Geology of Ste. Genevieve County, Missouri

By
STUART WELLER *and* STUART ST. CLAIR

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H. A. BUEHLER, *Director and State Geologist*

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LETTER OF TRANSMITTAL

Bureau of Geology and Mines,
Rolla, Mo., July 6th, 1928.

To the President, Governor Sam A. Baker, and the Members of Board of Managers of the Bureau of Geology and Mines:

Gentlemen: It is my pleasure to transmit herewith a report covering the geology of Ste. Genevieve County by Stuart Weller and Stuart St. Clair.

It is the first report of the Survey treating the stratigraphy of the region bordering Mississippi River south of St. Louis, and as the area includes a wide range of formations the volume is an important contribution to our knowledge of the geology of that region.

The map accompanying this report includes parts of Perry and St. Francois counties, and the descriptions given in the body of the text apply equally well to the entire area covered by the map.

Respectfully submitted,
H. A. BUEHLER,
State Geologist.

INTRODUCTION

Ste. Genevieve County has exposed within its borders a greater stratigraphic succession than any other county in the state, and is traversed from northwest to southeast by one of the most pronounced belts of faulting in the upper Mississippi Valley. It is therefore both stratigraphically and structurally a most important area for study, and correlations made in this county may be considered a key to the succession throughout that portion of the Ozark region bordering Mississippi River.

Within the area there are a number of formations that do not outcrop at any other point in the state, and until this work was undertaken the occurrence of these formations was virtually unknown. The mapping indicated the presence of an excellent marble which has since been developed by large quarry operations.

As shown on the topographic map there is a large area in which surface drainage is lacking due to numerous surface sinks. This area is one of the most typical sink hole regions in the Mississippi Valley.

Due to the fact that there is such a complete succession of the Paleozoic series, considerable attention has been devoted to correlation and to the geologic history.

Field work was started in cooperation with the United States Geological Survey during the summer of 1913. The present report is chiefly the result of work carried on by Stuart Weller and Stuart St. Clair. That portion of the report and map covered by formations younger than the St. Peter is the result of work by Mr. Weller and assistants, while that portion covered by the St. Peter and older series is the result of the work of Mr. St. Clair.

Field work on the upper series was started during the summer of 1913 by Mr. M. G. Mehl, who mapped a portion of the Weingarten quadrangle under the direction of Mr. Weller. During the summer of 1914 Mr. Weller, M. G. Mehl, R. W. Chaney, and V. O. Tansey extended the mapping started in 1913, and during September, Mr. Weller and students of the University of Chicago studied the faulted area. Mr. F. M.

VanTuyl spent one month in making sections of the Mississippian formations.

During 1916 and 1919, Mr. Weller and students made additional studies of the faulted area along Saline Creek.

Stuart St. Clair devoted continuous time to mapping the older formations, which occupy more than half of the county, during 1914 and part of the field season of 1915. He was assisted in the mapping for short periods by H. M. Scott and G. A. Muilenburg, and in the St. Francois County mapping by F. C. Greene.

Mr. E. W. Shaw of the United States Geological Survey made a brief study of the surficial deposits and contributed the discussion covering the Pleistocene and recent formations. During 1925 and 1926, Mr. Frank Leverett made more detailed studies of the Pleistocene throughout Southeast Missouri and has added his observations covering the former course of Mississippi River.

Special acknowledgment is due E. O. Ulrich of the National Museum for visits to the area of older formations with Stuart St. Clair, and for much study and cooperative field work covering the older formations of Southeast Missouri. His paleontologic and stratigraphic studies have been exceedingly helpful in separating the various formations. The fossil lists covering the formations below the St. Peter were furnished by him.

Each of the authors made observations on economic conditions covering the various formations. Mr. W. F. Pond and Mr. H. S. McQueen devoted considerable time to completing the chapter on economic geology.

H. A. BUEHLER.

CHAPTER I

LOCATION and AREA

Ste. Genevieve County is situated in the southeastern part of Missouri, being one of the Mississippi River counties. Its northernmost point is about 35 miles south of St. Louis, and the county extends for a little more than 25 miles along the river. The county is irregular in outline, with a maximum length in a north-south direction of somewhat more than 30 miles, and a width in an east-west direction of a little less than 30 miles. The total areal extent of the county is 481 square miles.

In general the boundaries of the county lie in directions oblique to the cardinal points of the compass. It is bounded as shown in Fig. 1, on the northeast by Mississippi River, on the southeast by Perry County, on the southwest by St. Francois County, and on the northwest by St. Francois and Jefferson counties.

Fig. 1. Location of Ste. Genevieve County.

HISTORY

The history of the settlement and development of Ste. Genevieve County is of notable interest, for it was here that the first civilized community was established in Missouri, and the residents of this settlement passed under three governments before the vast territory of Louisiana finally came under the United States flag.

The first Europeans to visit what is now Missouri were with the expedition of Hernando DeSota, the Spanish explorer. After landing in Florida these adventurers marched over-land through the unbroken forest, and on April 25th, 1541, they reached the bank of the Mississippi a few miles south of where the city of Memphis now stands. After crossing the Mississippi the party extended their explorations northward along the west bank of the river, into the region now known as New Madrid, in the southeastern part of Missouri. The next white men to visit this region were Marquette and Joliet. These travelers started from Canada on a journey of exploration and reached the upper Mississippi on the 17th of June, 1673. They journeyed southward by canoe past the present site of Ste. Genevieve as far as Arkansas River, and returned the same year to Canada. The next exploration party, under the leadership of LaSalle, also came by way of Canada, and descended the Mississippi to its mouth in the year 1682.

In 1712 the French crown conveyed by charter the colony of Louisiana to Anthony Cruzat who sent M. de la Motte as its first governor. Governor de la Motte explored a large part of the territory adjacent to the Mississippi in search of gold and silver, and he is supposed to have discovered the lead mine in St. Francois County which now bears his name. In 1720 Renault established himself at Fort Chartres, about 10 miles above the present site of Ste. Genevieve, near Prairie du Rocher, Illinois, on the east bank of the river, and sent prospecting parties through Ste. Genevieve County and neighboring areas, in search of the precious metals. The extensive explorations of these parties is evinced by the numerous old diggings which can be found over much of the county today. No gold or silver was found, but some lead was mined and conveyed on pack horses from the interior to Fort Chartres, and was from there shipped down the river to New Orleans and France.

With all of these operations no permanent settlements were made either at the mining camps or at any other localities on the west bank of the Mississippi until about 1735, the year generally accepted as being the time when the old village of Ste. Genevieve was founded. The site of "le vieux village de Sainte Genevieve" was three miles south of the present town, in what is known as the "Big Field." The population of Ste. Genevieve was greatly increased when the territory of Illinois east of the Mississippi, was transferred from France to England in 1765. Many of the inhabitants of the towns on the east bank, not desiring to come under the English government, emigrated to Ste. Genevieve and St. Louis, the latter town having been founded by Laclede in 1764. Prior to this time the civil business of Ste. Genevieve had been transacted at Kaskaskia, which was the metropolis of the west at this time, but when Kaskaskia passed to the English, a post was established at Ste. Genevieve in May, 1766, and Rocheblave was installed as the first commandant. The first legal proceedings on record occurred on May 19th, 1766. Near the close of 1769 the Spanish government assumed possession of upper Louisiana.

In 1785 a great flood inundated the Mississippi Valley, doing great damage to the towns which were situated in the fertile bottom lands, and destroyed many farms and their years' products. During this flood the river is said to have extended from bluff to bluff, and the year 1785 has always been spoken of as "l'année des grandes eaux." The old village of Ste. Genevieve suffered along with the rest of the river settlements, and after this disaster the village site was moved to its present location on higher ground. Some of the inhabitants of Kaskaskia, Illinois, also moved to the new town of Ste. Genevieve. When the town was established at its present site, the population was about 800; in 1799 the Spanish census showed 945; in 1804, when the United States purchased the Louisiana territory, there were 1,300 people, about one-third of them being slaves.

During the latter part of the 18th century and early in the 19th, Ste. Genevieve was a very important commercial town. Commerce was carried on by keel-boat transportation on the Mississippi and Ohio rivers, and much trading was done with the Indians of the interior parts of the territory. During these years all of the lead, copper, nickel, cobalt, and iron ore from Iron Mountain, Pilot Knob, Mine La Motte, Valles Mines, and

Potosi were brought on pack horses to Ste. Genevieve to be carried forward by river transportation.

In 1789 the post of New Bourbon was founded at a point about two miles south of Ste. Genevieve by members of the French aristocracy, large numbers of whom had been forced to flee from France during the Revolution of that year, but this little village ceased to exist many years ago.

In the year 1800 Louisiana was ceded back to France by Spain, but this act was not consummated until December 20th, 1803. In the meantime President Jefferson had been negotiating with France for the purchase of Louisiana by the United States. The transfer to our government was made by France in December, 1803, the purchase price being $15,000,000.

Few Americans resided in Ste. Genevieve up to 1804. The town was distinctively French in language, customs, and domestic economy, and at this time the population was concentrated at the villages of Ste. Genevieve and New Bourbon, but after the transfer of the territory to the United States, and upon the arrival of American settlers, it became more distributed. The inhabitants were engaged chiefly in cultivating the soil, as traders and as voyagers.

Cn June 4th, 1812, Missouri was organized by Congress into a Territory with a governor and General Assembly, and the districts were reorganized into five counties of which Ste. Genevieve was one. The first General Assembly was held in St. Louis on December 7th, 1812, the Ste. Genevieve representatives being George Bullet, Richard S. Thomas, and Issac McGready. For the council the President of the United States chose John Scott and James Maxwell from Ste. Genevieve. A few years later, in 1817, steam power was introduced on the Mississippi, and on August 1st of that year the steamer Pike tied up at Ste. Genevieve, which at that time was on the river bank. Missouri was admitted to statehood on August 10th, 1821.

The famous Plank Road was built in 1851 along the route of the present Ste. Genevieve-Farmington county road passing through New Offenburg and Weingarten. It extended from Ste. Genevieve to Iron Mountain, a distance of 42 miles, and an immense business was carried on over it for several years. A large part of the ore from the mines to the west, marble and granite from the quarries, and agricultural products of all kinds were hauled to Ste. Genevieve for shipment. This was the chief outlet for these products until the Iron Mountain railroad was built in 1857, when this new means of transportation diverted to St. Louis much of the trade which had formerly gone to Ste. Genevieve.

About thirty years ago Ste. Genevieve County had a boom in railroad building which has been an important factor in the economic development of the county. The most important line, running along the Mississippi River through Ste. Genevieve and St. Marys, the two largest towns in the county, is operated by the St. Louis and San Francisco Railway between St. Louis and southern points. The Illinois Southern, now the Missouri-Illinois Railroad, built in 1901, crossing almost the center of the county from east to west, opens up a large agricultural country, and connects with the mining districts of St. Francois County. In the southern part of the county the Cape Girardeau and Northern was built. This road ran east and west and connected with a branch to the south in Perry County. It has been abandoned.

During the time when Ste. Genevieve was the important commercial and trading post on the west bank of the Mississippi, the river flowed directly past the town and boats could moor at the foot of its streets. Today there is an island between the town and the main channel of the river, and the present boat landing for Ste. Genevieve is at Little Rock, about two miles north of the town, where the Missouri-Illinois trains are ferried across the river to Illinois. A similar fate has befallen the town of St. Marys. Cnly a few years ago the river boats docked at the town, but now the channel is several miles to the east, the earlier channel being represented only by a small slough, and even this is rapidly filling up. The old town of Kaskaskia, the capitol of Illinois during the days of early settlement of the Mississippi Valley, and which was at that time on the east bank of the river, is today entirely separated from its parent state by the main channel of the Mississippi, and may soon be completely connected with the Missouri mainland unless the river returns to its former channel.

The earliest mining operations in Missouri were carried on in Ste. Genevieve County by La Motte, Renault and others, although only small returns were realized from these ventures. At this time Ste. Genevieve County is not a mining community, but some local development along these lines has proved at least partially successful. Work was begun about 1848 at the Avon lead mine and was continued intermittently until about 1874. Dressing works and several furnaces were erected and preparations were made for extended work, but nothing has been done during recent years. The first recorded discovery of copper in the county was in 1863, when Simon Grass found outcropping ledges of this ore on the Grass side of what is now the Cornwall Copper Mining Company's property. In 1876 work was begun on the Chicago side of the property and operations by various parties have been carried on intermittently up to 1913, at which time new equipment was added and a small ore road was built connecting with the Missouri-Illinois railroad at a point west of Zell Station. At the time this report is being written the mines are idle, and it is reported that the property has again changed hands. The Swansea and Herzog mines were opened in 1876 and 1879 respectively. Work has been carried on at these two properties at irregular intervals, the last work being done in the Autumn of 1914.

Limestone quarries have been opened in a number of localities in the eastern part of the county, much of the stone being used in the manufacture of a high grade white lime, although some blocks have been shipped for building purposes. Rock taken from the government quarry at Little Rock has been used extensively for riprap work along the Mississippi. At a point about four miles south of Ste. Genevieve the Aux Vases sandstone has been quarried and shipped, a large amount of rock from this quarry being used in the construction of the Eads Bridge at St. Louis. In 1921 a marble quarry was opened on Little Saline Creek near Ozora, in the Devonian limestone, and in 1922 a marble quarry in the Kimmswick limestone was opened four miles southwest of Ste. Genevieve.

The population of Ste. Genevieve County is made up of English, German and French speaking people. The German population lives in communities or parishes, Ste. Genevieve being the largest. Other typical German settlements are Weingarten, New Offenburg, Zell, St. Marys, and River aux Vases, the last better known as Staabtown. In these communities religious and educational activities center about the churches. The southern, western, and northern parts of the county are typically American. The French are more scattered, although a number of families live in Bloomsdale and vicinity.

This brief sketch of the history of Ste. Genevieve County would not be complete without mention of the archeological investigations which have been carried on in recent years by the Smithsonian Institution.[1] Detailed examinations have been made near the mouth of Saline Creek and interesting evidence collected which gives some light on the people who lived in this locality before the advent of the white men. Some of the customs of these people, and some idea of their implements, pottery, and other articles, both useful and ornamental, have been made known. Excavations at Salt Spring near the mouth of Saline Creek, have revealed vast quantities of wood ashes and charred wood, and fragments of pottery. Most of these are relics of the Indian process of evaporating the water of the Salt Spring to recover the salt. Scattered over the surface of the sloping land on the left bank of the creek, above the spring, many fragments of small pottery vessels, some bearing traces of red pigment and others being pieces of thin, black ware of superior quality, together with numerous stone implements, have been found. All signs point to this having been a favorite abode of the Indians at some former time.

The peninsula between the Saline and the Mississippi was the site of a comparatively large settlement, and excavations have revealed many fragments of pottery, animal bones, shells, several kinds of implements, and chips of white and pink flint. A single mound stands near the center of this village site. It is about 90 feet in diameter with a height less than four feet, and an excavation near its center revealed three skeletons, a number of Indian ornaments, and war and other implements. Stone graves in large numbers have existed in the vicinity of the Saline, and nearly every elevated point appears to have been occupied by a group of them. However, in only a few places have they been found intact, for most of them have been at least partially destroyed by the plow or by other human agencies. In some of the graves parts of skeletons and more frequently pieces of pottery have been found.

A number of other sites in the eastern part of Ste. Genevieve County were probably occupied by Indian villages, the most prominent of which is at the rock cut, about three miles above the mouth of Saline Creek, on the north bank of River aux Vases near its mouth, and on the nearby hills and bluffs stone graves have been found. Along the Mississippi River bluffs there are many groups of stone graves and low mounds, the most important

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[1]Proc. U. S. Nat. Mus., vol. 46, pp. 641-668.

group of mounds being located a few miles south of the town of Ste. Genevieve in the "Big Field." In a small cave a short distance from the left bank of the Saline, about one-half mile southwest of the Salt Spring, a number of interesting petroglyphs, thirteen in number, are preserved, which were carved by the Indians on the floor of the cave.

An iron meteorite from Ste. Genevieve County has recently been added to the museum of the Bureau of Geology and Mines. The specimen was found in 1906 by Joseph Naeger on his farm in the north central part of sec. 3, T. 37 N., R. 6 E., three miles southwest of Lawrenceton. A corner of the meteorite was uncovered in plowing and it was subsequently dug up. The specimen weighs $171^1/_8$ pounds and is roughly the shape of a triangular prism. In general the surface has characteristic smooth polished scallops, but part of the surface is rough and jagged. No information regarding the date of the fall of the meteorite is available.

