was an original part of the formation, though perhaps not in its present form, seems to be a necessary conclusion. If it has been introduced into the limestone formation from some outside source, some distortion of the limestone layers around the chert masses might be looked for, but no such structures

have ever been observed by the writer. If cavities had been formed in the limestone by solution, and later been filled with silica from some outside source, an almost impossible conception, the line of demarkation between the chert and limestone should be very sharp in all cases, but such is not the case. In many cases a graduation from pure chert to pure limestone may be observed, without any demarkation, and fossil shells are sometimes found which are half calcareous and half siliceous. Nevertheless there seems to be abundant evidence that the chert, in its present condition, is secondary, and that it had assumed its present condition at a time when the limestone had not only become thoroughly consolidated, but after it had become crystalline, essentially the condition in which it is now found. In many places, though not in Monroe County, the silicification of the matrix in which fossils are buried, has become complete, while the fossils themselves, mainly fragments of crinoid stems, have not been changed. When such beds have been subjected to the influence of percolating ground waters, the calcareous fossils have been removed by solution, and there remains a more or less porous chert. In certain porous cherts of this sort, exceedingly thin diaphragms of silica may be observed, crossing the cavities left by the solution of the crinoid stems. These diaphragms have exactly the position of the cleavage planes of calcite, and must therefore have been formed subsequently to the crystallization of the original calcium carbonate of the fossil. The presence of such diaphragms may be explained by assuming that the rock strata, while in their original consolidated and crystalline condition, were subjected to some slight strain, sufficient to cause the fracture of some of the crystal forms, and to produce slight openings along some of their cleavage planes. Subsequently, during the silicification of the matrix surrounding the crystalline fossils, these thin cavities along the cleavage planes were filled with silica, and have remained after the final solution of the calcite fossils.

From what has been set forth, it seems clear that we must assume that the siliceous material constituting the chert masses must have been an original part of the formation, although its present condition is secondary, and furthermore that some ultimate source, other than ~~the~~ silica secreting organisms, must be appealed to.

At the present time all streams entering the sea carry silica in solution or suspension, which is precipitated in the colloidal condition on contact with the ocean water. Unless this colloidal silica is disposed of in some other manner, it must become mingled with the accumulating sediments. In the case of the limestones in question, large quantities of silica must have been supplied by the streams flowing into the sea occupying the Mississippi valley basin, while the clastic sediments being carried into the same basin were limited in amount, the accumulating sediments being in large part organic. The resulting formation, under such conditions, would be a limestone with large quantities of silica disseminated through it, which later in the history of the formation has become segregated into the chert bands and nodules as we observe it.

As has already been pointed out, the secondary accumulation ~~of~~ the silica has taken place subsequent to the consolidation of the formation and the crystallization of its calcium carbonate, and there is some evidence to suggest that this change has taken place only at or near the surface, that it is essentially a weathering process. The reason for such a supposition is, that in certain deep wells which have penetrated these Mississippian limestones, which are conspicuously cherty in their surface exposures, the records show no chert bands whatever, but do show silica finely disseminated through the limestone.

Field observations to be made on the Burlington

Re-examine the Dennis Hollow section and sections in ravines to the north. Get thickness more accurately and search for fossils.

Section in hollow between Dennis Hollow and Valmeyer quarry bluff.

5. Pleistocene.
4. Chert and limestone, Burlington 80 feet.
3. Limestone, red in color, somewhat argillaceous, with some chert. Fern Glen 20 "
2. Shale, olive-green or yellowish, weathering into a plastic clay. Maquoketa or Thebes 70 "
1. Limestone, crystalline, nearly white or slightly pinkish in color. Kimmswick limestone 120 "

WARSAW FORMATION

Succeeding the chert and limestone series which represents the Burlington and Keokuk formations of the upper Mississippi Valley, there is in St. Clair and Monroe Counties, a formation consisting of argillaceous and calcareous shales with intercalated limestone beds of greater or less thickness. This formation is best exposed in immediate association with the Columbia and Valmeyer anticlines. The northernmost exposures of the formation is in sec. 33, T. 1 N., R. 10 W., in the valley whose mouth is just south of Sugar Loaf School. This exposure, which is the only one observed in St. Clair County, is entirely surrounded by younger formations, being uncovered by the erosion across the axis of the northern portion of the Columbia anticline.

A section of the beds exposed in this Sugar Loaf Hollow, is as follows:

- 13. Limestone, light colored, mostly gray or brownish, more or less granular and crystalline in texture, occurring in thick and thin beds with some shaly and magnesian partings.
Salem limestone 33 feet.
- 12. Dolomite, blue-gray in color, homogeneous, fine-grained and gritty in texture. This rock was formerly extensively mined for cement rock , , 8 "
- 11. Limestone, thin-bedded 3 "
- 10. Limestone, filled with specimens of Spirifer washingtonensis 1 "

9. Limestone, thin-bedded ,.....	2 feet
8. Limestone with many fossils	0 " 6 in.
W 249.	
7. Shales and thin-bedded limestone	2 " 6 in.
6. Limestone, fossiliferous	1 "
W 248.	
5. Shale, buff or blue in color, with some lenses or thin bands of limestone	11 "
4. Shale, buff colored, calcareous, fossiliferous	2 "
W 247.	
3. Shale, buff or blue in color, with thin beds and lenses of limestone	8 "
2. Limestone, thin and irregularly-bedded, with layers of shale. Fossiliferous	2 "
W 246.	
1. Shale, blue and buff in color, fossiliferous	4 "
W 245.	

In this section the total thickness of the formation is not exposed, only the upper portion being uncovered. Bed 13 is unquestionably the Salem limestone, and the cement bed and underlying limestone, beds 12 and 11, may also be included in that formation in all probability, although there is no discontinuity in the sedimentation from the lower beds to the higher ones.

Under the deep talus covering of the northwesterly face in Mississippi river bluff, about one-fourth mile north of Sugar Loaf School, these same Warsaw shales must be present, but the formation is entirely covered at the present time.

Another area in which the Warsaw is the surface formation, is present in the Wilson Creek, valley immediately east of Columbia, up which a railroad spur has been built, and in the tributary to this valley from the north. In size this area about equals the one near Sugar Loaf School, and like it, it has been exposed by the erosion across the axis of the Columbia anticline, and is entirely surrounded by younger formations. No detailed section of the strata has been made in this valley, but the beds and their contained fossils are similar to those of Sugar Loaf hollow.

In the next valley south of Wilson Creek, in sections 22 and 23, T. 1 S., R. 10 W., an area of Warsaw shales ~~some~~ larger than the last is present, also exposed by the erosion across the axis of the Columbia anticline. Still another small, isolated area of the formation is exposed in a small ravine in the extreme northeast corner of section 27, T. 1. S., R. 10 W.

Beyond the last mentioned exposure, ~~in~~ southward direction, the Warsaw is continuously present upon the flanks of the elongate, dome-like portion of the Columbia anticline. At the north it occupies the greater portion of the valley heading near Shoemaker school, and also the tributary to this valley a little more than one-half mile further south, although in this tributary the erosion across the axis of the anticline has progressed so far that a narrow strip of the underlying chert formation has been exposed for a short distance. Along the western, steeply dipping flank of the anticline the formation is exposed, and in places well exposed, in nearly all the stream valleys which cross it, but the eastern flank is more heavily drift covered, and the stream erosion is much less deep, in consequence of which exposures are rare. At a number of points the blue clay of the Warsaw is reported in well records, and the character of the wash in some of the streams is indicative of the same

blue clay shale, but no really good exposure has been observed. The southernmost occurrence of the formation in the Columbia anticline is in a well excavation at the creamery in Waterloo, where some of the characteristic fossiliferous limestone from near the summit of the formation has been penetrated.

Throughout this area, the Warsaw strata most commonly met with are some of the limestone beds near the summit of the formation characterized by the abundance of the fossil branchipod, Spirifer washingtonensis, this Spirifer bed being one of the best horizon markers in the entire sub-Chester portion of the Mississippian in this region. The shales which comprise the major, lower portion of the formation, are so non-resistant in character that they are actually exposed only in especially favorable situations.

The outcrops of Warsaw associated with the Valmeyer anticline are first exposed in the short valleys intersecting the Mississippi river bluff in sec. 25, T. 2 S., R. 11 W., about three and one-half miles northeast of Valmeyer. The formation undoubtedly occurs in the base of the river bluffs in this same section, but the deep talus covers any exposures which may ever have existed here. From these northernmost exposures the gentle dip of the strata upon the northeastern limb of the Valmeyer anticline, carries the Warsaw strata to a higher elevation in a southwest direction. Good Warsaw exposures, distributed through the entire thickness of the formation are present in the two-headed hollow in sections 35 and 36, T. 2 S., R. 11 W. The lower portion consists for the most part of blue shales but in the upper portion limestone beds carrying the characteristic fauna with Spirifer washingtonensis, are met with. In this region this Spirifer bed is just as characteristic as in the outcrops associated with the Columbia anticline, but here another species, Productus magnus, is more commonly associated with the Spirifer, sometimes in the same bed, but more commonly it is best represented in a limestone horizon a few feet

beneath the Spirifer bed. The two species together, however, S. washingtonensis and P. magnus, characterize a very distinct faunal zone.

In the next ravine southwest of the two-headed one last mentioned, the Warsaw shales are again well exposed, and the formation covers the hill between this ravine and the one whose mouth is in the southwest corner of the same section. In this immediate region, where the Warsaw shales constitute the underlying rock over a considerable upland surface, the presence of the formation is shown by the extreme development of land-slide topography, due to the plasticity of the shales when wet, although most of the formation is buried beneath a thick mantle of loess.

In a southeasterly direction the formation occupies a sinuous belt around the heads of the ravines leading down to the Mississippi river bottoms, resting upon the underlying chert beds. The Valmeyer anticline, however, plunges to the southeast, and about two and one half miles southeast of Valmeyer this belt swings across the axis of the anticline and joins the narrower belt upon the more steeply dipping southwestern limb of the anticline. Still further to the southeast the Warsaw occupies the central portion of the anticline, although isolated areas of the underlying chert, of considerable size, are exposed in the valleys, which have been uncovered by the erosion of the streams across the axis of the anticline. This continuous area of Warsaw continues to the ravine tributary to Monroe City hollow, just northwest of Madonnaville. Beyond Maddonnaville only two small, isolated areas of Warsaw, both in sec. 19, T. 3 S., R. 10 W., in two ravines tributary to Monroe City hollow, where the formation is exposed by the erosion across the axis of the anticline.

In this entire Valmeyer anticline area of the Warsaw, the portion of the formation which is most commonly exposed, is the upper, more calcareous portion which is characterized throughout the area by the abundance of examples of

Spirifer washingtonensis and Productus magnus. Because of their non-resistant character, the shale beds which constitute the mass of the formation, are well exposed in only a few localities. The highly resistant chert beds, however which are superjacent to the Warsaw, almost everywhere furnish an abundance of outcrops in the area underlain by them, so that the limits of the formation are rather sharply marked in most localities by the chert beds beneath, and by the Spirifer-Productus beds just below the top. Not uncommonly, also, the position of the formation is indicated by the topographic features of the surface, even where no actual outcrops can be detected. Such a locality may be seen in the face of the bluff east of Valmeyer, just below the mouth of Dennis Hollow, where the position of the steeply dipping shale beds is indicated by a distinct depression of the surface, although it is entirely talus covered. This depression is much more clearly seen when viewed from a little distance, and although it is clearly discernible at a time when the vegetation is in full leaf, it is better defined after the leaves have fallen.

The lithologic characters of the Warsaw formations in the Valmeyer anticline outcrops is perhaps as well exhibited in the Dennis Hollow section as in any other, where the following succession of beds has been determined.

- ? Limestone, bluish-gray, crystalline, with shaly partings. Exposed in wagon road. The Spirifer washingtonensis bed ? feet
- 9. Shale, soft, bluish in color 12 "
- 8. Limestone, gray, crystalline, with many fossils. The Productus magnus bed 2 "

7. Shale, bluish in color, with some calcareous
bands and lenses 17 feet
6. Shale, bluish, filled with bryozoans 1 "
W 502.
5. Shale, blue in color, without grit, weathering
to a plastic clay 19 "
W 503.
4. Limestone, bluish-gray in color, crystalline,
with shaly bands, only slightly cherty 11 "
W 505.
W 506.
3. Chert beds, with some limestone intercalated 100 "
2. Limestone, reddish in color, somewhat argil-
laceous in part, with bands of chert in upper
portion. Fern Glen formation 25 "
1. Shale, olive-green, becoming plastic clay when
mixed with water. Thebes

Although this section in Dennis Hollow differs in its details from that in the Sugar Loaf Hollow, already recorded, the general composition of the formation in the two localities is the same, and the difference are probably no greater than would be recognized in any two similar sections of the formation taken at similar distances apart.

Southwest of the Valmeyer anticline the Warsaw is again exposed at a number of points along the Mississippi river bluffs, and in some of the tributary valleys and ravines intersecting the bluffs. Immediately southwest of the anticline the rock strata are folded in a very shallow synclinal trough, and at a distance of a mile or a mile and one-half from the axis of the anticline, the

beds are dipping gently to the northeast. This structure brings the upper part of the Warsaw formation to the surface again in the lower portion of Monroe City Hollow and its tributaries, the outcrop extending to a distance of three-fourths of a mile from the river bluff in the main valley. Excellent exposures of the higher limestone beds of the formation, with Spirifer washingtonensis and Productus magnus, are present in some of the ravines, especially in the forked ravine whose mouth is just above the mouth of Monroe City Hollow, and in the larger one of the tributaries of the Monroe City Hollow from the south. The Warsaw continues as the underlying formation in the lower portion of the bluff to the south of Mayestown Hollow. Good exposures of the Spirifer bed are present in the upper portion of the short ravine about half way between Monroe City and Mayestown Hollows, and limited exposures of the same bed may be seen close to the mouth of Mayestown Hollow, but along the bluff the presence of the formation is indicated only by the topographic features. Above the mouth of Monroe City Hollow, and again below the mouth of Mayestown Hollow, the river bluffs rise above the talus slope in abrupt escarpments, but between these two points abrupt bluffs are not present because of the nonresistant character of the soft Warsaw shales which have broken down and have formed a longer and more gentle slope of the surface.

Still further to the southeast, for a distance of between three and four miles along the river bluffs, just west and southwest of the village of Renault, the Warsaw formation again appears above the level of the Mississippian bottom. The first appearance of the beds in this area is in the mouth of a sort ravine, one mile below Fultz Hollow, where only the Spirifer bed is exposed. In the next small hollow, one-half mile further southeast, the uppermost beds of the Warsaw are again exposed, but not until the three larger ravines southwest of Renault,

whose mouths are situated in sec. 36, T. 4 S., R. 10 W., and in the extreme northeastern corner of the adjacent section 1 to the south, does the formation exhibit any conspicuous exposures. At the mouths of these hollows and in the points of the hills between, a thickness of from 80 to 100 feet of Warsaw beds is present, and the outcrops continue up the ravines for a distance of one-half to three-fourths of a mile.

No further exposures of the Warsaw formation are present upon the Illinois side of the Mississippi River, but in Ste. Genevieve County, Missouri, in a direction essentially following the strike of the beds in Illinois, the formation is again exposed, and bears the same characteristic fossil zones, especially the Spirifer washingtonensis and Productus magnus zone.

SALEM LIMESTONE

The dividing line between the Warsaw formation below and the Salem limestone above, lies within a few feet of the conspicuous Spirifer bed near the summit of the Warsaw. This line is marked by no break in the sedimentation although the transition from the lower to the higher formation is accomplished within a very few feet.

In its areal distribution the Salem occurs in two rather distinct regions, associated with the Columbia and Valmeyer anticlines. In the northern portion of the Columbia anticline a considerable area of Salem limestone occupies the axial portion of the fold. In the section already described from the Sugar Loaf School hollow, beds 11, 12, and 13 may be considered as constituting the lower portion of the formation, though bed No. 13 is its most typical expression at this point. No fossils have been observed in the cement bed, No. 12, so there is no paleontological evidence for placing it either in the Warsaw or the Salem, and no especial violation of the paleontological data would be done in placing bed No. 11 in either of

the formations. The fact remains that the dividing line is very near to the horizon of the cement bed, and if that bed were a continuous one, possible of recognition throughout the entire area, it might well be adopted as the marker of the dividing line.

In the region adjacent to Sugar Loaf School, the Salem limestone occurs in the Mississippi river bluff north of the school, in the several branches of the two stream valleys which join at a point about two-tenths of a mile south of the school, and in the hill separating these two valleys. In this portion of the Columbia anticline the fold is plunging to the south, and in that direction the Salem is exposed in smaller and smaller, isolated areas, along the axis of the anticline, where the stream valleys have been eroded across it, the size of the isolated area being dependent upon the depth of the valleys.

Just east of Columbia, at the northern extremity of the elongate, dome-like portion of the anticline, an area underlain by the Salem limestone originates, which is continuous around the entire dome-like structure. At the north, for a distance of two and one-half miles it occupies the axial portion of the fold, enclosing some isolated areas of the subjacent Warsaw which have been uncovered by the erosion of the stream valleys. Beyond the point indicated the formation continues on either side of the anticline, a narrow belt along the steeply dipping western flank, and a broader belt along the more gently dipping eastern flank of the fold. Good exposures of the formation are present in most of the stream valleys which lead away from the dome to the east and to the west, although continuous exposures are not always present because of the heavy mantle of drift which is present. From Waterloo south the Salem limestone again occupies the axial portion of the fold, but actual outcrops are almost wanting because of the heavy drift covering, and the actual extent of the area underlain by the formation in that direction can only be estimated. The main portion of the city of Waterloo is underlain by the Salem, and exposures of the formation may be seen in the

cellar of the brewery in the center of the city. The formation has also been penetrated at a number of excavations for wells and cisterns.

In the more northern portion of the Valmeyer anticline the Salem limestone is present upon both limbs of the fold. On the northeastern limb the gentle northeasterly dip of the beds carries the outcrops of the formation to a distance of five miles or more from the axis of the anticline, along the Mississippi river Bluff, and in the valley of Bond Creek, before it disappears beneath the next younger formation. In the area drained by the several heads of Bond Creek actual rock outcrops are few because of the deep covering of drift, but all of those met with are of Salem limestone, and the formation must underlie a belt two and one-half miles in width. Beyond this drainage area the belt of Salem becomes much narrower to Madonnaville, and from Madonnaville to the southeast it occupies the axis of the fold to a point one and one-half miles southeast of Mayestown, beyond which the anticlinal structures is no further evident. Upon the steeply dipping southwestern limb of the Valmeyer anticline there is a narrow, continuous belt of Salem from the Mississippi river bluff east of Valmeyer, to Madonnaville, where the belts upon the two sides of the anticline are joined across the axis of the fold. The dip of these beds changes, however, and becomes nearly horizontal within a distance of about one-half mile from the axis, and within little more than one mile the dip is reversed and the beds dip gently to the northeast. Because of this structure the outcrops of the Salem limestone continue along the sides and beds of the valleys leading westward and southwestward to the Mississippi river bluffs, and in the tributaries of these valleys, and are also present in the lower portion of the bluff itself for a distance of two miles below Valmeyer. Towards the mouth of Monroe City Hollow, however, the underlying Warsaw formation is brought to the surface, and the entire thickness of the Salem is exposed and occupies a higher position in the bluffs.

In the extension of the outcrops in a southeasterly direction, along the river bluffs, the Salem limestone is continuously present to a point less than one mile above Prairie du Rocher. Throughout the greater portion of this distance it is the lowest formation exposed in the bluffs, but from Monroe City Hollow to Mayestown Hollow, and again for a short distance north of Renault Station the underlying Warsaw rises above the level of the river bottoms. In the valleys intersecting the bluffs along the entire extent of these outcrops, good Salem exposures are present, and in some of the deeper valleys the formation has been uncovered to a distance of nearly two miles back from the river bluffs. In Mayestown Hollow the Salem limestone is exposed to the southwestern edge of the village of Mayestown, and in Fultz Hollow it extends back nearly as far.

Note on Salem-St. Louis contact.

Ulrich records Pentremites cavus n.sp., P. conoideus, Lithostrotion ? proliferum, and plates of Melonites and Archaeocidaris in lower St. Louis limestone, 4 miles northwest of Princeton, Ky. These beds are doubtless the same as those we have commonly placed at summit of Salem limestone. A bed which is conspicuously marked by echinoid remains is present in many localities in Monroe County, Illinois, and Ste. Genevieve County, Missouri, and at some localities Pentremites and Lithostrotion are also present.

(See Ulrich, P.P. 36, p. 57.)

Ulrich says, "plates like these and the preceding found with Lithostrotion ? proliferum and Pentremites cavus are always to be accepted as reliable indications of the lower half of the St. Louis limestone."

(Ulrich, P.P., 36, p. 34).

ST. LOUIS LIMESTONE

The St. Louis limestone underlies a much larger area within the region under discussion, than any of the formations which have been previously described. In St. Clair County excellent exposures may be seen in the Mississippi river bluffs, from Stolle, where the beds have been extensively quarried, to the intersection of the Columbia anticline with the bluffs. This area has undoubtedly been continuous, at one time, with the typical occurrence of the formation in the city of St. Louis to the northwest, although the continuity is now interrupted by the broad Mississippi river bottoms. Southward from Stolle the formation occupies a belt varying between one and three miles in width, to Burksville, where it joins with a broader belt to the west. The Stolle-Burksville belt includes the Columbia anticline in which some older formations are exposed, but the St. Louis limestone entirely surrounds all these older beds. A small isolated patch of St. Louis limestone is exposed east of the belt just described, in s.e. 1/4 sec. 31, T. 1 N., R. 9 W., in the bed of Hickman Creek, where the erosion of this stream has cut through the younger formations for the distance of about one-half mile.

For a distance of four or more miles below the intersection of the faulted western limb of the Columbia anticline and the river bluff, near Sugar Loaf School, the St. Louis limestone is not exposed in the bluff sections, but beyond this point the summit of the formation appears from beneath the younger beds. It continues to rise higher and higher in the bluffs towards the Valmeyer anticline, and for a mile or more on either side of Fountain Gap, it constitutes the entire exposure in the bluffs. For three and one-half miles below Fountain Gap the St. Louis limestone continues to constitute the more conspicuous upper portion of the bluffs, but beyond this its area of outcrop swings back from the bluffs because of the rising of the beds upon the northwestern limb of the anticline, and its place is taken by older formations. The southwestern extension

of the Fountain Gap belt occupies a large portion of the area between the Columbia and Valmeyer anticlines.

South of the Valmeyer anticline the St. Louis limestone again becomes a conspicuous formation in the Mississippi river bluff sections, and is almost continuously exposed for a distance of twenty miles, or more, to a point below Prairie du Rocher, the last exposure being present near the mouth of Barbers Hollow, two miles below Prairie du Rocher. In the more northern portion of this belt, between Monroe City Hollow and Dennis Hollow, the formation occurs in isolated areas capping the higher portions of the hills, and entirely surrounded by the younger Salem limestone. South of Monroe City Hollow, however, the area underlain by the St. Louis limestone is continuous, and is connected around the southern extremity of the Valmeyer anticline with the belt which extends southward from the river bluffs above and below Fountain Gap.

Lithologic characters. Throughout the entire extent of the St. Louis limestone as outlined above, the lithologic characters are quite uniform in their general features. The formation is in the main a light colored, gray, bluish gray, or in places nearly white limestone, deposited in even beds varying in thickness from a few inches to several feet, except in rare cases where some cross-bedding is developed. Greenish, shaly partings are present between some of the beds, and in some localities shaly limestone beds several feet in thickness are present. In general the limestone is dense, compact, and fine textured, some beds being nearly as fine grained as a lithographic stone. Most of the beds are hard and brittle, and break with conchoidal or splintery fracture. Locally there are beds which are more crystalline than common. The formation contains some chert which is very hard and brittle, and is commonly nearly white or bluish-white in color. The chert occurs in more or less continuous horizontal bands, or in horizontal bands of lenticular masses which are sharply defined from the

surrounding limestone. Some of the cherts are highly fossiliferous. The chert content of the formation is far less conspicuous than in the Burlington formation, and in many places considerable thicknesses of limestone are present in which no chert whatsoever is present. Locally some beds of the St. Louis limestone, especially in the lower portion of the formation, have become dolomitized, such beds commonly being of a light buff color.

Further north certain beds of the St. Louis limestone are distinctly brecciated. In the Mississippi river bluffs above Alton, Illinois, such a brecciated bed, twelve to fifteen feet thick, constitutes a conspicuous member near the middle of the formation, and Fenneman¹ has recorded similar structures in

¹ Bull. U. S. Geol. Surv., No. 438, p.24 ().

the outcrops of the formation in and near the city of St. Louis, although none of the beds in St. Louis is believed to be a continuation of the bed above Alton. In the region under consideration in this report, no such brecciated beds have been observed. No large portion of the St. Louis limestone is at all oolitic in character, although there are, in rare cases, some beds which seem to belong in this formation, which are distinctly oolitic. Both the formations below and above the St. Louis are conspicuously oolitic in many of their beds, and such beds as have been observed, which may belong in the St. Louis, occur near the top of the formation in such situations that it is not always possible to be sure, in the absence of fossils, as to which formation they are members of.

The Ste. Genevieve limestone was first named by Shumard from Ste.

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Trans. St. Louis Acad. Sci., vol. 1, p. 406 (1859); also Mo. Geol. Surv., Rept. for 1855-1871, p. 293 (1873).

Genevieve, Missouri, near which place the typical exposures of the formation occur in the Mississippi river bluff, beginning a mile or two below the town and continuing almost uninterruptedly to the mouth of Aux Vases creek. In the papers containing the original usage of the name, the Ste. Genevieve limestone was reported to occur in two Illinois localities. The first of these was said to be "a short distance above Prairie du Rocher," but unless there is an error in the published statement, with the word above substituted for below, the author of the name was mistaken in his determination. Above Prairie du Rocher for a long distance, only the St. Louis and Salem limestones are exposed, but below the town good beds of true Ste. Genevieve limestone are present beneath the overlying sandstone, and it is altogether probable that it was these beds that were seen by Shumard. The second Illinois locality mentioned by Shumard, is said to be "below the mouth of Mary's River, where they contain a large Pentremite." This pentremite is said to be P. obesus Lyon, and the beds containing it are said to be surmounted by 80 feet of ferruginous sandstone. During the recent work of the Survey, such a pentremite bed, in the same situation as regards the overlying sandstone, has been observed about two and one-half miles below the mouth of Mary's River, which is believed to be the same locality as that referred to by Shumard, but instead of being a member of the Ste. Genevieve limestone, this pentremite bed proves to belong in the Clore limestone, at the extreme top of the Chester Group, and the sandstone above it is Pennsylvanian in age rather than basal Chester, as is the case both below Ste. Genevieve and below Prairie du Rocher.

The best exhibition of the Ste. Genevieve limestone in Illinois is in the basin of Fountain Creek, southwest of Waterloo, Monroe County, where it is even better exhibited than in the bluffs below Ste. Genevieve, the typical locality. Good exposures of the formation are present in the base of the Mississippi river bluffs from just below the gap of Hill Lake Creek, about one mile north of Millstadt Junction, to about one-half mile below the mouth of Carr Creek, where the top of the St. Louis limestone appears beneath the Ste. Genevieve. From this last point the formation is more or less continuously exposed in the bluff sections for a distance of two and one-half miles, beyond which the boundary line between the Ste. Genevieve and the St. Louis swings back from the river bluffs. The belt of Ste. Genevieve limestone to which these bluff outcrops belong, varies in width from more than one mile to one-half mile or less, and continues in a southeasterly direction across Andy's Creek and along the east side of Fountain Creek to Fountain Creek School. Beyond this point the belt becomes much broader and occupies the entire Fountain Creek basin for a distance of two miles, beyond which it is again restricted to the east side of the creek, and continues to near Burkeville, beyond which locality no exposures have been observed. Extending northward from the broad belt occupying the Fountain Creek basin between Fountain Creek School and Waterloo, there is a narrow belt of Ste. Genevieve, with exposures at intervals along the western, steeply dipping limb of the Columbia anticline, separated from the much broader belt further west, by an area of younger formations.

A second district underlain by the Ste. Genevieve limestone, occurs in St. Clair County, east of the Columbia anticline. This area constitutes a belt from one-half to one mile wide, beginning two and one-half miles east of Columbia, and extending in a nearly north direction, probably to the gap of Prairie du Pont

Creek east of Stolle, although no rock outcrops occur in the last one and one-half miles of the Prairie du Pont valley. In the southern part of this area, one-half mile west of Rodemich, the outcrops of the Ste. Genevieve limestone occur only in some of the numerous sink holes, and such sink-hole outcrops continue northward through nearly the whole of this belt. From near the southeast corner of sec. 36, T.1N., R. 10W., and continuing for nearly a mile along the creek in the eastern portion of that section, good Ste. Genevieve outcrops are present more or less continuously.

East of the belt just described, the Ste. Genevieve limestone is again exposed in the bed of Hickman Creek, from near the middle of sec. 7, T. 1S., R. 9 W., northward to within one-half mile of its junction with Prairie du Pont Creek.

The Ste. Genevieve limestone is again exposed in northwestern Randolph and southwestern Monroe Counties, in a belt continuing from the n.e. 1/4 sec. 4, T. 5 S., R. 9W., in a nearly southerly direction to the Mississippi river bluffs below Prairie du Rocher. Good exposures are present between the St. Louis limestone and the overlying Chester, in the several tributaries of Prairie du Rocher creek, and again in the same stratigraphic position in the bluffs for about a mile below Prairie du Rocher, but nowhere in this belt is the formation so well exhibited as it is in the Fountain Creek basin.

In the area colored as St. Louis limestone, lying between Renault and Burksville, the Ste. Genevieve may be present in patches, which could be determined only through a systematic search for outcrops in all the sink-holes which are so numerous in that region. The examinations which have been made have shown that at some points at least, no Ste. Genevieve is present, and the Chester formations rest directly upon the St. Louis limestone.

Lithologic characters. The greater portion of the Ste. Genevieve formation is limestone, which in some of its features resembles the St. Louis. The two formations are commonly similar in color, being light-gray or bluish-gray, although the Ste. Genevieve locally has a purple or greenish coloration, especially along some of the bedding planes, a type of coloration which has nowhere been observed in the St. Louis limestone, at least in the region here under discussion. The St. Louis limestone is nearly everywhere very evenly bedded, and while the Ste. Genevieve is similarly bedded in many places, it also includes some of the most remarkable cross-bedded limestones anywhere to be met with in the Mississippi valley. In like manner the St. Louis limestone is commonly free from oolitic beds, while in the Ste. Genevieve such beds are conspicuously developed. To such extent is this last character a feature of the formation, that in the absence of fossils the presence of oolitic limestone has commonly been taken as being indicative of the Ste. Genevieve limestone in the prosecution of the geologic mapping of the region. There are, however, considerable limestone beds in the formation which are neither oolitic or crossbedded, such beds commonly being more or less coarsely crystalline limestone. Nowhere in the formation are close-textured, dense, and almost lithographic limestones, such as are commonly met with in the St. Louis, at all conspicuous in the Ste. Genevieve. Another feature of the Ste. Genevieve limestone differentiating it from the St. Louis in many localities, is the present of a considerable content of arenaceous material in the form of sand grains disseminated throughout the limestone. Locally a much cross-bedded, fine-grained sandstone member is present in the formation, with limestone both above and below it, such a member being well developed on Andy's Creek, three and one-half miles northwest of Waterloo, in n.e. 1/4 sec. 16, T. 2 S., R. 10 W., and elsewhere. In most places the formation is quite free from chert, but in its lower portion there are rather persistent bands of conspicuous, red chert, which have been observed in many different localities. It has not been established with entire

satisfaction that similar red chert beds are not present, at least locally, in the higher beds of the St. Louis limestone, but in any event such beds are restricted to a comparatively narrow horizon, and are believed to be near the base of the Ste. Genevieve in nearly all localities.

One of the best exhibitions of the Ste. Genevieve limestone, is in the valley of Fountain Creek, southwest of Waterloo, where the following succession of beds, starting from the stone bridge at Fountain Creek School and continuing up the stream for about one mile, may be seen.

9. Limestone, oolitic, white 5 feet.
8. Limestone, conspicuously arenaceous, and oolitic,
with a prolific fossil fauna 17 "
W 182.
7. Shale, a discontinuous bed, red, purple or
green in color, highly fossiliferous locally 14 "
W 181
6. Limestone, semi-oolitic, more or less cross-
bedded 5 "
5. Shale, calcareous in composition and greenish
in color, not continuously present 1 "
4. Limestone, thick or thin bedded, dense in
texture, white in color..... 7 "
W 180
3. Limestone, oolitic 3 "
2. Limestone, crystalline in texture, strongly
cross-bedded below, becoming more evenly bedded
above, with irregular, red chert masses in the
higher portion 12 "

- 1. Limestone in evenly bedded layers, fine textured
and compact, with some chert 10 feet.

W 179.

In the above section all of the beds except No. 1, which is the top of the St. Louis, are referable to the Ste. Genevieve, fifty-one feet altogether. This section was visited by Worthen many years ago, and he secured a number of fossils from bed No. 8, the first of which were described by Meek and Worthen.

¹
Geol. Surv. Ill., vol. 2. (1866)

and were referred to "Upper part of St. Louis group". At a later date Worthen himself described a number of additional species from the same bed which were

²
Geol. Surv. Ill., vol. 8. (1890)

referred to as coming from "the oolitic beds of the St. Louis limestone on Fountain Creek, Monroe County, Illinois".

In n.e. 1/4, sec. 16, T. 2 S., R. 10W., in the gorge of Andy's Creek, the following section through the Ste. Genevieve limestone is well exposed.

- 5. Limestone, mostly gray in color, much cross-bedded,
partly oolitic, and locally arenaceous, some
layers greenish in color or with greenish
partings, fossils common, but not well preserved 20 feet.

W 540

- 4. Sandstone, very fine-grained, gray or yellowish
in color, conspicuously cross-bedded 12 "
- 3. Limestone, thin-bedded, conspicuously cross-
bedded, more or less crystalline in texture,
abundantly fossiliferous in places 10 "

W 541

- 2. Limestone, hard and evenly bedded in beds about six inches thick, characterized by an abundance of deep red chert in irregular nodular masses arranged in somewhat regular, discontinuous bands 6 feet.
- 1. Limestone, rather evenly bedded or with some cross-bedding, hard and dense, fossils not conspicuous 6 "

In this locality the limestones of the section are followed by a talus slope with loose blocks of ferruginous sandstone towards the top. The entire limestone succession of 54 feet, including the sandstone be No. 4, is believed to belong in the Ste. Genevieve formation. The red chert bed is especially well developed at this locality, and beds No. 1 and 2 are probably the exact equivalent of bed No. 2 in the Fountain Creek section, although in that section the bed is much more conspicuously cross-bedded than in Andy's Creek.

In the Mississippi river bluffs northwest of Columbia, between the gaps of Carr Creek and Hill Lake Creek, the Ste. Genevieve limestone has been quarried for local use at a number of localities, and in a quarry just above the gap of Carr Creek the following section is exposed.