CLIMATE

The climate of Ste. Genevieve County is temperate and wholly continental. The summers are hot and the winters not severe. The air is dry as a rule, and the excessive temperatures in summer and in winter are not felt to the extent that they would be were the atmosphere heavy and damp. The annual mean temperature is probably near 55°. The average rainfall of the county is 42 inches, and the full amount is well distributed over the year. The greater amount commonly falls during the growing season, although there are exceptions to this rule, and occasional droughts occur, but they are not more frequent than in other parts of the Middle Western States. With favorable temperature conditions and ample rainfall, as a rule, the growing season is long enough to mature all ordinary crops grown in the central part of the United States.

CULTURE

The principal town and the county seat is Ste. Genevieve, with a population of about 2,000. Two railroads run through this town, the St. Louis and San Francisco, commonly called the "Frisco," connecting St. Louis with the south, and the Missouri-Illinois, extending westward to the mining district in St. Francois County. River steamers dock at Little Rock, two miles above the town.

St. Marys in the eastern corner is located on the bluffs and on the bottom lands of the Mississippi, on the line of the "Frisco" railroad about ten miles below Ste. Genevieve. This town was formerly situated on the bank of Mississippi River, but owing to changes in its channel the river now flows east of Kaskaskia Island about five miles east of St. Marys.

Bloomsdale is the largest village in the interior, its nearest railroad station being Brickeys on the "Frisco." The remaining villages are small, several of which are located on the railroads which cross the county.

The chief industry is agriculture. Over that part of the hilly country where the soil is tillable, as well as along the bottoms of the large and smaller streams, farmhouses dot the slopes. Some timbering is carried on, and tie making is an occupation which attracts a certain class of the inhabitants of the county. Grazing on a small scale is cooperative with the general farming industry. Although not a manufacturing district, there are a number of flour mills in various parts of the county, also several saw mills most of which are portable, a stave factory, several large lime plants, and smaller manufacturing industries. Mining has been carried on sporadically in the past in a few localities, and a few limestone and marble quarries are in operation at the present time.

CHAPTER II

TOPOGRAPHY

RELIEF

General Features. Ste. Genevieve County lies wholly within the Ozark Plateau, on the east slope of the uplift, and east of the St. Francois Mountains. The extreme eastern side is in the fertile bottom-lands of the Mississippi flood plain from which a well dissected country rises to the west. The gradual slope is broken by three well defined escarpments which extend in a general north-south direction through the greater part of the county. Marbut[1] has spoken of these as the Avon, Crystal, and Burlington escarpments. The names Avon and Burlington are retained in this report, but St. Peter-Joachim is used as the name of the third, instead of the Crystal. West of the Avon escarpment is the Jonca plain or plateau, a topographic division which occupies a comparatively large area in western Ste. Genevieve County. The highest points in the county are found in the Avon escarpment ridges where in several places rounded knobs reach an elevation of 1,100 to 1,200 feet above sea level. The points of lowest elevation are along Mississippi River. In the northern end of the county, at the mouth of Isle du Bois Creek, the flood plain of the river is about 370 feet above sea level, and at St. Marys in the southeastern part the elevation is about 355 feet, a drop of 15 feet in a distance of 24 miles.

All of the streams of the county have relatively steep gradients, and as a result have cut deep and narrow gorges in many places. Well developed water gaps have been formed where the streams have cut through the escarpments. More or less extensive bottom lands have been developed by the larger streams, especially in their lower courses.

The striking topographic feature of the Ozark region, the even-crested ridges of the divides, is represented by the even-crested hills which occupy the higher elevations in Ste. Genevieve County.

Uplands. A very large proportion of the area is what would be called uplands. As a whole it may be described as a very

[1]Missouri Geol. Surv., vol. 10, 1st Ser., p. 35, 1896.

hilly and much dissected country, and it is safe to say that more than one-half of the county is not adaptable to agriculture, the land being too rough and the hills too steep. The summits of most of the hills are rounded and roughly concordant in elevation, with the more gentle slope towards the east, and except for the ridges which suggest former base levels, the general elevation of the hills becomes lower to the east, a feature which evidently is controlled to some extent by the general dip of the underlying strata.

Throughout a large part of the county the topography has reached a stage of early maturity. This is evinced by the narrow divides, extensively dissected surface, and the development of relatively wide flood plains by the principal streams. On the western slope of the Jonca plain in the western part of the county the topography is much younger in its development, the divides being comparatively wide and the surface not so extensively dissected. The difference in the extent to which erosion agents have developed the topographic features is due chiefly to the differences in dip of the rock strata on the two sides of the Farmington anticline. The dip of the strata and the texture of the rocks have been of paramount importance in the topographic development of the county.

The detailed topography of the uplands of Ste. Genevieve County may be described under four headings given in the order of the age of the rock formations involved. These divisions are the Jonca plain, the Avon escarpment and cuesta plain, the St. Peter-Joachim escarpment and cuesta plain, and the Burlington escarpment and cuesta plain. There are a few other escarpments of smaller extent and minor importance which need no special mention.

Jonca Plain. This plateau or platform lies in part in Ste. Genevieve, St. Francois, and Madison counties, extending from French Village on the north to Fredericktown on the south. The area within Ste. Genevieve County is bounded on the north, east, and southeast by the Avon escarpment. The Farmington anticline divides the plain roughly into two parts. On the west side of the anticline in Ste. Genevieve County, the predominant rock formation is the Lamotte sandstone; on the east side the Bonneterre dolomite and the Lamotte sandstone occupy about equal areas of outcrop. Some granite ledges outcrop in the gorges of the main streams.

The divide between the east and west drainage extends northwesterly across the Jonca plain. On the east side of the divide the streams are deeply intrenched into the sandstone surface and the topography is, as a result, very broken. In the limestone area the country is more rolling and the streams have lower gradients. The photograph reproduced on Plate I, A, shows the southeastern Bonneterre area of the Jonca plain from the eastern Avon escarpment. The hills in the distance are part of the same escarpment which makes a westward swing south of the village of Avon. The northeastern Bonneterre area of the Jonca plain, north of the Missouri-Illinois Railroad, occupies a topographic trough which is formed by the Avon escarpment on the east, and the divide, which is approximately the axis of the anticline, on the west.

On the west side of the regional drainage divide the topography is younger in appearance than that to the east. The streams have not cut so deeply into the underlying rocks and the divides are much wider and less dissected. This more youthful topography is due chiefly to the lesser dip of the rock strata.

Although the Jonca plain is a much dissected area, when it is viewed from the surrounding escarpment, the general features which are presented to the eye warrant the use of the term plain in describing it as a topographic division of the region. The elevation of the main divide throughout its extent in the county does not vary more than 70 feet, and most of the ridge lies between 1,000 and 1,050 feet above sea level. The granite hills which are present in the Jonca plain area are knobs of the old land surface upon which the later sediments were deposited, and the removal of the sandstone has again exposed this ancient land surface to subaerial erosion.

There are two erosion features in the Jonca plain which warrant especial mention; these are known as Pickle Knob and Chimney Rocks. The first of these is in the west side of sec. 20, T. 36 N., R. 7 E., and is a knob about 1,040 feet in elevation and has been isolated from the main divide ridge by erosion. Its well rounded surface stands out in prominent relief with the deeply dissected surrounding country. The Chimney Rocks, in the northern part of sec. 27, T. 36 N., R. 7 E., are a series of well rounded sandstone chimneys which stand in prominent relief on the summit and on the slopes of a sandstone ridge, some of the rock masses being as much as 80 feet in height. They are composed of slightly indurated sandstone and grit, or

A. Bonneterre area of Jonca Plain from Avon Escarpment.

B. Upper terrace on Fourche a du Clos Creek at Bloomsdale.

fine conglomerate, and are erosion remnants of the surrounding Lamotte sandstone.

Avon Escarpment and Cuesta Plain. The Avon escarpment is one of the most prominent topographic features in the county. The escarpment is made of the Davis, Derby-Doerun, and lower part of the Potosi formations, the lower slopes being made up of soft shales and more resistant dolomites of the first named formations, while the rim rock is for the most part the resistant chert of the Potosi.

This escarpment enters Ste. Genevieve County from the north in sec. 34, T. 38 N., R. 6 E., and extends roughly in a southeast direction to the south branch of Establishment Creek, about 1½ miles west of Weingarten. At this point the escarpment becomes involved with the faulting which cuts across the county, and there is no well defined escarpment for the next four miles. Just south of River aux Vases, where the faulting turns eastward, the Avon escarpment again assumes its topographic prominence. From here the escarpment extends almost south to Saline Creek, being offset for some distances by the chief drainage streams. At Saline Creek it bends to the west along the south bank of the creek, passing south of Avon to sec. 16, T. 35 N., R. 7 E., where it turns south and crosses the county line.

Well developed water gaps are present in the Avon escarpment where the west branch of Establishment Creek (Hickory Creek on the map) and Madden Creek branch of Saline Creek cut through it. In the former the hills on both sides of the gap tower nearly 400 feet above the bed of the stream, imparting a view of picturesqueness and ruggedness. The Madden and Saline Creek gaps are dominated by more gently sloping hills and less rugged topography, although the immediate relief is between 300 and 400 feet. Fourche a du Clos Creek cuts through the escarpment a mile south of Lawrenceton, forming a narrow gap. Steeply sloping hills lie to the east; more gentle slopes prevail on the west side. The water gaps along Jonca Creek and River aux Vases are less pronounced as the streams are deeply incised in the Lamotte sandstone before cutting through the younger formations which have been brought down by faulting.

The Avon cuesta plain which slopes to the east from the top of the escarpment covers such an extensive area and is so deeply and intricately dissected that its generic character is not readily recognized. In their slopes to the northeast and east the summits of the divides are seen to be roughly concordant, and in the early stages of the present erosion cycle the country must have presented a typical undissected plain. The formations involved in the Avon cuesta plain range from the Potosi to the St. Peter, and some of the roughest topography in the county is found in its more dissected parts, the irregular brokenness of which is due to variations in the texture of the rocks of the various formations, some of which are resistant to weathering and erosion while others yield readily to agencies of denudation. The result is varying types of topography which extend in more or less parallel belts across the county. The most striking topographic feature in this area is the trough extending through the county which is occupied by the Everton and a part of the St. Peter sandstone. This easily eroded sandstone belt lies between the St. Peter-Joachim escarpment on the east and the steeply sloping cuesta-surface plain on the west.

St. Peter-Joachim Escarpment and Cuesta Plain. This escarpment is in part the same as the Crystal escarpment of earlier publications. It enters the county a little east of where the St. Louis road crosses Isle du Bois Creek and extends southeast across the county to River aux Vases, about one mile east of the village of that name. From this place southeast to the county line the St. Peter-Joachim formations are much broken and irregular in outcrop, owing to the complex faulting which cuts across the formations obliquely to the general strike. South of this line of faulting the escarpment is not again well defined in Ste. Genevieve County. This escarpment is best defined at Bloomsdale where it is about 130 feet high and includes a part of the underlying Everton formation.

The cuesta plain which lies between the St. Peter-Joachim and the Burlington escarpments is very narrow as a rule and in some places it is wanting, but where it is present it is well defined by its gentle eastward dip slope. The Ordovician formations are the only ones involved. Marbut[1] has spoken of this plain as the Zell platform. It is more typically developed in places north of Ste. Genevieve County than within the county. Its southern extension is cut off by the faulting south of River aux Vases, but south of the county line the plain again assumes its characteristic features.

[1]Missouri Geol. Surv., vol. 10, 1st Ser., p. 59, 1896.

Burlington Escarpment and Cuesta Plain. The Burlington escarpment is the most extensive in the state. It enters Ste. Genevieve County from the north near the mouth of Isle du Bois Creek and extends in a general southeast direction across the county roughly paralleling the Mississippi River. The escarpment is formed by the Lower Mississippian formations, expecially the Burlington and Keokuk limestones both of which are very cherty and therefore resistant to erosion. The topography of the escarpment hills northeast and east of Bloomsdale, northeast of Zell, and in the Beckett Hills north of River aux Vases, is exceedingly rough, the country being deeply dissected. In the faulted zone south of River aux Vases and south to the county line the escarpment is not prominent. It is, however, clearly defined along Mississippi River in Perry County.

Where the main streams cut through the Burlington escarpment well developed water gaps have been formed. This is especially true of Establishment Creek water gap east of Bloomsdale, and the River aux Vases gap where this stream cuts through the southern end of Beckett Hills, east of the village of River aux Vases (Staabtown). The immediate relief of the hills above the valleys is between 300 and 400 feet. The Burlington cuesta plain has been called the Barton platform by Marbut[1]. In Ste. Genevieve County it lies to the east of the escarpment and is made up of the Mississippian formations younger than those which form the escarpment. The slope of the plain towards Mississippi River is gentle and is less than the dip of the beds. The surface is gently undulating in the east central part of the county, but in the northern part, near Mississippi River, the surface is deeply dissected, and steep bluffs rising above the river flood plain are common. The difference in the topography of these two areas is due chiefly to the distance of the western border of the plain from Mississippi River, although the dip of the strata may be of minor importance.

South from the mouth of Establishment Creek the cuesta plain east from the Burlington escarpment becomes rapidly broader, and south from Little Rock to the faulted zone its width is five miles or more. The greater portion of this plain is underlain by the Mississippian limestones, and south from Frenchman Creek it includes a remarkable belt of sink-hole topography developed in the Spergen (Salem), St. Louis and Ste.

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[1]Op. Cit., p. 60.

Genevieve limestones. The size of these sink-holes varies from pits too small to be indicated upon the topographic map to such large depressions as that crossed by the Ste. Genevieve-Staabtown road 2½ miles southwest of Ste. Genevieve which has tributary drainage channels two miles or more in length. Many of these sink-holes have their outlets obstructed and in consequence are now filled with water to form ponds. Such ponds vary in size from a fraction of an acre in extent to such a body of water as Hook Pond, three quarters of a mile in length.

The three sink-hole marked limestone formations of this portion of Ste. Genevieve County are responsible for most of the sink-hole topography in the Mississippi Valley, and wherever these formations are present at the surface the greater portion of the drainage is subterranean. The sink-holes themselves, however, are not formed by the collapse of the roof of caverns. In the case of the smaller ones the depression is largely, if not wholly, confined to the surficial mantle rock overlying the hard rock, especially is this true where the surficial material is fine, like loess for instance, and of considerable thickness. Such sink-holes are formed by the washing down of the fine surficial material through an open joint crack into a cavern, much as the sand in an hour glass flows downward from the upper to the lower compartment. In many of the sink-holes of this sort the elevation of the hard rock surface at some distance from the rim of the depression, as shown in well excavations, is essentially the same as that shown in the bottom of the sink itself. Not infrequently, small sink holes are present in linear series, apparently along a more or less open joint crack in the underlying hard rock surface, and the presence or absence of water in the depressions is dependent upon whether or not the outlet is temporarily closed.

In many of the sink-holes, especially the larger and more or less irregular ones and where the surficial covering of the hard rock is of limited thickness, the depressions are largely in the limestone itself in which the funnel-shaped sink has been formed by surface solution.

The thickest loess deposits in the county occur along the eastern margin of the cuesta plain from the Burlington escarpment. These deposits are situated at the top of the Mississippi River bluffs and in places attain a thickness of thirty to forty feet. These windblown deposits, however, become much reduced in thickness back from the bluffs, and a few miles from the river they are inappreciable.

VALLEYS

Mississippi River bottom land occupies a small area in the extreme eastern part of Ste. Genevieve County. This land is almost perfectly level and lies but little above the normal gage of the river, and as a result the water frequently floods the flats and causes loss to the farmers commensurate with the height of the rise. At the town of Ste. Genevieve the upland slopes gradually down to the Mississippi flood plain, this feature being due to the synclinal fold at this point. Elsewhere along the river flat there are prominent bluffs, a feature best developed in the northern part of the county where in places the bluffs rise over 300 feet above the valley bottom. The widest part of the Mississippi bottom land lying in the county is south of Ste. Genevieve, where this area has the local name of the "Big Field," and it was here that the old town of Ste. Genevieve, the first civilized settlement in the Mississippi Valley, west of the Mississippi, was located.

In the upland area the larger streams have developed relatively wide valleys and bottom lands. These are found chiefly along Establishment Creek, River aux Vases, and Saline Creek, the three prominent tributaries to the Mississippi which rise in Ste. Genevieve County. Rarely do the bottom lands of these streams attain a width greater than half a mile, and as a rule they are considerably less than this. The bottoms include some of the most productive land in the county. Along many of the smaller streams there are irregular areas of bottom land commonly of very small width, but in most cases such areas are under cultivation.

Two sets of terraces are found along the Mississippi near Ste. Genevieve and in the valleys of the tributary streams within the county. The top of the upper or older terrace is at an elevation of about 420 feet; the top of the lower one between 390 and 400 feet. The sediments of these terraces are of fluvio-lacustrine origin and were formed by ponding during the Pleistocene epoch. They will be discussed under the description of the Quaternary formations, and their distribution is shown on the geologic map. A picture of the upper terrace on Fourche a du Clos Creek at Bloomsdale is shown on Plate I, B.

DRAINAGE

The Mississippi River is the master stream of the region and receives, directly or indirectly, all of the drainage of Ste. Genevieve County. The most important divide in the county is that one separating the east drainage which flows in a general northeast direction directly into the Mississippi, from the west drainage which flows in a west and southwest direction, emptying into the Big and St. Francois rivers respectively. The important streams within the county lie on the east side of the main divide, and the drainage basins may be designated by the names of the principal streams, Establishment Creek, River aux Vases, and Saline Creek.

Establishment Creek, with its headwaters on the east slope of the divide near Sprott, receives most of the drainage in the northern part of the county. This creek flows east to a point one mile west of Weingarten, then north to Bloomsdale, and from here the course is northeast to Mississippi River. The main tributaries are Fourche a du Clos which rises several miles southwest of Lawrenceton and joins Establishment Creek near Bloomsdale, the west branch of Establishment Creek (Hickory Creek on the map), Hickory Creek, and Indian Creek.

Establishment Creek itself is approximately 20 miles long and has a total fall of about 680 feet. In the first four miles of its course its descent is 350 feet, in the next five 200 feet, the next five but 100 feet, while in the last six miles, or from a point about one mile south of Bloomsdale to the mouth of the creek the fall is about 30 feet, or an average of five feet per mile.

River aux Vases which flows northeast across the central part of the county, rises at an elevation of 1040 feet at the divide in the southwestern part of the county. The stream is about 25 miles long and empties into the Mississippi River where the elevation is about 300 feet above sea level, which gives a fall of 680 feet. Of this amount the descent in the first 11 miles is over 600 feet, and in the remaining 14 miles the stream gradient averages but five feet per mile. The main tributaries of River aux Vases are Jonca and Pickle creeks which rise in the granite hills, and Flint Bottom and Mill creeks.

Saline Creek, the longest stream in the county, is the most southern of those described. It rises in the southwestern corner of the county along the main divide, and Greasy Creek is one of its forks. Its course across the county is east and northeast for a distance of approximately 30 miles. The fall from the highest point of the divide is about 850 feet, 800 of which is in the first 20 miles. In the last 10 miles the stream gradient averages five feet per mile. The main tributaries of Saline Creek are Coldwater, Madden, South Fork, and Little Saline creeks.

Other streams of minor importance that rise in the county and flow directly into the Mississippi are Isle du Bois Creek, which forms the northern boundary of Ste. Genevieve County over part of its course, and North and South Gabouri creeks, both of which enter Mississippi River at Ste. Genevieve.

The extreme northwestern part of the county is drained by Plattin Creek which flows north to the Mississippi at Crystal City. The flatwoods area in the extreme southern part of the county is drained by the headwaters of Castor Creek which flows almost due south to the swamp region in the southeastern corner of the state.

On the west side of the main divide there are two drainage basins. North of the Missouri-Illinois Railway the county is drained by Terre Bleue Creek into Big Creek which flows north to the Meramec, which in turn enters the Mississippi south of St. Louis. The remainder of the western part of Ste. Genevieve County is drained by St. Francois River which flows south and empties into the Mississippi in the state of Arkansas.

Springs, deep wells, caves, and sinks are the criteria from which deductions may be made concerning the underground drainage of the county. Springs with perennial flow are common in some of the formations, the largest of which probably come from the Gasconade and Potosi formations. There are few deep wells in the county, but in some districts there are numerous wells from 50 to 200 feet in depth, a few of which are flowing wells.

The presence of many sinks in the eastern part of the county speaks for a large system of underground drainage whose channels have been formed by solution along joint planes. The presence of numerous caves which are evidently old water channels, show the conditions which obtained in the past when the ground water level was higher than at the present time.

CHAPTER III

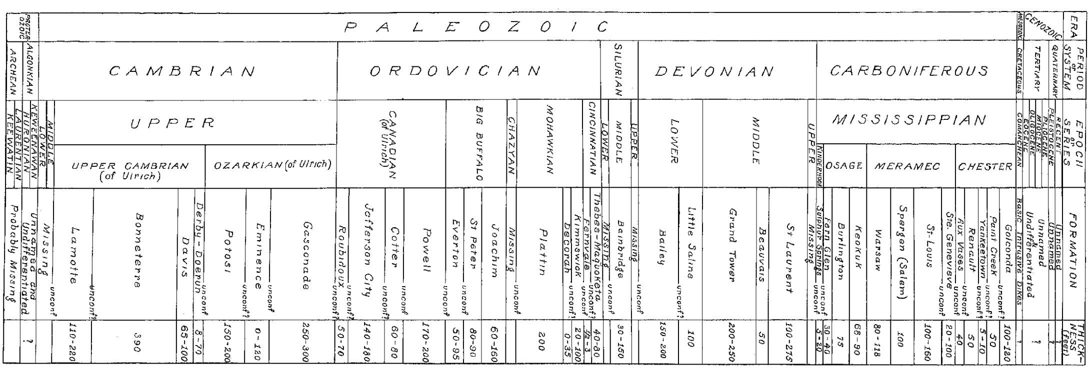
STRATIGRAPHY

Stratigraphic Summary. The stratigraphic column is more nearly complete in Ste. Genevieve County than in any other county in Missouri. The most ancient rocks that are exposed at the surface are the crystalline granites and porphyries of pre-Cambrian age; the youngest are the limestones, shales and sandstones of the Chester Series, the age of which is Upper Mississippian. These youngest rocks, however, are very old, for since they were formed all of the coal-bearing series of northern Missouri have been deposited, and in addition an enormous series of still younger beds that are not present anywhere in the state, although in some other parts of the world they are represented by many thousands of feet of a great variety of sediments. Furthermore, since the youngest of the rocks exposed in Ste. Genevieve County were deposited, great mountain ranges have been raised up in many parts of the world, some of which have been more or less completely cut away by the slowly acting energy of running water.

The sedimentary series in Ste. Genevieve County consists of a notable succession of dolomites, limestones, sandstones, and shales, exhibiting a great variety of lithologic characters. These sediments have an aggregate thickness here of approximately 3,500 feet, and have been subdivided in the course of our work into no less than 38 distinct formations, each of which will be described in the following pages.

The series in this area has many breaks in it, represented by unconformities between certain of the formations. The crystalline granites at the base of the section are pre-Cambrian, probably Algonkian. Above the Algonkian, sediments are present that are referable to the Cambrian, Ordovician, Silurian, Devonian, and Carboniferous (Mississippian) systems. If there have ever been any sedimentary rocks in the county younger than the Mississippian with the exception of the unconsolidated Pleistocene deposits, they have been completely removed by the processes of erosion during the enormous period of time that has elapsed since their formation and elevation above sea level.

See Geology of Ste. Genevieve County, Missouri (Figure 2) for full version.



Stratigraphic section Ste. Genevieve County.

The unconsolidated materials which more or less completely cover the hard rocks of the county, and which constitute the surface soils, clays, sands, etc., of the region, are commonly designated as surficial deposits. These are all very much younger than the hard rocks, and have all or nearly all accumulated during the present geologic period.

In the succeeding pages of this report each one of the stratigraphic units in the geologic section of Ste. Genevieve County will be fully discussed in relation to the part it takes in the geology of the region. These formations will be considered in order, beginning with the oldest, or lowest one in the section.

The stratigraphic relation and comparative thicknesses of the formations are shown on the geologic map accompanying this report, and are summed up in the table given in fig. 2.

PRE-CAMBRIAN ROCKS

The igneous rocks which outcrop in southeastern Missouri and which form the higher parts of the St. Francois Mountains are the oldest in the state. As described by Haworth[1] they consist principally of granites and porphyries with numerous small dikes of diabase or greenstone. A few quartz veins and pegmatite dikes which are supposed to be of later origin are also present. Outcrops of each of these types of rock are exposed in Ste. Genevieve County.

The exact age of the igneous rocks is not known, but as has been shown by Buckley[2] they are certainly pre-Cambrian and have heretofore been tentatively assigned to the Laurentian, a division of the Archean. The fact, however, that the granites of the Archean are so commonly somewhat gneissoid, whereas the Missouri granites and porphyries entirely lack this structure, suggests that the Missouri igneous rocks may be Algonkian rather than earlier. At no locality in the state have rocks of the early Archean or "basement complex" series been recognized.

In St. Francois County, chiefly at Pilot Knob, 200 feet of slate and conglomerate are found which may be Huronian in age, but aside from this restricted occurrence there are no sediments exposed in Missouri equivalent to the Huronian, Keeweenawan, or earlier pre-Cambrian epochs.

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[1]Missouri Geol. Surv., 1st. ser., Vol. 8, pp. 84-222, (1895).

[2]Disseminated Lead Deposits, Mo. Bureau Geol. and Mines, 2nd ser., Vol. 9. pt. 1, p. 16, 1909.

Areal Distribution. The total area occupied by the pre-Cambrian rocks in Ste. Genevieve County is small. As shown on the accompanying geologic map, they outcrop in rather narrow, irregular areas, occupying the valleys of Jonca, Pickle, and Fourche a du Clos creeks in the western part of the county. The granites are found chiefly in the areas of Jonca and Pickle creeks, and the porphyry occurs in the small areas along upper Fourche a du Clos Creek.

Topography. Topographically the pre-Cambrian area is extremely rough, due to the resistance of the rocks to weathering. The streams occupy narrow valleys, the sides of which are steep and cliff-like in places.

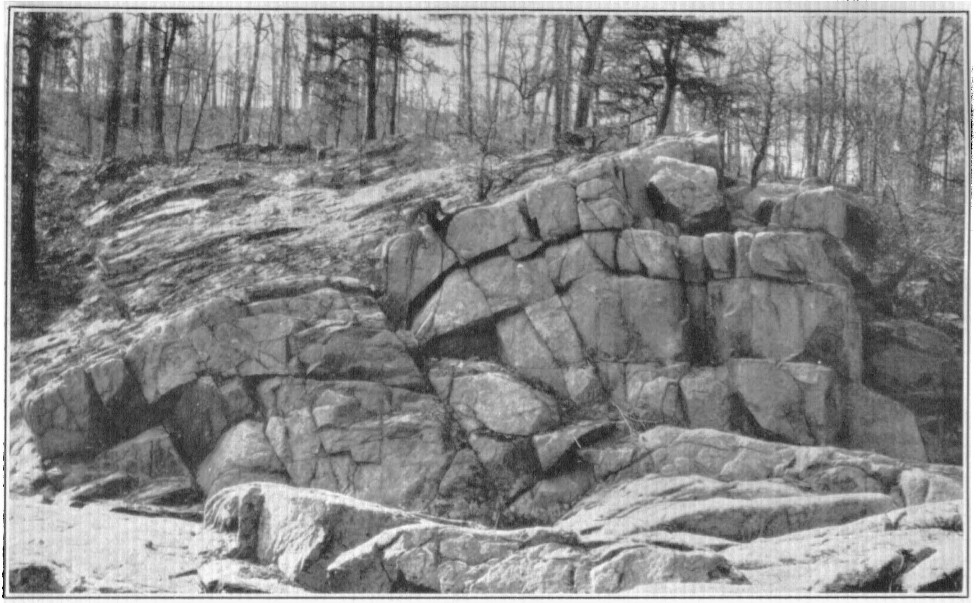
Lithologic Characters. The granite in Ste. Genevieve County is of two varieties, the red and the gray, the former predominating. The red granite is composed principally of quartz, orthoclase feldspar, and a subordinate amount of biotite mica, with locally a very little hornblende or pyroxene. The proportions of the principal minerals vary over comparatively small areas, and in a few places the granite contains a considerable amount of biotite.

The texture of the red granite is variable, ranging from finely to coarsely crystalline. Granite porphyry is not uncommon, the porphyry crystals being either quartz, feldspar, or biotite. Jointing is common, but as a rule the joint planes are very irregular.

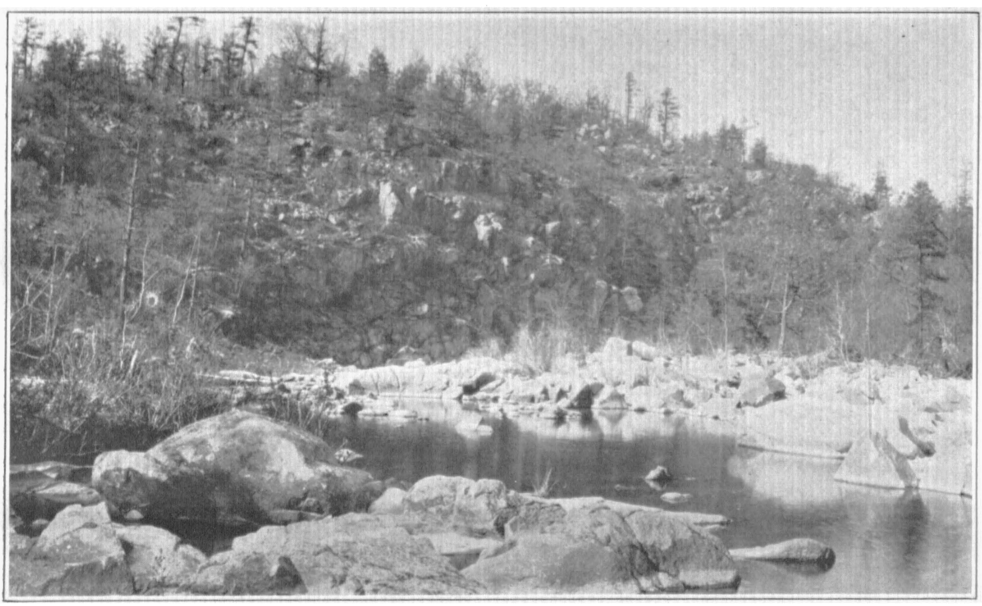
The gray granite is composed of quartz, a light colored feldspar, and in most cases biotite, and in a few places along Jonca Creek it contains more basic segregations which vary in size up to 18 inches. In the SW. cor. sec. 11, T. 36 N., R. 7 E., the gray granite cuts the red granite, in which it fills small fissures, but this relation is not so clearly defined at any other locality.

The porphyry is made up of a rhyolitic ground mass, in most cases dark in color, with phenocrysts of feldspar, either orthoclase or plagioclase, and in some places quartz. The ground mass is very similar in composition to the granites, and Haworth[1] says that scarcely a mineral is found in the porphyry that is not also present in the granite. The jointing in the porphyry is commonly very irregular, but in one locality two prominent sets of joints have been observed, with the directions N. 34° W., and N. 64° E.

[1]Op. Cit., p. 183.



A. Spherical jointing in granite.



B. Granite bluff on Jonca Creek.

Dikes. The dikes, which cut the granite in numerous places, are chiefly basic. They vary in width from a few inches to 5½ feet, and the rock is commonly finely crystalline and dark to greenish in color. Small crystals of pyrite scattered through the rock have been observed in a number of places, and in a few localities the surface has been partially or completely altered to serpentine. Many of the dikes observed have a northeast-southwest trend, with a very high angle of dip.

Feldspar veins in the granite occur on Jonca Creek in the south center of sec. 2, T. 36 N., R. 7 E., where they are small and irregular and seem to be associated with a basic dike. The largest one observed is several feet in width and is composed of large crystals of feldspar and quartz. Two other small feldspar deposits are present in secs. 10 and 11.

Small, fine-grained granite dikes cut the porphyry in secs. 9 and 10, T. 37 N., R. 6 E., most of which are but a few inches in width, although one has a width of four feet.

In the extreme southeast corner of sec. 11, T. 35 N., R. 7 E., there are loose fragments of a basic igneous rock on the surface, although no outcrop of the rock has been found. The pieces are much weathered and the texture is crypto-crystalline. This rock is probably pre-Cambrian as it differs widely lithologically from the later intrusives which are thought to be of Cretaceous age.

Structure. The granites are extensively jointed and in nearly all cases the joint planes are very irregular, right angle jointing being present in only a few localities. Excellent examples of spherical jointing is exhibited along Jonca Creek (see Pl. II, A.). The granites are faulted in a few places and the rocks near-by show considerable shearing.

Stratigraphic Relations of the pre-Cambrian. The pre-Cambrian granites and porphyries are unconformable with the overlying sediments. In Ste. Genevieve County the Lamotte sandstone is the only formation which is in contact with the pre-Cambrian, but west of here some of the younger formations rest upon the ancient plutonics.

The erosional unconformity between the pre-Cambrian plutonic rocks and the initial Lamotte sediments represents perhaps the longest emergent interval recorded in the state. This includes at least part of the Algonkian and probably all of Lower and Middle Cambrian time. The surface, therefore, upon which the Lamotte clastics were laid down was extremely rough and irregular. Granite and porphyry knobs in Ste. Genevieve County remained above the encroaching sea during the early part of the epoch, but as the sea advanced they were finally covered and became areas of sedimentation. The higher peaks to the west, in St. Francois County, however, remained above the sea and contributed clastic material to the lower areas where sedimentation was in progress.