- 10. Limestone, irregularly, and somewhat crossbedded, obscurely oolitic, much weathered 1 foot.
- 9. Limestone, hard, nearly white in color, granular in texture, somewhat cross-bedded 1 " 3 in.
- 8. Shale, calcareous 4 in.
- 7. Limestone, hard, slightly purpleish in color, very brittle, with oonchoidal fracture, oolitic in the upper portion. In the upper two feet there are one or two more or less continuous bands of red chert about two inches in thickness 6 "

- 6. Shale, calcareous, mostly yellowish but in part purplish in color, much of it irregularly bedded. some beds several inches in thickness, harder and less shaly than the interbedded material. Fossils occur in lenses and bands, in places crowded in great numbers 6 feet

W 552

- 5. Limestone, hard, dense, granular, composed largely of small crinoidal fragments 1 " 4 in.
- 4. Limestone, brownish-buff in color, probably magnesian 1 "
- 3. Limestone, hard and brittle, variable in texture, light gray in color, somewhat oolitic 2 " 6 in.
- 2. Limestone, brownish-buff in color, probably magnesian 2 " 6 "
- 1. Limestone, entirely similar to that of bed No. 3 2 " 6 "

This entire section of about 27 feet in thickness, belongs in the lower portion of the Ste. Genevieve limestone.

A consideration of these sections of the Ste. Genevieve limestone, brings out the variable character of the lithology of the different beds in the formation. Wherever any considerable section of the formation is exposed, there is commonly no difficulty in establishing its identity from the lithology alone, but difficulty is experienced in differentiating some Ste. Genevieve outcrops of limited extent, from the underlying St. Louis. This difficulty is increased by the fact that the more characteristic fossils of the formation do not occur in its lower most beds, being known only from above the red chert horizon.

Correlation. With the revival of the Ste. Genevieve limestone as a distinct formation in the Mississippian series, Ulrich has incorporated it in the Chester, as the basal formation in that Group. ¹ His basis for such a correlation is found

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U. S. Geol. Surv., Prof. Pap., No. 36, p.

in the recognition, by Engelmann, many years ago in his study of the Chester Group in Johnson County, Illinois, of two members, limestone and shale beds above, and a sandstone below, numbers 9 and 10 in his general section, which he believed to be sub-Cypress in position, the Cypress sandstone being No. 8 in his section. These beds, 9 and 10 of Engelman were described by him as resting upon a formation which was regarded as being St. Louis limestone.

In more recent times Ulrich recognized certain beds, during his study of the stratigraphy of the Mississippian in northwestern Kentucky, lying above the true St. Louis, but distinct from that formation, and subjacent to a massive sandstone formation which he correlated with the Cypress of Engelmann. The stratigraphic position of these beds was therefore identical with that of the sub-Cypress Chester beds of Engelmann. During a careful study of these beds by Ulrich, there were recognized three distinct members, limestone below and above, with sandstone between. Upon visiting the section in the Mississippi river bluffs two miles below Ste. Genevieve, Missouri, where the original Ste. Genevieve limestone of Shumard is exposed, Ulrich recognized in this formation also, lying between the St. Louis below and the "lower sandstone of the Chester Group," a succession similar to that with which he was familiar in Kentucky, limestone below and above with sandstone between. These observations led to the correlation of the beds in Kentucky with the Ste. Genevieve limestone of Shumard in Missouri. In Kentucky the formation was made to include a series of beds 245 feet in maximum thickness, but the original Ste. Genevieve in Ste. Genevieve County, Missouri, and the extension of the formation

into Randolph and Monroe counties, Illinois, nowhere exceeds 100 feet in thickness, and the median sandstone member is only a local development in the formation.

The criterion used by Ulrich for the identification of the Ste. Genevieve was a lithologic succession rather than any faunal characters of the beds, and since at least the uppermost limestone member in the Kentucky formation carries a prolific fauna of strong Chester facies, the Ste. Genevieve limestone in its entirety was included in the Chester as the basal formation of the group.

The studies of the writer, both in the field and in the laboratory, have led to the conviction that the so-called Ste. Genevieve limestone in southeastern Illinois and Kentucky includes much that is foreign to the true Ste. Genevieve, as it is represented in Ste. Genevieve County, Missouri, and Randolph and Monroe Counties, Illinois. In the Section in which Engelmann recognized his sub-Cypress members of the Chester, in the Cache river bluffs in southern Johnson County, the succession of beds exhibited is as follows.

- 4. Sandstone, massive, cross-bedded, coarse grained, but without quartz pebbles, much iron-stained, and with stringers of limonite. Lepidodendron trunks not infrequent..... 60 feet.
- 3. Limestone and shale, probably interbedded, talus covered, but with numerous slabs of limestone in the talus from this horizon, abundantly fossiliferous in places 40 "
- 2. Sandstone, much cross-bedded, and including considerable calcareous material, with numerous shale and some limestone pebble inclusions 10 "

1. Limestone, cross-bedded, with numerous crinoid stems
and bryozoans. Exposed 10 feet.

The section just described is without doubt Engelmann's typical section, it is situated in the Cache river bluffs about one mile east of the Burlington railroad cut three-fourths of a mile south of the junction of that road with the Big. Four. In this railroad cut itself, a part of the same section is exposed with the beds exhibiting a little different lithologic character, as follows.

3. Sandstone, thin-bedded, yellowish-brown in color, with no cross-bedding. The individual beds are two to four inches thick, with arenaceous shaly partings about one inch thick. The surfaces of the beds are somewhat hummocky, but not conspicuously wave marked..... 10 feet.
2. Limestone, with discontinuous sandy partings, and many limestone pebbles 1 to 2 "
1. Limestone, oolitic, cross-bedded in part, or thin-bedded with shaly partings. Fossils abundant, but usually not well preserved Exposed 12 "

In this section the limestone bed No. 1, is undoubtedly a continuation of bed No. 1 in the previously described section, and beds No. 2 and 3 together equivalent to Bed No. 2 of earlier section. Beds No. 3 and 4 in the bluff section are not exposed in the railroad cut section.

A study of the fossils from the beds exposed in these sections have shown that bed No. 1, is not St. Louis, as was supposed by Engelmann, but belongs to the Chester. The fauna is a characteristic Renault association and the bed doubtless represents a southern exhibition of that formation. The arenaceous beds following

this limestone constitute bed No. 10 of Engelmann's Chester section, and has afforded no fossils. No. 3 of the bluff section is Engelmann's No. 9 in his Chester section, and is abundantly fossiliferous, the association of species being characteristically Chester. It is, however, far from being a basal Chester fauna in aspect, and is strongly suggestive of a horizon as high as the Okaw Limestone in the Randolph County section. If these interpretations of the lower beds of the section are correct, and there seems to be no question whatever in regard to it, the sandstone bed No. 4, at the top of the section, cannot be the Cypress, a formation whose proper position must be beneath any of the beds here exposed. The lithologic character of the formation is totally different from that of the Aux Vases sandstone which is the basal portion of the Cypress, it is coarser, with the ferruginous content more irregularly distributed, and with numerous plant remains which are totally foreign to the true basal portion of the Cypress or Aux Vases. Engelmann has certainly mistaken a basal Pennsylvanian sandstone in this section, for his Cypress, and in consequence his sub-Cypress Chester beds lose their significance.

In the section in the Ohio river bluff below Rosiclare, one of the localities discussed by Ulrich, and mentioned as typical of the upper Ste. Genevieve¹, a limestone formation with shale partings is surmounted by a massive sandstone which has

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U. S. Geol. Surv., Prof. Paper, No. 36, p.

been called Cypress. This sandstone possesses lithologic characters similar to those of the supposed Cypress of Engelmann in the Cache river bluff section, it differs from the true Cypress in the same characters as does that sandstone, and like it, it carries numerous plant remains, and must be referred to the Pennsylvanian rather than the Cypress. The underlying limestone and shale formation is abundantly fossiliferous in at least one horizon, with a characteristic Renault fauna.

As interpreted by the writer, the Ste. Genevieve limestone of southeastern Illinois and Kentucky, as described by Ulrich, includes not only the true Ste. Genevieve, but also lower Chester beds of Renault age, and perhaps even younger beds. The Chester portion of the Kentucky Ste. Genevieve limestone has the same relations with the true Ste. Genevieve, as does the Renault in Monroe County, Illinois, where it extends beyond the Aux Vases by overlap, and rests directly upon the Ste. Genevieve. This same condition of overlap doubtless exists in the south as it does farther north.

With the preceding introduction, which is presented to clear up the Ste. Genevieve situation in some measure, the correlation of the true Ste. Genevieve may be considered without being complicated by a consideration of those beds in Kentucky which carry a characteristically Chester fauna. The characteristic fauna of the formation is present in the higher beds, above the conspicuous red chert horizon, and the species Pugnoides ottumwa is by far the most important index fossil. Associated with this Pugnoides, Girtyella indianensis is commonly present, and a species of Compsita which has been identified as C. trinuclea is generally present, and in some localities are very abundant. In some localities a large fauna of diminutive gastropods and pelecypod shells has been secured, some of the species of which have not been observed outside the Ste. Genevieve, while others occur in other formations, notably in the Salem limestone lower in the section, and in the oolite beds of the Okaw limestone in the Chester Group. Taken as a whole the Ste. Genevieve limestone fauna indicates a stage intermediate in position between the Salem-St. Louis horizon, and the Chester, just as might be expected from its stratigraphic position, and the important question in its correlation is, whether it should be closely associated with the formations beneath it or those overlying it, or should be kept separate from both and be considered as an independent unit in the Mississippian Classification.

In passing judgment on this question it is important to take into consideration the geographic distribution of the beds which are certainly the equivalents of the Ste. Genevieve, and the structural relations of the strata with those preceding and succeeding it. It has already been shown that the formation, in the region under discussion, is limited both above and below by unconformities. Both of these unconformities are of such a nature to indicate a complete withdrawal of sea from the Illinois basin, and the erosion of the surface before the sea again occupied the basin.

In searching for the extension of the Ste. Genevieve beds to the north, it is found that the highest beds in the Mississippi river bluffs at the city of Alton, Illinois, are Ste. Genevieve. At least 50 feet of strata, at this locality, are referable to this formation. They consist for the most part of fine-grained, calcareous sandstone beds which are conspicuously cross-bedded. In the midst of the formation is a conglomerate bed, and just above this is a horizon with numerous fossils, Pugnoides ottumwa being the most abundant species. Still further north, in Iowa, the Ste. Genevieve is represented by the Pella beds which have commonly been included in the St. Louis limestone. These beds have a prolific fauna in some localities, and of the species present Pugnoides ottumwa, Girtyella indianensis, and Composita trinuclea are among the most abundant. The Pella beds have a wide distribution in the Des Moines valley in Iowa, from Lee County in the southeastern corner of the state, to Fort Dodge more than 150 miles to the northwest, and wherever the formation has been critically studied¹ it is known to rest unconformably upon the subjacent formation.

¹
Van Tuyl.

These conditions suggest a complete withdrawal of the sea from the Iowa region as well as from the Illinois basin, preceding Ste. Genevieve time, and the faunal evidence is such as to show that the Illinois and Iowa basins were continuous when the sea readvanced for the deposition of the Ste. Genevieve formation.

The extent of the Ste. Genevieve sea, as indicated by the known distribution of the sediments deposited in it, is comparable with that of the earlier Mississippian seas in which the St. Louis, Salem, and preceding formations down to the Kinderhook, were deposited. The withdrawal, and later the readvance of the sea indicated by the Ste. Genevieve, is only one of a series of fluctuations of the Mississippian sea in its northern extension into Iowa, which are shown by the unconformities beneath the St. Louis, and beneath the Salem limestones¹. The

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Weller, Ill. State Geol. Surv., Bull. No. 8, pp. 83-88 (1907)

Van Tuyl, Proc. Iowa Acad. Sci., vol. 19, p. 167 (1912).

readvance in Ste. Genevieve time was perhaps greater than in either of the two earlier fluctuations, just as the preceding withdrawal was more complete. The pre-St. Louis and pre-Salem retreats were not sufficient to cause any interruption in the deposition of the sediments south of St. Louis, but the pre-Ste. Genevieve retreat left at least the entire Illinois basin exposed above sea level, and the sea perhaps withdrew from the whole Mississippi embayment.

In the interpretation of the Ste. Genevieve, the important fact to keep before us is that the expanding epicontinental sea in which the formation was deposited, spread over essentially the same area that had previously been occupied by earlier Mississippian seas, indicating that no warping of notable magnitude had taken place during the retreat and readvance. This lack of deformation is further suggested by the fact that the material constituting the formation is largely calcareous, and was that in the preceding formations, although the

presence of some clastic material in the form of sand, suggests that slight local deformation may have taken place though not of sufficient magnitude to notably modify the essential outline of the basin.

With the next advance, following the retreat of the Ste. Genevieve sea, which was probably complete so far as the Mississippi embayment is concerned, a basin was formed in which the Aux Vases sandstone was deposited. The outlines of this basin were entirely different from those of Ste. Genevieve time. It did not reach so far north by several hundred miles as did the earlier Ste. Genevieve sea, the northernmost outcrops of the formation being south of East St. Louis. The formation may extend away to the northeast beneath the Pennsylvanian beds, but there is no evidence that it has ever extended for any notable distance to the north and northwest. This Aux Vases basin was the beginning of a new order of things, and all the succeeding Chester formations were deposited in a basin or a succession of basins which occupied essentially the same area as the Aux Vases. The difference in outline between what may be called the Chester basin of Illinois, and that of the earlier Mississippian stages, must have been caused by deformation of the earth's crust, probably in the nature of gentle warping or folding, and in connection with such deformation some area immediately adjacent to the basin must have been sufficiently elevated to bring about a revival of erosion, to furnish the clastic sediments which constitute so large a part of the early Chester sediments. A probable change at this time was one of the series of uplifts of the Ozark region.

With these considerations before us, it seems only possible to consider the Ste. Genevieve as a part of the earlier Mississippian, to be associated with the St. Louis, Salem and other limestone formations of the Period, but in view of the fact that the withdrawal of the sea preceding Ste. Genevieve time was more

complete than during the several preceding fluctuations, the separation of the formation as a distinct division of the lower Mississippian is fully warranted.

In his subdivision of the Paleozoic into systems, Ulrich¹ has divided the old Mississippian into two systems, the Waverlyan below and the Tennessean above, placing the dividing line between the Keokuk and the Warsaw formations of the Mississippi valley, a line where there is neither a notable faunal nor stratigraphic interruption. If the Mississippian is to be broken up, the only logical position for a separation is between the Ste. Genevieve and the Chester, and in the present report such a division is made, the two series being designated as Lower and Upper Mississippian.

1

Subdivision of Ste. Genevieve into two formations ???

Reasons for not considering the Ste. Genevieve as a part
of the Chester Group.

Unconformities.

Geographic distribution - Pella beds of Iowa.

AUX VASES SANDSTONE

In the earliest description of the geology of the Mississippi Valley between St. Louis and the mouth of the Ohio¹, the conspicuous

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Shumard, 1st and 2nd Ann. Repts. Geol. Surv. Mo. (1855)

sandstone formation at the base of the Chester Group was apparently confused with a basal Pennsylvanian sandstone, and if referred to at all it was called the "Ferruginous Sandstone". The earliest definite reference to the formation is made by Hall, by whom it is

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Trans. Albany Inst., vol. 4, p. 2. (Read Nov. 1856)

considered as division V of the "Carboniferous limestone", and is defined as a "Gray, brown or ferruginous sandstone, overlying the limestones of Alton and St. Louis", the localities given for the formation being "below St. Genevieve, Missouri", and "between Prairie du Rocher and Kaskaskia, Illinois". The same statement in regard to the formation is repeated by Hall in his Iowa report³. In an

3

Geol. Iowa, vol. 1, pt. 1, p. 109. (1858)

"Explanation of the Geological Map of Missouri, and a section of its Rocks", Shumard⁴ has included the "Ferruginous sandstone" in

4

Proc. Amer. Ass. Adv. Sci., vol. 11, pt. 2, p. 5. (1858)

his list of Lower Carboniferous formations, between the St. Louis

limestone below, and the Upper Archimedes Limestone above. The same author at a later date, in a report on Ste. Genevieve County, Missouri⁵, gives a fuller description of the formation under the

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Trans. St. Louis Acad. Sci., vol. 1, p. 406 (1859), also, Mo. Geol. Surv., Rept for 1855-1871, p. 292 (1873).

name "Ferruginous Sandstone".

Worthen's early work in southwestern Illinois resulted in a more detailed description of the formations of Mississippian age in the Mississippi river section, than had been previously given. He rejected the name "Ferruginous Sandstone" which had been used by Shumard and also by Hall for this formation, and adopted "Lower Sandstone of the Chester Group"¹ for it.

1

Geol. Surv. Ill., vol. 1, p. 82, also p. 286 (1866). Republished in Econ. Geol. of Ill., vol. 1, p. 64, also p. 218 (1882).

In the extreme southern Counties of Illinois, the Mississippian section was first studied in detail by Engelman, and by Worthen, the most complete sections of the Chester Group being described in Johnson County by Engelm², and in Union County by Worthen³. In

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Geol. Surv. Ill., vol. 1, p. 381 (1866). Republished in Econ. Geol. of Ill., vol. 1, p. 326 (1882).

3

Geol. Surv. Ill., vol. 3, p. 44 (1868). Republished in Econ. Geol. of Ill., vol. 1, p. 487 (1882).

these counties these authors recognized eight divisions of the Chester which were numbered downward, the odd numbers, 1, 3, 5, 7, being applied to limestone, and the even numbers 2, 4, 6, 8, to sandstone members. In Johnson County Engelmann recognized two other members of the Chester which he believed occupied a position beneath bed No. 8, and designated them as numbers 9 and 10, 9 being a limestone and 10 a sandstone.

In the union County report by Worthen, the sandstone bed No. 8, is described as the lowest member of the Chester. Its thickness is said to be about 150 feet, and it is said to be a bed of sandstone to which the name ferruginous sandstone has sometimes been applied, implying the belief in the identity of this sandstone with the formation which had been called the "Ferruginous sandstone" in the Mississippi Valley, and which Worthen himself had called the "Lower Sandstone of the Chester Group" in his Randolph County Report. The best exposures in Union County were said to be along Cypress Creek.

1

In another paper Engelmann has again described the Mississipp-

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Trans. St. Louis Acad. Sci., vol. 2, p. 189 (1868)

ian section in southern Illinois, and has applied the formation name Cypress sandstone to the bed designated as No. 8 by both Worthen and himself in their County reports, but Worthen nowhere adopted this name, and it was overlooked for many years until it was revived by Ulrich.

At a later date the Mississippian section was discussed by
¹Keyes, and the name Aux Vases sandstone was proposed for this

¹Bull. Geol. Soc. Amer., vol. 3, p. 295 (1892), also Mo. Geol.
Surv., vol. 4, p. 72 (1894).

basal Chester sandstone which had formerly been known as the "Fer-
ruginous Sandstone", the name being taken from Aux Vases Creek in
Ste. Genevieve County, Missouri, near the mouth of which stream
good exposures of the formation are present in the Mississippi
river bluffs.

In connection with his correlation studies in the Mississippi
Valley, Ulrich² revived Engelmann's name Cypress, which had been

²Mo. Bureau Geol. and Mines, vol. 2, 2nd ser., p. 109 ().

wholly overlooked since its original publication, stating that it
had priority over Keyes later name, Aux Vases. He used the name
again in a table of Mississippian formations³, and described the

³Prof. Paper, U. S. Geol. Surv., No. 24, p. 90. (1904)

formation still more fully in his discussion of the Mississippian
section in the Fluorspar district of Kentucky⁴.

⁴Prof. Paper, U. S. Geol. Surv., No. 36, p. 53. (1905)

In connection with the prosecution of the present studies in
Monroe and Randolph Counties, the fact has become apparent that two

distinct geological formations are included in the basal, arenaceous portion of the Chester Group, the upper of which rests unconformably upon the lower. The lower one of the two formations is composed entirely of a massive sandstone, while the upper includes beds of shale and limestone, as well as sandstone. In a preliminary paper the name Brewerville¹ has been proposed for the lower, massive

¹ Trans. Ill. Acad. Sci., vol. 6, p. 121 (1914), also Ill. State Geol. Surv., Monog. I, p. 24 (1914).

sandstone formation, and Renault for the higher one, but since the publication of this preliminary statement, the section in Ste. Genevieve County, Missouri, has been carefully studied, and it has been established that the typical exposures of the Aux Vases sandstone of Keyes are wholly equivalent to the lower, more massive sandstone formation in the Illinois section, to which the name Brewerville was attached, and this prior use of the name Aux Vases seems to necessitate the discontinuance of the Brewerville and the use of Aux Vases in its place.

Areal distribution. The Aux Vases sandstone occupies a belt varying in width from less than a mile to about three miles, extending in a nearly north and south direction from the valley of Hickman creek three miles northwest of Millstadt, to the Mississippi river bluffs below Prairie du Rocher. Through a portion of this distance, southwest of Millstadt, the formation is apparently hidden by the overlapping Pennsylvanian formations, although this region is so

heavily drift covered and the outcrops consequently so few, that it is impossible to draw the boundary lines of the hard rock formations with any certainty.

The northernmost exposures of the formation within our area are in a short tributary of Hickman creek from the southwest, in the northern half of n.e. 1/4, sec. 31, T. 1N., R. 9W., where the sandstone has been quarried for local use. South of this locality, however, the formation has not been observed west of the creek, although it doubtless is present for some distance intirely covered with glacial drift. In the s. e. 1/4, sec. 6, T. 1S., R. 9W., however, the Renault formation whose normal position is over the Aux Vases, rests upon the Ste. Genevieve limestone, and the same condition exists in the east bank of Hickman creek near the middle of n.e. 1/4, sec. 7, T. 1S., R. 9W. Outcrops of massive sandstone, undoubtedly the Aux Vases, do occur in the bluffs along the east side of Hickman creek north from the road crossing the creek in s.e. 1/4, sec. 31, T. 1N., R. 9W., and in some of the short tributaries to that stream, but in none of these localities has the basal bed of the superjacent Renault been observed. Another outcrop of the same massive sandstone occurs in the extreme southeast corner of sec. 6, T. 1S., R. 9W.

By far the most important exhibition of the Aux Vases in this northern portion of our area, is in a tributary of Hickman creek from the southeast, which crosses nearly the middle point of the south line of s.w. 1/4, of s.w. 1/4, Sec. 32, T. 1N., R. 9W. At.

very near the point where the stream crosses the section line the following section is well exhibited.

4. Renault, arenaceous shales, etc.
3. Limestone conglomerate, with some foreign pebbles.
Basal bed of the Renault.
2. Sandstone, massive, yellow-brown in color, fine grained.

The Aux Vases.

1.

In this section only the uppermost surface of the Ste. Genevieve limestone is exposed, with the sandstone resting unconformably upon it. The sandstone rises as a vertical bluff of 20 (?) feet or more in the channel of the stream, causing a notable water-fall when the stream is flowing. Above this fall the gradient of the stream is again gentle, with the outcrops of the higher portion of the Aux Vases and the Renault more or less continuously exposed for some distance. The presence of the basal conglomeratic bed of the Renault in this section, which locally characterizes that formation from these northernmost exposures to the most southern ones in Ste. Genevieve County, Missouri, demonstrates conclusively that the sandstone forming the water-fall lies between the Ste. Genevieve limestone and the Renault formation, and can be nothing else than the Aux Vases, and this determination carries with it the correlation of the other outcrops of massive sandstone lying upon the Ste. Genevieve limestone elsewhere in the Hickman creek valley and the valleys of its tributaries.

The next exposures of the Aux Vases sandstone to the south are in Prairie du Long creek. A single, isolated outcrop in the bed of the stream in n.e. 1/4, s.e. 1/4, sec. 31, T. 1S., R. 9W., has the requisite lithologic character of the Aux Vases, and probably does represent that sandstone, although its relations with the overlying formations are wholly obscured by the heavy covering of the Pleistocene drift. In another fork of the same creek, about one mile southeast of the locality last mentioned, good exposures of the Aux Vases are present in the bed of the stream at the bridge, in s.w. 1/4, n.w. 1/4, sec. 5, T. 2S., R. 9W. At this point only the upper surface of the formation is exposed in the creek bed. The Renault formation is also present, and although it is arenaceous and is not marked by a basal conglomerata at this locality, the sandstone is very different in character from the underlying, massive Aux Vases, and it is succeeded by Variegated shales in a very short distance down the stream.

Good exposures of the characteristic, massive sandstone are present along that branch of Gerhardt creek crossing the southern half of sec. 8, T. 2S., R. 9W., and also along the main channel of Gerhardt creek running diagonally across sec. 17, T. 2S., R. 9W., Other good exposures are present in Köpp Creek, in sec. 20, and in n.w. 1/4, sec. 21, T. 2S., R. 9W. In Walker creek the exposures of the Aux Vases are present only in s.w. 1/4, sec. 28, T. 2S., R. 9W.

Among the best exposures of the Aux Vases sandstone anywhere in Monroe County, are those along Rock House creek, southeast of Waterloo. For a mile and one-quarter northeast from the bridge on the Waterloo-Red Bud road, in n.e. 1/4, or sw 1/4, sec. 8, T. 3S., R. 9W., the bed of the stream is upon the St. Louis Limestone, with the same limestone forming the bluffs along the northwest bank of the creek. On the southeastbank, however, the limestone does not rise much above the creek bed, and in the n.w. 1/4 of sec. 9, T. 3S., R. 9W., good exposures of Aux Vases sandstone are present at a much lower level than the limestone on the opposite bank a short distance up stream. From this point down stream the sandstone is well exposed, and at its base is a well developed basal conglomerata or breccia, the inclusions in the conglomerate being angular masses of chert from the St. Louis limestone, varying from a fraction of an inch to nearly two feet in maximum dimension. In the n.e. 1/4 of s.w. 1/4, sec. 4, T. 3S., R. 9W., the sandstone forms a bluff some 60 feet high, rising from the southeast bank of the creek. In the short tributary from the southwest, in s.e. 1/4, of the same sec. 4, the formation is conspicuously exposed, and for the distance of nearly one-half mile where the main stream has a southeasterly course across the s.w. 1/4, sec. 3, T. 3S., R. 9W., the Aux Vases sandstone forms the walls of a rather narrow gorge. In the tributary of Rock House creek from the west, flowing across the north half of sec. 10, T. 3S., R. 9W., the Aux Vases sandstone is well exposed, the lower portion of the stream valley being a

narrow rock gorge with sandstone walls, and the outcrops of the formation continue at intervals up both main forks of the stream into sec. 9, T. 3S., R. 9W.

Across the divide between Rock House creek and the North Fork of Horse Creek, the hard rocks are heavily covered with glacial drift and the boundary lines of the formations can only be approximately located. At the road corner just south of Burksville Station (New Design), a well has been drilled to a depth of 331 feet, giving the following section.

Soil and drift.....	28 feet.
Sandstone.....	69 feet.
Limestone.....	234 feet.

The sandstone first penetrated beneath the drift in this well section, must include the Aux Vases, but from the data at hand there is no way to determine whether or not any portion of the beds at the top of the section should be referred to the Renault. In drawing the Aux Vases-Renault line upon the accompanying geological map, it has been assumed that the uppermost portion of this sandstone is Renault, for the reason that within a distance of only a little more than one mile to the southwest of New Design, the Renault overlaps the Aux Vases and rests directly upon the underlying St. Louis limestone. The valley extending nearly due south from New Design which is perhaps the head of North Fork of Horse creek, is filled with glacial drift with no rock exposures whatever, but just south

of the junction of this valley with that of Dry Run creek, near the middle of the north half of sec. 29, T. 3S., R. 9W., good exposures of Aux Vases sandstone are present. Another exposure of massive sandstone, having all the lithologic characters of the Aux Vases, and doubtless belonging to that formation, is present just south of the highway crossing the valley in the middle of the east half of sec. 20, T. 3S., R. 9W., near the east line of the section, about three-eighths of a mile southeast of New Design.

In the several forks of Horse creek west of Red Bud, the Aux Vases, sandstone outcrops in more or less isolated areas because of the overlapping of the Renault formation to the west in this portion of our territory, but numerous excellent exposures of the formation are present along these streams, some portions of their valleys being bounded by conspicuous sandstone bluffs. In the valley of the main tributary of North Fork of Horse creek, in N.E. ~~k~~/⁴ of s.w. 1/4, sec. 4, T. 4S., R. 9W., the base of the Aux Vases is well exhibited resting directly upon the underlying St. Louis limestone, with a conspicuous basal conglomerate of the same character as that in Rock Horse creek. Along the south side of South Fork of Horse creek, in s.e. 1/4 of n.w. 1/4, and s.w. 1/4 of n.w. 1/4, sec. 15, T. 3S., R. 9W., the Aux Vases rises in nearly vertical bluffs 40 feet high, and in the north and south road between this section and the adjoining section 16 to the west, conspicuous ledges of sandstone are present which are a continuation of the bluffs

further down stream. In Dry Fork of Horse creek, the Aux Vases sandstone is exposed only in the bed of the stream for a distance of less than one mile, in sections 27 and 28, T. 4S., R. 9W.,

Southward from the outcrop last mentioned in Dry Fork of Horse creek, the Aux Vases sandstone is exposed only in those stream valleys leading southwest directly into the Mississippi River bottoms, and in the Mississippi river bluffs. Beyond the Monroe-Randolph county boundary line, the formation is not overlapped by the superjacent Renault, so that its outcrop is continuously exposed except where it is buried beneath Pleistocene deposits. The formation is well exhibited in the s.e. 1/4, of s.w. 1/4, sec. 3, T. 5S., R. 9W., along the highway and in the head of the tributary of Prairie duRocher creek. From this locality southward good exposures are present in all the tributaries of Prairie du Rocher creek from the east, and below the town of Prairie du Rocher the best exposures in the entire area under consideration are to be seen in the Mississippi river bluffs. In all the valleys intersecting the bluffs between Prairie du Rocher and Modoc, the formation is well exposed. The last outcrop of the formation is by the road side at the foot of the bluff a little over one mile below Modoc.

Lithologic characters. The Aux Vases formation, as it is developed in Illinois, is uniformly a fine or medium grained, yellowish-brown sandstone, commonly deposited in massive beds with more or less conspicuous cross-bedding. Locally some portions of the

sandstone are mottled with small, closely crowded, darker brown specks from one to three millimeters in diameter, other parts being entirely free from such markings. The color of the sandstone varies from nearly white, through light yellowish brown, to reddish-brown, the extremes in color being the less common. Upon the long exposed weathered surfaces of the sandstone, the reddish-brown, ferruginous coloring is more conspicuous than upon the freshly broken surfaces, but in the vertical or overhanging bluffs below Prairie du Rocher, the soft, yellow-brown color of the rock is not conspicuously different from the color of the freshly broken surfaces.

The massive character of the sandstone, and the absence of shale partings between the beds, causes it to form abrupt bluffs in favorable situations, and where stream channels have been eroded in it, picturesque gorges with nearly vertical walls have been locally developed. The best exposures of the formation within the area under consideration, are in the Mississippi river bluffs between Prairie du Rocher and Modoc.

In Missouri the formation is somewhat more variable in its lithologic characters than in the Illinois localities. Some of the exposures in Ste. Genevieve County are not unlike those in Illinois, but elsewhere it is more thinly bedded with no indication of cross-bedding. The color also is yellower in some of the Missouri localities, and at one locality in Perry County, in the Mississippi river bluffs southwest of McBride, the sand is coarser and the rock has much the appearance of the St. Peters sandstone.

The basal contact of the Aux Vases upon the underlying formation is in places a clean contact between the massive sandstone and the limestone, such a contact being well shown along the wagon road between Prairie du Rocher and Modoc. In other localities several feet of conglomerate and shaly beds are present in the base of the Aux Vases, beneath the massive sandstone. Such a contact is shown in the mouth of a small ravine tributary to the North Fork of Horse creek, in s. e. 1/4, of s.w. 1/4, sec. 28, T. 3S., R. 9W., just north of Tiptown church, where the following section is exposed.

7. Sandstone, massive, heavy ledges, yellow-brown in color, with cross-bedding. Exposed. 35 feet.
6. Sandstone, fine-grained, massive, yellowish in color, the lower surface, to depth of one or two inches, filled with lenticular or more or less angular clay pebbles which are washed out on the weathered surface, leaving cavities 1 foot
5. Shale, arenaceous, yellowish-green in color, with more or less contorted bedding 5 "
4. Sandstone, irregularly bedded, with conspicuous ripple-marks, some parts with numerous cavities probably formed by the removal of clay pebbles.....1 "
3. Shale 3 in.
2. Conglomerate, sand matrix with angular, St. Louis chert pebbles.....1 "

1. Limestone, hard and dense, gray in color, with some chert. St. Louis limestone. Exposed..... 6 feet

Other localities where the basal conglomerate of the Aux Vases is well developed, are on Rock House creek in s.w. 1/4, of s.w. 1/4, sec. 8, T. 3S., R. 9W., and again along the same creek in s.w. 1/4, sec. 4, T. 3S., R. 9W., where the sandstone rises in a bluff 60 feet or more in height. A very excellent locality for the basal conglomerate, where it may be seen resting directly upon the subjacent St. Louis limestone, is in s. e. 1/4, of n.e. 1/4, sec. 4, T. 4S., R. 9W., along the main tributary of North Fork of Horse creek from the west, and for a short distance down the stream into the adjoining section 3 to the east. In every locality where these basal conglomerate beds have been observed, the included fragments are masses of angular chert, shown by the fossils to have come from the subjacent St. Louis limestone, varying in size from a fraction of an inch to nearly two feet.

Sub-Aux Vases Unconformity. The unconformable relations of the Aux Vases sandstone to the subjacent limestones are clearly established in several ways. The contact between the sandstone and the underlying limestone is always a sharply defined line, with no inter-gradation of sediments whatsoever. The basal conglomerate which is generally present over a distance of about seven miles along the strike of the beds, from Rock House creek southward, is one of the best evidences of unconformity. A third strong proof of the unconformity is found in the uneven surface of the underlying limestone surface.

The time interval preceeding the Aux Vases, during which no sedimentation was in progress in our area, must have been long, and the relations are such as to establish the fact that dry land conditions prevailed. The cherts which are included in the basal conglomerate of the Aux Vases sandstone are not unlike great quantities of chert gravel from the St. Louis limestone along the courses of some streams which are flowing across that formation today. The presence of such cherts in the conglomerate proves that before the accomplishment of the pre-Aux Vases erosion, the calcareous ooze, the original substance of the St. Louis limestone, was completely consolidated into limestone, the appearance of which was doubtless in no wise different from the limestone as we see it today in the Mississippi river bluffs and elsewhere. Furthermore, the formation of the cherts, perhaps associated with the surface weathering of the limestone upon that ancient land

surface, had been carried as far as the chert formation in the same limestones today, and these cherts were accumulated as chert gravel, much as during the present time, which were finally worked over and spread out by the advancing Aux Vases sea, and were finally consolidated into a true basal conglomerate.

The erosion of the pre-Aux Vases land was considerable, as is evidenced by the complete removal of the Ste. Genevieve limestone over a considerable portion of the area. In the extreme northern portion of our map, in the valley of Hickman creek and its tributaries, the Aux Vases is everywhere underlain by the Ste. Genevieve limestone. The same condition prevails from a point three and one-half miles north of Prairie du Rocher, to where the basal contact of the Aux Vases disappears beneath younger strata between Prairie du Rocher and Modoc. In all the intervening area no portion of the Ste. Genevieve limestone has been observed beneath the sandstone. These facts can only be explained by assuming, either that the Ste. Genevieve was never deposited in this region, or that it was deposited and later removed before the deposition of the sandstone. The last of these explanations seems to be the most probable one. The Ste. Genevieve limestone is a wide-spread formation, extending northward all the way to Iowa. It is also present to the east, in Indiana, and has been encountered in the oil wells of eastern Illinois, and it seems to be reasonable to assume that the sea in which the formation was deposited stretched across the entire Illinois basin,

as did the earlier Mississippian seas. If the formation was never deposited where it is now absent, the Ste. Genevieve sea must have been a long, narrow, finger-like embayment, only a few miles wide, reaching up the Mississippi valley and then northwestward into Iowa along the Des Moines valley, connected somewhere at the south with a similar extension further east to take care of the Indiana and eastern Illinois occurrences.

The inequalities in the sub-Aux Vases surface due to erosion, are clearly evident in a number of localities. From a point in the Mississippi river bluffs one mile below Prairie du Rocher, to the mouth of the creek halfway between that town and Modoc, the lower contact of the Aux Vases is continuously exposed, and the dip of this surface is considerably greater than the dip of the strata in the underlying limestone, a number of the limestone beds being truncated in this short distance. Another locality where this uneven surface is again shown, is southeast of Waterloo, in the southern portion of sec. 5, and the northern portion of the adjoining section 8, T. 3S., R. 9W., between the Waterloo-Red Bud road and Rock House creek. In this area the St. Louis limestone is surrounded on three sides by the Aux Vases sandstone, and the base of the sandstone occurs at a very much lower elevation than the surface of the limestone in the immediately adjoining area, the difference in elevation being much greater than can be accounted for by the gentle easterly dip of the strata. This area of St. Louis limestone can only have been a small hill-like elevation upon the old sub-Aux Vases surface, around which the sandstones were deposited.

Source of Material in the Aux Vases Sandstone. All the Mississippian formations in the area under consideration, older than the Aux Vases sandstone, are in large part limestones of organic origin, although there is associated with these organic sediments a considerable amount of clay, in the form of shales, in certain horizons. In the Ste. Genevieve limestone formation some arenaceous material is present, but even here the organic limestones vary greatly preponderate. The Aux Vases is the first formation in the series which is made up wholly of sand, and the thickness of the formation and consequently the amount of material included in it is such as to presuppose some notable changes in the attitude of the lands surrounding the Illinois basin at this time, and it is important to determine, if possible, the source from which the sand was derived.

All the Mississippian formations in Illinois were deposited in a basin more or less shut off on the west by the Ozark region, which was probably an island rising above sea level, or was only slightly submerged during the entire period. North and west of the Ozark region there was free communication during the first half of Mississippian time, between the northern portion of the Illinois basin and the Mississippian waters of southwestern Missouri, Oklahoma and Arkansas. To the east the Illinois basin was limited by the Cincinnati arch, which was either a low lying island or a slightly submerged area; it was at least a barrier sufficient to separate very notably the Illinois basin from the Waverly basin still further east,

whose sediments were derived from the Appalachian land.

The lithologic character of the limestone formations of the first half of the Mississippian period are such as to make it certain that nowhere about the Illinois basin during this time, were there lands with any high relief. The entire submergence of the Ozark region during the time of deposition of the Burlington limestone, is evidenced by the occurrence of outlying remnants of that formation, with some of the characteristic fossils, near Rolla, Missouri¹. This submergence

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Mo. Bureau Geol. and Mines, vol. 12, 2nd ser., p. 41

may have continued through other periods of lower Mississippian, but no evidence to support such a conclusion is as yet forthcoming.

For a period immediately preceeding the deposition of the Aux Vases sandstone, the entire Illinois basin is believed to have been elevated above sea level, and it was during this period that the erosion of the Ste. Genevieve and St. Louis limestones, to form the uneven floor upon which was deposited the Aux Vases sandstone, was accomplished. With the subsidance following this dry land period, the resultant Illinois basin was far more restricted than it had been during the earlier periods of limestone deposition. It no longer reached northward in the Mississippi valley to Iowa and beyond. The northernmost deposits of this restricted basin, as they are actually exposed at the surface today, are south of East St. Louis, but their extension to the north, or rather to the northeast, beneath the Pennsylvanian formations, is unknown. There certainly was no communication to the southwest around the northern and western sides of Ozarkia during this

time, and all evidences indicate that the basin was limited on the east, probably by the low lying land occupying the position of the Cincinnati arch. The submerged area constituting the Illinois basin in Aux Vases time must, therefore, have been a rather broad embayment, between Ozarkia and Cincinnati, opening only to the south. In this Basin the Aux Vases and all the later Chester formations were deposited. The relief of the land surrounding this basin must have been greater than during the earlier, much more extensive Mississippian basin that had reached northward to Iowa, and from there far to the northwest, and in consequence of this greater relief clastic sediments became much more common than they had been previously. The greatest relief in the land adjacent to this basin was doubtless Ozarkia, where the sandstones of early Paleozoic age must have been well exposed. In no other direction near the shores of the Illinois basin at this time, were there extensive sandstone formations exposed which could have furnished the arenaceous material in the early Chester formations, and the conclusion seems justified that the material constituting the Aux Vases sandstone was derived from Ozarkia.

Paleontology. The only organic remains of any sort which have been observed in the Aux Vases, are some imperfect tree trunks, probably *Lepidodendron*, from the basal conglomerate in the bed of North Fork of Horse creek, in s.e. 1/4, of s.w. 1/4, sec. 28, T. 3S R. 9W. ? just north of Tipton Church.

Field Observations to be Made on the Aux Vases Sandstone

Re-examine section northwest of Millstadt, s.w. 1/4, s.w. 1/4,
sec. 32, T. 1N., R. 9W., Make careful measurement of the section, also
the superjacent Renault.

Discuss Aux Vases sandstone west of Columbia anticline.

RENAULT FORMATION

The Renault¹ formation is an exceedingly complex series of

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Weller, Trans. Ill. Acad. Sci., vol. 6, p. 122 (1914), also Ill.
State Geol. Surv., Monog. I, p. 24 (1914).

sediments whose lithologic characters change rapidly both vertically and in horizontal extent. The formation includes sandstones, arenaceous shales, variegated green, blue and purple shales, calcareous shales, thin platy limestone layers in some of the calcareous shales, dense arenaceous limestones, often greenish in color, argillaceous limestones, nearly pure, bluish-gray, crystalline limestone, rarely oolitic limestones, and at several localities distinct limestone and chert conglomerates. Locally the limestones include some chert; but in most localities the beds are free from such inclusions. The formation undoubtedly includes some portion of the "Lower sandstone of the Chester group" of Worthen, and it is believed that some portions of the Cypress sandstone of Engelmann and of Ulrich are in reality Renault. The thicker bedded sandstone and arenaceous limestone strata of the formation are conspicuously cross-bedded in almost every locality where they are exposed. In general the sandstones are thin-bedded with shaly partings, passing imperceptibly into arenaceous shales. In many localities thin, flaggy beds of sandstone are pierced by closely crowded

vertical, Scolithus-like burrows, a quarter of an inch or less in diameter, which, in a weathered condition occur as more or less complete perforations of the beds, these beds commonly being most conspicuous at or near the base or in the lower portion of the formation. Some of the more massive sandstone layers closely simulate the Aux Vases, but such beds, when present, have been observed more commonly in the higher portion of the formation, and they rarely or never attain a thickness of more than ten to twenty feet. When present these massive beds may be distinguished from the Aux Vases, not only by their less thickness, but also by the presence of the underlying shales, often variegated in color, and in many localities by the presence of limestone strata at a lower horizon in the formation. Furthermore the sandstones in the Renault not infrequently contain some fossils in an exceedingly fragmentary condition besides some fairly well preserved Lepidodendron stems, while the Aux Vases is entirely free from organic remains so far as observations have been made.

Areal distribution and description. The Renault formation is typically developed in the eastern portion of Renault township in Monroe County, where excellent exposures occur in the valleys of the two forks of Horse creek and their tributaries. The distribution of the formation throughout the area here being described, is in a belt lying just east of the Aux Vases sandstone belt, except in the extreme northern portion of the area and for a distance north of Prairie du Rocher, where the Renault is extended to the west by overlap. In these regions of overlap the Renault outcrops are present both east and west of the belt occupied by the Aux Vases, the outcrops of the older formation being included within the Renault belt as a series of isolated areas. Outside of this belt, which extends from Hickman creek at the north to the Mississippi river bluffs at and below Modoc, the formation is exposed at a number of localities east of the Columbia anticline, between that fold and the Mississippi river bluffs.

The northernmost exposures of the Renault formation are in the valleys of Hickman creek and its tributaries. In the bed of one of the tributaries of this stream which crosses the extreme northwestern corner of sec. 31, T. 1 N., R. 9 W., near the north line of the section and extending down stream for a short distance, yellow-brown fine-grained sandstone beds are exposed in which there are embedded numerous Lepidodendron trunks. This sandstone has been referred to

the Renault. The immediately underlying formation is Ste. Genevieve limestone, the Aux Vases being wanting in this section. In hand specimens it would be impossible to distinguish this sandstone from similar specimens which might be selected from some beds of the Aux Vases, but the common presence of Lepidodendron trunks in the Renault has been relied upon to differentiate the two formations. Furthermore the overlap of the Renault to the west in this northern area is clearly established in some of the exposures not far distant from this sandstone outcrop.

In the upper portion of a tributary of Hickman creek from the southeast, in s.w. 1/4 of n.e. 1/4, and n.w. 1/4 of the s.e. 1/4, sec. 31, T. 1 N., R. 9 W., other good exposures of Renault are present. A short distance below the junction of the three forks of this stream there are outcrops of the Ste. Genevieve limestone, while above this point, in the branch from the south, a series of beds is exposed at intervals, consisting of shales, in places greenish in color and elsewhere variegated red, purple and green, associated with sandstone layers which become more conspicuous towards the head of the valley, some of which have impressions of Lepidodendron trunks. No accurate measurements of this section have been made because the outcrops are not continuous, being exposed only at intervals in the banks or the bed of the stream, but a total thickness of from 40 to 50 feet is represented. No massive sandstone beds are exposed between this series and the underlying Ste. Genevieve limestone, and the interval

of several feet between the limestone and the first exposure of shale is probably occupied by the lower beds of this same formation, which is referred to the Renault, the Aux Vases being absent. This succession of beds, variegated shales and sandstones with tree trunks, is quite typical of the Renault.

One of the most important outcrops of the Renault in this northern portion of the region is in the n.w. 1/4 of n.w. 1/4, sec. 5, T. 1 S., R. 9 W., where it overlies the massive Aux Vases sandstone with a distinct basal conglomerate¹. This conglomerate has a lime-

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For description of section see page

stone matrix, the included pebbles being of limestone and chert, with an occasional bit of igneous rock. The pebbles are well rounded, closely crowded together, and vary in size from a fraction of an inch to four or five inches in maximum dimensions. The thickness of this conglomerate bed is several feet, and it is succeeded, up stream, by outcrops of impure limestone, thin-bedded sandstone, arenaceous shales, and argillaceous shales some of which are variegated in color, an association of sediments which is quite typical of the Renault formation.

Other good outcrops of the variegated shale and arenaceous sediments of the Renault in this northern region, are exposed in a number of the short tributaries of Hickman creek from the east, in several of the sections in T. 1 S., R. 9 W. Such outcrops are present in n.e. 1/4 of n.e. 1/4, sec. 6, in the short ravine heading near the public highway;

another locality is in the ravine in s.w. 1/4 of n.w. 1/4, sec. 5, and still others, perhaps the best of these three, in n.w. 1/4 of n.w. 1/4, sec. 8.

An instructive Renault section in this northern region is exposed in a short ravine heading in s.w. 1/4 of s.e. 1/4, sec. 6, T. 1 S., R. 9 W., and leading northwest into Hickman creek, where the following section has been measured.

6. Sandstone, shaly, irregularly bedded in convex masses.....7 feet
5. Quartzite, very hard, almost chert-like in part, red and yellow in color, interbedded with arenaceous shales, with imperfect fragments of Lepidodendron trunks. Yankeetown formation.....5 feet
4. Shale, variegated in color, purple to bluish, greenish and yellow, arenaceous below and somewhat conglomeratic..10 feet
3. Not exposed.....10 feet
2. Sandstone, fine-grained and even-textured, soft, yellow in color, thinly and very conspicuously cross-bedded.....12 feet
1. Limestone, hard and dense, with conspicuous red cherts, the uppermost beds arenaceous, or almost a sandstone. Ste. Genevieve.....6 feet

In the above section the total thickness of the Renault is 32 feet. It rests upon the Ste. Genevieve limestone without any intervening massive Aux Vases sandstone, such as is present only about one-fourth mile

southeast of this locality, and such as is finely exposed less than a mile northwest.

In an exposure in the east bank of Hickman creek, very near the middle of n.e. 1/4, sec. 7, T. 1 S., R. 9 W., the base of the Renault formation, represented by a conspicuous limestone conglomerate varying from one to two or more feet in thickness, rests uncomformably upon the Ste. Genevieve limestone with no intervening Aux Vases sandstone. The conglomerate is succeeded by a fine-grained, soft, light-yellow sandstone, totally different from anything which has anywhere been observed in the Aux Vases.

In none of the Renault outcrops situated within the Hickman creek drainage area has the typical fauna of the Renault formation been observed. This fauna is commonly present only in the limestone or calcareous shale beds of the formation, and such beds are only feebly represented in this area. Lepidodendron trunks have been observed in a number of localities, however, and such fossils have been found to be present commonly in the Renault sandstones throughout the entire area of outcrop of the formation, extending from the region under discussion to Ste. Genevieve county, Missouri. Furthermore the exceedingly varied nature of the sediments here referred to the Renault agrees well with the character of the formation as it is developed elsewhere. Perhaps the most important fact bearing upon the correlation of these beds, is the almost universal evidence of the presence of the Yankeetown formation immediately above them. This peculiar, siliceous, cherty, arenaceous or

or quartzitic formation, although very thin, can nowhere be mistaken for any other, and it is everywhere present, within our area, immediately overlying the Renault. Its distribution will be discussed later.

The localities next south of Hickman creek in which the Renault formation is exposed, are in the upper branches of Prairie du Long creek. Along this stream in the extreme northern part of sec. 5, T. 2 S., R. 9 W., a few exposures of sandstone and shale are present which appear to represent the Renault. Other exposures, with the Yankeetown above them, are present in a short ravine in ~~se.~~ 1/4 of s.e. 1/4, sec. 32, T. 1 S., R. 9 W., and at the house at the head of this ravine, in s.w. 1/4 of s.e. 1/4 of the same section, a well has been sunk which passes through the Yankeetown into the Renault, and penetrates a limestone bed of the formation. The well section at this locality, as reported by owner, is as follows:

Drift.....60 feet
Sandstone (Yankeetown).....4 to 6 feet
Variegated shale.....?
Hard Limestone.....4 to 5 feet

In this section the rock reported as sandstone is undoubtedly the Yankeetown, and the variegated shale is entirely similar to that in some of the Renault exposures a short distance to the south. Several masses of the limestone reported were seen lying near the mouth of the

well, and they resemble in every way some of the characteristic Renault limestone beds, and some of the characteristic fossils were observed. This is the most northerly observed occurrence of limestone in the Renault, but from here south some limestone beds are present in most long sections.

Much better exposures of the Renault are present in the south bank of the branch of Prairie du Long creek next south of the one last mentioned. At the bridge over this stream in s.w. 1/4 of n.w. 1/4, sec. 5, T.2 S., R.9 W., the massive Aux Vases sandstone is exposed in the creek bed. A few yards below the bridge the Aux Vases is overlain by a softer, fine-grained, light-yellow, conspicuously cross-bedded sandstone not unlike the basal bed of the Renault in the Hickman creek Renault section described on Page . In the bank of the stream below this, variegated shales are exposed almost continuously for over one-fourth mile with a gentle eastward dip. In the small tributary from the south in s.e. 1/4 of n.w. 1/4 of the same section, variegated shales are present below, followed by arenaceous beds with a thin limestone bed near the head of the ravine, just over the line in St. Clair County. There is evidence in the wash of other variegated shale beds above the limestone. The limestone at this locality contains numerous fossils, and upon the weathered surfaces in the bed of the stream, specimens of Zaphrentis spinulosa and the U-shaped bases of a Lyropora are especially conspicuous. A full list of the species collected at this locality are as follows.

Further down the main stream, in the southern part of the n.w. 1/4 of n.e. 1/4, of the same section, the 6 degrees eastward dip of the beds brings the limestone down to the level of the creek bed. In the upper part of the small ravine in the northwestern corner of s.e. 1/4 of n.e. 1/4 of the same section, an excellent outcrop of the Yankeetown is exposed.

In Gerhardt creek and its several branches and tributaries, above the point where it crosses the Monroe-St. Clair County boundary, the Renault is represented by numerous exposures of sandstone and shale, but no limestone has been observed. The shales are in part greenish or blue in color, and in part conspicuously variegated with red and purple. Some of the sandstones are much more thinly and more irregularly bedded than the massive Aux Vases sandstone which is well exposed higher up the stream to the west, but some of the beds are also massive and are lithologically like the Aux Vases, making it difficult to differentiate the two formations in all cases. At the point where the public highway crosses the main branch of Gerhardt creek in n.e. 1/4 of n.w. 1/4, sec. 16, T. 2 S., R. 9 W., massive sandstone ledges are exposed which are indistinguishable in lithologic characters and in manner of weathering from undoubted Aux Vases. This sandstone is overlain by a few feet of variegated shales entirely like those occurring at many localities in the Renault, and these shales are succeeded by other sandstones of Pennsylvanian age. Up the creek valley

from this locality, about one-fourth mile, is a good exposure of shales dipping gently to the east, entirely similar to shale beds of elsewhere present in the Renault at numerous localities. The situation of the massive sandstone in the bottom of the valley at the road-crossing is such as to suggest its inclusion in the Renault, and that has been done upon the accompanying geological map, but another interpretation of it is possible, viz., that it is really Aux Vases, and that its exposure at this point is due to the unconformable relations between the Aux Vases and the Renault, and the uneven upper surface of the lower formation.

In the valley of Kopp creek and its tributaries, the Renault is represented by shales, sandstone and limestone. In the rather broad and short tributary valley from the west, in s.w. 1/4 of sec. 16, T. 2 S., R.9 W., and extending down the creek into the s.e. 1/4 of the same section, numerous outcrops are present, the most conspicuous of which are shales, some of which are variegated, but on the north slope of the tributary valley, in the s.e. 1/4 of s.w. 1/4 of the section, slumped masses of limestone with the characteristic Renault fossils are present, which indicates the presence of a limestone member of the formation at this locality. Further west, only one and one-half miles out from the city of Waterloo, along a tributary flowing south through the west half of s.e. 1/4 of sec. 20, T. 2 S., R.9 W., impure, arenaceous, Renault limestone is exposed for the distance of a quarter of a mile

north from the east and west road on the section line. Upon the hill slope upon the eastern side of this valley, in the n.w. 1/4 of the s.e. 1/4 of the section, there is evidently a bed of calcareous shale, although it is now covered with talus and vegetation. This shale is fossiliferous, and many silicified fossils may be gathered here by diligent search, and the following species have been collected and identified.

In a small side draw from this tributary, south of the house in s.w. 1/4 of s.e. 1/4 of the section, a number of limestone slabs have been secured from a thin limestone layer interbedded with the shales, these slabs are covered with fossils, largely bryozoans, and the following species have been identified.

A small collection of fossils from a sandstone layer near the base of the Renault a little above the mouth of the tributary in which the last two fossil collections were secured, contains the following species.

In the valley of Walters creek, a little more than three miles east of Waterloo, at the road corner one-fourth mile east of the northwest corner of sec. 27, T. 2 S., R. 9 W., is an outcrop of highly fossiliferous Renault limestone and calcareous shales. The same beds outcrop south of the creek along the public highway. The beds at the road corner north of the creek contain a wonderful crinoid fauna in one thin layer, but south of the creek these fossils are not so conspicuous. The complete list of species collected at this locality, both north and south of the creek, are as follows:

Up the creek valley from these limestone outcrops for one-fourth mile, and thence up the tributary from the northwest heading in the s.w. 1/4, sec. 21, T.2 S., R.9 W., sandstone of the type common in the Renault, and argillaceous and variegated shales are exposed at intervals. Just above the point where this tributary crosses the east and west road, the presence of numerous limestone boulders in the drift suggests a limestone ledge, although it is not exposed in situ.

Downstream from the fossiliferous limestone locality the sandstone beneath the limestone is exposed for a quarter of a mile or more, and limestone outcrops are present in the short tributary from the southwest in the n.e. 1/4 of n.w. 1/4, sec. 27, T.2 S., R.9 W.

In the valleys of the several tributaries of the creek, unnamed on the map, lying between Walters creek and the Waterloo-Hecker road mostly in sections 26, 27, 34, and 35, T.2 S., R.9 W., there are numerous outcrops of the Renault beds. In the northernmost of the two main tributaries at the head of the stream, crossing the n.w. 1/4 of sec. 34, the only exposures are sandstones which in hand specimens might be mistaken for the Aux Vases, but in the outcrops it is thinner bedded and less massive than the sandstone of that formation, and it includes numerous specimens of Lepidodendron trunks. Further down stream, in s.e. 1/4 of n.e. 1/4, there are limestones and variegated shales which are referable to the Renault.

In the valleys of Rock House creek and its tributaries the Renault is exposed at a number of points. In the heads of the tributaries in the southern part of sec. 9, and the northern part of sec. 16, T.3 S., R.9 W., there are outcrops of sandstones and arenaceous and variegated clay shales which belong here, and in the south bank of the main stream where it crosses the line between sections 10 and 11, T.3 S., R.9 W., is a good exposure of limestone. This limestone is near the base of the formation, its highest outcrop being 45 feet above the creek bed where massive sandstone, presumably Aux Vases, is exposed. Below the limestone ledges in situ, there are numerous limestone masses which have slumped down the bank, suggesting that the limestone is underlain by shales, although the shale is not

exposed in the outcrop, and the actual thickness of the limestone is not shown. The fauna from the limestone at this locality is not so extensive as that which has been met with in some other localities in the Renault, but the following species have been determined.

Down stream from this limestone outcrop higher beds of the Renault are exposed, consisting of sandstones, most of which are thin-bedded and ripple-marked, and much less massive than the Aux Vases. At the bridge crossing the creek just south of Rock House school, there is a greenish, arenaceous limestone, locally capped with crinoidal limestone, which is a part of the Renault, and in the bank of the creek below the bridge an outcrop of variegated clay shale is exposed.

In the long tributary to Rock House creek, with its head near the middle of sec. 16, T.3 S., R.9 W., and in the branch of this stream from the west across the northern halves of sections 14 and 15, there are many outcrops of thin-bedded, ripple-marked sandstone, shale, some more massive sandstone, and some limestone referable

to the Renault. In the branch mentioned, the outcrops are all on sandstone and shale except at one point in the public road running east and west where it crosses a short tributary from the north near the middle of the north line of n.w. 1/4 of n.w. 1/4 of sec. 14, where there is a small limestone exposure. In the main valley there is a good exposure of Renault sandstone near the head, in n.w. 1/4 of s.e. 1/4, sec. 16, less than 20 feet below an exposure of Yankeetown residuum a few rods further northwest. Downstream in the s.e. 1/4 of s.w. 1/4 of sec. 15, are other outcrops of sandstone, limestone and arenaceous shale. Just below the broad bend where the stream turns to the northeast, the Yankeetown forms the bed of the creek for one-fourth mile. The highest bed of the Renault, just beneath the Yankeetown, is sandstone, but beneath this is an important limestone member in which there is a thin layer filled with the remains of crinoids, some of which are very perfectly preserved. The crinoid bed is exposed very near the point where the stream crosses the line between sections 15 and 14. Below this there are arenaceous and argillaceous shales, some of them variegated in color, sandstone beds and some limestone, but no great thickness of the formation is shown because the dip of the beds to the east is only a little greater than the gradient of the stream. In the s.w. 1/4 of n.e. 1/4, sec. 14, a massive ledge of sandstone is exposed which is suggestive of the Aux Vases, but it is near the top of the Renault, only a few feet below the Yankeetown, and its thickness is only a few feet. Furthermore it is underlain by the Renault limestone exposed up stream.

Near the north and south highway crossing the creek through the middle of the east half of sec. 14, there are good exposures of arenaceous shales, with thin sandstone layers covered with irregular, fucoid-like markings. In the crinoid layer of the section exposed in this valley, the following species of fossils have been determined.

Southeast of New Design the Renault is well exposed in the valley of Bradley branch, heading in the central part of sec. 21, T. 3 S., R. 9 W., most of the outcrops being sandstones. The sandstone is fine-grained and yellow-brown in color, somewhat resembling the Aux Vases, but thinner bedded and less dense and associated with arenaceous shales and in places with calcareous sandstones. Furthermore, the beds are characterized by the presence of Lepidodendron trunks. The massive Aux Vases sandstone is exposed in the bed of the same creek in the northern part of sec. 27, T. 3 S., R. 9 W., a little more than one-eighth of a mile south of the highway along the north line of the section, and continues to occupy the floor of the valley nearly to its junction with the North Fork of Horse creek, with outcrops of Renault above it in places and in some of the short tributaries from the east. A limestone member of

the Renault is exposed in the same valley in a small tributary from the northeast just west of Poe station, the outcrops being present both north and south of the highway a little over one-fourth mile west of the Mobile and Ohio railroad, and at other localities further south, especially a little north of the middle of n.e. 1/4, sec. 34, T. 3 S., R. 9 W.

The greater portion of the valley tributary to the North Fork of Horse creek, leading south from near the middle of the south line of s.w. 1/4 sec. 16, T. 3 S., R. 9 W., is filled with glacial drift, and no Renault outcrops are exposed, but near the head of the valley there is a good outcrop of Yankeetown, and about one-half mile south and at 40 feet lower elevation, there is a massive sandstone outcrop, probably Aux Vases. The interval between, it is assumed, is occupied by the Renault. In the valley leading nearly south from New Design there are no outcrops whatever, because of the deep drift cover, although the Renault is believed to extend as far west as the eastern side of this valley at least.

In the short tributaries to Horse creek from the east and northeast, between the mouth of Bradley branch in s.e. 1/4, sec. 34, T. 3 S., R. 9 W., and the southwest corner of sec. 13, T. 4 S., R. 9 W., the Renault formation is exposed in many localities. As elsewhere the beds consist of sandstone, commonly less dense than the Aux Vases, and in many places thin-bedded, cross-bedded, and ripple-marked, and associated with the sandstones are arenaceous and clay

shales, the latter of which are variegated in color in many localities, and locally limestones. In the upper part of the tributary crossing the n.w. 1/4 of sec. 35, T. 3 S., R. 9 W., there are good exposures of limestone, as much as 18 feet being present, while lower down there are sandstones. In a tributary crossing the north half of s.e. 1/4, sec. 2, T. 4 S., R. 9 W., good outcrops of arenaceous and clay shales, and limestones are exposed. In the s.e. 1/4 of n.e. 1/4, sec. 11, T. 4 S., R. 9 W., the outcrops are argillaceous shales, some of which are variegated in color. Near the mouth of a tributary in the south half of sec. 13, T. 4 S., R. 9 W., Renault limestone is exposed, and in a tributary crossing the s.e. 1/4 of the same section a number of outcrops of sandstone and variegated shale are exposed, about one-half mile from the mouth. In a number of these localities good exposures of Yankeetown are present above the Renault, showing that they are at or near the top of the formation.

The valley of Horse creek itself, south from the middle of sec. 2, T. 4 S., R. 9 W., is largely filled with alluvium, and outcrops of the hard rocks are essentially wanting except at long intervals, but the channel must be cut in the Renault formation to a point where the stream crosses the Monroe-Randolph County line. The extension of the Renault to the west, in the area drained by Horse creek and its tributaries, is considerably beyond the limits of the subjacent Aux Vases, and the formation underlies considerable areas in the uplands between the larger forks and tributaries, which are so heavily drift covered that no outcrops are exposed. The approximate limit of the formation has been

determined, however, by occasional outcrops in the upper portion of some of the tributary valleys. A series of sandstones are exposed in the n.e. 1/4 of n.w. 1/4, sec. 32, T.3 S., R.9 W., in the valley which crosses this quarter section diagonally to the northeast, which do not have the massive characters of the Aux Vases, but are thinly bedded and shaly in part, some of the beds being pierced by vertical Scolithus-like tubes. These beds have been considered as Renault although no Lepidodendron trunks have been observed in them. The contrast between these sandstones and the massive beds about three-fourths of a mile due north, which have been referred to the Aux Vases, is marked. In the head of the tributary valley in s.w. 1/4, of n.w. 1/4, sec. 33, T.3 S., R.9 W., undoubted Renault, variegated red and blue shales, is exposed, and in the south edge of n.w. 1/4 of s.w. 1/4 of the same section, in the head of the next valley to the south, there is a good outcrop of typical Renault limestone. In the same general region other sandstones of the character of those commonly present in the Renault, are exposed in n.e. 1/4 of n.w. 1/4, sec. 4, T.4 S., R.9 W.

Between the main tributary of North Fork of Horse creek from the west, and South Fork of the same creek, the Renault is especially well developed. In some of the shorter tributaries to the main stream between these two larger ones, there are especially good exposures of the Renault. The best of these is in the valley which traverses the

southern portion of s.w. 1/4 of sec. 2, T.4 S., R.9 W. heading in the northwest corner of sec. 10. In this ravine the rocks are almost continuously exposed, there being sandstone, calcareous sandstone, limestone and shales present. None of the sandstone layers present the massive character of the Aux Vases through any considerable thickness, and all the beds, both sandstone and limestone, are conspicuously cross-bedded. There are apparently three limestone members in the formation in this section, one near the base, another near the middle, and a third at the top. The uppermost of these limestones must underlie a considerable area, and is responsible for the development of the sink-hole topography in s.w. 1/4, sec. 2 and s.e. 1/4 sec. 3, T.4 S., R.9 W. The middle limestone member is well exposed just east of the private road which crosses the ravine in s.w. 1/4, of s.w. 1/4, sec. 3. It differs from most other Renault limestones which have been observed in being somewhat oolitic, and associated with this oolitic texture there are some elements in the fauna which have their most typical development in the oolite beds of the Okaw limestone, and which are foreign to the Renault as it has been observed elsewhere. The full list of species that have been identified in this fauna are as follows:

Cystelasma ? sp.

Pentremites pyriformis Say.

Cheilotrypa sp.

Leioclema ? araneum Ulrich

Fenestella cestriensis Ulrich.

F. serratula Ulrich.

F. tenax Ulrich

Polypora 2 or 3 sp.

Rhombopora sp.

Crania sp

Orthotetes kaskaskiensis (McChesney.)

Productus ovatus Hall.

P. sp.

Spirifer increbescens Hall, var.

S. Leidyi Norwood and Pratten.

Spiriferina transversa (McChesney.)

Reticularia setigera (Hall.)

Composita trinuclea (Hall.)

Cliothyridina sublamellosa (Hall.)

Eumetria verneuilliana Hall.

Girtyella indianensis (Girty.)

Sanguinolotes sp.

Nucula sp.

N. sp.

Leda sp.

Parallelodon sp.

Conocardium sp. aff. C. cuneatum Hall.

Myalina sp.

Aviculopecten sp.

Cypricardella sp.

Microdon sp. aff. M. oblonga Hall.

Bellerophon sp.

Euphemus sp.

Cyclonema ? sp.

Bulimorpha ? sp.

Holopea ? sp.

Orthonychia chesterensis Meek and Worthen

Platyceras sp.

Orthoceras sp.

Discitoceras sp.

Griffithides sp.

In another tributary valley across the s.w. 1/4, sec. 11, T.4 S., R.9 W., good Renault outcrops are exposed, arenaceous and cross-bedded limestone below, with sandstone and arenaceous shale further up the valley, some of the sandstone layers being pierced by vertical, Scolithus-like burrows, such as have been observed at numerous localities in the Renault. In the same general region the Renault is well exposed in the upper portion of the tributaries to the South Fork of Horse creek, heading in the southern part of sec. 10, T.4 S., R.9 W., where the beds exposed are arenaceous shales and sandstones. A limestone member of the Renault, with sandstone at a higher elevation is well exposed in the valley cross the n.e. 1/4 of n.e. 1/4, sec. 9, T.4 S., R.9 W., the underlying beds

being massive Aux Vases sandstone through which the stream has cut a gorge thirty feet deep.

In the main channel of South Fork of Horse creek, there is an exposure of arenaceous limestone in the extreme southeast corner of sec. 8, T. 4 S., R. 9 W., which is near the base of the Renault, there being only a few feet of shale with thin, interbedded layers of sandstone between it and the massive Aux Vases. Upon the weathered surface of this limestone numerous small crinoid stem segments are exposed. A few rods further up the stream the following section is exposed in the creek bank.

- 3. Sandstone, yellow-brown in color, mostly
thin-bedded.....10 feet
- 2. Limestone, arenaceous with numerous small
crinoid stems and other fossils upon the
weathered surface.....4 feet
- 1. Sandstone, massive.....2 feet

These beds are Renault, near the base of the formation, and higher up the valley nearly to its head, there are numerous outcrops of massive and thin-bedded sandstone and arenaceous limestone, but no pure limestones. The angle of dip of the beds is not far from the gradient of the stream, so no considerable thickness of the formation is exposed.

The Renault formation underlies all the upland between the South Fork of Horse creek and Paint creek, the Aux Vases being exposed

in only one narrow strip in this whole region, for about a mile in the bed of Dry Fork. In a portion of this area the younger formations, Yankeetown and Paint Creek, overlie the Renault, so that the actual outcrops of the formation are confined to the borders of the area and the deeper valleys. In the eastern part of this area, in the main valley of Horse creek, good Renault limestone outcrops are present in the highway running north and south near the western edge of s.w. 1/4, sec. 13, T. 4 S., R. 9 W., and in the bank of the creek at the south edge of the same quarter section. In the n.w. 1/4 of the adjoining section 24 to the south, two sink holes in this limestone are shown upon the topographic map and in the small valley leading to the east in this quarter section, there are other good limestone outcrops. The same limestone is again exposed in the two small valleys leading to the east in s.w. 1/4 of the same section 24, and rather extensive exposures are present in the somewhat larger valley in the extreme northwestern part of sec. 25, T. 4 S., R. 9 W. At this last locality the limestone is capped by the Yankeetown at the road crossing just over the line in the north-eastern corner of section 26, and in the midst of the limestone, some distance from the top, is a conspicuous chert horizon, which is unusual for the Renault.

At the house east of the road, in the southern part of s.e. 1/4 of n.e. 1/4, sec. 23, T. 4 S., R. 9 W., a well has been drilled to the depth of 140 feet. It is located a short distance down the hollow,

perhaps 20 feet below the level of the road, and the section, as reported by the owner, is as follows.