CAMBRIAN SYSTEM

Upper Cambrian Series (restricted) of Ulrich

LAMOTTE FORMATION

Name and Age. The Lamotte, named from Mine Lamotte, St. Francois County, is the oldest recognized Cambrian formation in Missouri. Identifiable fossil remains are rare in the formation, although Ulrich reports *Obolus lambornei*, a species which passes into the Bonneterre, the next higher formation. Many fragments of shells are found locally, which are probably the remains of linguloid species of brachiopods too incomplete for determination. In volume 9, 2nd. ser. Missouri Bureau of Geology and Mines, Buckley[1] considered the Lamotte to be Middle Cambrian in age, but Ulrich[2] at a later date has considered this oldest Paleozoic formation of the Ozark region to be of Upper Cambrian age.

Areal Distribution. The Lamotte outcrops occupy much of the western part of the county, the total area where it is the surface formation being nearly 90 square miles. The belt of outcrop varies from four to ten miles in width and follows the dividing ridge which separates the east and west drainage systems in that portion of the county.

Thickness. Deposited as it was upon a very irregular surface, the thickness of the Lamotte varies greatly over relatively small areas. In the St. Francois Mountains the formation is known to vary from a few feet to approximately 500 feet in thickness, and it may be much thicker in places. At Farmington, just west of the Ste. Genevieve County line, the city well passed through 451 feet of Lamotte sandstone before penetrating the granite.

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[1] E. R. Buckley, Disseminated Lead Deposits.
[2] Revision of the Paleozoic Systems, Bull. Geol. Soc. Amer., Vol. 22, Pl. 27, Sept., 1911.

In Ste. Genevieve County the maximum measurable thickness was observed one mile east of Sprott, and just north from a part of the granitic area. At this locality the formation has a thickness of about 220 feet, but the sandstone may be considerably thicker in the immediate vicinity for erosion has removed the upper portion in the section measured. The minimum thickness that was observed is in the northeast corner of sec. 10, T. 37 N., R. 6 E., where about 110 feet of sandstone outcrops between the porphyry and the Bonneterre limestone. There are no holes in the county which have been drilled through the formation, so comparative thicknesses cannot be given.

Topography. The highland area of the Lamotte sandstone belt presents a rolling topography, the hills being well rounded with gentle slopes. The larger streams, however, have cut deeply into the formation, and the valley walls in some cases are very precipitous. In the NW. 1/4 sec. 27, T. 36 N., R. 7 E., differential weathering has produced a number of interesting, rounded knobs or chimneys, known locally as Chimney Rocks, some of which are as much as 80 feet in height. Pickle Knob, in the NW. 1/4 sec. 20, T. 36 N., R. 7 E., also shows a prominent relief from the lower country which slopes rapidly away on three sides.

Lithologic Character. Practically the whole of the Lamotte formation is made up of sandstone, including a basal and numerous intraformational conglomerates. A minor amount of shale is locally present at various horizons, and a persistent dolomitic bed occurs near the top of the formation.

In color the sandstone is commonly yellow, but it varies from white to dark brown, depending upon the amount of iron present, whereas near the contact with the Bonneterre the sandstone is dark in many places. Locally the white sand is called "Pinery" sandstone. The texture of the sandstone varies according to the local conditions that obtained during its deposition, and to the amount of sorting to which the material was subjected. In general, the lower part of the formation is composed of coarse and angular sand grains, while near the top the grains are finer and more rounded. The sandstone is fairly friable but in places is partly indurated and many outcrops show surface hardening. The stratification is variable, ranging from thin, platy beds to layers several feet thick, all of which exhibit irregularities in many places. Cross-bedding is common, and aside from local variations has a general easterly dip, the individual cross-beds varying from thin laminar layers to beds one foot or more in thickness. The degree of dip exhibited by cross-bedding is commonly small, but in the railroad cut east of Sprott there are dips as high as 27 degrees.

The base of the Lamotte formation is in most places a conglomerate consisting of large and small boulders of pre-Cambrian rocks. The thicknesses of the basal conglomerate beds are variable. Along the west side NW. ¼ sec. 22, T. 36 N., R. 7 E., on north bank of Pickle Creek, about 15 feet is exposed. In other places it is much thinner but probably in favorable localities it may be as much as 30 feet thick. The intraformational conglomerates are commonly composed of sub-angular pieces of quartz which have been derived from local areas of igneous rocks, and their nearness to the source of the material is suggested by the variation in size of the included fragments, and the limited extent of the horizons.

The dolomitic bed in the upper part of the Lamotte formation outcrops in a number of widely separated localities, and is probably a more or less continuous horizon. Near Avon, where it occurs about 50 feet from the top of the formation, it is yellowish in color, calcareous, and has a thickness of from nine to ten feet. In the SE. ¼ sec. 19, T. 37 N., R. 6 E., this bed also occupies a position approximately 50 feet below the Bonneterre, and is associated with shale and quartzite. At other points it is somewhat nearer the top of the formation, and it may be only three or four feet thick. This layer probably corresponds to similar beds encountered in adjoining counties. Drill records at Farmington show five feet of dolomite, 90 feet below the top of the sandstone, and at Bonneterre five feet of calcareous, sandy dolomite is present 29 feet below the top of the formation. It is also common to find beds of similar dolomitic character in the Flat River mining district.

A few restricted lenses of shale have been observed at various horizons within the Lamotte formation, prominent exposures being present near the center and northern parts of sec. 26, and the south central part of sec. 23, T. 27 N., R. 6 E. Some of the shale is light green or yellow to white in color, and sandy in character, but resting upon the sandstone in sec. 23, and vicinity, there is a deep reddish-brown, waxy shale, sandy in places, which is very different from any other sediments of the Lamotte formation. Where shales of this last type have been observed they are always well up on the divides, and it is possible that they represent remnants of a much younger formation.

A few outcrops of a post-Middle Devonian conglomerate are found in the Lamotte area. These evidently were deposited in depressions in the uneven surface which existed at the time. Their lithologic characteristics and geologic relations will be discussed elsewhere.

Stratigraphic Relations of the Lamotte. The Lamotte formation lies unconformably upon the pre-Cambrian igneous rocks in Ste. Genevieve County. There is also exhibited a small interruption in the sedimentary record between the Lamotte and the overlying Bonneterre formation in southeastern Missouri. Drill records show that the surface of the sandstone rises and falls in gentle undulations, although in some places more or less abrupt escarpments of the underlying formation are apparently present. That portion of the Lamotte formation which lies above the persistent dolomite horizon is most variable in thickness. In comparatively short distances this difference is as great as 67 feet, although in most cases it is considerably less than this. The thickness of the overlying Bonneterre is also variable, a condition due to the uneven surface upon which it was laid down, rather than to any irregularity in deposition. The reason for this irregularity in the contact surface between these two formations is believed to be due to a period of post-Lamotte erosion.

The typical basal Bonneterre beds with their glauconitic content indicate the peculiar conditions which obtained during the early stage of this epoch, and the persistency of the beds show that these conditions were widespread. The local absence of this bed is most probably due to the uneven surface upon which the shallow Bonneterre sea deposited its first sediments, and the fact that some of the Bonneterre outliers occupy depressions in the underlying sandstone, in most of which the glauconite beds are more or less well-developed, suggests unconformable relations between the two formations.

Structure. The most important and most interesting structural feature in the Lamotte formation is the Farmington anticline, which crosses the western part of Ste. Genevieve County in a north-northwest direction. The divide which separates the east and west drainage of the county probably marks, approximately, the axis of this anticline. The exposure of Lamotte sandstone in the upper part of Salem Creek, in the western part of the county, is also due to a slight anticlinal fold.

Only in localities where the rocks have been disturbed by faulting does the Lamotte sandstone exhibit other than very gentle dips.

Jointing. In places the Lamotte sandstone is conspicuously jointed, and the following table shows the more important joint systems in a number of localities:

Table of Jointing in Lamotte

Section	Twp. N.	R. E.	Direction of jointing
SW. ¼ NW. ¼ sec. 29.........	37	7	N. 42° W., N. 4° W., and N. 70° E.
NW. ¼ SE. ¼ sec. 27.........	37	7	N. 65° W., and N. 25° E.
SE. ¼ sec. 27.........	37	7	N. 50° W., and N. 70° E.
SW. ¼ sec. 27.........	37	7	N. 45° W., and N. 70° E.
SW. ¼ sec. 11.........	37	6	N. 57° W., and N. 10° E.
NE. ¼ sec. 3.........	37	6	N. 78° W., and N. 20° E.
SW. ¼ sec. 12.........	35	7	N. 75° W., and N. 25° E.

Correlation. The Lamotte sandstone contains so few well-preserved fossils that exact faunal correlations with deposits in other basins is impracticable. However, since the Lamotte is believed to be the basal part of the Upper Cambrian sediments, it was probably deposited during the same general sea transgression as was the lower part of the Reagan formation of Oklahoma, the Rodgersville in Tennessee, and the lower part of the Conasauga in Alabama. The lower portion of the St. Croix in the upper Mississippi Valley is probably of approximately the same age.

Paleontology. Fossils are not generally abundant but here and there thin layers filled with shells of *Obolus lambornei* have been found. Occasionally a few imperfect remains of trilobites occur with the shells.

BONNETERRE FORMATION

Name. Bonneterre, as used in this report, is synonymous with the term defined by Buckley[1] in his report on the disseminated lead deposits. The formation includes all of the dolomite, shale and limestone members between the underlying Lamotte sandstone and the shale and dolomite members of the

[1]Bureau of Geol. and Mines, 2nd ser., Vol. 9, pt. 1, 1909.

overlying Davis formation. The name of the formation is taken from the town of Bonneterre in St. Francois County, where this stratigraphic unit is typically developed. The formation was first defined by Nason in 1901[1]. The St. Joseph, as used by Winslow[2], seems to have included all of the strata from the Lamotte to the formation now called Potosi, and would therefore be nearly synonymous with the Bonneterre of Nason. Nason recognized the shale and conglomerate zone which is at present included in the upper 65 or 70 feet of the Davis formation and placed the upper limit of the Bonneterre at the edgewise conglomerate horizon which is about six feet below the "Central" marble boulder member of the Davis. From sections given by Ulrich[3] in 1905 it would appear that he similarly revised the Bonneterre, as defined by Nason, his Elvins formation being above the conglomerate, just below the "Central" marble boulder member of Buckley's Davis. It will be recognized, therefore, from the foregoing statement, that the Davis formation as recognized in the latest reports, contains probably 100 feet or more of shale and shaly dolomite that had been included in the Bonneterre in earlier reports.

Areal Distribution. The Bonneterre outcrops over a considerable area in Ste. Genevieve County. The more eastern outcrop occupies a topographic trough between the eastern flank of the Farmington anticline and the rough hills of the younger formations on the east. In the neighborhood of the faulted region in the central part of the county, the formation is cut out completely for some distance. Farther south the belt expands and reaches its maximum development southeast and south of Coffman. The Bonneterre is also present in the western corner of the county, outcropping with the gentle dip of the western limb of the Farmington anticline.

Thickness. In Ste. Genevieve County the Bonneterre formation is variable in thickness. The maximum is shown in the area southeast and east of Coffman, where a drill hole in the south side of sec. 33, T. 36 N., R. 8 E., penetrated 344 feet to the Lamotte sandstone. This drilling was started about 45 feet below the top of the Bonneterre, thus making a thickness of about 390 feet for the whole formation in this district. The minimum observed thickness is in sec. 16, T. 35 N., R. 7 E.,

[1] Nason, F. L., Amer. Jour. Sci., 4th ser., Vol. 12, p. 358 (1901).
[2] Missouri Geol. Surv., 1st ser., Vol. 6, p. 331 (1894).
[3] Copper Deposits of Missouri, Bull. U. S. Geol. Survey, No. 267, 1905.

where there appears to be only about 40 feet of dolomite. Two miles east of this locality, however, in secs. 11 and 14, T. 35 N., R. 7 E., the base of the Bonneterre is at 740 feet, and the top at 980 feet, an apparent thickness of 240 feet. The distance between these observations is about half a mile, and the south dip appreciable, so that the thickness will be perhaps 50 feet greater, or more than 290 feet in all. Since nowhere else is so great a thinning of the Bonneterre known in so short a distance, it is more than probable that the apparent reduction results from faulting, since considerable faulting is known in the immediate vicinity. A detailed measurement of the thickness of the Bonneterre in the county has been impracticable, nor are there any drill records which show the entire formation, but the following thicknesses as recognized in drill holes at a number of localities were observed. In the NW. ¼ sec. 4, T. 35 N., R. 8 E., a drill hole passed through 265 feet of dolomite and shale to the Lamotte sandstone; at the east side of sec. 5, T. 35 N., R. 8 E., there are 360 feet to the sandstone; on the south side of sec. 12, T. 35 N., R. 7 E., 43 feet; near the center of sec. 12, T. 35 N., R. 7 E., 34 feet; south of the center of sec. 1, T. 35 N., R. 7 E., 200 feet; in the NE. ¼ NE. ¼ sec. 29, T. 37 N., R. 7 E., is a hole 85 feet deep to a sandstone which may be in the lower portion of the Bonneterre; and in the SW. ¼ sec. 35, T. 38 N., R. 6 E., a hole 310 feet deep probably penetrates nearly to the base of the Bonneterre. In all of these localities, the top of the formation has been removed by erosion so that the total thickness of the formation is not present. On the land grant, U. S. Survey 3036, north of Farmington Junction, there are several drill holes which indicate a thickness of about 380 feet of Bonneterre.

Topography. In general the Bonneterre topography is an undulating or rolling surface with rounded hills and sloping valleys, being in marked contrast to the steep and rough hills produced by the overlying formations. In the north central part of the county the formation occupies a topographic trough, the slopes from the hilly country to the east being very steep, with a more gentle rise to the sandstone hills on the west. Where streams have cut through to the underlying Lamotte sandstone, the valleys are commonly steep-sided. Likewise, in places where the more resistent younger formations overlie the more easily eroded Bonneterre, streams have cut deep valleys and the surrounding country is very rough. Such topography is exhibited along Greasy Creek and its tributaries in the southern part of the county. Although abundant outcrops can be found in the Bonneterre area, the rocks weather to form a thick soil, and most of the area has been cleared and presents to the eye a well-developed farming region, this being especially true around Coffman and in the western corner of the county. In a number of localities topographic sinks have been developed in this formation, solution evidently having enlarged certain joint planes or crevices in the rocks into which the surrounding soil and talus has been washed.

Lithologic Character. The Bonneterre formation is composed of dolomite, limestone, and shale, all of which may show gradations from one to the other. The largest part of the formation is composed of dolomite, and the limestone and shale horizons appear to be irregular in their development, and do not seem to occupy any definite stratigraphic positions in the formation. Pure limestone is exposed along Fourche a du Clos Creek in the southwestern part of sec. 36, T. 38 N., R. 6 E., where some of the beds contain many fragments of fossils. Other limestone outcrops occur along Saline Creek about one mile southeast of Avon, and on the county road in the southeast corner of sec. 35, T. 36 N., R. 7 E., where trilobite collections have been made.

In color, texture and composition, the Bonneterre rocks are very variable. The colors range from very light gray through shades of brown, and even pink, to dark shades of gray, bluish gray, pale green, and deep green, the last color being due to the presence of glauconite. Such a variety of colors is due partly to the chemical composition and to the constituents of the rocks. The texture of both dolomite and limestone is also variable, ranging from a dense, fine-grained rock to one having considerable pore space in which small crystals of calcite may be present. Patches of calcite are common in the upper beds of the formation. The dolomite commonly weathers to a craggy or honeycombed surface, a characteristic which is particularly well exhibited where the beds are exposed along gentle slopes, although in many places the outcrops have well rounded surfaces.

The basal beds which show a lithologic transition from the Lamotte sandstone are very characteristic, the presence of glauconite, locally in considerable amount, being a useful criterion in their identification. This transitional zone is made up of intercalated beds of dolomite, sandstone, calcareous sandstone, and shale, and although its relations vary from place to place, the following section which was made along the north branch of Establishment Creek in the NE. ¼ sec. 19, T. 36 N., R. 7 E., shows the general character of the basal 55 feet, where the formation is believed to be fully developed.

Section of Basal Part of Bonneterre Formation, NE. 1/4 sec. 19, T. 36 N., R. 7 E.