Soil.....24 feet
Limestone.....20 feet
Shale.....20 feet
Limestone.....20 feet
Shale.....20 feet
Sandstone.....36 feet

The sandstone in the bottom of this well is undoubtedly the Aux Vases, and all the beds above are Renault, unless a part of the uppermost limestone is really Yankeetown which appears to be a very hard, siliceous limestone in some localities under cover. The conspicuous development of limestone in the Renault here is in keeping with the character of the formation as it is exposed in outcrops in the immediate neighborhood.

In the valley of Prairie Branch, crossing the south half of sec. 26, T. 4 S., R. 9 W., the Renault is well exposed at a number of points, being represented by limestone, some beds of which are cherty, and by variegated shale.

In the tributary of Dry Fork of Horse creek, flowing northeast diagonally across the s.w. 1/4, sec. 23, T. 4 S., R. 9 W., there are most excellent exposures of Renault, limestone below, succeeded by sandstone with vertical Scolithus-like burrows, these again by lime-

stones and calcareous shales. Near the head of the valley, just over the line in the next section to the south, is an exposure of variegated shales at the top of the formation, just beneath the Yankeetown. About midway in the length of this valley is a continuous vertical exposure of about 25 feet, where the following beds are distinguishable.

4. Limestone, with some shale partings.....5 feet
3. Shale, calcareous, with thin limestone layers
Fossils abundant.....15 "
2. Limestone, arenaceous.....2 to 3 "
1. Sandstone, yellow-brown in color, massive,
with numerous vertical, Scolithus-like
burrows. Exposed.....3 "

In the calcareous shale bed, No. 3 of the above section, fossils are abundant and well preserved, and the following species have been identified.

Zaphrentis spinulosus Edwards and Haime.

Eupachycrinus sp.

Talarocrinus ovatus Worthen.

Pentremites pyriformis Say.

Pentremites florealis

P. symmetricus Lyon

Stenopora tuberculata (Prout.)

Fenestella cestriensis Ulrich.

- E. serratula Ulrich
Polypora cestriensis Ulrich
Cystodictya sp.
Glyptopora sp.
Orthotetes kaskaskiensis (McChesney.)
Productus ovatus Hall.
Diaphragmus elegans (Norwood and Pratten.)
Dielasma shumardanum (Miller.)
Spirifer increbescens Hall, var.
Eumetria verneuilliana Hall
Cliothyridina sublamellosa (Hall.)
Composita trinuclea (Hall.)
Conularia sp.
Cladodus sp.
Ctenecanethan sp.

The bed of Dry Fork of Horse creek is excavated in the Renault formation throughout its entire length, except for a distance of about one mile, across the western half of sec. 27, and into the s.e. 1/4 of sec. 28, T. 4 S., R. 9 W., where the upper beds of the Aux Vases are exposed. The Renault outcrops in the valley consists of sandstone, arenaceous shale, variegated shale, and limestone, some of which is arenaceous. In some of the sandstone Lepidodendron trunks are present. In the tributary to Dry Fork, flowing east across the northern portion of sections 27 and 28, T. 4 S., R. 9 W., there are numerous outcrops of Renault, mostly sandstones and arenaceous shale,

with one exposure of arenaceous limestone near the junction of the stream with the main valley. Some of the sandstone along this stream is more massive through a greater thickness than is usual in the Renault, which makes some of the outcrops to simulate the Aux Vases more than usual, but the association of these denser beds with the thinner bedded sandstones and arenaceous limestone, is unlike the Aux Vases.

The tributary to South Fork of Horse Creek flowing northeast nearly parallel with the lower Dry Fork Valley, across sections 22 and 23, T. 4 S., R. 9 W., has cut its bed entirely in the Renault, the strata exposed being limestone, shales, and sandstones, some of which are thin-bedded. Another tributary joining the South Fork near the middle of the north line of s.e. 1/4, sec. 15, T. 4 S., R. 9 W., with its head in n.w. 1/4 of n.w. 1/4, sec. 22, has excavated its valley in the Renault entirely. All the strata exposed are thinly-bedded sandstone, or arenaceous shales, with more massive beds of sandstone at intervals, no limestone being present in the section.

One mile west of the last mentioned tributary, an outcrop of arenaceous shale, capped by Yankeetown chert, is exposed in the highway a few rods north of the south line of the section, which must represent the top of the Renault. Still further west other outcrops of arenaceous and variegated shales are exposed above the massive Aux Vases in a short tributary across n.w. 1/4 of s.e. 1/4, sec. 16, T. 4 S., R. 9 W.

In the tributary leading to the north across the n.w. 1/4, sec. 21, T. 4 S., R. 9 W., no Aux Vases sandstone is exposed, and the Renault formation consisting of argillaceous and arenaceous shales, thin-bedded

sandstones, and calcareous sandstones, rests directly upon the St. Louis limestone. The further overlap of the Renault formation to the west is especially well exhibited in the valley heading in n.w. 1/4, sec. 30, T. 4 S., R. 9 W., about one-half mile north of the village of Renault. In the head of this valley the Renault formation, represented by sandstone, variegated shale, and arenaceous limestone, is exposed in actual contact with the St. Louis limestone. The basal bed of the formation is limestone with poorly preserved fossils of the sort commonly present in the Renault, and with numerous clay pebbles and other foreign inclusions. This basal limestone bed is comparatively thin, perhaps not over two feet, and passes up into arenaceous and shale beds. At an elevation of 20 to 25 feet above the contact, is a bed 5 or 6 feet thick of variegated red and blue shale, best exposed in a small side draw to the east. At a point a few rods further down the stream, on the west side of the valley, the basal member of the Renault is a much thicker limestone stratum which resembles in every way, the purer Renault limestones which have been observed elsewhere.

The southwestern boundary of the Renault formation, extending southeast from the village of Renault, is not determinable from outcrops because of the thick covering of loess and drift, but the limits of the St. Louis limestone is sharply defined by the sink-hole topography, and the approximate position of the line between the Renault and the St. Louis can be drawn on this basis.

The valley of Paint Creek, from its head to a point about one and one-half miles from its junction with Horse creek, is excavated

in the Renault formation, although outcrops of the rock strata are uncommon except in the uppermost half mile of the course. The only exposure in the lower portion of the valley are variegated shales in the n.e. 1/4 of n.e. 1/4, sec. 2, T. 5 S., R. 9 W. The exposed beds towards the head of the Paint creek valley are all sandstone which is somewhat more dense than usual, simulating the Aux Vases in its lithologic characters, but exposures are nowhere continuous in vertical walled gorges as is the case in many valleys cut in the Aux Vases, and the thinner-bedded sandstone and shaly layers of the formation are doubtless present in the intervals hidden by talus and drift.

South from the head of Paint creek the Renault exposures are limited to the valleys of streams flowing to the southeast and draining into the Mississippi river. The gradient of these streams is opposed to the gentle dip of the strata, so that the outcropping surfaces of the several formations involved are limited to rather narrow belts which follow the configuration of the topographic surface. Beyond this point, also, the overlap of the Renault to the west beyond the Aux Vases sandstone, is not exhibited, so that the massive sandstone is continuously present between the Renault and the Ste. Genevieve or St. Louis limestones.

In the branches of Prairie du Rocher creek from the east, the Renault is represented in almost every section by sandstone which is difficult, in places, to differentiate from the subjacent Aux Vases. In none of the sections, however, are the exposures continuous, and

it is the more massive layers, the ones which most closely resemble the Aux Vases, which are likely to be exposed, and the thinner-bedded and shaly layers being more commonly talus covered. The presence of an occasional trunk of Lepidodendron in the higher sandstone layers, however, stamps them as belonging to the Renault formation. At only one locality within the drainage area of Prairie du Rocher creek, in n.e. 1/4 of s.e. 1/4, sec. 15, T. 4 S., R. 9 W.,¹ are the

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In making locations in the areas covered by Spanish grants, the section lines have been projected through the grants, and the localities are described as if the area had been subdivided into sections.

arenaceous shale beds of the Renault well exposed, and at no locality has any limestone member been observed.

In the several tributaries of the stream draining the area south from Commons School, two and three-quarter miles northeast of Prairie de Rocher, there are many Renault outcrops. In the upper portion of the most westerly tributary, in the extreme northeastern corner of sec. 22, and the n.w. 1/4 of n.w. 1/4, sec. 23, T. 4 S., R. 9 W., the formation is represented almost entirely by arenaceous shales. In the tributary known as Barber hollow, in sections 14 and 23, T. 4 S., R. 9 W., the Renault is exposed in almost continuous outcrop along the bed of the stream for a distance of nearly three-fourths mile in s.w. 1/4 of s.e. 1/4, sec. 14, and n.e. 1/4, sec. 24. The direction of this portion of the stream is nearly along the strike of the rocks so no great thickness of strata are exposed, all

the outcrops belonging to one limestone and shale horizon at the top of the formation, with the Yankeetown overlying it. In the main valley leading almost straight southwest to the gap in the Mississippi bluffs, the Renault is not so well exposed, but limestone beds outcrop at intervals, with the Yankeetown only a few feet above. In the most easterly tributary the Renault is not well exposed, although the Yankeetown and the still higher Paint Creek formation outcrop at a few localities.

In the several tributaries of the creek intersecting the bluffs of the Mississippi at Modoc, the Renault is mostly drift covered, but in the tributary from the east an outcrop of Renault limestone and another of shale are exposed in the southern part of n.w. 1/4. sec. 31, T. 4 S., R. 9 W.

Along the bluff below Modoc the Renault is exposed in some of the small draws, being represented by shales and sandstones above the ledges of massive Aux Vases below. In the ravine whose mouth is one mile below Modoc, a number of Renault limestone outcrops are present about one-fourth mile back from the bluffs, and in the next ravine, four-tenths of a mile further along, a good Renault limestone exposure, with Yankeetown above it, occurs about 700 to 800 feet back from the highway at the base of the bluffs. At this locality a good specimen of the fossil crinoid Talarocrinus ovatus, one of the most diagnostic Renault species, was secured. The last exposure of Renault

before the formation finally passes beneath the younger formations, is by the roadside at the mouth of the short ravine about two-tenths of a mile still further down the bluffs, a little over one mile and one-half from Modoc. At this point some of the upper beds of the formation, sandstone and arenaceous limestone, are exposed.

East of the Columbia anticline, in the northern part of Monroe county and extending over the line for a short distance into St. Clair county, the Renault formation is exposed in a number of localities, at all of which it exhibits the same lithologic characters, and where fossils are present, the same faunal character as have been observed elsewhere.

The most northern of these outcrops is in St. Clair county, about one-fourth mile above Lake View, where a small quarry has been opened in the base of the Mississippi river bluff just east of the highway. At this locality about ten feet of strata are exposed, crinoidal limestone below with green, shaly partings, passing upward into greenish, arenaceous, irregularly bedded limestone, and this again passing into greenish and variegated shales. In the crinoidal limestone at the base fossils are fairly common and the following species have been identified from the collections secured.

Talarocrinus ovatus Worthen

Pentremites pyriformis Say.

Stenopora sp.

Archimedes sp.

Lyropora sp.

Productus ovatus Hall.

Diaphragmus elegans (Norwood and Pratten.)

Dielasma shumardanum (Miller.)

Girtyella brevilobata (Swallow)

Spiriferina transversa (McChesney.)

Spirifer increbescens Hall, var.

S. leidyi Norwood and Pratten.

Composita trinuclea (Hall.)

Cycloceras sp.

A little further south, opposite the road corner at Lake View, there are other limestone outcrops belonging to the Renault formation. Beyond this point there are no outcrops of any sort along the Mississippi bluff for a distance of three-fourths mile, where excellent exposures of Ste. Genevieve limestone are exhibited. There is no indication whatever of any Aux Vases sandstone occupying the interval between the Ste. Genevieve and the Renault, and as the dip of the beds is very gentle, the interval is probably not greater than is sufficient to accommodate the Renault sandstone and shale beds which are known to lie beneath the lowest limestone member of the formation a few miles further south. The only other Renault outcrops north of Carr creek are in two short ravines intersecting the bluff between Carr and Palmer creeks, where there are small outcrops of arenaceous and variegated shales. At the southernmost of these two

localities the shale outcrop is only a few feet above an outcrop of Ste. Genevieve limestone, with no Aux Vases present.

South of Carr creek the Renault outcrops occur in the stream valleys some distance back from the Mississippi bluffs. In the rather broad and short tributary to Carr creek heading in s.e. 1/4, sec. 20, T. 1 S., R. 10 W., and leading northwest, there are outcrops of variegated shale, and sandstone referable to the Renault, and in the still smaller tributary next east, in s.w. 1/4, sec. 21, T. 1 S., R. 10 W., there is a good exposure of arenaceous shale which undoubtedly belongs in the Renault.

In Little Carr creek the Renault is well in the upper part of the main valley and in a short tributary from the east, in s.w. 1/4, sec. 28, and n.w. 1/4, sec. 23, T. 1 S., R. 10 W. These exposures are chiefly limestone with some shale. The limestones are cross-bedded and variable in lithologic character, some beds being arenaceous, others almost wholly calcareous with numerous fragments of crinoid stems and other fossils on the weathered surfaces. In one shale bed in the side of the main valley, fossils are abundant and well preserved, and the following species have been recognized.

The very base of the Renault beds in Little Carr creek is exposed in the south end of an elongate sink hole in a tributary from the south, in the extreme northwestern corner of sec. 33, T.1 S., R. 10W. The basal bed is sandstone and rests upon Ste. Genevieve limestone in which the sink-hole is developed. The elevation of this basal sandstone member of the formation is the same as that of the fossiliferous limestones and shales in the main valley, not more than 1000 feet distant to the southeast, and the dip of the strata doubtless carries the sandstone just beneath the limestone. In the main valley of the creek, Pennsylvanian limestone, with such characteristic fossils as Spirifer cameratus, is exposed, less than one-fourth mile above the Renault outcrops, and about 20 feet higher in elevation. With these limits established, the total thickness of the Renault in this section cannot exceed 40 feet, and is probably less, and there is no place for the Aux Vases sandstone.

In the upper part of Carr creek valley, in s.e. 1/4, sec. 33, T. 1 S., R. 10 W., a number of limestone outcrops are exposed in or near the bed of the creek, at a little distance beneath the characteristic red clay in the basal part of the Paint Creek. Although no exposures of Yankeetown have been observed beneath the Paint Creek beds at these localities, and the limestones have afforded no faunas, as yet, their lithologic characters suggest the Renault, and they doubtless represent the uppermost beds of that formation.

About three-fourths of a mile northeast of New Hanover, in n.e. 1/4 of n.e. 1/4, sec. 5, T. 2 S., R. 10 W., a contact between the Ste. Genevieve limestone below and a sandstone formation above,

is present at the bridge on the north and south road. No fossiliferous limestone is associated with this sandstone, and no fossils of any sort have been found in it, so it is not possible to determine its age with certainty. It has none of the characters of the Aux Vases, however, and is undoubtedly either Renault or basal Pennsylvanian. Pennsylvanian beds are certainly present about one-half mile east, in the south branch of the valley, where a small outcrop of black, carbonaceous shale, characteristically Pennsylvanian in aspect, is poorly exposed. On the accompanying geological map these sandstones are in part at least, mapped as Renault, making the Renault belt continuous, but it is possible that the overlapping Pennsylvanian at this point extends beyond the Renault and rests upon the Ste. Genevieve limestone.

In the large tributary to Andys creek from the north, in sections 4 and 9, T. 2 S., R. 10 W., the Renault is well exposed. In the s.w. 1/4 of n.e. 1/4, sec. 9 the actual contact of the base of the formation upon the subjacent Ste. Genevieve limestone, is exhibited, with the following succession of beds.

6. Sandstone ledged, fine-grained, yellow brown
In color.....
5. Shale, variegated red and green, with thin
beds of limestone conglomerate.....2 feet
4. Talus covered.....4 "
3. Calcareous bed, tough and earthy in texture,
its base irregular, with irregular, knotty bedding

lower half.....1 foot

2. Shale, variegated red and green in color, with some calcareous beds at the top. Fossiliferous.....5 feet

W. 543

1. Ste. Genevieve limestone.....

Succeeding the basal 12 feet of strata in this section, above the Ste. Genevieve limestone, the sandstone strata of bed No. 6 are more or less continuously exposed in the bed of the creek to the junction of the main tributary from the east with those from the north, in n.w. 1/4 of n.e. 1/4, sec. 9. The several beds of this sandstone member vary in character, but in the main they are fine-grained and yellow-brown in color, some beds being marked by crowded darker brown specks. Some beds are dense and massive, others are thin-bedded and more or less shaly; some are even-bedded and others are much cross-bedded, but nowhere in the section is there that continuity of massive sandstones which characterizes the Aux Vases. At the junction of the tributaries mentioned above, is a thin, calcareous, sandstone bed, perhaps 6 inches in thickness and probably about 25 feet above the base of the formation, which is filled with a few species of fossils, the following forms being present in the collection secured.

A little further up stream in the tributary from the north, in with same bed as the fossiliferous one last mentioned, or in a closely associated one, numerous fragments of crinoid stems and plates are present, among which the plates of the characteristic Renault form, Talarocrinus ovatus, are not uncommon. About 10 or 15 feet higher up in the section, in the same valley with the last, is a bed of limestone with a thickness of not over two feet exposed, which is made up largely of crinoidal remains, with some poorly preserved pentremites, brachiopods and bryozoans. In this bed, among other things, the characteristic Renault forms, Talarocrinus ovatus and the bases of a large Lyropora, are present.

In the main valley of Andys creek, east from the mouth of the tributary from the north in which the section last described is exposed, the stream has cut a deep gorge in the Ste. Genevieve formation. The last outcrop of Ste. Genevieve is in the western part of n.w. 1/4 of n.w. 1/4, sec. 15, T. 2 S., R. 10 W., and beyond this point, up stream, the valley is cut in glacial drift for about one-fourth mile, but in n.e. 1/4, of n.w. 1/4, sec. 15, a few rods east of the road crossing, there are exposures of sandstone apparently belonging to the Renault formation, with Yankeetown beds above. Above the Ste. Genevieve bluffs in the gorge, a half mile down stream on the north side of the valley, there is much loose sandstone, but no outcropping ledges, suggesting the presence of shale or shaly beds below with more massive sandstones above, such as

is present in many places in the Renault. Higher up on the hill side masses of characteristic Yankeetown are present, which further suggests the presence of the Renault at this locality above the Ste. Genevieve.

In each of the tributaries to Fountain creek from the northeast between the s.e. 1/4, sec. 16, T. 2 S., R. 10 W., and the Harrisonville road leading west from Waterloo, there are numerous outcrops of sandstone, with some arenaceous and variegated shale, towards the heads of the valleys, which in each case rest upon limestone of the Ste. Genevieve formation. In none of these sections have there been observed any calcareous beds interbedded with or lying above the sandstones, and no fossils have been observed in the sandstones themselves, so that the determination of the true age of the beds is difficult. Individual outcrops of the sandstone are of such a character that they might be considered as Aux Vases, but the outcrops are nowhere continuous, and where the continuity is most complete there are beds of arenaceous and variegated shales present, an association which is not a character of the Aux Vases, but which is commonly found in the Renault. Another possibility is that the sandstone in these valleys is Pennsylvanian in age, but the presence of the variegated shales is not suggestive of such a correlation. On the whole the beds seem to agree best, in all the characters available, with the Renault as that formation is known throughout the region, and consequently they have been so considered on the accompanying geological map.

Sub-Renault unconformity. In the foregoing detailed descriptions of the outcrops, it is believed that sufficient data have been presented to make it clear that the Renault formation, largely sandstone in composition, must be differentiated from the basal, more massive, Aux Vases sandstone of the Chester group. This formation, at least the arenaceous portion of it, was undoubtedly included by Worthen in his "Lower Sandstone of the Chester Group", and its southern extension in Illinois and Kentucky was probably included in the Cypress sandstone by Engelmann and by Ulrich. The upper limit of the formation is very sharply defined by the siliceous Yankeetown which itself is succeeded in a very few feet by the red clay member of the Paint Creek formation. These two beds are remarkable for their persistence and can be followed with absolute certainty from the northern limits of the area under consideration, where they disappear beneath the overlapping Pennsylvanian strata, to the point where they pass beneath the younger Chester formations in the Mississippi river bluffs below Modoc. They reappear on the opposite side of the Mississippi river in Ste. Genevieve and Perry Counties, Missouri, where they continue to outcrop to the point where they finally disappear beneath the younger formations.

The basal line of the Renault is much less easy to follow than the upper, at least in that area where it is underlain by the Aux Vases. In the area where the Renault is in contact with the Ste. Genevieve or St. Louis limestone by reason of its overlap, the base of the formation is sharply defined, and the unconformable relations between it and the

subjacent limestone are clear. Where the Renault rests upon the Aux Vases, however, the unconformable relations between the two formations are obscure in many places. The discontinuous and talus covered exposures in most of the sections, combined with the similarity of the sand entering into the composition of the two formations, makes it impossible, in many sections, to determine with absolute certainty the line of separation between the two formations. Where the sections are continuously exposed, however, the line of division between the massive Aux Vases sandstone beds below, and the more thinly bedded or even shaly sandstones above, which are associated with variegated clay shales, and in many places with limestones, is distinct enough.

The unconformity of the Renault upon the Aux Vases, involving a retreat of the sea in post-Aux Vases time, the erosion of the Aux Vases surface, followed by a readvance of the Renault sea, is apparently established by the conspicuous development in some localities, of a basal conglomerate in the Renault, resting upon the Aux Vases. The best exhibition of this conglomerate in Illinois is in the section described on page of this report, exposed in a tributary of Hickman creek, in the extreme northern portion of our area, on the south line of S.W. 1/4 of s.w. 1/4, sec. 32, T. 1 N., R. 10 W. Less than one mile north of this locality, the Aux Vases is entirely wanting, although it seems to be present in a northwesterly direction. To the west and southwest the Aux Vases is also wanting in the sections. To the east the beds all pass beneath the Pennsylvanian in a short distance, so the stratigraphic relations

are hidden. Far to the south, across the Mississippi river in Ste. Genevieve county, Missouri, the basal conglomerate of the Renault, underlain by the Aux Vases, is again well exhibited¹. In the intervening region the

conglomerate has not been observed, but lack of knowledge of it is more likely to be due to the covering of the outcrops at critical points than to the absence of the bed.

If the western transgression of the Renault is not associated with a general unconformity at the base of the formation, but is rather indicative of a progressive transgression of the sea from Aux Vases time into Renault time, there should be no basal conglomerate in the Renault overlying the Aux Vases at any locality, and furthermore, the basal sediments in the transgressing sea should be uniform, or if there is a lack of uniformity there should be a gradual change, laterally, from one type of basal sedimentation. This is not the condition in the case of the Aux Vases and the Renault. There is no gradual transition from the Aux Vases type of initial sediments to the Renault type, but rather an abrupt change along a line where the Heterogeneous Renault formational unit passes from its contact with the Aux Vases to its contact with the Ste. Genevieve or St. Louis limestones.

Discuss thickness of Renault

RENAULT FIELD OBSERVATIONS.

See limestone exposures in upper part of valley, n.w. 1/4, sec. 35, T. 3 S., R. 9 W., three and one-half miles northwest of Red Bud. Collect fossils.

See outcrops in north 1/2 of s.e. 1/4, sec. 2, T. 4 S., R. 9 W.

Make measured section in ravine west of Horse creek, next south of Red Bud road.

Re-examine Renault section in n.w. 1/4, sec. 25, T. 4 S., R. 9 W. Measure section carefully, collect fossils.

Re-examine Renault overlap north of Renault, and collect fossils from the basal limestone beds.

YANKEETOWN FORMATION

The Yankeetown¹ formation, although it is a thin bed which

¹Weller, Trans. Ill. Acad. Sci., vol. 6, p. 124 (1914), also Ill. State Geol. Surv., Monog. I, p. 25 (1914)

probably never exceeds and rarely attains a thickness of 20 feet, is one of the most persistent members in the Chester Group of the Randolph-Monroe County area, and it continues southward across the Mississippi river into Ste. Genevieve and Perry counties, Missouri, without essential change to the point where it finally disappears beneath the younger formations. In all the outcrops where the formation has been

exposed to long weathering, it is a hard, siliceous rock, in some localities a true chert, in others an arenaceous chert, and rarely a quartzite. At a few localities it has been observed to be a very hard, siliceous limestone, and this seems to be its condition in some places where it has been encountered in well digging. The color of the formation is commonly light buff to gray or nearly white, although in a few localities, especially where the quartzitic character is well developed, it is distinctly rose-colored. In many localities the beds are distinctly banded with alternately lighter and darker bands from one to three or four millimeters in width. In many localities the bedding of the formation is exceedingly irregular and knotty, or contorted, while in other places it is more even.

Areal distribution and description. The northernmost point where any indication of the Yankeetown formation has been observed is in the public highway just west of the road corner in s.w. 1/4, sec. 30, T. 1 N., R. 9 W. At this locality the formation does not occur in place, but masses of cherty rock are present in the gutters by the roadside which have the lithologic character of the Yankeetown. In the creek bed only a few rods further west, sandstones of Renault age are exposed, so the Yankeetown might well be looked for at this point.

In a southeast direction from the locality just mentioned, the Yankeetown is well exposed at a number of places. In the head of a short ravine from the west, tributary to Hickman creek, in the s.e. 1/4, sec. 6 T. 1 S., R. 9 W., the Yankeetown is present immediately overlying a series

of Renault shales and sandstones, the detailed section of which has been given on page of this report. Here the Yankeetown is rose-colored and conspicuously quartzite in part, other portions being of the ordinary color and arenaceous or cherty in texture. The presence of Yankeetown residuum towards the heads of the valleys in the s.e. 1/4, sec. 32, T. 1 N., R. 9 W., gives indication of the presence of the formation, although no outcrops have been observed. Further south, in the head of a tributary to Hickman creek, in the extreme northeastern corner of s.e. 1/4 of n.e. 1/4, sec. 7, T. 1 S., R. 9 W., good Yankeetown exposures are present, and although the formation is deeply drift covered, it doubtless underlies a considerable area in n.w. 1/4 of n.w. 1/4, sec. 8, and in the s.w. 1/4, sec. 5.

Northwest of Millstadt the Yankeetown is exposed in two isolated areas where a tributary of Prairie du Pont creek has cut through the overlying Pennsylvanian beds into the uneven surface of the underlying Chester. In a branch of this stream from the west the formation is exposed in s.w. 1/4 of s.e. 1/4, sec. 5, T. 1 S., R. 9 W., and the exposures continue with some interruption in the bed of the branch and in the bed of the main stream nearly to the north line of n.w. 1/4, sec. 4, T. 1 S., R. 9 W. In another small tributary of the same creek, entering from the south, the Yankeetown is well exposed in n.w. 1/4 of n.e. 1/4, Sec. 4, T. 1 S., R. 9 W., and continued northward into the next section for a short distance, in the main valley of the stream. In this last locality the beds have been folded

into the two small anticlines with a syncline between, or into a single anticline with one limb faulted, some of the dips being as high as 60 degrees. This deformation is very local, however, and has not been observed beyond a single forty acre tract.

Southwest of Millstadt other isolated areas of Yankeetown are exposed in the beds of some streams where the erosion has cut through the overlying Pennsylvanian formations into the uneven Chester surface. One such area is in the beds of the two forks of a tributary of West Fork creek, in the s.e. 1/4, sec. 20, and along the extreme northern margin of n.e. 1/4, sec. 29, T. 1 S., R. 9 W. A second area of the same sort is south of Bohleysville, in n.e. 1/4 sec. 32, T. 1 S., R. 9 W. In both of these localities the Yankeetown is a very irregularly bedded, knotty, siliceous cherty formation, with some thinly-bedded, undulating, discontinuous, shaly layers, and with occasional small pockets of plastic clay of a bluish color.

In the valley of Prairie du Long creek, the Yankeetown is exposed at two localities overlying the Renault beds, and presumably succeeded by the Pennsylvanian, although the deep drift covering obscures the contacts. These two outcrops are in the s.e. 1/4, sec. 32, T. 1 S., R. 9 W., and n.e. 1/4, sec. 5, T. 2 S., R. 9 W., one on the north side of the north fork of the stream, and the other on the south side of the south fork, just above the junction of the two forks.

In the n.w. 1/4 of n.w. 1/4, sec. 9, T. 2 S., R. 9 W., on the line between Monroe and St. Clair Counties, a good typical exposure of the Yankeetown is present in the bed of a tributary to Gerhardt creek.

The formation probably extends for a half mile or more in a southeast direction from this outcrop, along the stream valley, but there are no other exposures because of the thick drift.

Southward from the locality last mentioned, no Yankeetown outcrops have been observed for a distance of seven miles or more, to a point south of Rock House creek, about three miles east of New Design. In this interval the formation is doubtless covered in part by the overlapping Pennsylvanian sandstones, and in part is obscured by the thick mantle of glacial drift. From the localities east of New Design, however, south to the Mississippi river bluffs, the Yankeetown is continuously exposed except where it is hidden by the Pleistocene deposits. Throughout this area it is nowhere covered by the overlapping of the Pennsylvanian beds, or of any of the younger Chester formations, and actual exposures are sufficiently numerous to make the mapping of the formation a comparatively simple matter.

East of New Design the Yankeetown is the surface rock, beneath the drift mantle, over a considerable area. An excellent exposure is present in the head of the valley in n.w. 1/4 of n.w. 1/4, sec. 21 T. 3 S., R. 9 W., a little over one-half mile east of New Design. Other exposures are present in the heads of the valleys in s.w. 1/4 of n.e. 1/4, and in the n.w. 1/4 of n.e. 1/4 of the same section 21. In the s.w. 1/4 of n.e. 1/4, sec. 16, T. 3 S., R. 9 W., there is a good exhibition of residuum from the formation, although no beds in place are exposed. This residuum, however, must be nearly in place, since the Renault sand-

stone is exposed only a few rods down the valley to the southeast. In the same valley, where it makes a turn to the northeast, in n.w. 1/4, sec. 22, T. 3 S., R. 9 W., the stream flows over a bed of Yankeetown for a distance of nearly a quarter of a mile. Good Yankeetown exposures are again present in a tributary of this stream from the west, in n.e. 1/4 of s.e. 1/4, sec. 15, T. 3 S., R. 9 W. In the public highway running north and south through the center of n.e. 1/4, sec. 14, T. 3 S., R. 9 W., the Yankeetown is exposed just south of the crossing over the creek, but it is here a highly siliceous limestone rather than the cherty rock which is its more usual facies. Associated with all of these outcrops the Renault is exposed at only a little lower elevation, and in some of the localities the actual contact between the two formations is exhibited.

In tracing the formation further south a number of good exposures of the Yankeetown have been observed in some of the short tributaries of Horse creek from the east, between Poe Station on the Mobile and Ohio railroad and the junction of Paint and Horse creeks. Less than one-fourth mile west of Poe Station, exposures of Yankeetown are present both north and south of the east-west road in little draws which are tributary to Bradley branch from the east. Below the mouth of Bradley branch, the Yankeetown is exposed towards the head of a short valley in s.w. 1/4 of s.e. 1/4, sec. 35, T. 3 S., R. 9 W. Other excellent exposures occur in two valleys near the western border of n.w. 1/4, sec. 12, T. 4 S., R. 9 W., and

in another valley in s.e. 1/4 of s.e. 1/4, sec. 11, next west. Beyond this the drift is thick and obscures all outcrops, but in the n.e. 1/4 of s.e. 1/4, sec. 13, T. 4 S., R. 9 W., abundant Yankeetown residuum is present, and the formation must be close at hand. In all these localities some beds of the Renault formation are present, either in direct contact beneath the Yankeetown, or with an interval of only a few feet.

In the upland between the South Fork of Horse creek and Dry Fork creek, the Yankeetown is the surface rock, immediately beneath the drift, throughout a considerable area. Satisfactory outcrops of the formation are not common in this area, being restricted to some of the deeper valleys for the most part, because of the thick covering of drift, but enough outcrops have been observed to make possible the mapping of the outlines of the formation in a fairly satisfactory manner. The formation outcrops in the north-south public road between sections 15 and 16, T. 4 S., R. 9 W., just north of the south line of the sections. In the upper part of a tributary of Dry Fork creek, from near the middle of section 29, to a point in the n.e. 1/4 of n.w. 1/4, sec. 28, T. 4 S., R. 9 W., the Yankeetown is exposed at a number of points and virtually forms the bed of the stream for the distance of nearly one mile, the eastward dip of the rocks being about equal to the gradient of the stream. Other outcrops of the formation are present in the bed of another tributary of Dry Fork creek in s.e. 1/4 of s.w. 1/4, sec. 28 about a half mile south of the outcrops last mentioned.

Between Dry Fork and Paint creeks the Yankeetown is well exposed at a number of localities. Towards the heads of many of the short tributaries to Dry Fork creek from the south, situated in n.w. 1/4, sec. 34, and in sec. 27, T. 4 S., R. 9 W., the formation is exhibited, either in actual outcrop or as residuum which is essentially on the outcrop. A similar occurrence is present near the head of a longer tributary of the same creek, in n.w. 1/4 of n.w. 1/4, sec. 26, T. 4 S., R. 9 W., variegated shales of the Renault being present beneath the Yankeetown. Good outcrops of Yankeetown, or residuum not far removed from its original position, occur in the short valleys tributary to Horse creek from the West, between Dry Fork and Prairie Branch. In the southernmost of these valleys, heading in n.e. 1/4 of n.e. 1/4, sec. 26, T. 4 S., R. 9 W., one of the best outcrops of the formation to be seen anywhere, is exposed in the north-south public highway, and in the bank of the creek just east of the road. A half mile further south along this same road, the Yankeetown is exposed on both sides of Prairie Branch north of Yankeetown School, and towards the head of Prairie Branch, in each of the two forks, the formation is well exposed in s.w. 1/4 of s.w. 1/4, sec. 26, T. 4 S., R. 9 W.

Several of the tributaries to Paint creek from the northwest exhibit good exposures of Yankeetown, the best outcrops being in s.w. 1/4 of s.w. 1/4, sec. 35, T. 4 S., R. 9 W., and in the extreme southeastern corner of section 34 next west. In a tributary to the same creek from

the south, in the east half of sec. 2, T. 5 S., R. 9 W., at the point where the valley crosses the Randolph-Monroe County boundary line, the Yankeetown is finely exposed in the creek bed, and its relations to the overlying Paint Creek formation are well exhibited. Other outcrops are present in another short tributary of Paint Creek, in s.w. 1/4 of s.w. 1/4, sec. 2, T. 5 S., R. 9 W., and from this point the line of outcrops passes across the divide, and to the south the formation is exposed only in the valleys draining south and west directly into the Mississippi.

In the heads of most of the tributaries to Prairie du Rocher creek from the east, the Yankeetown is well exposed, and in others its presence is indicated by the characteristic residuum. Such exposures are present in n.w. 1/4 and in s.e. 1/4, sec. 11, T. 5 S., R. 9 W. An abundance of residuum occurs in n.e. 1/4 of s.e. 1/4, sec. 15, T. 5 S., R. 9 W., only a few feet above outcrops of arenaceous shale and sandstone of Renault age. Still another outcrop in the same drainage area is exposed in the northern part of s.e. 1/4 of n.e. 1/4, sec. 22, T. 5 S., R. 9 W.

In the heads of the two large central branches of the stream intersecting the Mississippi river bluffs one and one-half miles above Modoc, south and southwest of Common School, the Yankeetown is especially well exposed. The best of these exposures are in the several tributary valleys just south of the center of sec. 14, T. 5 S., R. 9 W., and in the bed of the main stream at this locality the contact between the Yankeetown and cross-bedded limestones of Renault age is more or less exposed for about one-half mile, extending over into section 23 next south. In the

In the next valley to the east, good exposures are present in the west 1/2 of n.w. 1/4, sec. 24, T. 5 S., R. 9 W. In another tributary of this same drainage system, from the east, the Yankeetown is exposed in s.w. 1/4 of n.w. 1/4, sec. 25, T. 5 S., R. 9 W., although the exposures in this valley are much less extensive than in either of the other two.

A little less than one-half mile above Modoc a small, two-forked ravine intersects the bluffs, and in the northernmost branch the Yankeetown is exposed at a point a little more than three-tenths of a mile back from the mouth of the ravine.

In Burns Hollow, opposite the village of Modoc, Yankeetown exposures have been observed only in the lowermost tributaries, one from the west and the other from the east. In the tributary from the west the outcrop is situated on the line between sections 25 and 36, T. 5 S., R. 9 W. In the tributary from the east the outcrop is in a small side branch about one-fourth mile over the hill northeast of Modoc.

The last exposure of the Yankeetown, before the formation finally passes out of sight beneath younger formations, is in the valley intersecting the Mississippi river bluffs one and one-half miles below Modoc. The outcrop is a typical exposure of the formation, and is situated three-tenths of a mile up the valley from the highway at the foot of the bluffs. A few feet below it a bed of Renault Limestone is exposed, and only a short distance up the valley there is an outcrop of the characteristic red clay bed of the Paint Creek formation.

PAINT CREEK FORMATION

The Paint Creek¹ formation succeeds the Yankeetown with apparent

¹

Weller, Trans. Ill. Acad. Sci., vol. 6, p. 125 (1914), also, Ill.

State Geol. Surv., Monog. I, p. 26 (1914).

conformity, and is uniform in its lithologic character throughout the entire Randolph-Monroe county area. It is divisible into two distinct members, the lower of which includes a most persistent and characteristic deep-red clay, which can nowhere be confused with any other bed of the Chester in the entire region. The higher member consists of calcareous shales with thin beds of limestone in the lower portion, passing upward into thicker beds of limestone with less shale.

The deep-red, compact clay in the lower member of the formation is without lamination or bedding planes, and is commonly without inclusions of any sort, but at a single locality of Gerhardt creek, in n.w. 1/4 sec. 15, T.2 S., R.9 W., a number of irregularly rounded limestone pebbles from one to several inches in diameter have been observed, and fossils preserved in the pebbles show them to be of Chester age. The position of the pebbles seems to be original, but occurring as they do in a single locality, on or near the surface of an outcrop in the creek bank, the possibility of their having been recently introduced can not be eliminated. On freshly exposed surfaces in creek banks, under the influence of weathering, the clay first crumbles into angular fragments an inch or less in diameter, and finally breaks down

into fine red mud. When encountered in well digging the bed is very hard and tough, and can be excavated only by the aid of blasting, but when exposed to the weather it rapidly slacks and forms red, sticky mud when wet.

In all localities where measurements have been possible, the summit of the red clay bed is uniformly from 20 to 25 feet above the Yankeetown. The exact thickness of the red bed itself, however, can be observed in but few localities because of the talus accumulations which commonly obscure the surface, but where the interval immediately above the Yankeetown has been best seen, a series of bluish, calcareous shales with plates of limestone is present for several feet above the chert. The actual thickness of the red bed is about 12 or 15 feet in such natural outcrops as have been observed, and this thickness is confirmed by the records of several dug wells which have penetrated the stratum.

The origin of such a bed as has been described, persistent as it is through a distance of at least 32 miles of outcrop in St. Clair Monroe and Randolph counties, and continuing without change across the Mississippi river into Perry county, Missouri, a total distance of nearly 50 miles, is not easy to explain. In its physical characters the bed closely simulates certain red residual clays, especially such as are so conspicuously developed in southwestern Missouri. These residual clays, however, commonly rest upon a surface made extremely uneven by the differential decomposition of the underlying limestone, while the bed in question exhibits an even basal surface. The residual clays, furthermore, contain numerous inclusions of chert in most cases, while such inclusions are wholly wanting in this Paint Creek bed. The original source of the

Paint Creek red clay probably was from a great body of residual clay which had been accumulating during a long age upon some not too far distant land surface. The fineness of grain, the absence of gritty material and chert inclusions, the homogeneity and wide extent of the bed as it now occurs, suggests an origin through a process of gradual settling of material which had been held in suspension in a body of quiet water. During the period of great turbidity of the waters, adverse life conditions prevailed throughout the region, in consequence of which no fossils occur in the red bed, but as the waters became clearer through the settling of the suspended red mud, and conditions for the depositions of calcareous shales and limestones were reestablished, the faunas returned to the region and soon flourished as prolifically as they had ever done before.

The higher beds of the Paint Creek formation, consisting as they do of interbedded shales and limestone, are not notably different lithologically, from similar shales and limestones in other parts of the Chester group. The shale beds are more conspicuous in the lower portion, immediately succeeding the red clay. They are commonly calcareous and contain a considerable number of fossils, and at some localities they carry an extremely rich fauna. The limestones are commonly more or less argillaceous below, with shaly partings, higher up in the formation they become more massive, purer and more crystalline, all are more or less fossiliferous. At the summit of the formation a solid limestone bed, perhaps as much as ten feet thick, seems to be a persistent member.

Areal distribution and description. The Paint Creek formation is exposed near the northern border of the area under consideration, on Prairie du Pont creek, one mile northwest of Millstadt. At this point the red clay member of the formation is well exhibited in the bank of the creek a few rods north of the road crossing, and the limestone beds overlying the red clay continue across the road, the total length of outcrop being about one-fourth mile. Down the creek the formation passes beneath the Yankeetown. This Paint Creek and Yankeetown together constitute an isolated exposure of Chester, entirely surrounded by Pennsylvanian. About one mile further up the same creek, near its head, just north of the crossing of the Millstadt branch of the Mobile and Ohio railroad, is another small, isolated outcrop of the Paint Creek, entirely surrounded by Pennsylvanian sandstones. This outcrop is less than one-fourth mile in length, and includes exposures of both the lower red clay member and the limestone above. The limestones at this locality have afforded a few fossils, the following species being recognized.

Along Prairie du Long creek, west of Floraville, the Paint Creek occupies a much larger area than either of those already mentioned, but this too is isolated and is entirely surrounded by the Pennsylvanian. The surficial glacial deposits are thick in this part of the territory which has been mapped, and the actual outcrops of the underlying hard rocks are far from being continuous along the stream, but they do occur at intervals for a mile and one-half or more, and throughout the distance

the bed of the creek is undoubtedly excavated in the Paint Creek formation. By far the most important outcrop of the formation in this area is in the bank of the creek above the bridge, near the middle of the north line of sec. 10, T. 2 S., R. 9 W. In the east bank of the creek at this point, beds of limestone and shale are well exposed which occupy a position above the red clay member of the formation. A few rods up stream, around the bend and on the opposite side of the stream, the red clay beds of the formation are well exposed, with the more calcareous, fossiliferous beds above them. The complete section exhibited in the two localities, is as follows.

4. Limestone, hard, gray, crystalline, without shale partings, conspicuously crinoidal..... 8 to 9 feet.
3. Shale, laminated, mostly blue or yellowish, with slight admixture of red and purple..... 12 "
2. Limestone, thinly and irregularly bedded, with shaly partings, very fossiliferous..... 2 "
1. Shale, deep red in color, breaking into angular fragments a fraction of an inch in diameter.
Not fossiliferous 6 "

Beds two and three in this section are highly fossiliferous, and the following species have been identified. The shale bed No. 2 is especially characterized by the remarkable number of beautifully preserved blastoids.

On Gerhardt creek in n.e. 1/4 of n.w. 1/4 sec. 15, T. 2 S., R. 9 W., the red clay member of the Paint Creek formation is well exposed in the

south bank of the creek, with the more calcareous beds above, the entire formation being surmounted by sandstone of Pennsylvanian age. The section exposed at this point is as follows.

6. Sandstone, evenly bedded, in thick layers, light yellow or buff in color, speckled with brown.
Quarried for building stone. Pennsylvanian..... 28 feet.
5. Limestone, a thin ledge not well exposed, the actual contact with the overlying sandstone not uncovered..... 1 "
4. Unexposed, probably shaly beds, or intercalated shale and limestones passing into more calcareous beds above 15 "
3. Shale, dark red, consolidated clay, nonlaminated, the line between this bed and the one above not sharply defined..... 25 "
2. Shale, green, nonlaminated 1 "
1. Limestone, hard, crystalline, somewhat crinoidal .. 2½ "

In the same quarter-section, on the opposite side of the creek just below the mouth of the tributary from the south, some limestone beds of the Paint Creek formation are exposed, from which the following fossils have been collected.

Zaphrentis spinulosa Edwards and Haime

Pentremites pyriformis Say.

Eupachyocrinus sp.

Pachylocrinus sp.

Southward from these localities on Gerhardt creek, the Chester strata are believed to be continuously exposed, although the heavy covering of drift makes it difficult to locate the line between the Pennsylvanian and the underlying formations with entire certainty in all places. Outcrops of the red Paint Creek bed or the overlying limestone, or of both members of the formation, are well exposed in the valleys of all the creeks tributary to Prairie du Long creek from the west. In Walters Creek no outcrops of the red bed have been observed, but in the short tributary valleys from the south, in the south half of s.w. 1/4, and in s.w. 1/4 of s.e. 1/4, sec. 23, T. 2 S., R. 9 W., the limestones of the upper member of the formation are exposed, and from one outcrop in sw. 1/4 s.e. 1/4, sec. 23, the following species of fossils have been collected.

Pentremites pyriformis Say.

Talaroorinus ovatus Worthen.

Palaeacis sp.

Stenopora

Fenestella cestriensis Ulrich.

Archimedes communis Ulrich.

Polypora cestriensis Ulrich.

Cliothyridina sublamellosa (Hall.)

Composita trinuclea (Hall.)

Between Walters creek and the Waterloo-Hecker road, the red clay member of the Paint Creek formation is exposed at two localities.

One of these is in n.w. 1/4 of s.w. 1/4, sec. 26, T.2 S., R.9 W., where the red clay is succeeded by more calcareous, fossiliferous shales, and this again is succeeded by limestones. Fossils from the more calcareous shales have been weathered out and washed down upon the slope underlain by the red clay, and in the collection secured from here the following species have been identified.

Zaphrentis spinulosa Edwards and Haime

Pentremites pyriformis Say.

Stenopora tuberculata (Prout.)

Eridopora punctifera Ulrich.

Fenestella cestriensis Ulrich.

Archimedes compactus Ulrich.

Lyropora ranosculum Ulrich.

Girtyella brevilobata (Swallow.)

G. indianensis (Girty.)

Spiriferina spinosa (Norwood and Pratten.)

Spirifer increbescens

Cliothyridina sublamellosa (Hall.)

Composita trinuclea (Hall.)

The second locality in the area above mentioned is in n.e. 1/4 of s.e. 1/4, sec. 34, T. 2 S., R. 9 W., where the characteristic, deep red clay member is succeeded by fossiliferous, calcareous shales, which have afforded the following species. W 576

In the s.w. 1/4 sec. 36, T. 2 S., R. 9 W., limestone is exposed more or less continuously for nearly a quarter of a mile in the bed of a minor tributary of Prairie du Long creek flowing to the northeast. This limestone is along the strike of the Paint Creek formation, and although no characteristic fossils have been observed, and the red clay bed is not exposed, it is believed to be near or at the very summit of the formation.

South of the Waterloo-Hecker road, the characteristic red clay member of the Paint Creek formation is exposed in the bed of the creek in s.e. 1/4 of s.e. 1/4, sec. 2, T. 3 S., R. 9 W., and further down the creek, in sec. 1, more calcareous shales with intercalated limestones are well exposed to the point where the Chester formations are covered by Pennsylvanian sandstones.

In the valley of Rock House creek, where the Paint Creek beds ought to be exposed, the glacial drift is thick and obscures the hard rocks to a large extent, but a few limestone exposures in the southern part of sec. 12, T. 3 S., R. 9 W., are present, which probably belong to this formation. There are excellent exposures of the higher limestones of the formation, however, in a small side draw from the southeast, in n.e. 1/4 of n.w. 1/4, sec. 13, T. 3 S., R. 9 W.

In each of the two small valleys tributary to Rock House creek, heading in s.e. 1/4, sec. 14, T. 3 S., R. 9 W., there are good exposures of both the red clay member and the higher limestones and calcareous shales of the Paint Creek formation, and in the southernmost of the two valleys the following species of fossils have been collected.

Zaphrentis spinulosus Edwards and Haime.

Pentremites pyriformis Say.

Eupachycrinus tumulosus Miller.

Agassizocrinus sp.

Lyropora ranosoulum Ulrich.

Spiriferina spinosa (Norwood and Pratten.)

Spirifer increbescens Hall, var.

Cliothyridina sublamellosa (Hall.)

Composita trinuclea (Hall.)

At the house situated at the road corner in the middle of the quarter-section, a well has been recently dug which penetrates the Paint Creek red clay, a large amount of which was still lying near the well at the time it was visited by the writer. The well section as reported by the owner of the property, who dug the well, is as follows:

Soil.....	12 feet
Limestone	23 "
Red rock	15 "

Another dug well, about three-fourths of a mile southwest of the one just mentioned, near the northwest corner of the section 23, T. 3 S., R. 9 W., two and one half miles east of New Design, has also penetrated the red clay bed of the Paint Creek formation, the well section at this point, as reported by the owner, being as follows:

Soil	16 feet
Flinty layers	4 inches
Red rock	12 feet

Blue shale 4 feet

All of the hard rock strata penetrated in both these wells are Paint Creek, the excavation being discontinued when a rock described as being "too hard to do anything with" was reached, which was undoubtedly the Yankeetown.

In the two forks of Rocky Branch, and their tributaries, east and northeast of Poe Station, the Paint Creek is exposed at intervals in the beds of the streams from near their heads to the range line between R. 8 W., and R. 9 W., in the north branch, and about one-fourth mile west of this line in the south fork. At Poe Station, and for some distance north, judging from the position of the Yankeetown outcrops, the Paint Creek formation must extend a little west of the Mobile and Ohio railroad track, but the first actual exposures are met with only in the western half of sec. 23, T. 3 S., R. 9 W. The Pennsylvanian sandstones occupy the divide between the two forks, and also the high land both to the north and to the south. Most of these Paint Creek outcrops are limestone, but at a number of points the red clay is exposed. In a small side ravine from the northwest, in s.e. 1/4 of n.e. 1/4, sec. 23, T. 3 S., R. 9 W., the calcareous shales and limestones are abundantly fossiliferous, and the following species have been determined in the collections secured.

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Another locality where the Paint Creek formation is fossiliferous and where a collection has been secured, is at the road crossing over the north fork of Rocky Branch, near the middle of sec. 24, T. 3 S., R. 9 W. The following species have been identified from this exposure.

Zaphrentis spinulosa Edwards and Haime.

Pentremites pyriformis Say.

Eupachyrcrinus tumulosus Miller.

Anisotrypa solida Ulrich

Cystodictya labiosa Ulrich MS.

Fenestella cestriensis Ulrich

Lyropora ranosculum Ulrich.

Septopora subquadrans Ulrich.

Spiriferina spinosa (Norwood and Pratten.)

S. transversa (McChesney.)

Spirifer increbescens Hall, var.

Cliothyridina sublamellosa (Hall.)

Composita trinuclea (Hall.)

West and south of Red Bud, between that city and Horse Creek, except where the Pennsylvanian sandstone is the underlying hard rock, the Pleistocene drift deposits are thick, and exposures of the Paint Creek formation are few and isolated. The lower boundary of the formation is fairly well established by the outcrops of the subjacent Yankeetown, but the upper limit of the formation in this region is more or less conjectural

in many places. Two miles southwest of Red Bud, in n.w. 1/4 of n.e. 1/4, sec. 18, T. 4 S., R. 8 W., limestone outcrops which have been quarried for local use do occur along a valley east of Erlic School, the actual thickness of the beds exposed at this point is only from four to five feet, the limestone is a hard, gray, crystalline bed exhibiting cross-bedding, and with some scattered oolitic grains. The fossils are fragmentary and poorly preserved, and are not at all distinctive, but the position of the outcrops is such as to indicate that they must belong near the summit, of the Paint Creek formation. In a tributary of this same valley from the west, in the s.e. 1/4 of s.w. 1/4 of the same section 18, the presence of the lower, red clay member of the Paint Creek formation is indicated, and a little higher up in the same tributary there are limestone beds which must belong in the same formation. The tributary of Horse Creek heading just south of the Fair Ground at Red Bud, and flowing due south is especially choked with glacial drift, but in a branch of this valley crossing the s.e. 1/4, sec. 17, T. 4 S., R. 8 W., diagonally from northwest to southeast, are a number of limestone outcrops which must be at the top of the Paint Creek formation, since there is a sandstone bed, evidently belonging in the Ruma formation, above them. The extension of the Paint Creek formation down the valley of Horse Creek is conjectural because of the deep alluvial deposits, but the eastward limit of the formation here, must be somewhere near the middle of sec. 28, T. 4 S., R. 8 W.

South of Horse Creek the Paint Creek formation occupies an isolated area of considerable size between Dry Fork creek and Paint Creek.

Within this area the lower, red clay member of the formation is well exposed near the head of the north fork of Prairie Branch in n.e. 1/4 of s.e. 1/4, sec. 27, T. 4 S., R. 9 W., and the limestone in the upper part of the formation are the reason for the group of sink-holes developed just west of Ames, in some of which the rock is exposed.

South of Paint Creek the formation is present in a continuous belt to the Mississippi river bluffs below Modoc. The limestone of the formation is well exposed in the bluff south of Horse Creek in s.e. 1/4, sec. 30, T. 4 S., R. 8 W., and extends eastward into sec. 29 and the red clay member outcrops near the center of the same quarter-section of section 30, in the bank of a tributary to Horse Creek from the south just below the junction of its two forks.¹ The higher limestones are again

1

For full section at this point see page .

well exposed above this red clay outcrop in both forks of the tributary just mentioned, and continue southward into section 31. Along the public highway which parallels the westernmost of the two forks, the limestone is especially well exposed, and from this locality the following species of fossils have been collected.

Zaphrentis spinulosa Edwards and Haime.

Zeacrinus sp.

Agassizocrinus chesterensis

Pentremites godoni de France.

P. pyriformis Say.

Anisotrypa symmetrica Ulrich

Polypora cestriensis Ulrich.

Fenestella serratula Ulrich.

Archimedes invaginatus Ulrich.

Orthotetes kaskaskiensis (McChesney.)

Productus ovatus Hall.

Diaphragmus elegans (Norwood and Pratten.)

Spiriferina spinosa (Norwood and Pratten.)

Spirifer leidyi Norwood and Pratten

Martinia contracta Meek and Worthen.)

Eumetria verneuiliana Hall.

Cliothyridina sublamellosa (Hall.)

Composita trinuclea (Hall.)

Bellerophon sp.

Between the group of outcrops just described and a line running south from Ames, the hard rocks are mostly drift covered, but a few exposures are present in some of the tributaries to Horse and Paint creeks, both the basal red clay member and the higher limestones being exposed.

One of the very best Paint Creek sections which has been observed anywhere in the territory, is exposed in a tributary to Paint creek from the south, which crosses the east half of sec. 2, T. 5 S., R. 9 W., about one and one-half miles south of Ames. The succession of beds at this locality is as follows:

5. Shale, bluish in color and variegated with red or purple, with thin bands of limestone and

some sandstone. Thickness ?

Ruma-Paint Creek contact.

4. Limestone, rather thickly bedded with some shale partings 5 to 6 feet.
3. Shales with numerous intercalated limestone bands, both the shales and limestones vary in their lithologic character, but the shales are nearly all calcareous, of a gray color, and with no variegated bands. Both shales and limestones are highly fossiliferous, and the following species have been identified... 20"

Zaphrentis spinulosa Edwards and Haime.

Eupachyrcrinus tumulosus Miller. ?

E. sp.

Pentremites pyriformis Say.

P. godoni deFrance.

P. gemmiformis Hambach.

P. conoideus Hall

Stenopora tuberculata (Prout.)

Lyropora ranosculum Ulrich.

Fenestella cestriensis Ulrich.

F. serratula Ulrich.

F. exigua Ulrich.

Archimedes communis Ulrich.

Eridopora punctifera Ulrich.

Intrapora undulata Ulrich.

Orthotetes kaskaskiensis (McChesney.)

Productus ovatus Hall.

Diaphragmus elegans (Norwood and Pratten.)

Dielasma shumardian (Miller.)

Girtyella indianensis (Girty.)

Spiriferina spinosa (Norwood and Pratten.)

S. transversa (McChesney.)

Spirifer increbescens Hall, var.

S. Leidyi Norwood and Pratten.

Cliothyridina sublamellosa (Hall.)

Composita trinuclea (Hall.)

Myalina sp.

Aviculopecten sp.

2. Red clay shale, compact, non-laminated, crumbling on weathering, without fossils, passing upward into the calcareous shales above, the transition accomplished in about four or five feet..... about 25 feet

Paint Creek-Yankeetown contact.

1. Chert, very irregularly bedded, more or less twisted and contorted in appearance, with occasional pockets of included clay. Only the upper surface

and perhaps a foot or two at the top exposed.

Yankeetown formation.

For some distance south from the section last described, the glacial drift is thick and no Paint Creek outcrops are exposed, but a number of Yankeetown exposures determine the position of the lower boundary of the formation within very narrow limits. The formation is well exposed again, however, in some of the branches of the creek intersecting the Mississippi river bluffs two miles below Prairie du Rocher. In the heads of the two main branches of this creek, south of Commons School, the higher limestone member of the formation is well exposed, and in the easternmost of the two branches, in s.e. 1/4 of s.w. 1/4, sec. 13, T. 5 S., R. 9 W., one bed near the top of the formation is abundantly fossiliferous, and the following species have been identified.

Zaphrentis spinulosa Edwards and Haime.

Pachylocrinus sp.

Zeacrinus sp.

Eupachyrcrinus tumulosus Miller?

Eupachyrcrinus sp. a.

Agassizocrinus chesterensis Meek and Worthen.

Dichocrinus sp. a.

D. sp. b.

Talarocrinus ovatus Worthen.

T. sp.

Pterotocrinus sp.

Acrocrinus urnaeformis Hall.

Taxocrinus sp.

Pentremites pyriformis Say.

P. godoni-florealis

P. gemmiformis Hambach.

Archaeocidaris sp.

Fistulipora excellens Ulrich.

Eridopora sp.

Stenopora tuberculata (Prout.)

Anisotrypa solida Ulrich.

Fenestella cf. cestriensis Ulrich.

Archimedes communis Ulrich.

Lyropora sp.

L. ranosculum Ulrich.

Septopora subquadrans Ulrich.

Glyptopora sagenella Ulrich, var.

Productus ovatus Hall.

Diaphragmus elegans (Norwood and Pratten.)

Spiriferina spinosa (Norwood and Pratten.)

Spiriferina transversa (McChesney.)

Spirifer increbescens Hall.

Eumetria verneuiliana Hall.

Cliothyridina Sublamellosa (Hall.)

Composita trinuclea (Hall.)

Girtyella sp.

In a small tributary from the northwest, of the same branch in which the fossiliferous beds last mentioned are exposed, in the northeastern corner of s.e. 1/4 of n.e. 1/4, sec. 23, T. 5 S., R. 9 W., east of the residence of Mr. J. W. Brewer, the following section from the upper portion of the Renault formation into the Paint Creek, is exposed.

- 9. Shales, gray, argillaceous and calcareous, becoming more calcareous above, with hard layers a fraction of an inch thick..... 18 feet.
 - 8. Red clay, non-laminated, Paint Creek red bed.
Exposed..... 7 feet.
 - 7. Unexposed, probably continuation downward of the red bed above 13 "
 - 6. Limestone, impure, in thin layers with interbedded shales 10 "
- Yankeetown-Paint Creek contact.
- 5. Yankeetown, cherty, arenaceous, siliceous rock, with some impure, highly siliceous limestone..... 12 "
- Renault-Yankeetown contact.
- 4. Unexposed 6 "

3. Chert bed 1 foot
2. Limestone 2 "
1. Sandy chert 3 "

The characteristic, lower, red clay member of the formation is again exposed further south, on the north side of another branch of the same creek, in s.w. 1/4 of n.w. 1/4, sec. 25, T. 5 S., R. 9 W., and again in a short tributary of the same branch from the south in the n.w. 1/4 of s.w. 1/4 of the same section. Southeast of Modoc, the limestone of the formation is exposed at a number of points in the short ravine which intersects the Mississippi river bluffs one mile below the village. In the next ravine, four-fifths of a mile further from Modoc, a good exposure of the characteristic red clay bed of the Paint Creek formation outcrops in the bank of the creek about one-half mile back from the bluffs. The red bed is overlain at this point by blue and gray shales, and limestones, in one bed of which the following species of fossils have been collected.

W607

The last exposure of the Paint Creek formation on the Illinois side of the Mississippi river, is in the mouth of the small ravine two and one-half miles below Modoc, where the following succession of beds has been observed.

Ruma-Paint Creek contact.

- 7. Limestone, somewhat oolitic 3 feet
- 8. Limestone, the beds varying in lithologic character,
some beds being crystalline and others being more or
less siliceous. Fossiliferous. W. 225. 12 "
- 5. Limestone, thin layers with Archimedes, crinoids etc. 1 "
W 224.
- 4. Limestone, very white and crystalline..... 3 "
W 223.
- 3. Limestone, crystalline and cross-bedded 9 "
- 2. Shale and thin limestones, with Pentremites 1 "
W 222.
- 1. Talus covered 8 "

Thin section must include nearly the whole of the Paint Creek formation above the red clay member, and the presence of the red bed is also indicated by the color of the soil in the public road a few rods above the mouth of the ravine where the section just described is exposed.

West of the Columbia anticline, in the northern part of Monroe County, the Paint Creek formation is well exposed at a number of localities and exhibits its characteristic features. These exposures are all south of Columbia along Carr creek and its tributaries. If the formation is present elsewhere in the region it is covered by the thick mantle of Pleistocene

drift. The lower, red clay member of the formation is well exposed at a number of points in some of the short tributaries to Carr creek from the west, in sections 28 and 33, T. 1 S., R. 10 W. One such locality is near the head of a short ravine south of the house in the n.e. 1/4 of n.w. 1/4, sec. 28. Other good exposures are present in the heads of the small tributary crossing the south half of n.e. 1/4 of the same section. Another outcrop is present in the road near the southeastern corner of s.w. 1/4 of s.e. 1/4 of the same section 28, and a few feet below it at this point is a ledge of arenaceous limestone which is probably Renault. In the s.e. 1/4 of s.e. 1/4 of the same section the presence of the red clay bed in the road following the valley of the west branch of Carr creek, is indicated by the color of the soil and a good outcrop of the bed is exposed in the creek bank, west of the road in s.e. 1/4 of n.e. 1/4, sec. 33.

East of the line of outcrops described above, the red clay bed is carried beneath the surface by reason of the easterly dip of the strata, and the higher limestones of the formation are exposed. At one such exposure in the east side of the valley of the west branch of Carr creek, in s.e. 1/4 of s.e. 1/4 sec. 28, the limestone has been quarried for local use, about ten feet being exposed. Along the east branch of Carr creek, upon which the Columbia Clay Plant is located, the Paint Creek limestone is exposed at a number of points in the creek bed in s.e. 1/4 of n.w. 1/4, sec. 34, T. 1 S., R. 10 W.

At the trestle where the switch track for the Columbia Clay Plant crosses this creek, at the point where it leaves the main track of the

Mobile and Ohio railroad, the same limestone is well exposed, and is very fossiliferous, the following species being identified in this fauna.

W 251

In the shaft of the Columbia Clay Plant, whose depth is said to be about 80 feet, the following section has been reported.

8. Soil..... 10 feet
7. Limestone, thin(3) "
6. Red shale 40 "
5. Sandy flint 3 "
4. Sandstone, white 7 "
3. Shale, blue 6 inches
2. Clay, gray 6 1/2 feet
1. Shale, variegated, blue and violet 10 feet

This section is perhaps not entirely accurate in all details.

Bed No. 6 evidently includes the red clay bed of the Paint Creek, and bed No. 7 is a part of the limestone of the same formation. The sandy flint bed, No. 5, is doubtless the Yankeetown, and beds 1, 2, 3, and 4 are in the Renault formation.

Historical Note.

During the early portion of Paint Creek time an enormous amount of red mud was poured into the Illinois basin occupied by the Chester sea. The source of this mud was probably from the north, at the head of the embayment occupied by the Chester sea. It was doubtless derived from great accumulations of red residual clays upon the old land surface which had not been submerged since Silurian time. During the time of accumulation of the residual material, the land had doubtless remained in a stable condition at base level, but with a slight elevation of the region in Paint Creek time, the streams became more active and carried away vast quantities of the red residuum and dumped it into the sea. The coarser material doubtless accumulated along the shore near the mouths of the transporting streams, while the fine material was held in suspension and floated far out into the sea where it gradually settled, and has been preserved to the present time in the sedimentary series. During this time the entire Illinois basin must have been a veritable "red sea," with waters so turbid that no life could exist in them. The occupancy of the entire Illinois basin by this red sea, is indicated by the uniform presence of a red bed, apparently entirely similar to the outcropping Paint Creek red clay, and in the proper stratigraphic position, in the well sections in the eastern Illinois oil fields. The extent of the red bed to the south is not known. Where the outcrop passes beneath younger beds in Perry county, Missouri, it apparently possesses its full thickness and its typical characters. Too little is

known of the Chester succession in the extreme southern counties in Illinois upon which to use a statement as to the presence of the bed in that region. The coarser beds, contemporaneous in age with the red clays, which must have been present in the north, if the hypothesis here proposed is the correct one, are nowhere known. Either they are buried beneath the Pennsylvanian formation, or they were eroded before the Pennsylvanian beds were deposited.

Although the early Paint Creek was the most conspicuous period of deposition of red muds in the Illinois basin, the same type of sediments do occur earlier than this, in the Renault, and also later in the Ruma. The source of all these red sediments was doubtless the same, but except in Paint Creek time, they were apparently mingled with other sediments, and gave rise to blue and red or purple variegated shales.

RUMA FORMATION.

The Ruma¹ formation succeeds the Paint Creek conformably. The

¹

Weller, Trans. Ill. Acad. Sci., vol. 6, p. 126 (1914), also, Ill.

State Geol. Surv., Monog. I, p. 26 (1914).

name is taken from the village of Ruma in northern Randolph county, near which place the formation is well exposed in some of the stream valleys tributary to Horse Creek, west and northwest of the town. The formation is

essentially a series of shales and sandstone, although locally a thin limestone member has been observed. The shales predominate in most localities, but in all sections where the formation is well exposed, there are important, thin-bedded sandstone layers and some arenaceous shales near the middle of the formation, and in places such beds continue to the top. The more shaly beds are in almost all localities, conspicuously variegated, being blue, reddish and purple in color, not unlike some of the shale beds of the Renault formation. The Ruma is the highest formation in the Chester group in Randolph and Monroe counties, in which conspicuous variegated shale beds have been observed.

On the whole the Ruma is a soft and non-resistant formation, and consequently furnishes poor exposures in much of the area which is underlain by it. Its non-resistant character has also made it especially liable to glacial erosion during Pleistocene time, and in consequence it is commonly more deeply drift covered than some of the other formations in immediately adjacent areas.

Areal distribution and description. The northernmost outcrops of the Ruma formation occur along Prairie du Long creek and some of its tributaries, about three miles northeast of Poe Station on the Mobile and Ohio railroad. In the n.e. 1/4 of n.e. 1/4, sec. 13, T. 3 S., R. 9 W., there are some sandstones on the south side of Rock House creek, near its mouth, which are here referred to the Ruma formation, and along a very short tributary of Prairie du Long creek entering the main stream just below the mouth of Rock House creek, in the same quarter-quarter-section

with the sandstone outcrops just mentioned, there are other good sandstone exposures. These sandstone outcrops are more massive than common in the Ruma formation, and are strongly suggestive of the Pennsylvanian sandstones which immediately overlie the Ruma in this part of the area, but no fossils of any sort have been observed in them, and about one-eighth of a mile up the valley of the small tributary mentioned, at a higher elevation than the sandstone, there are outcrops of an arenaceous limestone or calcareous sandstone, wholly different from anything observed elsewhere in the Pennsylvanian in the immediate neighborhood.

In the longer tributary to Prairie du Long creek from the southwest, with two heads in s.w. 1/4, sec. 13, T. 3 S., R. 9 W., there are sandstone outcrops in the upper portion of both forks which have been referred to the Pennsylvanian, but lower down, towards the junction of these forks, there are sandstones of a somewhat different character which have been referred to the Pennsylvanian, but lower down, towards the junction of these forks, there are sandstones of a somewhat different character which have been considered as belonging in the Ruma. Along the bed and banks of the stream below the junction, there are numerous outcrops of blue and variegated shales which are undoubtedly parts of the Ruma formation.

In still another tributary to Prairie du Long creek from the southwest, with two heads in the north half of n.e. 1/4 sec. 24, T. 3 S., R. 9 W., there are excellent exposures of the Ruma, mostly the variegated shale beds, but with some sandstone. For a quarter of a mile along this valley, in s.w. 1/4 of s.w. 1/4, sec. 18, T. 3 S., R. 8 W., there are extensive

outcrops of variegated shales capped with sandstone, and similar shale outcrops are present in the north fork of the tributary in s.e. 1/4, of s.e. 1/4, sec. 13, T. 3 S., R. 9 W. There is also some sandstone beneath the shale.

In the bank of Prairie du Long creek just below the mouth of Rocky branch, the Ruma is exposed in a section 18 feet in height, as follows.

Arenaceous limestone	8 feet
Arenaceous shale	9 "
Red shale	1 "

The last observed outcrop of the Ruma along Prairie du Long creek, is in a short tributary from the south, in n.w. 1/4 of n.e. 1/4, sec. 20, T. 3 S., R. 8 W., where the typical variegated shales of the formation are exposed. Beyond this point such Chester outcrops as are exposed are limestones of the Okaw formation.