		Feet	Inches
16	Magnesian limestone, light gray, crystalline, streaked with yellow argillaceous material. Weathers into thin beds ½ to 2 inches thick	4	10
15	Limestone, yellow, argillaceous; contains patches of light gray crystalline limestone. Weathers more rapidly than the enclosing beds	1	2
14	Limestone, light gray crystalline; some glauconite. Splits into beds ½ to 2 inches thick	5	4
13	Dolomite, arenaceous, yellowish gray, beds 1 to 12 inches in thickness. Thin seams ½ to 2 inches, of drab-colored shale with thin lenses of dolomite. Some of the beds are more sandy than others and contain some glauconite	11	6
12	Dolomite, thin-bedded, alternating with blue shale. Dolomite is light gray and crystalline. Some beds are arenaceous and glauconitic, others slightly calcareous. Shale is more abundant in upper part. The dolomite occurs in lenses	10	—
11	Dolomite, thin layers, 1 to 4 inches, fine to medium-grained, light gray in color. Some layers contain considerable glauconite, others but little or none	4	10
10	Dolomite, yellowish, argillaceous, non-crystalline	—	4
9	Shale, greenish-yellow in color, argillaceous	—	2
8	Dolomite, gray, fine to medium-grained. Weathers to beds 2 to 5 inches thick; pitted surface	5	4
7	Limestone, varying in magnesian content, light gray, thin-bedded, 1 to 8 inches thick; contains abundant glauconite, especially along bedding planes. Some beds are arenaceous	5	—
6	Sandstone, white, medium-grained, very glauconitic, giving whole bed a general green color. Small thin lenses of dolomite	3	6
5	Sandstone, interbedded with thin layers of gray, very arenaceous, dolomite; glauconite abundant	—	4
4	Sandstone, medium grained, much glauconite, gray color to outcrop	—	3
3	Sandstone, very calcareous, medium-grained, closely-cemented	—	5
2	Sandstone, slightly calcareous, yellow well-rounded grains but very unequal in size	2	—
1	Sandstone, typical yellow to white, Lamotte		

The shales of the Bonneterre are found principally in the lower and middle parts of the formation, very little being present near the top. They are commonly fissile, argillaceous, pale green to gray in color, yellowish in places, and may grade into shaly, argillaceous dolomite. The greatest amount of shale is found in the southern part of the county, the lower 80 to 100 feet of the formation in the vicinity of Coffman and Avon locally being made up to a considerable extent of greenish to yellowish fissile shale; but the beds, some of which are 6 to 8 feet thick, are not persistent. About a mile east of Coffman, along the railroad, there is a shale bed several feet thick in the upper part of the formation.

There are several exposures of conglomerate which occur as outliers in the Bonneterre area but which are post-Middle Devonian in age, since they have in their heterogeneous make-up limestone boulders containing Middle Devonian fossils. These outliers will be described under their proper heading. In a conglomerate outcrop exposed in a railroad cut about one-half mile east of Coffman, the matrix is magnesian limestone and the pebbles or small boulders, which are very irregular in size and shape, are likewise limestone, and the general appearance of the beds suggests a basal deposit, filling a depression. This outcrop may be a remnant of the post-Middle Devonian conglomerate, but it has not been mapped as such because there is no direct evidence to show that it is younger than Bonneterre.

In at least three localities post-Bonneterre igneous rocks are exposed, surrounded by the regular Bonneterre dolomites. These areas are described elsewhere.

Structure. The Bonneterre formation exhibits a number of interesting structural features. The diastrophic movements which at various times affected the whole region more or less produced numerous small folds and irregularities in the beds; and the Farmington anticline, the largest of these folds in Ste. Genevieve County, very probably involved the lower beds of the Bonneterre formation.

The general dip of the Bonneterre beds is to the east and northeast on the east limb of the anticline, the degree of dip being variable. In the southern part of the county, in the broad areal outcrop southeast and south of Coffman, the average dip of the formation is slightly over 2°. In the areas to the north, where the outcrop is narrow, the average dip is about 4°. On the west limb of the anticline the general dip is west and southwest, but it is much less than on the east side, the average being about one degree.

A glance at the map exhibiting the distribution of the formations in and around sec. 24, T. 35 N., R. 7 E., on Greasy Creek, will show a small synclinal trough having a centroclinal dip, the apex of which is close to the stave factory. A very peculiar irregularity is exhibited in the branch in the NE. ¼ sec. 15, T. 35 N., R. 7 E., where there is a steep quaquaversal dip over a very small area. Since there are a few places where post-Bonneterre igneous intrusions are known to exist, it is possible that this small dome was formed by an intrusion which has not yet been exposed by erosion.

Near the center of sec. 10, T. 35 N., R. 7 E., there is a partial sink structure with beds dipping strongly toward the hill-top on the north and west sides, but with little disturbance on the south side. Large chunks of iron sulphide, some partially changed to limonite, can be found on the hilltop and slopes. A small fault may be the basic cause of this structure.

Jointing. The Bonneterre limestones and dolomites exhibit excellent jointings in many localities. So universal is the tendency to develop joint planes in this formation, that this feature may be applied in places as a criterion for distinguishing the Bonneterre from the overlying formations. The following table shows the directions of the more important systems of jointing at various places throughout the county.

Table Showing Direction of Jointing in Bonneterre Formation

Fraction	Sec.	Twp.	R. E.	Direction of Jointing
NW. ¼ NE. ¼......	29	37	7	N. 44° W. and N. 43°-53°E
SW. ¼ SW. ¼......	36	37	6	N. 45° W., N. 10° W. and N. 35° E
NE. ¼ NE ¼.......	2	37	6	N. 68° W. and N. 40° E
NW. ¼ NE. ¼......	12	35	7	N. 45° W. and N. 50° E
NW. ¼ SE. ¼......	27	37	7	N. 70° W. and N. 40° E
NE. ¼ SE. ¼.......	28	37	7	N. 10° W. and N. 85° E
NW. ¼............	20	37	7	N. 80° W. and N. 78° E
SE. ¼ NE. ¼.......	19	37	7	N. 25° W. and N. 65° E
SW. ¼ NE. ¼......	20	37	7	N. 10° W. and N. 78° E
SW. ¼ NE. ¼......	13	37	6	N. 52° W. and N. 63° E
SW. ¼ NE. ¼.....	13	37	6	N. 36° W. and N. 40° E
SE. ¼.............	2	37	6	N. 60° W. and N. 58° E
NE. ¼............	2	37	6	N. 38° W. and N. 28° E
SE. ¼.............	34	38	6	N. 52° W. and N. 65° E
NW. ¼ SE. ¼......	11	35	7	N. 70° W. and N. 15° E
NW. ¼............	23	35	7	N. 83° W. and N. 16° E
NW. ¼............	18	35	8	N. 30° W. and N. 85° E
NW. ¼............	19	35	8	N. 4° W. and N. 88° E
NW. ¼............	33	36	8	N. 52° W. and N. 30° E
NW. ¼............	5	35	8	N. 30° W. and N. 40° E
NW. ¼............	6	35	8	N. 68° W. and N. 12° E
SW. ¼............	36	38	6	N. 45° W. and N. 75° E
SW. ¼............	17	37	7	N. 62° W., N. 70° W. and N. 48° E
SW. ¼............	1	37	6	N. 50° W. and N. 50° E

Stratigraphic Relations of the Bonneterre. The Bonneterre lies unconformably on the underlying Lamotte sandstone, but it is apparently conformable with the overlying Davis, for in a few places at least, there is a transition between the two formations.

Correlation. The Bonneterre formation, being Upper Cambrian in age, may be correlated with some of the known Upper Cambrian formations in other provinces. Over great distances such correlation must be done entirely by means of the fossil faunas found in the various formations. The Bonneterre is supposed to be of approximately the same age as the upper part of the Reagan formation found in the Arbuckle and Wichita Mountains of Oklahoma, and the Katemcy of Texas. Similar species of fossils are also found in the Deadwood formation in the Black Hills of South Dakota and in the Big Horn Mountains of Wyoming. In Alabama a part of the Conasauga formation is supposed to correspond to the Bonneterre of Missouri, and the Maryville limestone of Tennessee is represented in part by the Bonneterre. Certain horizons of the formation east of the Farmington anticline are made up of relatively pure limestone, resembling in this respect the Maryville formation more closely than it does the typical Bonneterre of the Flat River district.

Paleontology: A composite but far from complete list of fossils found in the lower 100 feet of this formation at four places in Ste. Genevieve County—Terre Bleue Creek; 3½ miles south of French Village; 1 mile southeast of Avon; near Avon; and 2 miles southwest of Coffman—follows:

Fauna of the Bonneterre Formation

Lingulella leos Walcott.
Obolus 2 undet. sp.
**Micromitra alabamensis* Walcott.
**Micromitra sculptilis* (Meek).
Acrotreta.
Linnarssonella girtyi Walcott.
Hyolithes sp.
Plates of some chiton?
**Agnostidae* of at least five species.
Four species all closely allied to Appalachian and cordilleran forms assigned to *Anomocarella* by Walcott.
Maryvillia sp.
Hystricurus, 3 species.
**Menomonia* cf. *calymenoides* (Hall).
**Kingstonia*, 2 n. sp.
Millardia.
**Norwoodia* aff. *gracilis* Walcott.
"*Saratogia*" aff. *wisconsinensis* (Hall).
*"*Crepicephalus*" *texanus* Shumard.
**Crepicephalus comus* Walcott.
**Crepicephalus thoosa* Walcott.
**Crepicephalus*, 5 or 6 unnamed species.

The extraordinary development of the genus "*Crepicephalus*" is the most striking, and, for correlation purposes, also the most important feature of this fauna. All of the species have close allies in east Tennessee, Alabama, Central Texas and Montana. The other starred species usually also occur with the same or closely allied species of *Crepicephalus* in the mentioned states.

DAVIS FORMATION

Name. The Davis formation was first described in detail by Buckley[1] and the upper part of the formation corresponds to the lower part of the Elvins of Ulrich[2]. In the type section in the Flat River district, the formation consists of between 150 and 190 feet of intercalated shales, dolomite, limestone and conglomerate, the formation varying considerably in lithologic character and thickness in comparatively short distances. In Ste. Genevieve County the formation is much thinner and less well developed, but it is more constant in thickness. It is similar, however, in its lithologic characters and variability.

Areal Distribution. The areal extent of the Davis is very limited, its outcrops being commonly situated on hillsides having well-developed slopes. Except locally where the formation outcrops on hilltops or ridges, the belt which extends through the county east of the Bonneterre area is narrow, varying from a few hundred feet to approximately one-fourth mile in maximum width.

Thickness. The Davis varies in thickness from 65 to 80 feet, and in most places about 70 feet of dolomite and shale constitute the formation, although in the southwestern part of the county there are a few places where the thickness may reach as much as 100 feet.

Topography. The Davis formation has no distinctive topographic features. Along with the Derby-Doerun beds it is commonly exposed well up on the hillsides, some of which are quite steep, but in other places where there is considerable shale in the formation, the slopes are gentle. On the whole the formation occupies steep and very rough, hilly topography, a large part of which is talus covered.

There are several caves in the Davis formation in Ste. Genevieve County, one, with a small sink hole for its entrance, is situated in the SE. ¼ sec. 18, T. 36 N., R. 8 E., and apparently extends for a considerable distance, said to be over a mile. Other caves, some of which contain stalactites and stalagmites, exhibit good-sized chambers which are the result of solution.

Lithologic Character. The Davis formation is composed of intercalated beds of dolomite and shale, both of which vary in

[1]Disseminated Lead Deposits, Missouri Bur. of Geology and Mines, 2nd ser., vol. 9, pt. 1, 1909.

[2]Copper Deposits of Missouri; Bull. U. S. Geol. Surv., No. 167, 1905.

chemical composition and in lithic characters. The dolomite is medium to finely crystalline in texture and commonly dense, although some porous spaces and small cavities exist which are in some cases filled with calcite crystals. In many places it is sandy or argillaceous and the color gray to buff, but where the shale in the dolomite is greenish, a similar color is imparted to the dolomite. The color of the fine-grained dolomite is commonly dark gray on fresh surfaces, and the more crystalline portion in most places has a very glistening appearance. Weathered surfaces vary in color from dark bluish-gray to various shades of brown, the latter depending upon the amount of iron present. In the unaltered rock the iron commonly occurs as small crystals of pyrite and marcasite, which on weathering are changed into the yellowish-brown oxide of iron, limonite, present as rounded concretions in the dolomite. More iron is present in the formation in the northern part of the county than elsewhere. Fucoidal (?) markings in the dolomite occur locally.

The individual beds of the dolomite vary considerably in thickness. Some of the horizons are composed of thick ledges, which, upon weathering, break up into thin layers ranging in thickness from less than an inch to several inches or a foot. Some of the beds have thin shale partings and others have very thin discontinuous lines of wavy shale within the layers, and upon breaking along these lines they give rise to a very irregular fracture. The shale partings vary in thickness irregularly, expanding in short distances to beds from a few inches to several feet in thickness. The color of the shale in most places is greenish-gray to light yellow or dark bluish-gray, the yellow shale being typical of the more southern part of the county, the other colors being present more commonly in the northern part. Thin-bedded, argillaceous dolomite commonly yellowish in color, is found locally interbedded with the fissile shale. Shale beds several feet in thickness occur at two distinct horizons in the formation in many parts of the county, but they are not continuous. The base of the uppermost shale horizon is about 15 feet from the top of the formation, and the top of the lower one is from 15 to 20 feet above the base. In many places shale beds occur between these two more persistent horizons mentioned. Probably the best shale exposure, situated practically at the base of the formation, is in the NW. ¼ SE. ¼ sec. 1, T. 37 N., R. 6 E., where the bed is about 11 feet thick and consists predominantly of blue shale, although in the upper part it is yellow. Interbedded with this shale there are a few thin, lenticular or dividing beds of argillaceous dolomite, one to three inches thick, which are present near the bottom and near the top of the shale horizon. Above this shale bed there are 4 feet of thin-bedded, yellowish to bluish-gray dolomite, divided by thin shale partings. The same horizon is present at another locality along the main road in the NW. ¼ NW. ¼ sec. 12, T. 37 N., R. 6 E., but only about six feet is exposed, most of which is yellowish-gray in color, and below the shale there are two feet of thin-bedded, light-brown, argillaceous dolomite resting directly upon the Bonneterre dolomite.

Near the top of the Davis formation in several localities, there is a ledge of dolomite which, in general appearance, partly resembles edgewise conglomerate, and a similar ledge is also present near the bottom of the formation in places. The dolomite in these ledges shows distinctly different colors and calcium content, the elongate parts, which resemble pebbles, are much more calcareous and have a deeper brown color than the remainder of the rock, which is commonly a gray, greenish-gray, or very light brown. Upon close examination it can be determined that in many cases the crystallinity of the apparent pebbles is the same as the matrix and that there is no line of separation at their border except in color, but elsewhere the texture of the two parts is different. This occurrence is the nearest approach in Ste. Genevieve County to the edgewise conglomerate of the formation that is present in the Flat River district, but if it were a conglomerate originally, recrystallization has completely obliterated the boundaries of the pebbles except for color and composition.

The following detailed section through the Davis formation, made along Fourche a du Clos Creek in the south side of sec. 36, T. 38 N., R. 6 E., one mile above Lawrenceton, will apply in general to the northern area of the Davis in Ste. Genevieve County:

Section of Davis Formation, South Side Sec. 36, T. 38 N., R. 6 E.

		Feet	Inches
11	Shale, bluish to greenish, fissile		2
10	Dolomite, argillaceous, brown to gray, contains shale in small patches. Hard, finely crystalline; contains many pieces of fresh pyrite and limonite	8	
9	Shale, calcareous, or argillaceous dolomite, light and brown in color, thin-bedded	4	6
8	Dolomite, brown, finely crystalline, with some greenish shale spots and small specks of chlorite	3	

		Feet	Inches
7	Shale and shaly dolomite, thin-bedded	9	
6	Dolomite, hard, finely crystalline, shiny. Some small crystals of iron sulphide. Bedding 1 to 16 inches thick. Shows some irregular, thin, clay seams. Seven feet from the top is a thin shaly horizon, very argillaceous; contains iron specks throughout. Pyrite occurs near top. On weathered edges, breaks up into thin layers	21	
5	Dolomite, thin-bedded, shiny, brown color. Grayish-green shale, seams and some iron	1	4
4	Dolomite, dark, finely crystalline, alternating with dark-gray beds showing fine depositional laminae; hard with some iron concretions and brown spots	1	3
3	Dolomite, shaly, argillaceous, brownish-green in color; beds ¾ in. thick	2	6
2	Dolomite, hard, finely crystalline, brown to gray in color; ovoid spots resembling pebbles of edgewise conglomerate, brown specks, due to iron; bedding 6 to 12 inches	5	
1	Not exposed. Probably shale and shaly dolomite as described for the basal beds in sections 1 and 12, T. 37 N., R. 6 E	15 +	

A comparison of the foregoing section with that of the type locality in the Flat River district[1] shows a great similarity in lithic characters of the dolomite and shale, but the conglomerates and limestone are conspicuously absent in Ste. Genevieve County.

In the southern part of the county the Davis formation differs somewhat from the section given, chiefly in the dolomite. In many places the formation is essentially all dolomite similar in character to the underlying crystalline light to dark gray Bonneterre dolomite, and but for the occasional bed of yellowish shale and shaly, argillaceous dolomite, the separation of the two formations would be difficult. As it is the contact is poorly defined in many places.

Stratigraphic Relations of the Davis. The Davis is apparently conformable with the Bonneterre below, and with the Derby-Doerun above. The contacts are not everywhere distinct, for locally there is a gradation from the underlying and a gradation into the overlying formation, but elsewhere the contacts are well marked by lithologic differences in the beds. However, the absence of the lower part of the formation in Ste. Genevieve County, which is below the "Central" marble boulder horizon in the Flat River district about 15 miles to the west, suggests the possibility of an emergent stage of the epoch on the east side of the Farmington anticline.

Structure. In the northern part of the county the Davis, as well as the overlying Derby-Doerun and the underlying upper beds of the Bonneterre, have a steep dip in practically all localities, the average being between 6° and 9°, which is somewhat higher than the normal dip of the other formations. In the

[1]Mo. Bureau of Geol. and Mines, 2nd ser., Vol. 9, pt. 1, pp. 39-43, 1909.

southern part of the county the dip is about normal, usually being but a few degrees. The Davis and the beds in close relations have been faulted in a number of places, principally in the areas of relatively high dips, and some of the faulting may be due to solution in the Davis and the underlying Bonneterre dolomites and the consequent settling of the beds.

Correlation. A comparison of the Davis formation in Ste. Genevieve County with the typical Davis in the Flat River district brings out a strong similarity between the Ste. Genevieve manifestation of the formation and its upper 63 feet in the type locality or the beds above the "Central" marble boulder horizon. Neither this boulder horizon nor any equivalent of it has been recognized east of the Farmington anticline, which makes it appear that the lower part of the Davis formation may be wanting in Ste. Genevieve County.

Paleontology. No fossils were collected from the Davis formation in Ste. Genevieve County and the lists given below are compiled from collections made at typical exposures of the Davis formation in the Flat River district. The following fossils were collected on Shaw Branch of Davis Creek, from a thin layer of limestone 15 feet beneath the so-called "Marble Bed."

Fauna of the Davis Formation, Shaw Branch

Lingulepis aff. *acuminata* (Hall).
Linnarssonella girtyi Walcott.
Agnostus sp.
Irvingella sp. 1.
Irvingella sp. 2.
"*Saratogia*" cf. *hera* Walcott.
Plataegis n. sp.
Housia n. sp.
Three small new trilobites of undetermined generic relations.

Though this fauna lies only a few feet above the base of the Davis shale it is unquestionably younger than any found in the Bonneterre. The latter are particularly characterized by a great development of trilobites now assigned to the genus *Crepicephalus*. Compared with Upper Cambrian faunas in Wisconsin the Bonneterre fossils indicate an age corresponding to that of the Eau Claire shale. This lowest of the Davis fauna zones, on the contrary, is shown by the presence of *Irvingella* and "*Saratogia*" to be younger than the top of the Dresbach sandstone. Probably it falls into the stratigraphic hiatus that is known to occur in Wisconsin between the Dresbach and the varying base of the next following Franconia formation.

The fossils given below were collected from three layers in a 10-foot zone of the Davis shales lying 26 to 36 feet above the top of the massive Bonneterre dolomite, at Flat River, just south of Federal Lead Co. shaft No. 4.

Fauna of the Davis Formation at Flat River

Pterocephalia sp.
Dokiomorphalus gregeri Walcott.
Elvinia roemeri (Shumard).
Elvinia texanus (Walcott).
Elvinia large n. sp.
Five or six new species of an undescribed genus closely allied to *Taenicephalus*.
Wilbernia sp., also other undetermined trilobites.
Linnarssonella girtyi Walcott.

This fauna is very widely distributed in the United States and hence of great value in stratigraphic correlation. Outside of Missouri it is recognized by identified species in the lower third of the Honey Creek formation of Oklahoma, in the Wilberns formation of central Texas, in the Dunderberg shale of Nevada, in the Deadwood formation of South Dakota and in the Ironton sandstone member which lies at the base of the Franconia formation in Wisconsin. Unlike the *Crepicephalus* the fauna of the Bonneterre, which spreads even farther over North America, this Davis shale fauna did not extend into the Appalachian region.

In the Flat River district, as in Oklahoma and Wisconsin, the *Elvinia-Pterocephalia* fauna is succeeded first by brachiopod faunas, comprising little else than species of *Eoorthis*, among them *Eoorthis remnicha* and *Eoorthis texana.* These brachipods also attained great and very similar distribution to the preceding Elvinia fauna and like it failed to reach the Appalachian region. Above the *Eoorthis* zone one rarely finds a weak representation of the *Taenicephalus shumardi* fauna which holds the middle part of the Franconia formation in Wisconsin and a similar position in the Honey Creek formation in Oklahoma.

DERBY-DOERUN FORMATION

Name. The Derby and Doerun formations were named by Buckley[1] from localities south of the Flat River district in St. Francois County, where they are typically developed. In his report the two formations were mapped separately on the detailed geological maps, there being definite lithologic differences between them, but there is no such lithologic uniformity in Ste. Genevieve County, and on account of the very small development of the formations it has been impracticable to separate them. They are, therefore, mapped and described as the Derby-Doerun.

[1]Disseminated Lead Deposits, Mo. Bureau of Geol. and Mines, 2nd ser., Vol. 9, pt. 1, 1909.

Areal Distribution. The areal extent of the Derby-Doerun beds is very small in Ste. Genevieve County. They are found principally in a narrow belt of outcrop along steep hillsides, parallel with the underlying and the overlying formations.

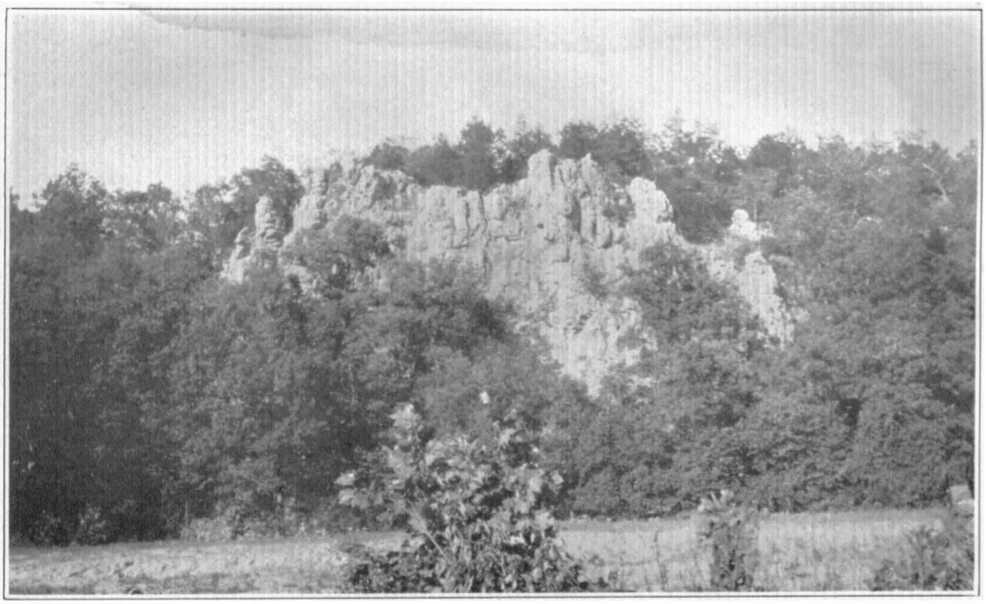
Thickness. In the northern half of the county the Derby-Doerun formation is about 70 feet thick, the variation in thickness not exceeding 10 feet. To the south the thickness is much reduced, varying between 8 and 35 feet, with the average thickness about 15 feet.

Topography. The Derby-Doerun formation does not produce a characteristic topography, but in connection with the overlying and underlying formations, it is instrumental in forming steep hills and deep ravines. This is especially true in the northern part of the county where it is thickest. Elsewhere the formation has little effect on the topography. The outcrops of the formation usually occur well up on the hillsides.

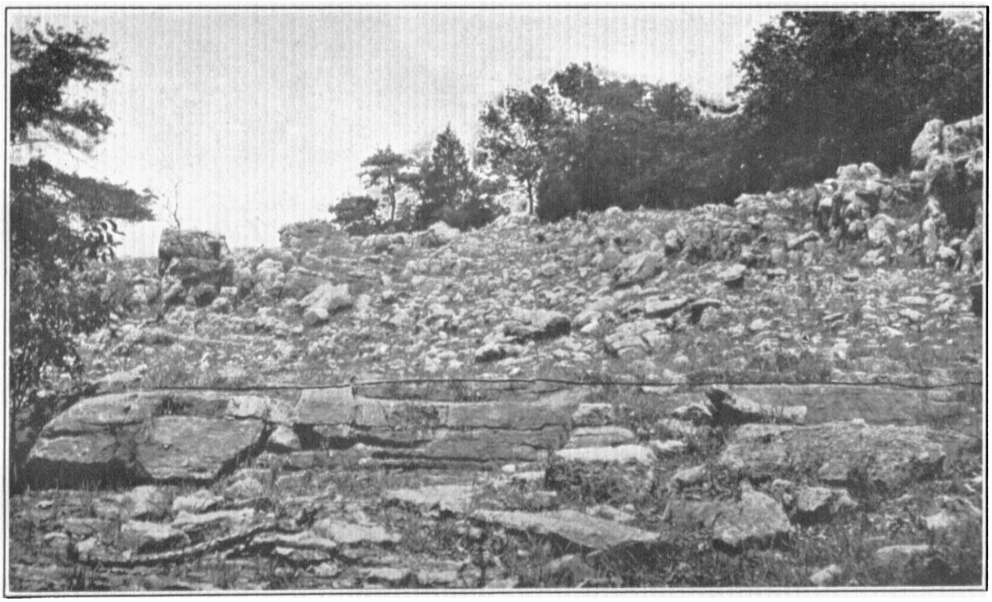
Lithologic Character. The whole of the Derby-Doerun is composed of dolomite. In the northern part of the county it is very finely crystalline, dull gray in color, with an irregular fracture. In places the beds contain a considerable amount of calcite in the upper part. The beds range in thickness from six inches to five feet or more, and commonly form massive outcrops which are very resistant to weathering. Some of the beds yield a calcareous material which collects as a froth-like powder under outcropping ledges, or as a white stain on the surface, and in places the under sides of ledges have a deposit of rod-like stems of calcareous matter. In most outcrops in the northern part of the county, the Derby-Doerun resembles the Derby of the type locality, and in only one locality, so far as observed, are the upper beds composed of the typical, buff-colored, argillaceous dolomite of the Doerun formation as it is exhibited in the Flat River district.

The following section in the bluff on Fourche a du Clos Creek, in the south side of sec. 36, T. 38 N., R. 6 E., shows the homogeneity of the formation:

		Feet	Inches
2	Dolomite, partly argillaceous, fine-grained, hard, gray to buff color, with irregular fracture. Ten feet from the top is a ledge which is much pitted, almost cavernous, on the upper surface. Resembles some of the Derby beds at Flat River..................................	20	
1	Dolomite, finely crystalline, very hard, gray in color with even fracture. In places the rock is brown, due to the presence of small particles of iron. Bedding varies from a few inches to several feet in thickness. Ten feet from the base is a fossiliferous bed containing brachiopods..	50	



A. Bonneterre dolomite on River aux Vases.



B. Contact between Derby-Doerun and overlying Potosi.

In the southern half of the county the Derby-Doerun beds are very different. The formation is much thinner, being composed of but two ledges where the thickness is but eight to 12 feet. In many places the upper part is an argillaceous, buff colored dolomite which locally contains sugary quartz druses and displays cross-bedding characteristics which make it the counterpart of the upper Doerun in the Flat River district. The remaining portion of the formation simulates more closely the typical Derby. The beds are composed of dark, finely crystalline, irregularly fractured dolomite, most of which is very resistant to weathering. The surfaces of some of the ledges is pitted and the extreme hardness of the rock is a persistent character.

Stratigraphic Relations of the Derby-Doerun. The Derby-Doerun is apparently conformable with the underlying Davis formation, although a stratigraphic break may exist. In many places there seems to be a gradation from the lower formation into the upper, but elsewhere the lithologic difference is fairly well defined.

No direct evidence of an erosional unconformity between the Derby-Doerun and the overlying Potosi formation has been observed, although the variation in thickness of the Derby-Doerun, especially the local variations found to exist in the southern part of the county, suggest that parts of the formation may have been removed by erosion before the Potosi was deposited. Ulrich's correlation of the Potosi formation of Missouri with certain beds in Alabama[1] indicates a deposition of between 1,500 and 2,000 feet of sediments in the Cahaba Valley which are entirely wanting in Missouri, and if his interpretation is correct, a considerable hiatus is expressed in an unconformity between the Derby-Doerun and the Potosi. The unconformity between the Derby-Doerun and the overlying Potosi is used by Ulrich to mark the boundary between his Upper Cambrian (restricted) and his Ozarkian.

Paleontology. No fossils having been found in these dolomitic beds trustworthy data are as yet lacking that would indicate their correlates elsewhere. As the highest of the underlying Davis shale faunas are of middle Franconia age the Derby-Doerun may be either late Franconia or Trempealeau age.

[1]Revision of the Paleozoic Systems, Bull. Geol. Soc. Amer., vol. 22, 1911.

OZARKIAN SYSTEM OF ULRICH

POTOSI FORMATION

Name. The name of this formation was taken from the town of Potosi, in Washington County, Missouri, and was first proposed by Winslow[1], although the formation was not correctly understood by that writer. As used by Bain and Ulrich[2], the term included the group of formations between the Elvins below and the St. Peter sandstone above, but Buckley[3] used the name in the sense that it was being used in the mining districts, that is to cover the horizons of cherty, drusy, dolomites which overlie the Doerun formation of the Elvins. The usage in the present report conforms with that of Buckley. The Potosi formation as here interpreted was included under the Gasconade by Bain and Ulrich, and Swallow's "Fourth Magnesian limestone" was, in part at least, equivalent to it as it has been differentiated in the latest reports. The formation constitutes the lowest member in Missouri of Ulrich's Ozarkian.

Areal Distribution. The Potosi formation outcrops in a belt of variable width which crosses the county in a general northwest-southeast direction, lying east of the next older formations, with the narrowest part of the outcrop in the northern part of the county. North of the Missouri-Illinois Railroad the average width is less than one-fourth of a mile, between River aux Vases and Saline Creek the belt averages between two and three miles in width, and south of Saline Creek the formation covers irregular areas of hilltop and valley.

Thickness. At no place in the county has it been possible to make a complete section of the Potosi or to measure its thickness accurately. In the northern part of the belt, northwest and southeast of Lawrenceton, the thickness is approximately 160 feet, but the greatest thickness is in the central and southern parts of the county where the average is about 200 feet. In the extreme southern part of the county, in the Greasy Creek drainage, there are places where the thickness cannot be more than 150 to 160 feet.

Topography. The general topography of the Potosi area is hilly and rough. The stream valleys are commonly narrow

[1]Mo. Geol. Survey, 1st ser., vol. 6, 1894.
[2]Copper Deposits of Missouri, Bull. U. S. G. S., No. 267, 1905.
[3]Missouri Bureau of Geology and Mines, 2nd ser., vol. 9, part 1, 1909.

and steep-sided, although in a few of the larger streams good bottom-land areas have been developed and the immediate hill slopes are more rounded and are well adapted for agricultural purposes. In the northern part of the county the Potosi is found only on narrow ridges between steep-sided valleys. In the central part, at the headwaters of Little Saline Creek, there are several square miles of rolling country most of which is under cultivation. In the remainder of the county, especially south of this area, the Potosi caps many hills and occupies steep slopes and narrow valleys, although along Saline Creek some of the hillsides have gentle slopes. Most of the Potosi ridges are covered with residuum and are wooded, but in the southern part of the county some show outcrops of granular dolomite nearly bare of vegetation, and similar conditions prevail on some of the hills south of Mill Creek. This granular dolomite from later studies is now considered Eminence in age.

Lithologic Character. The Potosi formation consists of crystalline dolomite, most of which contains quartz druses; and honeycombed chert, most of which shows crystalline quartz.