South from that portion of the Prairie du Long creek valley which is excavated in the Ruma formation, to a point south of Red Bud, the formation is nowhere exposed, being entirely covered by the Pennsylvanian formations. South from Red Bud to the valley of Horse Creek, the hard rock formations are for the most part buried by glacial drift, but a few sandstone exposures have been met with which probably represent the Ruma formation. One of these localities is in a small tributary valley leading southeast, in s.w. 1/4 of n.e. 1/4 sec. 9, T. 4 S., R. 8 W., where a small outcrop of sandstone is exposed, below which are some limestones

(DHS, 1957)

which doubtless belong in the upper portion of the Paint Creek formation. Two other small sandstone outcrops have been observed in the same section as the last, and at essentially the same elevation, in the public highway near the corner at the middle of the south line of the s.w. 1/4 of the section, one of the outcrops being only a few feet west of the corner and the other a few rods north. The extent of the formation down the valley of Horse creek, and in the tributary running northeast from Ruma, cannot be determined because of the extensive alluvial deposits, but it doubtless underlies considerable areas. North and west of Ruma, however, the formation is well exposed at a number of localities in some of the valleys tributary to Horse creek, and from these exposures the formation has been named.

An outcrop of sandstone and arenaceous shale in the side of the Public road between Red Bud and Ruma, a little over one-fourth mile south of the bridge across Horse creek, is referable to the Ruma formation, and also an outcrop of variegated shale in n.w. 1/4 of n.e. 1/4, sec. 32, T. 4 S., R. 8 W., about eight hundred feet southwest of the public road, in a small valley. An excellent exposure of the formation occurs in the east fork of a valley tributary to Horse creek, about one and one-half miles northwest of Ruma, leading north along nearly the middle line of n.e. 1/4 sec. 31, T. 4 S., R. 8 W., where the following succession of beds is exposed, comprising nearly the whole of the Paint Creek and Ruma formations.

14. Limestone, slabs slumped, not in place.
13. Shale, bluish-green in color, perhaps with some limestone
lenses or beds. Shale becoming red in places 12 feet
12. Limestone, arenaceous, about 2 "
11. Shale, argillaceous, greenish, with red streaks
and bands?20 "
10. Sandstone, with many impressions of Lepidodendron
trunks 1 "
9. Shale, thin-bedded, arenaceous, greenish in color 1 "
8. Shale, reddish in color 1 "
7. Shale, rather thick-bedded and arenaceous above or
thin-bedded sandstone, yellowish, green or reddish in
color, much ripple marked and with numerous "fucoid"
markings. Passing into bluish green or red shales
below..... 12 "
6. Sandstone, irregularly bedded, 1 "
5. Shale, argillaceous, variegated greenish and red, thin-
bedded and fissile 14 "

Paint Creek-Ruma contact.

4. Limestone, gray, crystalline, more or less cross-bedded,
some layers with many fossils, Pentremites, Zaphrentis,
and brachiopods, no Archimedes observed 12 "
3. Limestone, yellow in color, earthy in texture, irregularly
bedded, passing downward into shale 6 "

2. Limestone, irregularly bedded, fossiliferous. No
Archimedes observed 12 feet
1. Red clay-shale, non-laminated, breaking into
irregular, angular fragments Exposed.. 3 "

In the western fork of the same tributary the Ruma is again exposed, the beds exhibited being sandstones for the most part, but with a bed of limestone a foot or two thick in the midst of the formation. from which the following species of fossils have been collected.

Along the tributary to Horse creek leading from the southeast corner of sec. 31, northeast across sec. 32, T. 4 S., R. 8 W., and in some of the small side branches, to about the middle of sec. 32, there are numerous outcrops of sandstone and shale which are referable to the Ruma formation. Perhaps the best exhibition of the formation anywhere to be seen in the region under discussion, is in the s.e. 1/4 of s.e. 1/4 sec. 36, and s.w. 1/4 of s.w. 1/4 sec. 31, T. 4 S., R. 9 W., and R. 8 W., along two forks of a small stream tributary to Paint Creek. Both the shale and sandstone members of the formation are well exposed, and practically the entire thickness of the formation, from the massive limestone at the top of the Paint Creek to the basal limestones of the Okaw formations.

In the n.e. 1/4 of n.e. 1/4, sec. 11, T. 5 S., R. 9 W., near the head of the valley tributary to Paint Creek in which the Paint Creek section described on Page is exposed, there are a few small outcrops of variegated shales which undoubtedly belong in the Ruma formation. The formation is again exposed in a short side branch of Camp creek from the southwest, in the south half of s.e. 1/4, sec. 12, T. 5 S., R. 9 W., where there are good outcrops of variegated shales, and in another tributary of the same creek one-half mile further west there is good evidence of beds of Ruma in the wash but no strata exposed in place. In the bed of Camp creek near the mouth of the small tributary mentioned, in which the variegated shale outcrops are exposed, there are numerous masses of fossiliferous sandstone, nowhere observed in situ, but which is

almost certainly from somewhere in the Ruma formation. The fossil species determined from these sandstones are as follows.

Southward from the localities last mentioned, except for some small outliers to the east, the Ruma outcrops are limited to the valleys of some of the streams tributary to the Mississippi river, but the deposits of glacial drift are so thick that the exposures are few in number. At the head of the valley southwest of Commons School, in s.e. 1/4 of s.w. 1/4, sec. 13, T. 5 S., R. 9 W., there are small outcrops of variegated shale and sandstone which doubtless belong in the Ruma formation. The southernmost exposure of the formation in the area under consideration, is in a small ravine intersecting the Mississippi river bluff in s.w. 1/4, sec. 4, T. 6 S., R. 8 W., about two and one-half miles below Modoc. In the section at this point the subjacent Paint Creek formation is well exposed, and also the Okaw formation above, the complete section being described on page of this report. The Ruma is represented by an excellent exposure of variegated shales, but the total thickness of the formation is not visible because of the talus covering, and if any sandstone is present it does not show either as outcrops or in the talus.

East of the continuous belt of the Ruma formation already described, the formation is exposed in a few limited outcrops in the valley of Camp Creek and some of its tributaries, and in one small tributary of the Okaw river. The presence of the formation in the n.w. 1/4

of s.w. 1/4, sec. 9, T. 5 S., R. 8 W., is indicated by sandstone outcrops with some shale beneath, the section exposed being as follows:

4. Limestone, gray and crystalline, with numerous
Agassizocrinus bases and Martinia, the basal
part of the Okaw formation 3 feet
3. Sandstone, brown 2 1/2 "
2. Shales, only 2 feet exposed, but 12 feet of talus
covered slope is doubtless underlain by the
same shale 14 "
1. Limestone, top of ledge exposed, probably the top
of the Paint Creek formation.

In this section the shale and sandstone beds, 2 and 3, between the two limestone members, is doubtless Ruma, and the presence of the formation is further indicated by the wash in the creek bed.

In the main valley of Camp creek, from near the southeastern corner of sec. 8, T. 5 S., R. 8 W., diagonally across sec. 16 of the same township and range, the Ruma formation is probably present, between the Paint Creek limestone exposed in the bed of the creek and the Okaw near the summits of the valley sides. Variegated shales having all the characteristics of the Ruma are exposed to a limited degree at one or two points, but the interval between the two limestones is occupied by a talus slope which is probably underlain by shales. The presence of an outcrop of variegated shales in the valley of the large tributary to Camp Creek from the west, in n.w. 1/4 of n.w. 1/4 sec. 21, T. 5 S., R. 8 W., is

suggestive of a small, isolated area of the Ruma formation, and it has been mapped as such. The last outcrop of the formation is in the valley of a small tributary of the Okaw river in n.e. 1/4 of n.e. 1/4, sec. 28, T. 5 S., R. 8 W., where there is a good exposure of the characteristic variegated shale of the formation.

West of the Columbia anticline the Ruma is the youngest Chester formation anywhere exposed, and it outcrops in only one limited area. At the point of the hill in the southwest bank of a tributary to Carr creek, in s.e. 1/4 of n.w. 1/4, sec. 27, T. 1 S., R. 10 W., three-fourths of a mile north of the Columbia Clay Plant, ten or twelve feet of variegated shales are exposed, with impure, arenaceous limestone bands from one to four inches thick, intercalated at intervals of three or four feet. The entire exposure at this point, both the shales and the limestone, are conspicuously red in color, though not so red as the Paint Creek red bed. A little further south, in the west bank of the creek, a hard, arenaceous ledge is exposed which is doubtless a member of the Ruma formation. Elsewhere throughout this portion of the area studied, the Ruma is either absent, or it is covered by the Pennsylvanian formations.

Field observations to be made on the Ruma.

Reexamine limestone bed west of Ruma and secure fossils. Secure fossils from the sandstone in upper part of Camp creek valley.

OKAW FORMATION

¹
The Okaw is the thickest one of the Chester formations in the

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Weller, Trans. Ill. Acad. Sci., vol. 6, p. 127 (1914); also Ill. State Geol. Surv., Monog. I, p. 27, (1914).

Randolph County, and it includes the most typical beds of the "Upper Archimedes Limestone" of Shumard, and the "Kaskaskia limestone" of Hall. The name of the formation is derived from the Okaw or Kaskaskia river, good exposures being present in the Mississippi river bluffs both above and below the mouth of that stream, and the valley of the stream itself is excavated in the formation for more than twenty miles from its mouth.

The formation rests conformably upon the Ruma, and is made up of a series of alternating beds of limestone and shale, with some sandstone locally present near the top, which have an aggregate thickness of about 200 feet. The limestones are the most conspicuous members of the formation. They are variable in lithologic character and in thickness, some being nearly pure, light gray or bluish in color, more or less coarsely crystalline, others being more argillaceous, thick or thin bedded, with shaly partings. Conspicuous, white, oolitic limestone beds are present in the lower and more rarely in the upper portion of the formation, and not uncommonly some of the limestone beds which are not conspicuously oolitic show some scattered oolite grains when examined closely. All of these limestones are commonly free from chert, nearly all of the chert which has been observed in the formation being confined to a thin band of ten feet or less in thickness, about 90 or 100 feet from the base. Aside from this one conspicuous chert bed which is well exposed in the heads of the ravines south of Marigold, cherty limestone beds have been observed in only one or two localities.

The shales of the Okaw formation vary as much in character as do the limestones. Some beds are nearly pure argillaceous shales, others are highly calcareous, but at no locality in the formation, unless it be near the top, in association with some of the local sandstone beds, have any arenaceous shales been observed. Most of the shales are gray, bluish, or yellowish in color, but at a few localities a limited admixture of red or purple colors occur, although no such conspicuously variegated shale beds as are present in the lower formations, are known.

The exposures of the shale members of the Okaw formation are commonly obscured by the talus in the Mississippi river bluff sections, but in many of the ravines intersecting the bluffs, good clean sections are exposed. The limestones are well exposed, not only in the ravines, but also as more or less continuous ledges in the bluffs. Because of the lithologic character of the formation, the alternation of shales and limestones, the Okaw formation in the Mississippi river bluffs is not exposed in the high, nearly vertical escarpments which are so characteristic of the St. Louis limestone, but rather as steeply sloping hill sides upon which the limestone beds form terrace-like benches at intervals. In no one section in the region being described, is the entire thickness of the Okaw exposed, but the characters of the formation may be shown by combining a number of sections. The basal portion of the formation, with the underlying Ruma and the upper portion of the Paint Creek, is exposed in the small ravine intersecting the Mississippi river bluff in s.w. 1/4 sec. 4, T. 6 S., R. 8 W., about two and one-half miles below Modoc. In this section the following succession of beds is exposed.

Areal distribution and description. Because of the greater thickness of the Okaw formation, it occupies a much broader belt than any of the older members of the Chester group, but in the northern portion of the area mapped, the overlapping Pennsylvanian formations entirely cover it. The northernmost outcrops

of the formation occupy small, isolated areas entirely surrounded by the Pennsylvanian formations, their presence being due to the uneven nature of the pre-Pennsylvanian surface along the courses of the erosion channels in the present topographic surface. The northernmost of such inlying areas, in the bed of West Fork creek, in n.e. 1/4 of s.e. 1/4 sec. 27, T. 1 S., R. 9 W., is very small, and the actual outcrop does not occupy an area of more than a few square yards. A much larger outcrop is present in the valley of the same creek, and in the lower portion of a tributary valley from the west, in n.e. 1/4 of sec. 2, T. 2 S., R. 9 W., about one and one-half miles north of Floraville. At this locality the limestones are well exposed in the bed of the creek, with Pennsylvanian strata resting upon them. The limestones are irregularly bedded and are more or less impure, with shaly partings. Fossils are not uncommon, a species of Zaphrentis being the most common form. Some of the beds contain great numbers of the axes of a species of Archimedes, a character which is indicative of the Okaw age of the beds, since that fossil is not common in the Chester formations older than the Okaw. Pterotocrinus plates have not been observed, however, and Agassizocrinus bases are not abundant, as might be expected in the basal Okaw where the beds probably belong. Other limestone outcrops are present in the valley of the same stream, in the west half of s.w. 1/4, sec. 6, T. 2 S., R. 8 W., and in a small tributary from the west in section 1 to the west, this area being about equal in size to that last described, and at one point a thickness of 20 feet of limestone is exposed. A very much smaller outcrop of Chester limestone, referable to the Okaw formation, is exposed beneath the bridge at the corner of the public road one and one-fourth miles southwest of Smithton, at the middle of the south line of the s.w. 1/4, sec. 5, T. 2 S., R. 8 W. Other small isolated outcrops have been observed in n.w. 1/4 of n.w. 1/4 sec. 13, T. 2 S., R. 8 W., a mile and one-half northwest of Paderborn, and in s.w. 1/4 of n.w. 1/4, sec. 13, T. 2 S., R. 9 W., a little over one-fourth mile west of Paderborn.

In the s.e. 1/4 sec. 29, T. 2 S., R. 8 W., about one and one-half miles northwest of Hecker, along a small valley tributary to Richland creek, there are a number of limestone outcrops in a small area, entirely surrounded by the Pennsylvanian, from which the following fossil fauna, very characteristic of the basal part of the Okaw, has been collected.

Other similar isolated patches of the Okaw limestone have been noted by E. W. Shaw northeast of Hecker, in n.e. 1/4 of s.w. 1/4 sec. 27, and in n.w. 1/4 of n.e. 1/4 sec. 33, T. 2 S., R. 8 W., in the valley of a small tributary to Richland creek.

In the lower portion of the valley of Prairie du Long creek, between two and three miles from its junction with Richland creek, the beginning of a continuous belt of the Okaw formation is exposed. It stretches eastward to the east side of the Okaw river, and probably extends a long distance northward in the Okaw valley beneath the alluvial deposits of that stream. East and northeast of Red Bud the glacial drift mantle is very thick over most of the area, and rock outcrops are scarce, but about a mile northeast of the town there are exposures of Pennsylvanian sandstone overlying the Okaw, and this outlier of the younger formation perhaps extends nearly to the Okaw river, as it has been mapped, although the actual outcrops are limited to the western margin.

The continuous belt of the Okaw formation extends southward to the Mississippi river bluffs, and the entire channel of the Okaw river, probably from New Athens or above, to the mouth of the stream lies in this formation. The average width of the belt is between six and seven miles, although along a line about two miles north of Evansville the width is as much as ten miles. In the Mississippi river bluffs the formation first appears about three miles above the Okaw river gap, and continues to the mouth of Marys river, although from about a mile above

Fort Gage to the southernmost exposure, the formation occupies only a narrow strip at the base of the bluffs, below the younger formations.

In the northwestern portion of the broad, continuous belt underlain by the Okaw formation, outcrops of the limestones and shales are present at many points along the courses of the streams, but south and southeast of a line passing east and then north from the city of Red Bud, to about the northeastern corner of sec. 3, T. 4 S., R. 8 W., to the Okaw river on the east and Horse Creek on the south, the glacial drift is generally from 50 to 100 feet or more in depth, and no rock outcrops are exposed. Within the northwestern area where scattered outcrops are present, the limestones are exposed in sec. 20, T. 3 S., R. 8 W., along a tributary of Prairie du Long creek which crosses the section diagonally from the n.w. 1/4 of s.w. 1/4 to s.e. 1/4 of n.e. 1/4, and to a less extent along the tributary which joins the last one after crossing diagonally the s.e. 1/4 of the same section. North of Prairie du Long creek, from the localities just mentioned, the glacial drift covering is thick and no rock outcrops have been observed, although the Okaw formation probably underlies a considerable portion of the southern half of sec. 17, T. 3 S., R. 8 W.

In a small draw east of the public road from Red Bud to Hecker, north of the bridge over Prairie du Long creek, one of the limestone beds of the Okaw has been quarried for local use, and some of the shaly partings between the limestones are abundantly fossiliferous, and the following species have been recognized.

W 259

Along the Black Creek tributary to Richland creek which crosses the Red Bud-Hecker road in n.w. 1/4 of n.w. 1/4, sec. 33, T. 3 S., R. 8 W., tongue-like areas of the Okaw formation have been exposed by the cutting of the streams through the overlying Pennsylvanian sandstones, in the north fork as far as s.e.

1/4 sec. 30, and in the south fork as far as the n.w. 1/4 sec. 32, T. 3 S., R. 8 W., and while the bottoms of these valleys, especially that of the northern one, are much filled with alluvium, there are a number of limestone outcrops at intervals. By the roadside just south of the bridge, a calcareous shale member of the formation is exposed which is fossiliferous, and the following species have been identified from the locality.

W 255

Along a branch of the last mentioned stream, which flows south through the western part of the city of Red Bud, and then east to its junction with the branch from the north, the Okaw is well exposed at a number of points, from the n.e. 1/4 of n.e. 1/4, sec. 8, to the n.w. 1/4 of n.e. 1/4 sec. 4, T. 4 S., R. 8 W. The city of Red Bud has opened and operates a quarry for road material in the east bank of this creek just north of the Red Bud-Waterloo road leading west from the city. In this quarry from eight to twelve feet of blue, crystalline limestone with some shaly partings, are exposed. This limestone is near the base of the formation, it is fossiliferous and the following species of fossils have been collected and identified.

W 253

Along the same creek a small quarry has been opened about one-half mile north of the railroad station at Red Bud, east of the Red Bud-Hecker road. The limestone exposed at this locality lies a little higher in the formation than that in the city quarry. At the time it was visited the bottom of the quarry was filled with water, so the total thickness of limestone exposed could not be seen, but there is probably eight feet or thereabouts. The rock is a much lighter colored limestone than that in the city quarry, being nearly white. It is crystalline and abundantly fossiliferous, some beds being composed almost entirely of fragments of bryozoans and crinoid stems. One bed in the quarry is

somewhat impure, and is characterized by the presence of numerous, rounded, black pebble-like inclusions, which are probably phosphatic. The fossils are not well preserved, but the following species have been recognized.

W 254

Down stream from the quarry last mentioned, for about one-half mile to the next north and south road, there are a number of outcrops of limestone and calcareous shale, all more or less fossiliferous, but beyond this point the bottom of the valley is filled with alluvium.

In the upper portion of the valley crossing diagonally from northwest to southeast, the s.e. 1/4 sec. 28, T. 3 S., R. 8 W., and also in the s.w. 1/4 of s.w. 1/4, sec. 27, there are a number of outcrops of Okaw limestone, and in the east half of n.e. 1/4 sec. 34, T. 3 S., R. 8 W., near the mouths of two small valleys from the east, there are other outcrops. At these last localities the Okaw limestone beds are overlain by Pennsylvanian sandstones. The city of Red Bud is underlain by the Okaw limestone, and although there are no exposures except along the creek in the western part of the town, the dug wells which pass through the overlying drift mantle, invariably penetrate the limestones. One mile north-east of Red Bud, in n.e. sec. 3, T. 4 S., R. 8 W., a group of sink holes indicates the presence of limestones, and the Okaw limestone is actually exposed at a number of points.

Aside from the outcrops mentioned, the deep drift covering hides all the rock exposures between Red Bud and the Okaw river, but east of this stream the Chester formations are exposed at a number of points in the beds of some of the tributaries of the Okaw river just above where they enter the bottom lands. The northernmost of such outcrops are near the mouth of Dozaw creek, in n.w. 1/4 sec. 4, T. (3) S., R. 7 W., near the middle of the north half of the quarter-section.

4

Other outcrops are present in the same quarter-section, just south of the central portion of its southern half. Much more extensive outcrops occur in the bed of an unnamed creek in n.e. 1/4 of s.w. 1/4, and in n.w. 1/4 of s.e. 1/4 of the same section 4, where limestone with shaly partings is exposed almost continuously for the distance of nearly a quarter of a mile. In all these outcrops the strata exposed belong in the upper portion of the Okaw formation. Above the limestone there are a few outcrops of sandstone which are believed to be Pennsylvanian, although there is locally developed a thin sandstone member in the upper portion of the Okaw, and these sandstones may be that Okaw member.

West of Baldwin, in the lower portion of both of the forks of the tributary to the Okaw river whose mouth lies just north of the Mobile and Ohio railroad bridge, the upper portion of the Okaw formation, characterized by Archimedes and Pentremites sulcatus, is well exposed. In the north fork of the stream the outcrops continue at intervals for about one-half mile from the junction with the south fork, but in the south fork the last outcrop is beneath the railroad bridge.

In the creek about three-fourths of a mile south of the Mobile and Ohio railroad, the upper beds of the Okaw are exposed in the s.e. 1/4 of s.w. 1/4 sec. 16, and in n.e. 1/4 of n.w. 1/4, sec. 21, T. 4 S., R. 7 W. The outcrops consist of more or less argillaceous and crystalline limestones with shale partings, most of the beds being fossiliferous although the fossils are difficult to remove from the limestones. One shale bed less than a foot in thickness, contains great numbers of good examples of Pentremites sulcatus, and a few other species, as follows.

W 622

Another group of outcrops occurs in s.w. 1/4 of sec. 21, T. 4 S., R. 7 W. In the n.e. 1/4 of the quarter-section limited limestone and shale exposures are present in the bed of the creek, but in the s.w. 1/4 of the quarter-section

the beds are much better exposed in the Okaw river bluff, and in the short draw leading to the northwest. In this draw a series of calcareous shales and some limestones is exposed, the shales containing numerous specimens of Orthotetes kaskaskiensis in some horizons. In the river bluff the shales have slumped a great deal, and the ledges have been more or less completely covered by talus, but some of the beds are abundantly fossiliferous, and the following species have been collected lying loose upon the slope.

W 624

A single small outcrop of thinly bedded, siliceous limestone is present near the mouth of a short valley, in s.w. 1/4 of n.w. 1/4, sec. 5, T. 5 S., R. 7 W. It doubtless belongs in the upper portion of the Okaw formation although no fossils have been observed.

From Horse creek south, on the west side of the Okaw river, and from Plum creek south, east of the Okaw, the Pleistocene deposits are much less deep than north of these two streams, and outcrops of the underlying hard rocks are met with in most of the stream courses, all the way to the Mississippi bluffs.

At a spring west of the Red Bud-Ruma road, a little over one-half mile south of the bridge over Horse creek, in s.e. 1/4 of s.e. 1/4, sec. 29, T. 4 S., R. 8 W., and in the small valley crossing the northern portion of sec. 32, next south, the lower beds of the Okaw are well exposed and are abundantly fossiliferous. From the exposures at the spring the following species have been determined.

W 590

W 256

In the section exposed in the small valley south of the spring, there are about four feet of variegated shales at the base, which doubtless represent the upper portion of the Ruma formation, passing up into more calcareous gray shales. Higher up there are 20 feet or more of limestones in beds one foot thick or less, with shaly partings. These limestones are fossiliferous, some layers being especially filled with Productus ovatus and Diaphragmus elegans, some beds have many crinoid stems, and in other beds bryozoans are abundant, although Archimedes is not common as is usually the case in the lower Okaw. Some oolitic beds are present, but they are neither very thick nor conspicuous.

Good exposures of the lower Okaw are present in most if not all of the tributaries to Horse creek and Paint Creek, west of Ruma, in which the Ruma formation is exposed, and at one locality by the roadside, in s.w. 1/4 of s.e. 1/4, sec. 30, T. 4 S., R. 8 W., the following species of fossils have been collected.

W 602

In the two valleys leading to the north across the n.e. 1/4, sec. 1, T. ⁵4 S., R. 9 W., and the n.w. 1/4, sec. 6, T. ⁵4 S., R. 8 W., which join further north, the lower Okaw beds are exposed above the Ruma formation. In these localities the beds are characterized by an abundance of bases of Agassizocrinus, the spatulate, wing-plates of Pterotocrinus, and the axes of Archimedes, characteristics which have been met with very frequently in the lower Okaw beds. The limestones are in beds a foot, more or less, in thickness, with shaly partings, and the successive beds vary more or less in lithologic characters, and commonly the three fossil forms mentioned above are each abundant in separate beds.

In the bed and banks of Camp creek there are excellent Okaw exposures in n.w. 1/4 of s.w. 1/4 sec. 7, T. 4 S., R. 8 W., mostly limestones but with some shale beds containing numerous Pterotocrinus wing plates. At this locality some

of the beds are literally filled with bryozoans, and in one bed upon a surface of about square feet the following species of bryozoans and other fossils have been identified.

At this same Camp creek locality, one thin bed contains numerous, dark, pebble-like inclusions, apparently phosphatic, associated with numerous fossils which were waterworn before burial. Beds of similar character have been observed at a number of localities in the lower part of the Okaw formation, as in the quarry one-fourth mile north of Red Bud, and elsewhere, but it has not been possible to establish the exact equivalence of the beds at all points.

Excellent exposures of the lower portion of the Okaw occur in the northern part of the s.e. 1/4 of n.w. 1/4 sec. 18, T. 5 S., R. 8 W., in one of the branches of Camp creek, about two and three-fourths miles southwest of Ruma. At this locality the following section is exposed.

- 8. Limestone, crystalline in texture, with the exposed upper surface covered with great numbers of the "wing plates" of Pterotocrinus 1 foot
- 7. Limestone, crystalline, irregularly bedded, with great numbers of Archimedes 6 inches
- 6. Limestone, filled with fossils, the fauna comprising a prolific assemblage of brachiopods, gastropods, pelecypods, trilobites and bryozoa 1 foot

- Zaphrentis sp.
- Pentremites pyriformis Say.
- Agassizocrinus (bases).
- Pterotocrinus (wing plates).
- Chilotrypa sp.

Stenopora sp.

Archimedes sp.

Polypora sp.

Lyropora sp.

Lyropora sp.

Orthotetes kaskaskiensis (McChesney.)

Productus ovatus Hall.

Diaphragmus elegans (Norwood and Pratten.)

Camarophoria explanata (McChesney.)

Rhynchopora ? perryensis Weller.

Spiriferina spinosa (Norwood and Pratten.)

S. Transversa (McChesney.)

Spirifer increbescens Hall, var.

S. leidyi Norwood and Pratten.

Martinia contracta (Meek and Worthen.)

Eumetria vera Hall.

Cliothyridina sublamellosa (Hall.)

Composita trinuclea (Hall.)

Girtyella brevilobata (Swallow.)

Sanguinolites sp.

Edmondia ? sp.

Nucula sp.

Leda sp.

L. sp.

Parallelodon sp.

P. sp.

Conocardium sp.

Myalina angulata Meek and Worthen.

M. sp.

Aviculopecten chesterensis Worthen

Allorisma ? sp.

Cypricardinia sp.

Ptychomphalus sp.

P. sp.

Murchisonia sp.

Bellerophon sp.

B. sp.

Euphemus sp.

Patellostium sp.

P. sp.

Straparollus planidorsatus Meek and Worthen

Holopea sp.

Orthonychia chesterensis Meek and Worthen.

Dentalium sp.

Enchostoma sp.

Orthoceras okawense Worthen.

O. randolphense Worthen.

O. sp.

Discitoceras sp.

D. sp.

Griffithides sp.

Helodus sp.

Petrodus sp.

5. Limestone, blue, crystalline, more or less

irregularly bedded, with many fossils 3 feet.

Zaphrentis sp.

Pachylocrinus sp.

Pentremites pyriiformis Say.

Archimedes swallowianus Hall.

Orthotetes kaskaskiensis (McChesney.)

Productus ovatus Hall.

P. inflatus McChesney.

Pustula punctatus (Martin.)

Diaphragmus elegans (Norwood and Pratten.)

Spirifer spinosa (Norwood and Pratten.)

S. transversa (McChesney.)

Spirifer increbescens Hall, var.

S. leidyi Norwood and Pratten.

Martinia contracta (Meek and Worthen.)

Eumetria vera Hall.

Cliothyridina sublamellosa (Hall.)

Composita trinuclea (Hall.)

Myalina sp.

Orthoceras sp.

Griffithides sp.

4. Limestone, blue, crystalline, with many specimens
of Zaphrentis..... 6 inches
3. Limestone, irregularly bedded, similar to the
subjacent bed but more crystalline in texture,
bluer in color and with the fossils much more
conspicuous 3 feet.

2. Limestone, bluish-gray in color, with irregular knotty bedding, more or less earthy in texture. The basal six inches with great numbers of Agassizocrinus bases and plates, the upper portion with many examples of Martinia 2 1/2 feet

Zaphrentis sp.

Pentremites pyriiformis Say.

Agassizocrinus (bases)

Orthotetes kaskaskiensis (McChesney.)

Productus ovatus Hall.

Diaphragmus elegans (Norwood and Pratten.)

Camarophoria explanata (McChesney.)

Spirifer leidyi Norwood and Pratten.

Martinia sp.

Composita sp.

Straparollus planidorsatus Meek and Worthen.

Orthoceras sp.

Griffithides sp.

1. Shale, argillaceous, blue in color. Exposed 2 feet.

Just below the junction of the stream in which the last section occurs, with Camp creek, in a short tributary from the south, by the roadside in n.e. 1/4 of n.e. 1/4, sec. 17, T. 5 S., R. 8 W., the lower portion of the Okaw formation is again exposed, and the following species of fossils have been collected.

Zaphrentis sp.

Palaeacis cuneiformis Milne-Edwards

Pentremites pyriiformis Say.

Agassizocrinus (bases).

Pterotocrinus (wing plates)
Chilotrypa sp.
Archimedes swallovianus Hall.
Polypora cestriensis Ulrich.
Lyropora divergens Ulrich.
Intrapora undulata Ulrich ?
Crania sp.
Orthotetes kaskaskiaensis (McChesney.)
Productus ovatus Hall.
Diaphragmus elegans (Norwood and Pratten.)
Rhynchopora ? perryensis Weller.
Spiriferina transversa (McChesney.)
Spirifer increbescens Hall, var.
S. leidyi Norwood and Pratten.
Eumetria vera Hall.
Cliothyridina sublamellosa (Hall.)
Composita trinuclea (Hall.)
Nucula sp.
Leda sp.
Conocardium sp.
Myalina angulata Meek and Worthen.
Aviculopecten sp.
A. sp.
Straparollus planidorsatus Meek and Worthen.
Enchostoma sp.
Griffithides sp.

Between Camp Creek and Horse Creek the Okaw beds outcrop at many points in the tributaries of the two streams, and at a number of localities collections of fossils have been secured. A mile and one quarter northeast of Ruma there are good exposures of oolitic and other limestones along a small creek crossing the s.e. 1/4 of s.e. 1/4, sec. 28, T. 4 S., R. 8 W. Some of these beds contain numerous examples of the spatulate wing plates of *Pterotocrinus*, a faunal character which is commonly met with in the lower Okaw. In the collection of fossils secured at this locality the following species have been identified.

W 620

Other good exposures of the *Pterotocrinus* bearing limestones are present one and three-fourths miles east of Ruma, in s.e. 1/4 of s.e. 1/4, sec. 34, T. 4 S., R. 8 W.

A little less than one-half mile southeast of Ruma, in s.e. 1/4 of n.e. 1/4 sec. 4, T. 5 S., R. 8 W., a bed of bluish Okaw limestone is exposed in the bed of a small creek just below the public road, from which a fauna very similar to that in the city quarry at Red Bud has been collected, containing large numbers of the brachiopod shell *Martinia contracta*. The completed list of species from this locality is as follows:

W 257

This *Martinia* fauna is apparently a persistent one in the basal part of the Okaw, and occupies a position a little below the beds containing such a great number of *Pterotocrinus* "wing plates."

At a number of points in the bed of Horse Creek in sections 1 and 2, T. 5 S., R. 8 W., the Okaw limestone is well exposed, and some of the strata are fossiliferous.

South of Camp creek, in a large tributary of that stream from the west, limestone and shale beds of the Okaw formation are well exposed. At one point where one of the branches of this stream crosses the line between sections 17 and 20, T. 5 S., R. 8 W., the following succession of beds occurs.

5. Shale, calcareous, with some limestone lenses and bands. Abundantly fossiliferous.....8 feet.

Zaphrentis sp.

Amplexus ? sp.

Pentremites pyriformis Say.

P. godoni DeFrance.

P. abbreviatus Hambach.

P. elegans Lyon.

Zeacrinus sp.

Hydreionocrinus sp.

Agassizocrinus (bases).

Pterotocrinus depressus Lyon and Casseday (wing plates.).

Fistulipora excelens Ulrich.

Stenopora tuberculata Prout.

S. sp.

Fenestella serratula Ulrich.

F. tenax Ulrich.

F. exigua Ulrich.?

Archimedes swalloviana Hall.

Polypora cestriensis Ulrich.

P. tuberculata Prout.

P. radialis Ulrich?

P. internodata Ulrich?

Septopora subquadrans Ulrich.

W595

Glyptopora ? sp.

Diaphragmus elegans (Norwood and Pratten.)

Gamarophoria explanata (McChesney.)

Spiriferina spinosa (Norwood and Pratten.)

Spirifer leidyi Norwood and Pratten.

Reticularia setigera (Hall.)

Eumetria verneuilliana Hall.

Cliothyridina sublamellosa (Hall.)

Composita trinuclea (Hall.)

Straparollus sp.

Orthonychia chesterenses (Meek and Worthen.)

Orthoceras sp.

Discitoceras sp.

4. Shale, variegated red and blue in color, not calcareous...8 feet.
3. Shale, argillaceous, blue in color.....6 "
2. Limestone, thin-bedded.....1 "
1. Shale, argillaceous, thinly laminated, blue in color.....12 "

This section is one of the few localities where variegated shales have been observed in the Okaw formation. Beneath the blue shale at the base of the section, there is an interval without outcrops of bed rock, but a short distance down stream a hard, dense limestone forms the floor of the creek and so continues for the distance of more than one-half mile. The unexposed interval between the limestone in the bed of the creek and the lowermost shale is approximately ten feet.

Other good outcrops of the Okaw limestone are exposed in the several valleys tributary to Camp Creek, heading in sec. 21, T. 5 S., R. 8 W., and flowing north and east.

In most of the valleys heading on the opposite sides of the ridge extending southeast from Marigold to Roots, the Okaw formation is well exposed. In the valleys to the west the Okaw is present only in the heads in the northern portion of the area, their lower portions being occupied by older formations, but a little less than two miles above Roots the older formations pass beneath the level of the Mississippi bottoms, and the Okaw formation constitutes the entire height of the Mississippi bluffs. In this region the basal portion of the formation, with the underlying Ruma and the upper portion of the Paint Creek, is exposed in the small ravine intersecting the Mississippi river bluff in s.w. 1/4 sec. 4, T. 6 S., R. 8 W., about half way between Roots and Modoc. In this section the following succession of beds is exposed.

- 18. Limestone, ledges more or less continuously exposed.....19 feet
 - 17. Talus covered, probably shale.....18 "
 - 16. Limestone, with chert..... 3 "
 - 15. Talus covered, probably shale.....16 "
 - 14. Limestone, ledges more or less continuously exposed, in part oolitic and in part crystalline.....19 "
- W 227
- 13. Talus covered, probably shale.....17 "
 - 12. Limestone ledge..... 1 "
 - 11. Talus covered, probably shale.....12 "
 - 10. Shale, argillaceous, bluish or yellow in color.....12 "
 - 9. Limestone, crystalline, variable in texture...16 "

Okaw-Ruma contact.

8. Shale, the upper portion of the interval talus covered, but with good exposures below of conspicuously variegated, red and blue, argillaceous shale.....37 feet

Ruma-Paint Creek contact.¹

¹ The portion of this section below the Ruma-Paint Creek contact has been described in connection with the discussion of the Paint Creek formation on page .

In the bluff sections the beds exhibit a gentle dip down the valley and a few rods above the mouth of the ravine in which the above section is exposed, and stratigraphically beneath the lowest of the described beds, the color of the soil in the highway and in the talus above the road, shows clearly the position of the characteristic red clay member of the Paint Creek formation. Of the beds exposed in the section the lower thirty feet constitute the upper portion of the Paint Creek formation. The succeeding 37 feet, which is variegated shale, so far as it is exposed, without sandstone, is the Ruma formation. The upper 123 feet of the section is Okaw, and the alternating character of the shale and limestone beds of the formation is well brought out by the outcropping limestone ledges which are exposed at intervals, with the intervening talus covered shale beds.

South of Marigold, in the three heads of Crooked creek, a tributary of the Okaw river, there are good exposures of a conspicuous oolite bed whose position is about 50 or 60 feet above the base

of the Okaw formation. In the first of these ravines in the northern part of sec. 29, T. 5 S., R. 8 W., the following succession of beds is exposed.

- 5. Limestone, white, oolitic, with numerous fossils, the lower six feet not well exposed.....18 feet

W. 596

- 4. Limestone, crystalline, blue-gray in color, not continuously exposed, Archimedes common. Somewhere in the interval there is probably a chert bed about one foot thick.....18 "
- 3. Unexposed, probably shale, the talus with numerous tumbled masses of limestone from above.....30 "
- 2. Limestone, cross-bedded, crystalline, blue-gray in color. The outcrop is not a solid ledge, but is represented by tumbled masses because of the underlying shale..... 6 "
- 1. Shale, argillaceous, blue to variegated in color..... ? "

In the ravine heading in s.w. 1/4 sec. 29, T. 5 S., R. 8 W., the following section is exposed.

- 9. Chert bed, about one foot exposed, passing down into hard, cherty limestone..... 3 feet
- 8. Unexposed..... 6 "
- 7. Limestone, hard and crystalline..... 2 "
- 6. Shale, yellowish in color, probably blue when not weathered, with many bryozoans and some other fossils..... 6 "

W 598

- 5. Unexposed.....17 feet
- 4. Limestone, blue, crystalline, non-oolitic..... 1 "
- 3. Unexposed..... 5 "
- 2. Limestone, white in color, conspicuously oolitic
in texture. Fossiliferous.....12 "

W 597

- 1. Limestone, hard, crystalline in texture, with
shaly partings.....10 "

In the next hollow south, heading near the middle of the east half of sec. 32, T. 5 S., R. 8 W., the following succession is exposed.

- 6. Limestone, massive beds, somewhat variable in
texture.....15 feet
- 5. Unexposed.....14 feet
- 4. Limestone, very cherty, with some nearly solid
chert beds.....12 "
- 3. Shale and unexposed interval, outcrop of shale
for two feet only at the top, it is doubtless
shale below with perhaps some thin limestone
bands. The basal part of the interval may be
occupied by the upper portion of the oolite
below.....48 "
- 2. Limestone, white, oolitic, fossiliferous..... 6 "

W 599

- 1. Limestone, hard and non-oolitic..... ? "

The oolite exposed in the three sections just described from south of Marigold, is undoubtedly the same, continuous bed, and

is exposed again in the upper portions of the ravines heading on the west side of the ridge. About 40 feet above the oolite is a conspicuous chert bed associated with cherty limestone, which is about the only cherty horizon in the entire Okaw formation so far as observations have been made, and this bed also is exposed in a number of localities in the heads of the ravines west of the ridge.

In the area between the Okaw river and the Mississippi river bluffs, below Crooked Creek, rock outcrops are not so abundant as further north, but good exposures are present at intervals in the beds or banks of nearly all the streams. All of these outcrops belong in the Okaw formation, and at most of them the beds are more or less fossiliferous. The oolite bed is well exposed at one point a little more than one-fourth of a mile northwest of Roots, in the banks of an unnamed creek, near the line between s.e. 1/4 of s.w. 1/4, and s.w. 1/4 of s.e. 1/4 sec. 2, T. 6 S., R. 8 W., where the following species of fossils have been collected.

W 616

East of the Okaw River and south of Plum creek, only the middle and upper beds of the Okaw formation are exposed. In the eastern part of the city of Evansville a number of sink holes are present, in some of which the limestone is exposed, and in one quarry has been opened to furnish rock for local use. The rock taken out is a white oolite, probably the same bed as that exposed south of Marigold, and the following species of fossils have been identified from it.

W 626

Northeast of Evansville the Okaw formation is exposed in all of the tributaries of the Okaw river and Plum creek from the

south, between that town and Preston, although east of section 18, T. 5 S., R. 8 W., formations younger than the Okaw are exposed in the upper portions of the valleys. The uppermost member of the Okaw formation, consisting of a greater proportion of shales than are present in the beds below, with thin, bryozoan covered limestone layers, some of which contain black, rounded, probably phosphatic, pebble-like inclusions, besides some foreign pebbles, and many fish teeth, are especially well developed in some of the tributaries of Plum creek west of Preston. One of the best of these localities is situated about one mile west of Preston, in the southern part of s.e. 1/4 sec. 9, T. 5 S., R. 7 W., where the following species of fossils have been collected.

W 619

Some of the arenaceous beds which are present in this uppermost member of the Okaw formation, are poorly exposed in the upper part of the small valley crossing the eastern part of s.w. 1/4, sec. 18, T. 5 S., R. 7 W.

South of Evansville the limestone members of the Okaw formation are exposed at intervals in most of the tributaries of the Okaw river, but the country is so deeply drift covered that there are few if any outcrops exposing any great thickness of strata. The sink hole topography developed in places indicates the presence of limestone beneath the drift mantle, but actual rock outcrops are present in but few of the depressions. In the valley of Butter creek the Okaw formation extends eastward to within one-half mile of Walsh, and in some of the tributaries there are good exposures of the upper, shaly member of the formation, although the bed of the main stream is filled with alluvium for most of its length.

One of the best of these upper Okaw exposures in the basin of Butter creek is about two miles southeast of Evansville, in the bank of a tributary from the northwest, in the s.w. 1/4 of n.w. 1/4, sec. 29, T. 5 S., R. 7 W., where the following species of fossils have been collected.

In the valley of Nine-mile creek the Okaw formation extends eastward into section 2, T. 6 S., R. 7 W., but here, as in Butter creek, the exposures are confined chiefly to the tributary valleys, the main valley being largely filled with alluvium. The outcropping strata are mostly confined to the upper, shaly member of the formation, although at a number of localities some of the more massive limestones beneath the shaly beds are exposed. In the s.w. 1/4 of s.w. 1/4 sec. 33, T. 5 S., R. 7 W., the upper shaly member is well exposed, and the following species of fossils have been collected.

W 618

Among the best exposures in the Nine-mile basin, are those in two tributaries from the south which cross the s.e. 1/4 sec. 4, T. 6 S., R. 7 W. In the lower part of these valleys massive beds of Okaw limestone are well exposed which are succeeded by a series of about 40 feet of shales, thin limestones, and arenaceous beds. A similar section is exposed in a tributary crossing the southern half of sec. 3, T. 6 S., R. 7 W.

In Little Nine-mile creek a finger-like extension of the Okaw formation reaches to the n.w. 1/4 sec. 16, T. 6 S., R. 7 W. The exposures are confined to the last mile of the distance, and are limited to the uppermost member of the formation, being shales, sandstone and limestone.

South from the junction of Nine-mile creek with the Okaw

river the drift cover is thick, but the Okaw formation is exposed in small outcrops at numerous points, and in a few localities the outcrops are somewhat extensive. In the Okaw river bluff beside the Illinois Southern railroad track, about three-fourths of a mile above Collins (Missouri Junction), a limestone member of the formation has been quarried, and at this locality the following fossils fauna has been collected.

W 614

A few rods above the station at Collins there are other limestone outcrops, but they are much less extensive than at the quarry further north. One mile west of Ellis Grove, in s.w. 1/4 of n.w. 1/4 sec. 18, T. 6 S., R. 7 W., and in the s.w. 1/4 of n.e. 1/4 sec. 13, T. 6 S., R. 8 W., the limestones just below the upper shaly member of the Okaw formation are almost continuously exposed for a distance of about one-third of a mile in the bed of a stream tributary to the Okaw river, but beyond these outcrops the entire valley is filled with drift and alluvium to its mouth. There are numerous good exposures in Moccasin hollow, heading in s.w. 1/4, sec. 18, T. 6 S., R. 7 W., and about one-half mile from the mouth of the valley the white oolite beds near the middle of the formation are well exposed and have afforded the following species of fossils.

W 615

South of Ellis Grove the upper limit of the Okaw formation must extend nearly to the southern limits of the village, but the deep covering of drift obscures all the underlying hard rocks. Lower down in the valley, however, which originates in the south edge of the town, and in its tributaries, there are good exposures

of some of the limestone members of the Okaw, at intervals all the way to its mouth just above Reiley Lake. In the valley whose mouth is at the lower edge of Reiley Lake, at a point about one-half mile from the river bluffs, there is a series of good exposures which include a part of the uppermost shaly and arenaceous member of the Okaw formation and also some of the more massive limestones beneath these beds.

From Reiley Lake southeastward along the Mississippi River bluffs, the Okaw formation is limited to a narrow band in the lower portion of the bluffs,^{and to finger-like extensions into the short ravines which intersect the bluffs} Because of the nature of the formation, an alternation of shaly beds with more massive limestones, the face of the bluff is a steep slope almost wholly talus covered, and grown up with underbrush. There are at intervals, limestone outcrops in the bluffs, but the best exposures are met with in the ravines, some of which are almost continuous rock outcrops from the mouth to near the head.

A little above Fort Gage one of the limestone members of the Okaw formation outcrops for a distance of nearly one-half mile, in the bank of the Mississippi River. Opposite the railroad station at the same place, the bluff has been cleared of underbrush, and a limestone ledge is exposed at an elevation of 100 feet above the railroad track, where the following fauna has been collected.

W 211

Pentremites cf. elegans Lyon.

Archimedes swallovanus Hall.

Lyropora subquadrans Hall.

Septopora subquadrans Ulrich.

W 211

Diaphragmus elegans (Norwood and Pratten.)

Camarophoria explanata (McChesney.)
Spiriferina spinosa (Norwood and Pratten.)
Spirifer increbescens Hall. var.
Reticularia setigera (Hall.)
Eumetria vera Hall.
Composita trinuclea (Hall.)
Holopea ? sp.
Griffithides sp.

A little above the last mentioned ledge, at an elevation of 120 feet above the railroad track, is another and more extensively outcropping ledge, which is abundantly fossiliferous in places, and has furnished the following species.

W 212 A Zaphrentis sp.
Amplexus sp.
Pentremites pyriformis Say.
Stenopora sp.
Fenestella (fragments)
Polypora sp.
Orbiculoidea sp.
Productus ovatus Hall.
Diaphragmus elegans (Norwood and Pratten.)
Camarophoria explanata (McChesney.)
Dielasma shumardana (Miller)
Girtyella indianensis (Girty.)
Spirifer increbescens Hall, var.
S. leidyi Norwood and Pratten.
Reticularia setigera (Hall.)
Eumetria vera Hall.

E. verneuilliana Hall.

Cliothyridina sublamellosa (Hall.)

Composita trinuclea (Hall.)

Edmondia sp.

Paralleledon sp.

Myalina sp.

Aviculopecten sp.

A. sp.

Mourlonia sp.

Bellerophon sp.

Orthonychia chesterense Meek and Worthen.

O. sp.

Platyceras sp.

Platyostoma ? sp.

Griffithides sp.

These fossiliferous ledges at Fort Gage must occupy a position 100 or more feet above the white oolite member of the formation, and are probably near the top of the massive limestone beds lying just beneath the upper, shaly and arenaceous member of the formation. In the several branches of the valley whose mouth is just below Fort Gage there are thick drift deposits, but the hard rocks do outcrop at intervals, and the Okaw formation occurs for a distance of one mile back from the bluffs.

At a locality about one mile below Fort Gage an attempt to open a quarry was made by the Illinois Southern Railroad at the time of its construction, but the rock proved to be too shaly for practical purposes. The beds excavated were in the uppermost, shaly member of the Okaw formation, and the following species of fossils

have been collected from this locality.

In one of the short ravines about half way between Fort Gage and Menard, the following succession of beds is exposed.

- 15. Sandstone, fine-grained, cross-bedded, ripple-marked, yellow or light-brown in color, becoming somewhat more shaly above.....47 feet
- 14. No exposures.....11 "

Palestine-Menard contact.

- 13. Limestone, compact, in beds a foot or less in thickness, and including some more or less irregular, concretionary masses of chert.....49 "
- 12. Talus covered.....18 "

Menard-Okaw contact.

- 11. Limestone, fossiliferous..... 5 "

Zaphrentis spinulosa Edwards and Haime.

Productus ovatus Hall.

W 212 B

Diaphragmus elegans (Norwood and Pratten.)

Camorphoria explanata (McChesney.)

Dielasma sp.

Bellerophon sp.

Griffithides cf. granulosa Wetherby.

- 10. No exposures.....44 feet
- 9. Limestone, fossiliferous..... 4 "
- Leptodictya tubularis n. sp.
- Productus ovatus Hall.
- Diaphragmus elegans (Norwood and Pratten.)
- Camarophoria explanata (McChesney.)
- Girtyella brevilobata (Swallow)
- Spiriferina spinosa (Norwood and Pratten.)
- Eumetria vera (Hall.)
- 8. Shale, lower portion talus covered.....12 "
- 7. Limestone ledges, the several beds more or less fossiliferous, with one ledge forming a waterfall near the middle of the member. Collections of fossils secured from the top, from 10 feet below the top, and from the bottom of the member.....42 "

W 213

W 214

251

216

- 6. Limestone, thin-bedded with calcareous shales... 7 "
- 5. Shale..... 6 "
- 4. Limestone ledges..... 5 "
- 3. Talus covered, with no exposures.....39 "
- 2. Limestone ledge..... 1 "
- 1. Talus covered, with no exposures to the level of the Iron Mountain Railroad track.....10 "

In this section beds No. 1 to 11, a total thickness of 175 feet are undoubtedly Okaw, and the talus covered No. 12 may

also be a member of that formation, although it is more likely to be the base of the formation above. Beds No. 8, 9, 10, 11, and perhaps 12, constitute the upper, shaly member of the formation, while the more continuous limestone outcrops below constitute the more massive limestone member next below. All the beds of the section belong above the white, oolitic limestone member of the formation which is exposed further north. Bed No. 13 in the section is the Menard limestone, and 14 and 15 are probably the Palestine sandstone, although the section may extend up into the Pennsylvanian.

Another excellent section through the upper half of the Okaw formation, is exposed in the ravine whose mouth is near the middle of the north line of sec. 15, T. 7 S., R. 7 W., one and one-half miles above the Southern Illinois Penetentiary at Menard. The succession of beds exposed is as follows.

7. Shale, poorly exposed in the bank of the creek.. ? feet
6. Limestone, variable in lithologic character but dominantly bluish-gray in color, and dense in texture, for the most part in layers one foot, more or less in thickness, separated by shaly partings and with hummocky bedding planes. Twenty feet above the base of the ledge some beds are somewhat crystalline and crinoidal, and some loose slabs occur which are covered with delicate echinoid spines and some plates. Other slabs exhibit many fossil gastropods in section. Cherty layers are present, and some layers without chert are apparently siliceous. Fossils collected from the lower 15 to 20 feet.....55 "

Menard-Okaw contact.

5. Shale, argillaceous, bluish-black in color, without fossils in lower part, the upper six to eight feet becoming more calcareous and with some fossils.....40 feet
4. Limestone, surface of ledge with imbedded black, phosphatic ? pebbles.
3. Limestone, thin-bedded, variable in lithologic character, but more or less crystalline, with at least one cherty band, the upper beds almost shaly, with numerous bryozoans..... 8 "
2. Shale, with minor limestone layers, exposed at intervals but much talus covered.....45 "
1. Limestone, crystalline, light colored, gray to white, in thick ledges without shaly partings...60 "

In this section the lower 153 feet constitute the upper portion of the Okaw formation. The highest beds of the formation here exposed, include some 90 feet of strata which are dominantly shaly with some subordinate limestone bands, too much talus covered in this section to allow a detailed section to be made, but the same interval is well exposed in the newer quarry at the Southern Illinois Penetentiary at Menard. The thick limestone member at the base is the same bed as the more massive limestone mentioned in earlier sections, and is well exposed in the prison yard at Menard. It is the most massive and thickest limestone member in the Okaw formation and has its greatest development in the neighborhood of Chester.

The section exposed in the newer quarry at Menard, outside

the prison yard, is as follows.

- 13. Limestone, conglomeratic, blue-gray to brown, irregularly thin bedded and more or less cross-bedded, crystalline in texture, with many more or less fragmentary fish teeth. The included pebbles are most abundant at the base, they are mostly dark, irregularly rounded, smooth, phosphatic ? nodules, with some bits of shale and other material. Fossils collected at the base and at the top..... 6 feet
Fauna from base of bed.

Crinoid stems.

Fenestella sp.

W 192

Lingula sp.

Diaphragmus elegans (Norwood and Pratten.)

Spirifer increbescens Hall, var.

Comularia chesterensis Worthen ?

Fish teeth, fragmentary, abundant

Fauna from top of bed.

W 193

- 12. Shale, calcareous, fossiliferous.....2½ "

Meekopora clausa Ulrich.

Stenopora tuberculata (Prout.)

Fenestella serratula Ulrich.

Archimedes laxis Hall.

Palypora cestriensis Ulrich.

Septopora subquadrans Ulrich.

Orthotetes kaskaskiensis (McChesney.)

Spirifer increbescens Hall, var.

Composita trinuclea (Hall.)

11. Limestone, hard, blue, mostly compact with conchoidal fracture, rather thin bedded with shaly seams.....12 feet

Productus ovatus Hall.

Diaphragmus elegans (Norwood and Pratten.)

Composita sp.

Pelecypod (undetermined)

10. Shale, yellowish when weathered, blue when fresh, with a thin limestone band 0 to 4 inches thick about the middle. Above the limestone band numerous bryozoans..... 5 "

W 189

9. Limestone, thin-bedded with bands of shale..... 7 "
8. Sandstone, fine-grained, light-yellow in color, more or less cross-bedded, with some fragments of plant remains. Varying in thickness from 0 in south part of quarry to 14 feet at the north end.
7. Sandstone, thin-bedded and arenaceous shales.... 6 "
6. Shale, blue, argillaceous..... 4½ "
5. Limestone..... 1½ "
4. Shale, partly covered..... 3 "
3. Limestone..... 1½ "
2. Shale..... 1½ "
1. Limestone, only the upper surface exposed, at level of floor in engine room. This is bed No. 1

in the last section described, and is continuous with the ledge quarried in the prison yard.

The limestone bed No. 1, in this section, is the same as bed No. 1 in the section last described, and is continuous with the ledge quarried in the prison yard. The exposed face of the quarry about 50 feet high, constitutes the upper, shaly member of the Okaw formation, and it is exposed in greater detail at this locality than anywhere else in the region studied. The section as described was made at the time when the quarry was first opened, but since that time the excavation has been carried back into the bluff where the beds have not been subjected to the weathering exhibited on the surface, and the beds do not appear to be so different in character as in the earlier stages in the development of the quarry.

In both of the valleys leading back from the prison yard at Menard, the Okaw formation is exposed at intervals for over one-half mile from the river bluffs. Above the south gate at the penitentiary another detailed section has been studied, the following succession of beds being recognized.

11. Shale, yellowish in color, more or less fissile with a few harder bands an inch or more in thickness.....12 feet 6 in.

Fauna W 196 (basal part)

Pterotocrinus cf. depressus Lyon and Casseday.

Hydreionocrinus sp. (spine plates of ventral sack).

Agassizocrinus dactyliformis Roemer (?), (base).

Stenopora tuberculata (Prout).

Fenestella serratula Ulrich.

Archimedes terebriformis Ulrich.

A. distans Ulrich

A. swallovanus Hall.

Spirifer increbescens Hall, var.

Composita subquadrata (Hall).

10. Limestone.....3 feet 6 in.

9. Shale.....3 "

Fauna W 197.

Polypora approximata Ulrich.

Lyropora quincuncialis Hall (?)

Fenestella serratula Ulrich (?)

Archimedes terebriformis Ulrich.

A. distans Ulrich.

A. sublaxus Ulrich.

Diaphragmus elegans (Norwood and Pratten).

Spirifer increbescens Hall var.

Reticularia setigera (Hall).

Cliothyridina sublamellosa (Hall).

C. cf. hirsuta (Hall).

Composita trinuclea (Hall).

8. Limestone, in several thin beds.....1 foot 6 in.

Fauna W 198.

Productus ovatus Hall.

Diaphragmus elegans (Norwood and Pratten).

Spirifer leidyi Norwood and Pratten

Reticularia setigera (Hall).

Eumetria vera (Hall).

Cliothyridina cf. hirsuta (Hall).

7. Limestone, one solid ledge.....2 feet

6. Shale, a parting of buff-colored, apparently

- magnesian material..... 6 in.
- 5. Limestone, in several beds, thinner below, becoming thicker-bedded above.....7 feet
- 4. Shale with limestone, abundantly fossiliferous.1 foot 6 "

Fauna W 195

Zaphrentis spinulosa Edwards and Haime.

Pterotocrinus depressus Lyon and Casseday.

P. acutus Wetherby.

P. bifurcatus Wetherby.

Agassizocrinus dactyliformis Roemer (?) (bases).

Pentremites sulcatus Roemer.

Spirorbis sp.

Stenopora rudis Ulrich.

Lyropora subquadrans Hall.

Archimedes terebriformis Ulrich.

A. distans. Ulrich.

A. communis Ulrich.

A. compactus Ulrich.

Dichytrypa n.sp.

Spirifer increbescens Hall, var.

Spiriferina transversa (McChesney).

Reticularia setigera (Hall).

Eumetria vera (Hall).

Cliothyridina sublamellosa (Hall).

Composita trinuolea (Hall).

Fish teeth (Cochleodonts).

- 3. Limestone.....3 feet 6 "
- 2. Shale, yellow, gritty, with many fossils..... 6 "

Fauna W 194

Eupachyerinus sp.

Agassizocrinus dactyliformis Roemer (?), (bases).

Pentremites tulipaformis Hambach.

P. turbinatus Hambach.

Archimedes swallovanus Hall.

A. meekanus Hall.

Diaphragmus elegans (Norwood and Pratten).

Reticularia setigera (Hall).

Eumetria vera (Hall).

Composita trinuclea (Hall).

1. Limestone, massive, quarry beds in prison yard.....Exposed 37 feet 6 in.

In this section bed No. 1 is the top of the massive limestone beneath the upper shaly member of the formation, but the thirty-six feet of beds, Nos. 2 to 11, does not include the whole of the upper member, its upper portion being covered with talus.

Between Menard and Chester the higher beds of the Okaw are well exposed in a short ravine, for the distance of about four-fifths of a mile back from the river, and just south of the mouth of this ravine there is a good exposure of sandstone which belongs near the base of the upper member of the formation. In the ravine situated in the eastern portion of the city of Chester, whose mouth is a little below the Iron Mountain Railroad station, there are other good exposures extending back for one-half mile from the river bank.

In the ravine just below Cole's Mills, in the lower part of the city of Chester, a massive limestone, the continuation of

the quarry ledge in the prison yard at Menard, extends to an elevation of about 23 feet above the Iron Mountain railroad tracks. This bed is followed by the upper shaly member of the formation, which is more arenaceous in this section than in any of those further north, so far as they have been examined. Between this section and the mouth of Marys River the upper portion of the Okaw formation is exposed in most of the short ravines intersecting the bluffs, but the more conspicuous rock outcrops in the bluffs between these two points are of a higher formation, the Menard limestone. The last exposure of the Okaw, below Chester, outcrops in the west bank of Marys River just above the water level, above the bridge crossing the river near its mouth. The beds exposed here are shales and limestones belonging near the very top of the formation, and from them the following species of fossils have been collected.

W 632

Aside from these exposures of the Okaw formation along the Mississippi river bluffs, the top of the formation outcrops in the banks of one of the tributaries of Gravel creek from the south, about two miles north of Chester. The formation also occupies, without doubt, the bottom of the valley of Gravel creek for the distance of a mile or more, in sections 1 and 22*?, T. 7 S., R. 7 W., although all the hard rocks are buried beneath the alluvium. The outcrops are situated along the stream which crosses the north half of section 12, in a northeasterly direction, and consists of shales with some thin limestone bands, and from some beds near the top of the outcrop the following species of fossils have been collected.

(*blurred in copy)

W 641

At the mouth of the short tributary to Gravel creek, next west of the one last mentioned, there is a small outcrop of sandstone which is without doubt a bed in the uppermost shaly and arenaceous member of the Okaw.

Thickness. At no locality in the entire area which has come under observation, is there any exposure which includes the entire thickness of the Okaw limestone. The total thickness of the formation, therefore, has to be determined through the piecing together of a number of different sections. The lower portion of the formation, from its contact with the Ruma formation upward, is exposed in a number of localities along the eastern border of the outcrop, especially in the Mississippi river bluffs, and one of the best of such sections is that about half way between Modoc and Roots, which is described on page , In this section the top of the oolitic limestone member of the formation is essentially 77 feet above the Okaw-Ruma contact. Elsewhere in the same general portion of the area mapped, the position of the oolite bed seems to occupy approximately the same position, but nowhere else has so satisfactory a measured section been observed. It seems safe to consider that the thickness of the Okaw from the base of the formation to the top of the oolite member is in round numbers 75 feet.

In Moccasin hollow, nearly two miles below Roots, the same oolite member is exposed at an elevation of from 20 to 40 feet above the level of the Mississippi bottom, and at Fort Gage the dip of the strata has doubtless carried it to near or somewhat below the level of the river bank. The fossiliferous ledges in the bluff back of Fort Gage station occupy a position as high as 120 feet

above the railroad track, and the elevation above the oolite must be at least as great. The position of the highest of the ledges at Fort Gage must be near the summit of the massive limestone member which continues along the bluff down the river, and is so well exposed in the prison yard at Menard, and the interval between the top of the oolite and the top of the upper limestone member may be assumed to be approximately 125 feet.

The thickness of the upper, shaly and locally arenaceous member of the formation is shown at a number of localities in the vicinity of Chester. In the section described on page , exposed in a short ravine between Fort Gage and Menard, beds Nos. 8 to 11, with a total thickness of 65 feet, certainly belong above the massive limestone member. In the section exposed in the ravine one and one-half miles above Menard, described on page , beds Nos. 2 to 5 constitute this part of the formation with a thickness of 93 feet. In the newer quarry in the bluffs just above the prison yard at Menard, described on page , beds Nos. 2 to 13, with a thickness of 64 feet constitute this upper member, but in the section there may be a considerable thickness of shale, similar to bed No. 5 of the last section, which is not exposed. Certainly the top of bed No. 13 of the quarry section with its pebbles, phosphatic nodules and fish teeth, must be the equivalent of bed No. 4 in the ravine section. In the section at the south gate of the prison yard, 35 feet of beds above the massive limestone quarry ledge, are exposed, but still above these exposures there is an interval of 74 feet, talus covered for the most part, before any characteristic Menard limestone beds are exposed. It is by no means certain that these Menard limestone exposures occur at the bottom of that formation,

but there must be a considerable portion of the upper member of the Okaw which is hidden, and its total thickness is doubtless essentially the same as in the other sections mentioned. The variations in these recorded thicknesses of the upper Okaw member, are from 64 to 93 feet, and a fair estimate of its average thickness may be assumed to be about 75 feet, and this corresponds in general with the topographic interval commonly occupied by the shaly and arenaceous beds in other portions of the region studied.

Combining these several thicknesses, the total thickness of the Okaw formation must be about 275 feet, and its maximum thickness may be even greater, perhaps as much as 300 feet. On the other hand there is some reason to believe that in some portions of the area which has been mapped, the thickness of the Okaw is not so great as indicated in these bluff sections which have been cited, and that a minimum thickness of 200 feet or perhaps less, may be present in some places.

The position of the Okaw oolite bed at Evansville is such as to suggest that the interval above it is considerably less than is indicated in the Mississippi River bluff sections below the mouth of the Okaw river, and it is possible that the formation does not maintain a uniform thickness throughout the entire area. The upper shaly member of the formation, however, is present wherever observations have been made, and if there is any great difference in thickness it would seem to be associated with the series of beds between the top of the oolite and the base of the upper shaly member. The situation is such as to suggest the possibility that the Okaw should perhaps be divided into two separate formations, separated by an unconformity due to an erosion interval during which the

upper portion of the lower division was removed in a portion of the area studied, before the upper division, represented by the upper shaly member of the formation as here described, was deposited. Another feature suggestive of such an unconformity, is the variable nature of the sandstone beds which are commonly present near the base of the uppermost member. The establishment of the suspicion in regard to the constitution of the Okaw formation, expressed above, has not been possible because of the thick covering of drift by which the hard rocks are partially or wholly hidden in Monroe and Randolph counties.

MENARD LIMESTONE

The Menard¹ limestone succeeds the Okaw with apparent

¹Weller, Trans. Ill. Acad. Sci., vol. 6, p. 128 (1915); also, Ill. State Geol. Surv., Monog. I., p. 28 (1914).

conformity. The formation consists largely of limestone, but, as in the Okaw there are intercalated shale beds. The shale beds, however, are less conspicuous than those in the subjacent formation, and rarely, if ever, do they exceed five to ten feet in thickness. The individual beds of the Menard limestone are comparatively thin, in most cases being less than one foot. The bedding planes between them are commonly more or less undulatory or hummocky, and the beds themselves are commonly separated by thin, shaly partings.

The lithologic character of most of the limestone beds in the Menard formation, is in sharp contrast with the limestone members of the Okaw. In the earlier formation the limestones are nearly all more or less crystalline in texture, some of them are oolitic, chert inclusions are commonly absent, and they vary in color from light gray to nearly white. The Menard limestone, on the other hand, are commonly gray or bluish gray in color, finely granular, dense or compact in texture, no oolitic beds have been observed, and a small amount of chert in thin, more or less irregular and discontinuous bands, is commonly present at most horizons, and some beds in which no chert is present are apparently somewhat siliceous. Some of the denser beds are almost lithographic in texture, and such beds break with a conchoidal fracture. Some beds, apparently containing a larger amount of argillaceous matter

than common, exhibit a distinctly earthy lustre on fractured surfaces. Locally, near the summit of the formation in the region about Chester, and perhaps elsewhere, a coarsely crystalline ledge occurs, filled with broken fragments of crinoid stems, which closely resembles some of the more crystalline beds of the Okaw formation, but it is limited in thickness and its association with the other Menard beds will serve to distinguish it from any of the Okaw beds.

Areal distribution and description. In the northern portion of the area which has been mapped, the Menard limestone is completely covered by the Pennsylvanian formations, if it is present. The northernmost outcrops occur along Plum creek, north of Walsh station on the Illinois Southern railroad. Excellent exposures of the typical expression of the formation occur in the bed and banks of this stream, in s.w. 1/4 of sec. 1, and s.e. 1/4 of sec. 2, T. 5 S., R. 7 W., about two and one-half miles northeast of Walsh. The formation is exposed towards the head of Butter creek, in the north half of s.e. 1/4, sec. 22, T. 5 N., R. 7 W., a little over one-half mile southwest of Walsh. The valley of Butter creek, except near its head, has been cut through the Menard into the Okaw formation, but towards the heads of some of its tributaries, outcrops of the Menard are exposed, and similarly, towards the heads of some of the tributaries flowing north into Plum creek and into the Okaw river, west of Preston to within a mile of Evansville, Menard outcrops are east of Rocky branch, a tributary of Butter creek from the northeast, the Menard limestone is well exposed at a large spring in s.w. 1/4 of n.w. 1/4, sec. 33, T. 5 S., R. 7 W., where the following species of fossils have been collected.

The valley of Nine-mile creek, above the mouth of Butter creek, has been cut through the Menard limestone into the upper beds of the Okaw east to sec. 2, T. 6 S., R. 7 W., but beyond this point there are good Menard exposures in the bed and banks of the stream and its branches, at a number of localities. Some of the tributaries also, of this stream, which join it below the point where the Okaw limestones are exposed in its bed, have good Menard outcrops near their heads.

Little-Nine-mile creek is another stream which, like the Nine-mile and Butter creeks, has eroded its valley through the Menard into the Okaw formation for a distance of nearly three miles from its mouth, to a point in n.w. 1/4, sec. 16, T. 6 S., R. 7 W. The tributaries of this stream, however, east and northeast of Ellis Grove, have many good exposures of Menard limestone, beginning a short distance above their junction with the main stream. In the main stream also, above the point where the upper Okaw is exposed, the Menard limestone is well exhibited at numerous points.

South from Ellis Grove the Menard limestone occupies a comparatively narrow belt east of the much broader Okaw belt, to the Mississippi river bluffs, some outcrops being present towards the heads of most of the short tributaries to the Mississippi river in this region, although the hard rocks in these valleys are very generally much obscured by the deposits of glacial drift. Beginning at a point about one and one-half miles below Fort Gage, the Menard limestone outcrops occupy a narrow, sinuous belt in the upper part of the bluffs, which winds in and out around the heads of the short ravines, this condition continuing to the mouth of

Marys river. In the section described on page , which is exposed in one of the short ravines about half way between Fort Gage and Menard, bed No. 13, with an exposed thickness of 49 feet is the Menard limestone, and a portion at least of the talus covered slope below and perhaps also of that above, is doubtless underlain by the same formation. In the section described on page , exposed in a ravine about one and one-half miles above the prison at Menard, bed No. 6, 55 feet in thickness, represents the Menard, and from it the following species of fossils have been collected, all of them coming from the lower third of the formation.

W 210 W 627

Between Menard and Chester the formation outcrops in the upper portion of the bluff, an especially good exposure being present southeast of the hospital for criminal insane at Menard, the name of the formation being suggested by the excellent exposure at this point. In the ravine east of the City of Chester, the Menard limestone is well exposed, and has been quarried at one point for local use. The formation is exposed at frequent intervals in the river bluffs between Chester and the mouth of Marys river, above the talus slope and in the ravines which intersect the bluffs. About one-half mile above the mouth of Marys river, in the point of the bluff west of a short ravine, the limestone is exposed above a talus slope of about 100 feet, and the following species of fossils have been collected.