Crystalline Dolomite. The crystalline dolomites have a characteristic shiny, dark brown to light chocolate color on fresh surfaces, but when weathered, the color is dark gray to very dark bluish gray. In a few horizons the Potosi dolomites are light in color, but the characteristic appearance is brown. In texture these dolomites are medium to coarsely crystalline, hard, rather dense, and they break with an uneven fracture. Numerous small and large cavities exist in the rocks, some of which are lined with small crystals of dolomite, but most of them are filled with crystalline and chalcedonic quartz. The crystalline dolomites are massive in most places, although bedding is exhibited locally.

The dolomite is not very resistant to weathering agents, and in only a few places does it outcrop in cliffs. Some of the more pronounced cliffs are along Goose Creek near the county boundary, on the west side of Establishment Creek in the northwest corner of sec. 21, T. 37 N., R. 7 E.; and at the mouth of Coldwater Creek in the southern part of the county. The presence of many large springs shows that the dolomite is easily soluble. Excepting the outcrops along streams, the larger part of the Potosi is residual, the quartz druses being found scattered over the surface in great profusion in some places. Weathering of the dolomite which contains the quartz druses results in a rough surface to the outcrop, the quartz being more resistant than the dolomite, and standing out in clear relief on the surface. Weathering also produces a very irregular system of vertical joints, and the rocks split along irregular semi-bedding planes, a manner of breaking which produces angular and jagged surfaces upon the outcrop.

Quartz Druses. The quartz druses are the most characteristic feature of the Potosi, and their presence or absence is the chief determinative criterion for recognizing the formation. They occur as stringers and small geodes in the crystalline dolomite, as concretionary growths about a nucleus, or partially covering some surfaces. In some places the stringers are continuous and connect with the geodes, or both forms of occurrence may be isolated within the dolomite with apparently no outside connections.

The druses are composed of bands of finely and coarsely crystalline quartz and chalcedony. The banding may be produced by alternating layers of crystalline and cryptocrystalline quartz, but more commonly several bands of crystalline quartz occur together, differing a little in the size of the crystals, and interlayered with very thin beds of chalcedony. In one concretionary specimen studied, the banding is 12 mm. wide, with about 70 distinct bands of crystalline and chalcedonic quartz. Another 13 mm. in width, has 98 bands. In the stringers and geodes within the dolomite, the banding has grown from the walls towards the center, completely filling the cavities in some cases, but where the quartz has formed about a central nucleus the growth has been outward. In the former occurrences the quartz crystals are all very small, except in a few of the larger geodes, but in the latter the quartz crystals become larger as the growth progresses, and several of the outer layers may be composed of crystals as much as one-fourth inch across. Most of the quartz in the druses is white to clear in color, but in some specimens the banding is in varying colors of red to white, produced by the presence of iron in the solutions which furnished the silica.

Chert. Nearly all of the chert in the Potosi is drusy. In places there are massive beds of honeycombed chert with many drusy stringers running through them, and with the surface commonly covered by crystalline quartz. On weathering these beds break into fragments of various sizes and a residuum of crimson colored clay soil. Many of these beds of honeycombed chert closely simulate the horizons of honeycombed chert which are so typically developed in the Gasconade, (see illustration page X), but the latter lack the druses. This type of Gasconade chert is thought to be organic, probably representing some vegetable life which lived in the shallow Upper Cambrian seas, and it seems only reasonable, considering the marked similarity in structure and appearance of the Potosi chert, to consider it also as representative of some organic life. A species of Cryptozoon has been observed in the Potosi, which shows that some marine vegetable life did exist during this time in these seas.

Age of the Druses. The age of formation of a portion of the druses, at least in Ste. Genevieve County, can be determined accurately within definite limits. The basal deposits of the overlying formation, which is unconformable upon the Potosi, contain in numerous places in the southern part of the county typical Potosi druses as inclusions in a conglomerate with a dense chert matrix. Such a situation shows that these particular druses were formed prior to the deposition of the overlying beds, and also that the silica from which they were formed was in all probability indigenous to the Potosi formation. Some of the druses, therefore, were formed either during Potosi time or during a period of post-Potosi emergency.

Structure. The Potosi rocks show numerous irregularities in dip, and in a few places very pronounced faulting. Many such irregularities may be the result of solution and settling within the formation. The area most affected in this manner is along Goose Creek, about two miles north and northwest of Lawrenceton. The number and position of the faults, the irregularity in their direction and degree of dip, and the presence of several large springs, suggest that solution may have been of primary importance in the dislocation of the beds. In numerous other localities in the county, irregularity in the dip of the beds is common.

Stratigraphic Relations of the Potosi. The Potosi rests unconformably upon the Derby-Doerun. The exact relation to the overlying Eminence was not determined although no evidence of unconformity was observed.

Correlation. The Potosi formation of Missouri is very closely simulated by certain deposits in the Cahaba Valley of Alabama[1], formerly referred to as the Potosi by Ulrich but more recently designated as the Bib dolomite by Butts. In the Mis-

[1] U. S. National Museum, Bull. 92, Vol. 2, Plate 2, 1915.

souri localities the Potosi rests upon the Elvins formation, of which the Derby-Doerun is a constituent part, with unconformable relations, but in Alabama the supposed equivalent, or Bib dolomite, is said to wedge in between the Knox dolomite above and the Ketona formation below. The pre-Potosi hiatus in Missouri is represented in Alabama by the Briarfield and Ketona dolomite formations which have an aggregate thickness of over 1,500 feet.

Fossils are very rare in all of these lower formations in Missouri. In the Potosi only one poorly preserved Cryptozoon has been observed, and Ulrich has reported only two specimens, one an indeterminable gastropod about one inch in height, and the other a fragment of a Cryptozoon.

EMINENCE FORMATION

Name. Eminence is the name which has been used by Ulrich[1] to cover the cherty dolomites which overlie the Potosi. The type section is at Eminence, Shannon County, Missouri, where Ulrich divided the formation into the lower and upper Eminence, the maximum thickness of the two members together along Current River in the type locality being approximately 350 feet.

One of the most difficult parts of the stratigraphy of the Ozark region is involved in the differentiation of that part of the geologic column between the Potosi and Gasconade formations. At the time the field work for this report was being carried on the lithologic character and stratigraphic relations of the Eminence formation were not thoroughly worked out even in the type area, and as a consequence in this work no endeavor was made to map the Eminence as a separate formation, although its presence was recognized at that time. The scope of the work did not include the extensive studies necessary to work out the complete stratigraphy of the succession, and the light colored beds of the Eminence were included as the upper part of the Potosi or the lower part of the Gasconade, and they have been so included on the geological map which was published some years ago.

More recent field work throughout the Ozark region by C. L. Dake, J. Bridge and E. O. Ulrich has definitely determined

[1]Ulrich, E. O., Revision of the Paleozoic Systems; Bull. Geol. Soc. America, No. 122, 1911.

the character and position of the Eminence and the following description as prepared by Mr. Dake indicates the beds in Ste. Genevieve County that can now be assigned to the Eminence.

Areal Distribution. At the sharp bend in Goose Creek, near the common corner of secs. 23, 24, 25, and 26, T. 38 N., R. 6 E., the northeast wall of the valley is composed of a cliff or steep slope exposing 120 feet of typical Eminence dolomite, carrying some chert. The Eminence extends from creek level to the basal Gunter sandstone of the Gasconade. In this section the base of the Gasconade is correctly located, and the Eminence is shown on the map by the color and symbol of the Potosi formation.

On the top of the hill in secs. 16 and 21, T. 36 N., R. 8 E., the patch of material mapped as Gasconade comprises one of the areas where the Eminence has been included in the higher formations. Also on the ridge across sec. 10, T. 36 N., R. 8 E., where, at bench-mark 886, near the center of the south line of the section, typical Eminence fossils were taken from heavy masses of chert, essentially in place in the road ditch, 100 feet above the horizon shown on the map as the base of the Gasconade. At this point the Eminence is included in the Gasconade as mapped.

The uplands about Womack, in the south edge of the county, show a capping of from 20 to 50 feet of Eminence, mostly obscured by heavy residual cherts, which yield characteristic fossils. This area is included in the Potosi section. An effort was made in the original mapping to include what was known to be Eminence in the Potosi color on the map.

Thickness. The greatest thickness of the Eminence noted is on Goose Creek, in the SE. ¼ sec. 23, T. 38 N., R. 6 E., where the valley side shows 120 feet of practically continuous dolomite ledges, from creek level to the base of the Gunter. How far the formation may extend below creek level is not known.

In sec. 10, T. 36 N., R. 8 E., Eminence fossils were collected in place, mixed with residual Gunter, about 100 feet above the highest typical Potosi druses, so that the formation probably does not exceed 100 feet in thickness in this locality. About Womack, on the south border of the county, there does not appear to be over 50 feet of Eminence between the highest typical Potosi druse and the base of the Gasconade, and south of the county, near Higdon, in Madison County, Gasconade appears to rest directly on Potosi or older beds, with no intervening Eminence.

Topography. The Flatwoods area in the southern end of the county in the neighborhood of Womack, is the only area where the Eminence rocks have had much influence on the topography of the county. This flat is covered by hard, residual chert boulders of Eminence age, the resistence of the rocks and the gentle dip of the underlying strata being factors in the development of this striking topographic feature. In other parts of the county the formation is commonly found in the rough, broken country which is so characteristic of the area occupied by the Potosi and Gasconade formations.

Lithologic Character. The formation consists essentially of gray crystalline dolomite and chert.

Dolomite. The exposure on Goose Creek, in secs. 23, 24, 25, and 26, T. 38 N., R. 6 E., is not only the most extensive but also the most typical noted. The rock is a light gray to almost white, completely crystalline, medium to coarse-textured dolomite. It weathers to a darker gray, and appears granular to sandy on extensively weathered surfaces. Cavities lined with dolomite crystals occur locally and the surface is commonly more or less pitted or cavernous.

The formation occurs in heavy beds, or is locally very massive, and outcrops in irregular crags and pinnacles, in this respect closely resembling the underlying Potosi from which it differs in being much lighter colored and somewhat more coarsely crystalline.

It is also differentiated from the Potosi by the almost entire absence of the druses that are so typical of that formation.

It is distinguished from the overlying Gasconade by its much more massive bedding, in contrast to the well-bedded, often thinly-bedded basal layers of that formation; also by the absence of the dense white, very fresh-looking chert so common in the lower Gasconade, which contrasts strongly with the old-looking, more or less rusty, and commonly porous cherts of the Eminence.

Cherts. On cliffs and steep hillsides, the dolomites appear to be nearly chert-free, but on more gentle slopes, and upland divides, chert occurs as a thick mantle of residuum, and in road excavations, seems to be in definite beds, replacing the limestone as it weathers.

A very common type is a massive, more or less porous or honeycombed chert, ordinarily rusty looking, but locally grading into denser nearly white masses. This type carries some of the most diagnostic of the Eminence trilobites, and occurs in abundance along the hilltop in sec. 10, T. 36 N., R. 8 E.

A conglomeratic or breccia chert is also characteristic of the Eminence areas in Ste. Genevieve County. The matrix of the conglomerate is hard and dense, white to gray in color, with small and large fragments of quartz druses, most of which are angular, scattered through it. The distribution of this conglomerate is confined entirely to the Greasy Creek Hills where residual masses are found resting upon the Potosi formation, and also upon the Davis and Bonneterre. The largest masses have been observed in sec. 15, T. 35 N., R. 7 E., some being as much as 20 or more feet high and measuring more than 30 feet on a side at the base. At this locality the conglomerate boulders are resting on the Bonneterre formation. This has been considered "Upper Eminence," and may represent remnants of a formation once present, but removed by pre-Gasconade erosion; or it may be a phase of the Gasconade conglomerate.

Stratigraphic relations of the Eminence. Whether or not there is an unconformity at the base of the Eminence has not been determined from the work done in this county. It is now believed that the conglomerate mentioned in the foregoing paragraph is either basal Gasconade or younger.

The Eminence passes beneath the Gasconade with obvious unconformity, sandstone beds occurring widely at this contact, and conglomerate being common.

Correlation. According to Ulrich the Eminence of Missouri can be correlated by its fauna with the lower part of the Copper Ridge division of the Knox dolomite in Alabama, Tennessee, and Virginia, and with the lower part of the Oneota in the upper Mississippi Valley. It is an almost exact lithologic equivalent of the Eminence of the type section in Shannon County, and carries a practically identical fauna.

GASCONADE FORMATION

Name. Nason[1], in 1892, was the first to use the name Gasconade for one of the geological formations in the Ozark regions of Missouri. Under this term he included the Third and Fourth Magnesian limestones of Swallow's classification[2]. Bain and Ulrich[3] included under the name Gasconade all of the dolo-

[1] Rept. on Iron Ores, Mo. Geol. Surv., vol. 2, p. 115 (1892).
[2] First and Second Ann. Rep., Missouri Geol. Surv., pp. 114-131 (1855).
[3] Copper Deposits of Missouri, Bull. U. S. Geol. Surv., No. 267 (1905).

mites, cherts, and sandstones below the Roubidoux and above the non-cherty Elvins. Ball and Smith[4] confined the term Gasconade to the magnesian limestone between the Roubidoux above and the Gunter sandstone below, and in later state reports their usage has been followed. In this report the same interpretation is given to the formation with the Gunter sandstone, which occurs in only a few localities, considered as a basal member.

Areal Distribution. The Gasconade occupies an irregular belt of rough country from two to four miles wide which extends in a northwest-southeast direction through the county. The widest portion of the belt lies in the highland area east of Plattin Creek in the northwestern part of the county. East from Lawrenceton and as far south as River aux Vases, the belt of outcrop is more limited, but from there south it widens and an extensive development is again reached in the southern part of the county.

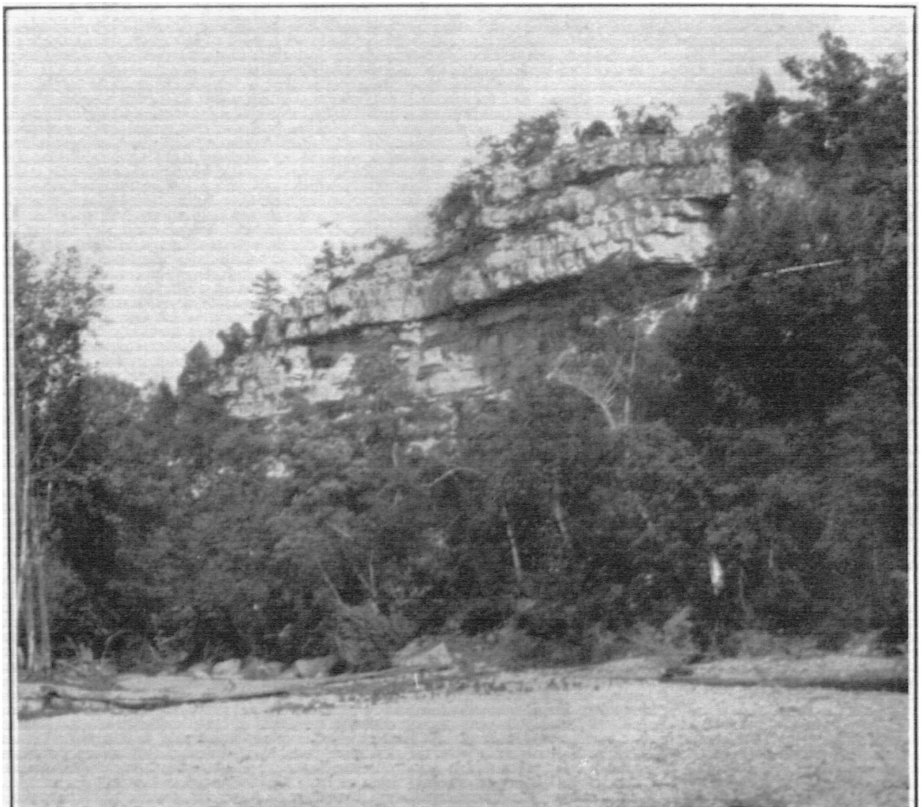
Thickness. The thickness of the Gasconade formation is variable. The section on Jonca Creek, which will be given later, where the whole formation is thought to be exposed, measures about 250 feet. The thickness undoubtedly varies in many places, probably reaching a maximum from Lawrenceton north, where about 300 feet is exposed, with the basal Gunter sandstone present.

Topography. The greater portion of the Gasconade area is deeply dissected. The stream valleys in many places have precipitous sides, cliffs from 20 to 50 feet high being common, and along some of the larger streams the cliffs range up to 200 feet in height. Probably the best exposures are along Jonca Creek, River aux Vases, Establishment Creek, and Goose Creek. Most of the divides close to the larger streams are very narrow, but a little farther back they are wider and considerable areas of rolling and gently dissected topography have been developed.