W 207

North of Chester there are extensive areas in the valleys of Gravel creek and its tributaries, which are underlain by the Menard limestone. The westernmost outcrops of the formation in

these valleys are in the s.e. 1/4, sec. 33, T. 6 S., R. 7 W., and at a point near the middle of the north line of sec. 16, T. 7 S., R. 7 W., both of these localities being less than one mile from the outcrops of the same formation in the heads of the short valleys to the west, which drain directly into the Mississippi river. In these forks and tributaries of Gravel creek some of the most extensive and most typical outcrops of the Menard limestone anywhere present in the whole region, are exposed. One of the most noteworthy of these exposures is in s.w. 1/4, sec. 35, T. 6 S., R. 7 W., where the north fork of Gravel creek has cut a channel with nearly vertical rock walls in the Menard limestone, for the distance of a quarter of a mile. Near the upper end of this rock gorge there are several feet of limestone which are more abundantly fossiliferous than any bed elsewhere observed in the Menard, and the following species have been identified.

Productus ovatus Hall.

Diaphragmus elegans (Norwood and Pratten)

Spirifer increbescens Hall.

Composita subquadrata (Hall.)

Eumetria sp.

Sulcatopinna sp.

Myalina augulata Meek and Worthen.

Schizodus chesterensis Meek and Worthen.

Aviculopecten sp.

Allorisma sinuata McChesney.

A. clavata McChesney.

Dentalium sp.

Bellerophon sp.

Euomphalus sp.

Naticopsis sp.

Comularia sp.

Orthoceras ? sp.

Cyrtoceras ? sp.

Vestinautilus ? sp.

Phillipsia sp.

Fish teeth

Other excellent exposures of the Menard limestone are present in s.w. 1/4, sec. 2, T. 7 S., R. 7 W., along the south fork of Gravel creek and its tributaries. In nearly every tributary of Gravel creek, from the junction of the two forks in sec. 1, T. 7 S., R. 7 W., to the mouth of Little Marks river, the Menard limestone is well exposed, and in many the outcrops are extensive. The formation may everywhere be recognized in this region, by its dense texture, its even bedding, and its blue-gray color.

In Tindall creek, a branch of Little Marys river with a course parallel with Gravel creek and a little over a mile to the north of it, the Menard limestone is exposed at numerous localities in the bed and banks of the stream, and in its tributaries, from the s.w. 1/4, sec. 25, T. 6 S., R. 7 W., to its mouth, although the exposures in the bed of the stream in the last mile of its course are wholly covered by alluvial deposits. The divide between Gravel and Tindall creeks is for the most part occupied by strata younger than the Menard limestone, but across a belt a little over one-half mile wide at its narrowest point, extending northeast from the n.e. 1/4, sec. 1, T. 7 S., R. 7 W., the Menard is the formation underlying the surficial drift deposits, the presence

of the limestone being indicated by the numerous sink-holes throughout the belt.

In the valleys of Little Marys river, and in Gravel creek below the junction of the two streams, the elevation of the upper surface of the Menard limestone is not much above the flood plane, but there are outcrops of the formation at a number of localities in the mouths of some of the short tributaries. Such outcrops indicate that the formation continues northward in the valley of Little Marys river, to a point in the s.w. 1/4, s.e. 1/4, sec. 21, T. 6 S., R. 6 W., and southward in Gravel creek nearly to its mouth.

The valley of Marys river, three miles below Chester, is filled with alluvium for a distance of three miles from its mouth, but the Menard limestone is exposed in the bank of the stream at a locality in the n.e. 1/4 of s.e. 1/4, sec. 22, T. 7 S., R. 6 W., and a quarter of a mile further up the stream there are exposures of the overlying Palestine sandstone. In the bed of the branch of Marys river from the northwest, rising in n.w. 1/4 of s.e. 1/4, sec. 13, T. 7 S., R. 7 W., in the northern portion of the city of Chester, the outcrops of Menard limestone are present in s.e. 1/4 of n.e. 1/4, sec. 18, T. 7 S., R. 6 W., and continue at intervals to a point within one-half mile of its mouth. Throughout this distance, however, the formation occupies only a narrow belt in the bottom of the valley extending a short distance up the valleys of the short tributaries, in many of which there are also good exposures of the limestone. The short branch of Marys river flowing southeast across the west half of sec 21, T. 7 S., R. 6 W., has numerous outcrops of the Menard limestone to a point in n.w. 1/4 of n.w. 1/4 of the section. The valley of Patten branch which has

several heads in the eastern part of Chester, is filled with alluvium through the last mile of its course, but above this towards the heads, the Menard limestone outcrops are abundant. In the north branch, the first outcrops of the summit of the formation occur near the middle of the south half of sec. 18, T. 7 S., R. 7 W.; in the middle branch they are in s.e. 1/4 of n.e. 1/4, sec. 19, and in the south branch in n.w. 1/4 of s.e. 1/4 of the same section 19, T. 7 S., R. 7 W. In the shorter tributaries also, both from the west and from the east there are a few outcrops, most of which are near the top of the formation, only a short distance below the contact with the Palestine sandstone.

Below the mouth of Marys river, to Rockwood, the Menard is the lowest exposed limestone in the Mississippi river bluffs, although for some distance below the mouth of this stream the uppermost Okaw beds may be present beneath the talus covering. The formation is exposed at a number of points in the north half of sec. 33, T. 7 S., R. 6 W., in the short valley which intersects the Mississippi bluffs a half mile below the mouth of Marys river. In the face of the bluff below the mouth of the valley last mentioned, the Menard limestone is exposed almost continuously, its upper surface dropping to a lower and lower elevation down stream. In the short ravine whose mouth is situated in s.e. 1/4 of n.w. 1/4, sec. 3, T. 8 S., R. 6 W., the elevation of the top of the Menard limestone is approximately 45 feet above the Iron Mountain railroad tracks. In another short ravine a little over one-half mile beyond the one last mentioned, in n.w. 1/4 of s.w. 1/4, sec. 2, T. 8 S., R. 6 W., the summit of the formation rises only about 16 feet above the same railroad track. In the first one of these

two ravines, a one foot shale bed, 35 feet beneath the top of the formation, contains a number of fossils, among which *Pentremites* is a common form, the entire fauna of the bed being as follows.

W 637

Thickness. In every section which has been examined, where the entire thickness of the Menard limestone is present, some portion of the formation has been covered with talus, so that the exact contacts with the subjacent and superjacent formations have been rarely observed. The thickness of the formation, therefore, has to be, in a measure, estimated, but these estimates can be made with a high degree of accuracy because of the numerous localities where the lower and upper boundaries of the formation can be approximately determined. Throughout the area underlain by the formation, the interval between outcrops of the Okaw formation and the Palestine sandstone, vary between 60 and 80 feet, and the assumption of 70 feet as the average thickness of the formation cannot be far from the truth.

PALESTINE SANDSTONE

In a paper entitled "Explanations of the Geological Map of Missouri, and a Section of its Rocks," published by Swallow in 1858¹ the sandstone exposed in the upper part of the Mississippi

¹

Proc. Amer. Ass. Adv. Sci., vol xi, pt. 2, p. 5.

river bluffs at Chester, was described as the "Chester Sandstone." The original description of the formation is as follows:- "65 feet of a heavy bedded, irregularly stratified, brownish sandstone. It is made up of round and angular pellucid particles, having the interstices filled with a fine, opaque, brown substance, which is often replaced by oxides of iron and manganese." This formation, as defined by Swallow, is clearly that sandstone which has been extensively quarried for building purposes in the environs of Chester, and which has furnished the material for the buildings of the Southern Illinois Penitentiary, at Menard. This application of the name Chester to this sandstone was the earliest usage of the name for a geological formation, and if the law of priority were strictly adhered to, the name would be restricted to this sandstone formation. The use of Chester group, however, has become so firmly fixed in our literature, that it seems unwise to drop it at this time, and consequently a new name has been proposed for the sandstone in question, from Palestine township in Randolph County, where it is well exposed.²

²

Weller, Trans. Ill. Acad. Sci., vol. 6, p. 128 (1914); also Ill. State Geol. Surv., Monog. 1, p. 29 (1914).

The Palestine sandstone is somewhat variable in its lithologic characters, being massive and thick-bedded in some places, where it has been used in a number of localities for a quarry stone. Elsewhere it is thin-bedded and ripplemarked, and locally it is somewhat shaly, and may be represented in part by argillaceous shales. Generally the sandstone is porous and not firmly cemented, but in some of the observed localities it has been very firmly cemented by calcium carbonate to form an arenaceous limestone, and in such localities the beds give forth a metallic ring when struck with a hammer. The rock is for the most part light yellow-brown in color, some beds are locally more ferruginous than usual, and the harder, metallic beds just mentioned, are commonly of a darker brown color. Locally the sandstone is conspicuously marked by dark brown specks, the sandstone is uniformly fine-grained, and nowhere has it been observed to be notably conglomeratic, although a few shale pebbles are included in it at some points, which may weather out and leave rounded cavities.

In those portions of the region which has been mapped, where the Pennsylvanian sandstones lie in contact with the Palestine, it is difficult to differentiate between the two formations in many localities especially where the hard rock formations are thickly drift covered, and where the outcrops are few. In general, however, the Pennsylvanian sandstones are much coarser grained and more ferruginous, and in some portions of the region the basal beds are conglomeratic. With these characteristics in mind it has been possible to draw the line between the two formations with a fair degree of certainty, although its position has been arbitrarily located in part. Where the superjacent Clere limestone of the

Chester group, is present, there is no difficulty in fixing the upper limit of the Palestine sandstone somewhat closely.

Areal distribution and description. The northernmost outcrops of the Palestine sandstone are about six miles southwest of Evansville, south of Nine-mile creek and east of Robinson creek. In the n.w. 1/4 of n.w. 1/4, sec. 1, T. 6 S., R. 7 W., the formation is represented by arenaceous shales and thin-bedded sandstones, lying nearly in contact with the Menard limestone in the bed of Nine-mile creek. These arenaceous beds are quite different in character from the basal portion of the Pennsylvanian, which is represented by a conglomerate bed at a distance of a little over one-half mile in the bed of a branch of Nine-mile creek, just south of the center of the same section. The formation is also exposed in a short valley tributary to Nine-mile creek from the south, in the n.e. 1/4, sec. 2, T. 6 S., R. 7 W., where the lithologic characters are similar to those in the first locality mentioned. It is quite possible that the formation may be present beneath the drift for some distance north of Nine-mile creek, but there are no outcrops of any sort to indicate whether the Palestine or the Pennsylvanian lies in contact with the Menard limestone in that direction.

From the localities mentioned above, the Palestine occupies a narrow belt extending southwestward towards the Mississippi river bluffs, but it is largely drift covered, which makes it difficult to determine its upper limit. There are exposures of arenaceous shales and sandstones in sec. 11, T. 6 S., R. 7 W., above the Menard limestone, in the two valleys tributary to Nine-mile creek, which are believed to belong to this formation. Other outcrops

occur in the upper portion of the valley of Robinson creek in s.w. 1/4 of s.w. 1/4, sec. 14, T. 6 S., R. 7 W., and in a tributary of the same creek from the southwest, in the eastern part of sec. 15. The last exposures in this direction are towards the head of Little Nine-mile creek, in s.e. 1/4, sec. 21, T. 6 S., R. 7 W.

South of the belt of Palestine sandstone just described, the Pennsylvanian sandstone overlap to the west and rest upon the Menard limestone without any intervening Palestine sandstone, the base of the Pennsylvanian being generally characterized in this portion of the area by conspicuous beds of conglomerate.

The area in which the Palestine sandstone is best developed lies northwest, north, northeast, and east of the city of Chester, throughout which region the formation outcrops around the heads of the ravines intersecting the Mississippi river bluffs, around the heads of Gravel and Tindall creeks and their tributaries, and in the sides of the valley of Little Marys river, and of Marys river and its tributaries. The divides between these streams and tributaries, except their very highest portions which are occupied by a younger formation, are covered by the Palestine sandstone except for a small area between Gravel and Tindall creeks.

In all the important tributaries of Morrison branch running southeast from the village of Palestine, especially in one from the northeast in the western part of sec. 29, T. 6 S., R. 6 W., and in two tributaries from the northwest in sec. 30. In the southernmost of the last two mentioned valleys, the sandstone is very massive and the beds are continuously exposed for a half mile or more, and in places are deeply undercut by the erosion of the stream. These massive sandstones suggest the Pennsylvanian, but

in the n.e. 1/4 of s.w. 1/4 of the section, there is an outcrop of shales which contains imperfect Chester fossils. In none of these tributaries of Morrison branch has the Clore limestone been observed, neither have any outcrops believed to be Pennsylvanian been noticed, so that the line separating the Palestine from the Pennsylvanian is somewhat arbitrarily placed, and the same may be said for its position all the way west to the headwaters of the north fork of Gravel creek.

In the valley of the tributary to Tindall creek flowing south through the east half of sec. 29, T. 6 S., R. 6 W., the Palestine sandstone is well exposed for a distance of over one-half mile, beginning at a point in the n.w. 1/4 of n.e. 1/4, of the section. Above this point the superficial Clore limestone is exposed, and below the sandstone outcrops, the Menard limestone. Along all the tributaries of Little Marys river, both from the east and the west, from the s.w. 1/4 of sec. 21, T. 6 S., R. 6 W., to its junction with Gravel creek, the Palestine sandstone is well exposed. In some of the tributaries the Menard limestone is exposed near their mouths, and in others the Clore limestone is present above the sandstone. Good exposures of the sandstone are present along the Chester-Sparta road east of Little Marys river, a mile and one-half southwest of Bremen. The valleys heading south and southwest of Bremen, tributary to Gravel creek are largely filled with glacial drift, but in all of them there are some outcrops of the Palestine sandstone.

In the area lying between Little Marys river on the east, Tindall creek on the north, and Gravel creek on the south, and extending west to within one-half mile of the line between ranges

6 and 7 west, the Palestine sandstone underlies an isolated area entirely surrounded by the Menard limestone. The sandstone is exposed in the upper portion of most of the short valleys leading from this upland to the streams mentioned, and in some of them outcrops are numerous.

In most of the branches and tributaries of Tindall creek west from the mouth of Morrison branch, the Palestine sandstone is exposed above the Menard limestone, although in some of the valleys the outcrops are few or even wanting altogether because of the deep covering of glacial drift. In the valleys of the branches and tributaries of Gravel creek, also, the Palestine sandstone is exposed in many places above the Menard limestone which is present in the beds of the streams throughout much of their extent. In some of these valleys the drift covers all outcrops, in others the hard rock outcrops are present at long intervals, but in a few the sandstone outcrops are well exposed. One of the good exposures of the Palestine sandstone in this region, is on the line between the n.w. 1/4 and the s.w. 1/4 of sec. 2, T. 7 S., R. 7 W., where the sandstone may be seen resting directly upon the Menard limestone, being the best exposure anywhere observed exhibiting the actual contact of the two formations.

Towards the head of one small tributary to Gravel creek from the south, in the n.w. 1/4 of s.w. 1/4, sec. 7, T. 7 S., R. 6 W., about one mile north of Chester, the Palestine sandstone is well exposed, and a quarry with a face of 15 to 20 feet has been opened to supply building stone in the city of Chester. From this quarry east for a distance of nearly four miles the formation is more or less well exposed in the several short tributaries to Gravel creek,

the contact line between the Palestine and the Menard formations being carried lower and lower in that direction, by reason of the eastward dip of the strata, until it lies nearly at the level of the flood plane of the creek.

In the Mississippi river bluffs the Palestine sandstone outcrops about half way between Fort Gage and Menard, in the heads of some of the small ravines. In the section described on page , bed No. 15 represents this formation, and from this point to Rockwood the sandstone is present, although in many places it is hidden by talus or loess deposits. North from the first outcrops mentioned above, for a distance of about three miles, to the Palestine sandstone belt southeast of Ellis Grove, the westward overlap of the Pennsylvanian covers the Palestine, and comes into contact with the Menard limestone.

In the section which has been described from one and one-half miles above Menard, on page , the Palestine sandstone is not exposed, the outcrop being hidden by the accumulations of drift and loess. The formation is poorly exposed near the heads of the ravines about three-fourths of a mile above Menard, and in the northern one of the two ravines at whose mouth the prison is located. In the head of the southern one of the two prison ravines, there are better outcrops of the sandstone, and it is here, just south of the cemetery, that the quarry was formerly situated from which the rock for the prison buildings was secured, although the quarry face is entirely hidden at the present time by the washing down of the loess. In the several heads of the north branch of the ravine just south of Chester, the Palestine sandstone is exposed to some extent, and in this locality there was found almost the

only fossil which has been observed in the formation, a fragment of a *Lepidodendron* stem. In the heads of most of the short ravines between Chester and the mouth of Marys river, the sandstone is exposed, but in some of them the outcrops are limited.

East of Chester the Palestine sandstone is exposed at many points in the upper portions of the valleys of the several branches of Marys river, and in their short tributaries, above the outcrops of Menard limestone which are commonly present towards their mouths. An especially good exhibition of the formation is in the road running down the hill east of the County Farm, a mile and one-half east of Chester.

South of Marys river the Palestine sandstone is exposed in the valleys of most of the tributaries of that stream, and it outcrops in the bed of the river itself in s.w. 1/4 of sec. 23, T. 7 S., R. 6 W., where the eastward dip of the strata has carried the Menard limestone beneath the surface. In the ravine whose mouth is situated in s.e. 1/4 of n.w. 1/4, sec. 3, T. 8 S., R. 6 W., the following section has been carefully measured, in which the Palestine sandstone is present.

13. Sandstone, coarse grained and ferruginous.

Pennsylvanian..... ? feet

Pennsylvanian-Clore contact.

12. Talus covered.....15 "

11. Limestone, thin-bedded..... 8 "

10. Limestone, crystalline, with many large Pen-
tremites..... 2 "

W 629

9. Shale..... 4 "

- 8. Limestone, thin-bedded, with Productus,
Composite, etc..... 1 foot
- 7. Limestone.....15 feet

Clore-Palestine contact.

- 6. Mostly talus covered, with some shale exposure..37 "
- 5. Sandstone, cross-bedded, marked by brown specks.13 "
- 4. Arenaceous shale.....10 "

Palestine-Menard contact.

- 3. Limestone, blue-gray in color, evenly bedded in
layers about one foot or less in thickness,
more or less talus covered.....34 "
- 2. Shale, fossiliferous..... 1 "

W 637

- 1. Limestone, exposed.....16 "

In this section the Palestine formation is more or less talus covered, but the interval of 60 feet occupied by beds Nos. 4, 5, and 6, arenaceous and shaly beds, is referable to the formation.

In the short ravine a little less than three-fourths of a mile below the last one, whose mouth is in n.w. 1/4 of s.w. 1/4, sec. 2, T. 8 S., R. 6 W., another section is exposed with the following succession of beds.

- 8. Sandstone, massive and ferruginous, Pennsylvanian.....78 feet
- 7. Talus covered slope.....18 "

Pennsylvanian-Clore contact.

- 6. Limestone, blue-gray or dark in color.....31 "

Clore-Palestine contact.

- 5. Talus covered for the most part, with some shale

exposures above and sandstone layers in the lower portion. The lower portion of the shale is argillaceous, becoming more arenaceous above.....43 feet

Marked by brown specks, some beds ripple-marked, and some with shale pebbles..... 8 "

3. Talus covered..... 8 "

Palestine-Menard contact.

- 2. Limestone, blue-gray in color, typical Menard... 7 "
- 1. Talus covered to level of road..... 9 "

In both the sections just described the Palestine formation is represented more largely by shales than is commonly the case farther north, and the rather coarsely speckled character of the sandstone is much more noticeable than in any other place where the formation has been studied.

Sub-Palestine Unconformity. It has not been possible to determine with entire satisfaction whether the Palestine sandstone rests conformably or not upon the Menard limestone. The exact contact between the two formations has been only rarely observed, and in only one locality can it be said to be satisfactorily exhibited. This locality is in the bed of a branch of Gravel Creek, near the middle of the north line of s.w. 1/4, sec. 2, T. 7 S., R. 7 W., about three miles northwest of Chester. At this locality the line of contact is entirely without transitional beds of any sort, the change from the limestone to the sandstone being abrupt, a condition which suggests the initiation of a new period of sedimentation subsequent to an earlier withdrawal of the sea. The suggestion of unconformable relations between the two formations is further

indicated by the somewhat greater elevation of the upper surface of the Menard limestone at the exposures in another branch of Gravel creek less than one thousand feet distant in a southerly direction from the locality exhibiting the actual contact. This difference in elevation is greater than can be accounted for by the normal dip of the strata, and suggests an uneven surface of the Menard limestone preceeding the period of deposition of the Palestine sandstone. The evidence presented by this single locality is altogether too inadequate to satisfactorily establish the fact that the contact between the two formations is an unconformable one, but it does lend a suggestion to that effect.

Thickness. In the two Mississippi river bluff sections, about two and one-half miles or thereabouts below the mouth of Marys river, which have been described on pages , and , the entire thickness of the Palestine formation is present, although it is more or less covered by talus and by other material which has been washed down the ravines in which the sections occur. In these sections which must be occupied by the formation are respectively 60 and 67 feet. This interval corresponds quite closely with the observed difference in elevation between outcrops of Menard and Clore limestones, wherever the two formations have been observed in the same section, though some of these intervals are somewhat greater, perhaps being as much as 80 feet. Taken altogether the observations seem to be such as to warrant an estimate of 70 feet for the average thickness of the Palestine formation.

CLORE LIMESTONE

The youngest formation of the Chester group in Randolph County is the Clore limestone.¹ The actual outcrops of the formation

¹Weller, Trans. Ill. Acad. Sci., vol. 6, p. 129 (1914); also Ill. State Geol. Surv., Monog. I, p. 29 (1914).

are commonly limestones which exhibit considerable variety in their lithologic characters, some beds being similar in texture and bedding to the usual phase of the Menard limestone, other beds are similar to that formation but are darker, sometimes almost black, in color and still others are shaly in character, breaking up on weathering into thin, splintery, or plate-like, brittle fragments. Associated with the limestones there are some argillaceous and calcareous shale beds, usually gray or bluish in color, and in the lower part of the formation some of the beds are arenaceous, the transition from the underlying Palestine sandstone being gradual, indicating the absence of any unconformable relations between the two formations. The limestones of the formation are not infrequently fossiliferous.

A persistent member near the summit of the formation, especially in the region northwest of Bremen, is a finely laminated and banded, fine-grained sandstone, only a few feet thick. This bed is not fossiliferous, and no fossils have been observed in any higher member of the formation, and it was for a time believed to belong in the basal portion of the Pennsylvanian, but at one locality in n.w. 1/4 of n.e. 1/4, sec. 22, T. 6 S., R. 6 W., two miles north of Bremen, masses of this bed are included in the basal conglomerate

of the Pennsylvanian, which shows it to be a part of the Chester formation.

At a number of localities in the area which has been mapped, fine springs issue from the Clore formation. There are, indeed, a far greater number of large springs in this formation, relative to its areal extent, than in any other of the Chester formations, and a peculiar circumstance connected with some of these springs is, that they issue from the formation at points where it caps the higher elevations of the region.

Areal distribution and description. The best exhibition of the Clore limestone within the area studied, is in the valley of Little Marys river northwest of Bremen. In the s.w. 1/4 of sec. 15, and s.e. 1/4 of sec. 16, the formation is well exposed at a number of points in the bed of Little Marys river and in one of its branches from the northwest, as well as in some of the short tributaries to these streams. The outcrops are limestones, shales, and the banded sandstone member at the summit of the formation. The overlying formation is Pennsylvanian sandstone, the basal beds of which are generally conglomeratic in this region.

South of the localities just mentioned, in the n.e. 1/4, sec. 21, and n.w. 1/4, sec. 22, T. 6 S., R. 6 W., the Clore limestone occupies a belt with a maximum width of nearly one mile, upon both sides of Little Marys river, but from a point in the s.e. 1/4 of sec. 21 the Palestine sandstone, and further south the Menard limestone, occupies the bed of the stream, and the Clore limestone outcrops continue southward along two narrow, sinuous belts, one on each side of the valley of Little Marys river. In the area above mentioned, where the Clore limestone exhibits its greatest extent,

on both sides of Little Marys river, the topographic surface is marked by numerous sink holes, a number of which are indicated on the map. In this area also, in a short tributary from the one of the largest springs of the area studied, issues from a small cavern in this limestone.

In the narrow belt of outcrops east of Little Marys river, exposures of the Clore limestone are present in the heads of most of the short tributaries to that stream, and in some of them the Palestine sandstone is well exposed below and the Pennsylvanian above the limestone. South of Bremen this belt of outcrops continues about the heads of the tributaries to Gravel creek flowing south, and at one point a half mile southwest of Bremen, the following species of fossils were collected from a small outcrop.

Diaphragmus fasciculatus (McChesney.)

Spirifer increbescens Hall.

Reticularia setigera (Hall.)

Composita subquadrata (Hall.)

The belt of outcrops west of Little Marys river is similar to that on the east side, being a sinuous band around the heads of the short tributaries. Fewer outcrops have been observed here, however, than on the east side, because of the thick drift covering, the last outcrop being in the n.w. 1/4 of n.e. 1/4, sec. 29, T. 6 S., R. 6 W., in the bed of a tributary to Tindall creek. Beyond this point the overlapping Pennsylvanian probably cuts out the Clore limestone in a short distance, the younger formation coming to lie in contact with the Palestine sandstone.

In the south half of s.w. 1/4, sec. 13, T. 6 S., R. 7 W., in the bed of one of the long tributaries of Nine-mile creek, there

are a number of outcrops of limestone which belong to a formation beneath the Pennsylvanian sandstone, and as the outcrop lies to the east of the bely of Palestine sandstone east of Robbinson creek, it is doubtless a part of the Clore limestone. The entire area of this outcrop is not over one-fourth mile in length, it is present in two small forks of the stream to the south, and extends for a short distance southward down the valley below their junction.

Between Tindall and Gravel creeks the Clore limestone underlies an area a little more than one-fourth mile in length and breadth, in the southern part of sec. 32, T. 6 S., R. 6 W., and the northern part of sec. 5, T. 7 S., R. 6 W. There are no really good outcrops of the formation in situ in this locality, but in the valley on the south of the area there are masses of limestone having the characteristics of the Clore as it occurs elsewhere, lying upon the hillside, but not in place. These limestone blocks have not been moved far, and appear to be the slumped masses of a harder bed which overlies a shale. The Palestine sandstone is exposed lower down in the same valley, and there can be no doubt as to the identification of the limestone as a part of the Clore.

South of Gravel creek, between that stream and Marys river, the Clore limestone underlies a number of isolated areas of irregular outline, upon the higher parts of the divides between the stream valleys. Eastward the elevation of the formation is reduced because of the eastwardly dip of the strata, and beyond the limits of the area which has been mapped, in the valley of Marys river, the formation must come down to the level of the flood plane of that stream, and pass beneath it as the older formations do. The largest and most irregular of these areas occupies the elevated region where the city

of Chester is situated. Most of the city on the hill is underlain by the Clore limestone. The thick Pleistocene deposits, drift and loess, cover most of the outcrops, but the formation is exposed in the heads of a number of the ravines which originate in the confines of the city. One of the best of these exposures is in the head of a ravine in s.e. 1/4 of n.e. 1/4, sec. 24, T. 7 S., R. 7 W., just below the ridge road leading southeast from the city. This outcrop is in the edge of the town and has been quarried to some extent for local use. Further southeast along this same road the limestone and shale of the Clore formation are exposed near the middle of the south line of the s.w. 1/4 of sec. 19, T. 7 S., R. 6 W., near the head of the ravine which intersects the Mississippi river bluffs at Cole's Mills. On the opposite side of the ridge along whose southwestern side the two outcrops mentioned occur, there are no exposures in the heads of the more southern of the tributaries of Patten branch, although the formation must be present beneath the covering of mantle rock. Towards Chester, however, in the head of the tributary to Patten branch directly opposite the first of the two outcrops mentioned above, there are limestone exposures which must belong to this formation. In the head of the main valley of Patten branch, in s.w. 1/4 of s.w. 1/4, sec. 18, T. 7 S., R. 6 W., the limestone is poorly exposed, but the formation is better represented by outcrops of shales and limestones a half mile to the southwest, in the head of the ravine directly opposite, leading into the Mississippi river. Further north in this Chester area the outcrop of the Clore limestone is almost entirely obscured by the drift and loess, but at one point in the extreme northern part of the area, in the n.e. 1/4 of s.e. 1/4, sec. 12, T. 7 S., R. 7 W.,

there is a good exposure from which issues a fine spring.

Farther east, between Gravel creek and a tributary of Marys river, the Clore formation occupies an irregular area situated largely in sections 9, 8, 16, and 15, T. 7 S., R. 6 W. Along the northern border of this area the limestones outcrop in the heads of two of the short ravines tributary to Gravel creek, in n.w. 1/4 of sec. 9. Other exposures are present upon the southern border of the area, in n.e. 1/4 of sec. 16 and in the west 1/2 of sec. 15, in the heads of some of the short ravine tributaries to the branch of Marys river, and in these localities several excellent springs issue from the formation. In n.w. 1/4 of s.w. 1/4, sec. 15, T. 7 S., R. 6 W., the following succession of beds in the Clore formation are well exposed.

9. Limestone, massive, resembling the Menard in lithologic character, the ledges slumped down on the underlying shale..... 5 feet
8. Shales, mostly talus covered.....10 "
7. Limestone ledge, shaly cleavage, fossiliferous.. 2 "
6. Shales, argillaceous, gray in color.....15 "
5. Limestone, thin-bedded, dense and compact, with shaly cleavage, becoming more shaly below..... 5 "
4. Shales, somewhat calcareous, gray in color, with a thin, calcareous Bryozoan ledge near the middle..12 "
3. Limestone, impure, argillaceous, fossiliferous.. 1 "

Stenopora sp.

Fenestella tenax Ulrich

Archimedes sp.

Polypora sp.

Septopera subquadrans Ulrich ?

Rhombopera sp.

Strebletrypa nicklesi Ulrich

Orthotetes kaskaskiensis (McChesney.)

Productus ovatus Hall.

Spirifer increbescens Hall.

Eumetria costata (Hall.)

Composita trinuclea (Hall.)

2. Shale, dark, bluish, argillaceous..... 5 feet

1. Shale, arenaceous, with thin beds of sandstone..20 "

Near the middle of the north line of n.e. 1/4, sec. 22, T. 7 S., R. 6 W., in the upper part of a short tributary to Marys river, the Clore limestone is exposed with the Palestine sandstone below. At this locality the Clore formation does not constitute the capping of the hill in which the outcrop occurs, there being sandstone ledges at a higher elevation which must be basal Pennsylvanian. The Clore must form a narrow band completely around the hill at this locality, although its outcrop is covered by the drift at all points except on the south side.

In the public highway in s.w. 1/4 of n.e. 1/4, sec. 21, T. 7 S., R. 6 W., there is a small limestone outcrop, and another in the head of a short ravine a few rods to the west in the same quarter-section. These outcrops occupy a higher stratigraphic position than numerous Palestine sandstone exposures which are present on the south, west, and north sides of the hill which occupies the larger part of this quarter-section, and undoubtedly represents the Clore limestone, and the entire hill is doubtless capped by the formation although the drift covering obscures all save the

two outcrops mentioned, so far as observations have been carried.

The long ridge extending southeast from the County Farm, east of Chester, to Clore school near the extreme southeastern corner of sec. 20, T. 7 S., R. 6 W., is capped throughout its entire length by the Clore limestone. Outcrops of the formation are present in the heads of most of the short ravines on the southwest slope, which are tributary to Patten branch. The northeast slope of the ridge is more thickly drift covered, and no outcrops of the Clore have been observed, although some may have been overlooked.

South of Marys river the Clore formation is exposed in the Mississippi river bluffs in sections 3 and 2, T. 8 S., R. 6 W., where it occupies a position immediately beneath the Pennsylvanian sandstone, and its lithologic character in this portion of the area studied is shown in the two sections which have been described on pages , and .

From loose blocks of Clore limestone in the ravine in s.e. 1/4 of n.w. 1/4, sec. 2, T. 8 S., R. 6 W., the following species of fossils have been collected.

Zaphrentis sp.

Z. chesterensis Worthen ?

Fenestella tenax Ulrich

Productus ovatus Hall.

P. inflatus McChesney.

P. sp.

Diaphragmus elegans (Norwood and Pratten)

Camarophoria explanata (McChesney.)

Girtyella brevilebata (Swallow.)

Spiriferina spinosa (Norwood and Pratten.)

Eumetria vera (Hall.) ?

Composita sp.

In the section exposed in the ravine whose mouth is in s.e. 1/4 of n.e. 1/4, sec. 3, T. 8 S., R. 6 W., bed No. 10 of the section is characterized by the presence of many individuals of a very large species of Pentremites, the entire list of species being as follows:

W 629

From loose slabs in this same ravine, probably coming from just above the Pentremites bed, when in place, the following fauna has been collected.

W 630

The formation is present in the upper portion of the valley leading to the northwest across sections 33 and 34, T. 7 S., R. 6 W. The hard rocks are obscured throughout the greater extent of the valley by the surficial deposits, although the Pennsylvanian sandstone is well exposed near the heads of the several forks of the valley. In the main or southern fork and its branches there are no hard rock exposures of any sort beneath the Pennsylvanian sandstone, but in the middle one of the three main branches of the northern fork, the Clore limestone is poorly exposed, and a little farther down the valley there is a shale bank with some limestone layers above, which may be referred to the formation. A little east of the series of outcrops in the valley just described and in the Mississippi river bluffs, the Pennsylvanian sandstones seem to overlap the Clore limestone, and rest upon the underlying Palestine sandstone, this apparently being the condition in sections 28 and 33, T. 7 S., R. 6 W. This overlapping of the

Pennsylvanian has not been established beyond question because of the thick talus covering which has obscured the rock outcrops to a great extent.

Thickness. In the two sections exposed in the Mississippi river bluffs about two and one-half miles below the mouth of Marys river, described on pages , and , the possible intervals which may be occupied by the Clore limestone are 31 and 45 feet. In the larger of these intervals there is included a number of feet of talus covered slope which in all probability is underlain by the basal portion of the superjacent Pennsylvanian sandstone, so that the actual thickness of the Clore limestone in the two sections is probably essentially the same, about 30 feet or a little more.

In a measured section through the formation in sec. 15, T. 7 S., R. 6 W., described on page , the total thickness of beds above the sandstone at the base, which may be considered as the upper portion of the Palestine formation, is 55 feet. In much of the area where the formation is present it is the highest hard rock stratum, and being largely hidden by the surficial deposits, its thickness cannot be determined. In the region adjacent to Bremen, however, the Clore formation is capped by the Pennsylvanian sandstones, and at a number of points the interval between the Palestine sandstone below and the Pennsylvanian above, can be estimated with some certainty, which establishes approximately the thickness of the Clore at those points. At some of these localities the thickness of the formation is thus estimated to be between 20 and 40 feet, and elsewhere it is 60 or more feet. These observed differences in thickness vary altogether from a minimum of perhaps 20 feet or even less, to a maximum of 60 or more feet, and are to be accounted

for, not by any great variation in the original sedimentary deposits, but by reason of the great pre-Pennsylvanian unconformity at the summit of the Chester group. Could the formation to the east where it passes entirely beneath the Pennsylvanian, thickness might be found to become much greater than in any of the observed outcrops, and still younger Chester formations might be present between it and the Pennsylvanian, which are now completely hidden from view.