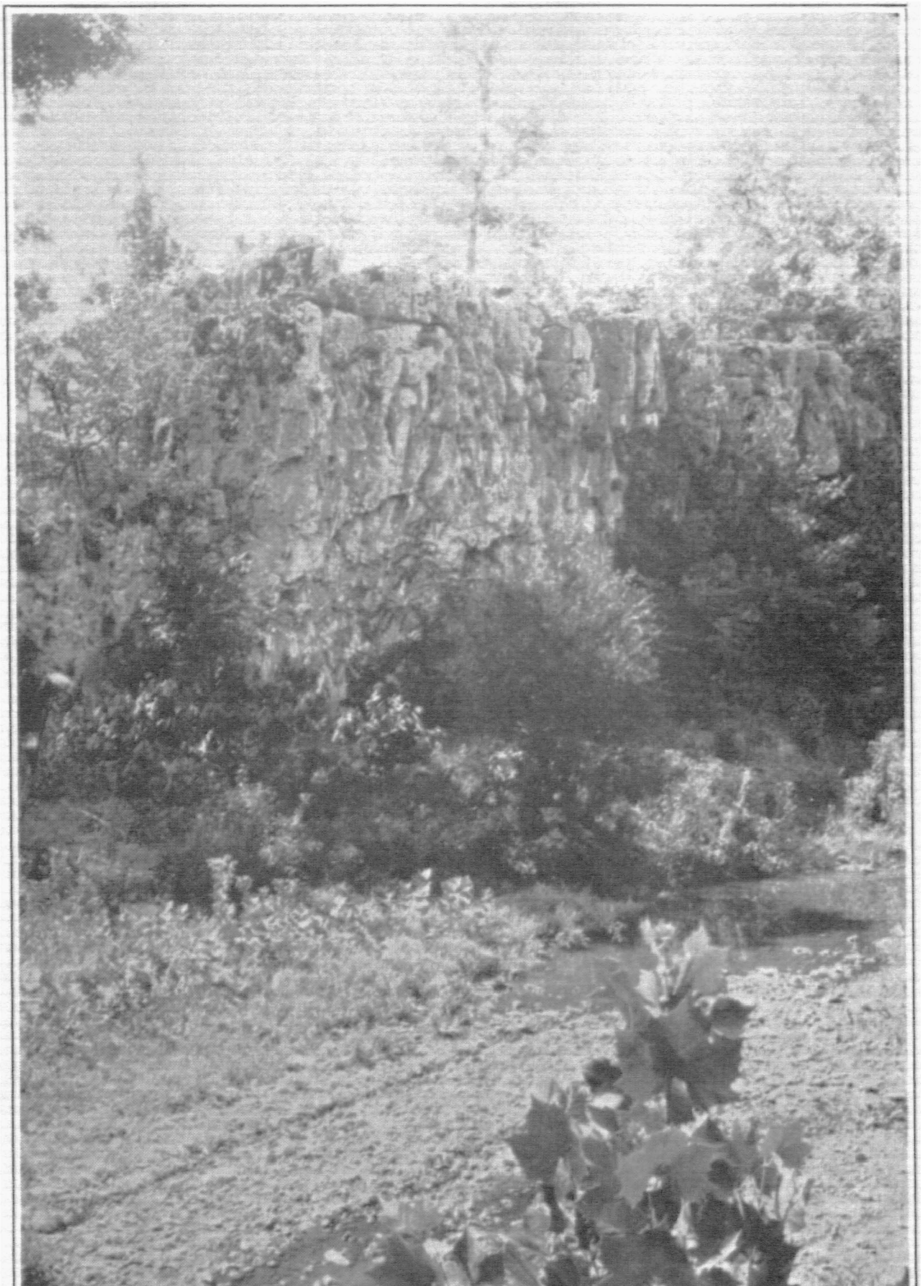
Caves of varying size are numerous in the Gasconade, and are the result of solution, some along old underground water channels, Salt Peter Cave, in the northeast corner of sec. 24, T. 36 N., R. 8 E., being the largest of this type. There are a few sink holes, the largest one being at the north entrance to Salt Peter Cave.

Lithologic Characters. The Gasconade formation is composed chiefly of crystalline dolomite with considerable chert

[4]Geology of Miller County, Mo. Bureau of Geol. and Mines, vol. 1, 2nd series (1903).



A. Potosi dolomite, junction Coldwater and Saline creeks.



B. Gasconade dolomite at Bee Bluff, Jonca Creek.

in beds and in concretionary masses. There are a few lenticular sandstone horizons and locally the basal Gunter sandstone shows distinct development. The following section of the entire Gasconade formation was made at the Jonca Creek bluff on the south side of sec. 31, T. 37 N., R. 8 E.:

Section of Gasconade Formation on Jonca Creek

		Feet	Inches
12	Residual Roubidoux chert containing many fossils. Alternating ledges of light-colored crystalline dolomite and talus, probably the whole thickness being represented by dolomite	25 +	—
11	Chert, cellular, yellowish to gray on weathered surfaces. Brownish, bluish, and light-colored quartz druses, very finely crystalline. Many small gastropods in chert	4	6 +
10	Fragments of chert containing small gastropods, white chert, some heavy unweathered layers probably in place	30	—
9	Chert bed, white	4	—
8	Dolomite, light grayish-brown in color, crystalline. Small cavities filled with calcite crystals. On weathered surface, pitted and yellowish in color	2	
7	Chert, light colored, honeycombed surface, small siliceous druses. In some places brownish in color	2	6
6	Dolomite, light brownish-gray, crystalline, pitted surface. Bedding 3 to 4 inches thick	3	6
5	Chert, white, fine-grained	4	—
4	Dolomite, pitted, medium-bedded, brownish-gray to light gray color, crystalline. Upper part has a little chert, including one 12-inch bed; lower part very cherty. Weathered surface of upper part gray; lower part very dark gray with very irregular surface, the latter due probably to the presence of much chert. Lower part is heavily bedded	46	—
3	Chert, white, compact, contains large concentric cryptozoon several feet in diameter	3	6
2	Dolomite ledges and talus. The dolomite is crystalline and light gray in color. Contains varying amounts of chert some of which has fine light to green-colored quartz on surface. Near bottom is a 6-inch bed of argillaceous dolomite	120 +	—
1	Sandstone, upper four feet brown, medium-grained, and shows large ripple marks. Lower three feet white, friable, cross-bedded and ripple-marked. Probably Gunter sandstone member	7	—
		252 +	—

Dolomite. The crystalline dolomite is the typical rock of the Gasconade formation. It is siliceous in places, the proportion of silica being sufficient to bring out the forms of fossils which are entirely obliterated in the ordinary dolomitic condition. The siliceous dolomite locally contains small patches and stringers of partially segregated silica which produce rough surfaces on the outcrops when weathered. The color of fresh surfaces varies from light to deeper shades of gray, although in places the rock is tinted with pale shades of pink or brown. On weathered surfaces the color is light to dark gray, or bluish-gray. Although the larger part of the dolomite is coarsely crystalline, some beds are finely crystalline, all are dense and commonly show comparatively little pore space although small cavities or vugs and porous patches are present in places, the vug containing small brownish crystals of calcite or dolomite in most cases, and the porous patches, which commonly run in narrow bands and streaks, containing fine brownish incrustations of calcareous matter. In a few places there are soft granular horizons which weather rapidly to dolomitic sand.

Most of the dolomite beds are several feet or more in thickness but upon weathering they break up into much thinner beds varying from a few inches to a foot or two. The weathered surfaces of some of the beds are much pitted, others weather uniformly, the irregular surface of the beds being the result, in large part, of partial segregation of the silica. Some beds show undercutting, a feature which is the result of solution together with alternate freezing and thawing of the water in the pore spaces of the rocks, causing fragments to break off from the under side of the outcrops. In some of the steeper draws, falls of from 10 to 40 feet in height have developed in the beds of intermittent streams, the rocks being in semicircular outcrop, with the lower side of the cliff undercut, due to its weathering back faster than the stream is eroding the top layers. In some places the Gasconade dolomite weathers to small polygonal blocks which have a semi-conchoidal fracture, a characteristic which is well shown along Hickory Creek in the south side of sec. 3, and the north side of sec. 10, T. 37 N., R. 7 E.

Chert. The chert of the Gasconade formation occurs as nodules or concretions. The nodular chert is everywhere extremely dense and fine grained, varying in color from white to shades of gray, and when broken open some of the masses exhibit a concentrically banded structure. The nodules occur either along the bedding planes or within the beds, the former being the more common position. They are ovoid in shape with the longer axis from four to eight times that of the shorter.

The chert occurring in beds is of three distinct types, viz, dense, white chert, cryptozoon chert, and cellular and ropy chert. The dense or fine-grained chert, white to gray in color, occurs in beds which commonly vary from a few inches to as much as three feet in thickness, although a few beds as much as 8 or 10 feet thick have been observed. In many places these beds grade into unchanged dolomite, the transition stages in the change from dolomite to chert being exhibited. Upon extensive weathering this chert changes into a soft, white, porous rock of uniform texture, known as tripoli. Residuum of the bedded chert is common on the hills and in the valleys in Gasconade areas.

The cryptozoon type of chert is the result of the silicification of certain fossil organisms to which the name *Cryptozoon* has been given. Two species of this organism are apparently represented, a concentric form very similar if not the same species as one found in some of the higher beds, and a laminar form. The concentric cryptozoon ranges in size from a few inches in diameter to several feet, and is not very abundant in the Gasconade, but specimens have been observed in a number of widely separated localities, a few of the more important occurrences being in the northwest corner of sec. 31, T. 38 N., R. 7 E., across the creek from Lawrenceton; in the south side of sec. 31, T. 37 N., R. 7 E., in the bed of a draw; and in the south side of sec. 31, T. 37 N., R. 8 E., about half way down the Jonca Creek bluff, in siliceous dolomite and chert. The more abundant variety of cryptozoon in the Gasconade, and a form which may be used as a distinguishing marker of the formation, is the species having a laminar structure. This form occurs in masses several feet thick, commonly, and is coarsely vesicular in texture. The laminae are minutely cellular plates arranged one above the other with but minute spaces between, they are convex and are divided laterally at intervals of about two inches. This type is found nearly everywhere near the top of the Gasconade, but its vertical distribution is not restricted, many fragments of it being strewn over the Gasconade area.

The cellular and ropy varieties of chert are common in the Gasconade, and their abundance at many horizons is a reliable guide in the recognition of the formation. Very close to the top of the formation in a number of localities, is a bed of cellular to ropy chert, hard, fine-grained in texture, light to dark gray on fresh fractures, and reddish-brown on weathered surfaces, which is very characteristic and is probably the preservation of some organism. Ulrich states that very similar beds occur in places near the top of the Oneota formation in Wisconsin, which is the equivalent in part of the Gasconade in Missouri. The best exposure of this type of chert which has been observed in Ste. Genevieve County is in the southwest corner of sec. 17, T. 38 N., R. 7 E., in the stream bed on the main road. A similar exposure may be seen on the road in the extreme north center of sec. 31, T. 38 N., R. 7 E., in the lower part of the Gasconade. (See illustration, Pl. V, A.) The organic structure is dimly exhibited in some of the dolomites, but it is not brought out distinctly until the dolomite has been silicified. A number of masses of the ropy chert have been found which are composed of thin, intertwining, silicified stems of some organism, and up to the present time this type has been found only in the Gasconade formation in Ste. Genevieve County.

Sandstone. The sandstone horizons found within the Gasconade are thin and extend over but small areas. Such horizons are known in only a few places, but these localities are widely separated in most instances. Such sandstone beds are not more than 3 feet in thickness where they have been observed.

Gunter Sandstone Member. The best development of the basal Gunter sandstone member of the Gasconade is exposed about 1½ miles northwest of Lawrenceton, in parts of sections 23, 24, 25, and 26, T. 38 N., R. 6 E. Just south of the center of sec. 26, about 30 feet of white, thin to thick-bedded, medium-grained sandstone is exposed, part of which is quartzitic, with the surface somewhat cavernous. A fault is present at this point and in consequence the exact thickness of the bed cannot be determined. A short distance northeast the thickness of the same bed is but 8 or 10 feet, and the sandstone has been largely changed to quartzite. From Goose Creek at the county line, east to Blue Spring, in the southeast corner of sec. 24, the basal horizon is composed of sandstone, quartzite, and some chert, the thickness varying from 8 to 25 feet, and at one place in the center of the NW ¼ sec. 25, where the sandstone dips under the creek, there is a thin bed of shale at the base of the formation.

West of the area described above, in the NW ¼ sec. 26, and in the NE ¼ sec. 27, T. 38 N., R. 6 E., in St. Francois County, the same basal horizon is present, but south of this, in sec. 26, the sandstone is absent. At Jonca Creek, in the south side of sec. 31, T. 37 N., R. 8 E., at the base of the detailed section already given, the 7-foot bed of ripple-marked white and brown sandstone is considered to be the Gunter member. On the ridge running through sections 19 and 20, T. 35 N., R. 8 E., much residual sandstone is present which is probably form the base of the Gasconade. Residual sandstones also occur along the hillsides bordering Coldwater Creek, in sections 22 and 27, T. 35 N., R. 8 E., which is believed to be from the base of the Gasconade, and these sandstones may be facies of the Gunter.

Structure. The Gasconade beds show considerable local structure throughout the county, flexures and sharp irregularities in dip are common along the larger streams, and although some of these flexures are clearly the result of the general crustal movements to which the region has been subjected, many of them must be attributed to conditions and movements within the formation itself, and the underlying Potosi. Underground solution has caused differential setting and probably some faulting. The presence of many large springs point to subterranean channels, and the numerous caves show the importance to be attributed to solution in previous times.

Stratigraphic Relations of the Gasconade. The Gasconade rests unconformably upon the underlying Eminence and in places on the Potosi, and in only a few localities is the basal Gunter sandstone known to be present at the base of the formation. The Gasconade is also unconformable with the overlying Roubidoux, there being a distinct stratigraphic break between these two formations.

The unconformity between the Gasconade and the Roubidoux formations in Missouri, marks the line of separation between the Cambrian Ozarkian of Ulrich and the Lower Ordovician or Canadian Series of Ulrich. In Ste. Genevieve County there are only a few places where the basal Roubidoux sandstone appears to fill small irregularities in the surface of the upper Gasconade ledges. The elevation of the land during the interval between the deposition of these two formations, must have been but slightly above critical level, for erosion agents apparently had but little effect upon the Gasconade surface, at least in Ste. Genevieve County, but the sudden and complete change in the character of the sediments, the variation in thickness of the basal sandstone, and the faunal change are evidence of the interruption in sedimentation.

In at least two localities there is evidence of contemporaneous erosion within the Gasconade. In the south side of sec. 19, T. 38 N., R. 7 E., at the down-stream end of the big bend on Goose Creek, the overlying beds rest upon a very uneven surface, in part filling the latter. Another similar condition is present in the extreme southwest corner of sec. 10, T. 37 N., R. 7 E., on the east bank of a small stream where evidence of slight erosion is exhibited. Doubtless other similar irregularities are present in the Gasconade rocks in the county, and such irregularities in the formation may have been produced by marine scour and not by subaerial erosion.

Correlation. The Gasconade fauna is a large one, and therefore correlation over wide areas is possible. In the upper Mississippi Valley the higher beds of the Oneota formation contain many of the Gasconade species of fossils, but a fauna said to occur in the lower Oneota includes forms similar to Eminence species. The faunal evidence indicates, however, that the Oneota is at least in part equivalent to the Gasconade. The Chepultepec formation of Ulrich, in Alabama, is upon faunal evidence, equivalent to the Gasconade and the Oneota. This Alabama formation is composed of about 1,000 feet of cherty, magnesian limestone, and is the youngest Ozarkian formation in the Alabama basin. Another formation containing some of the Gasconade-Chepultepec fauna is the upper part of the Little Falls dolomite in New York.

Paleontology: The fauna of the Gasconade is a large one and entirely confined to the formation in the state and to correlated formations in other states to the north and east. Of the abundant and easily recognized species the following may be mentioned:

Fauna of the Gasconade Formation

Eoorthis n. sp.
Sinuopea obesa (Whitfield).
Sinuopea regalis Ulrich.
Rhacopea grandis Ulrich.
Gasconadia putilla (Sardeson).
Chepultapecia leiosomella (Sardeson).
Helicotoma uniangulata (Hall).
Ozarkotoma acuta Ulrich.
Ozarkispira typica.
Ozarkispira valida.
Ozarkspira complanata.
Ophileta supraplana Ulrich.
Ophileta, at least six other undescribed species.
Camaroceras huzzahensis Ulrich & Foerste.
Walcottoceras shannonense Ulrich & Foerste.
Buehleroceras compressum Ulrich & Foerste.
Clarkoceras crassum Ulrich & Foerste.
Clarkoceras obliquum Ulrich & Foerste.
A number of tuberculated trilobites of or related to the genus *Hystricurus.*

ORDOVICIAN SYSTEM

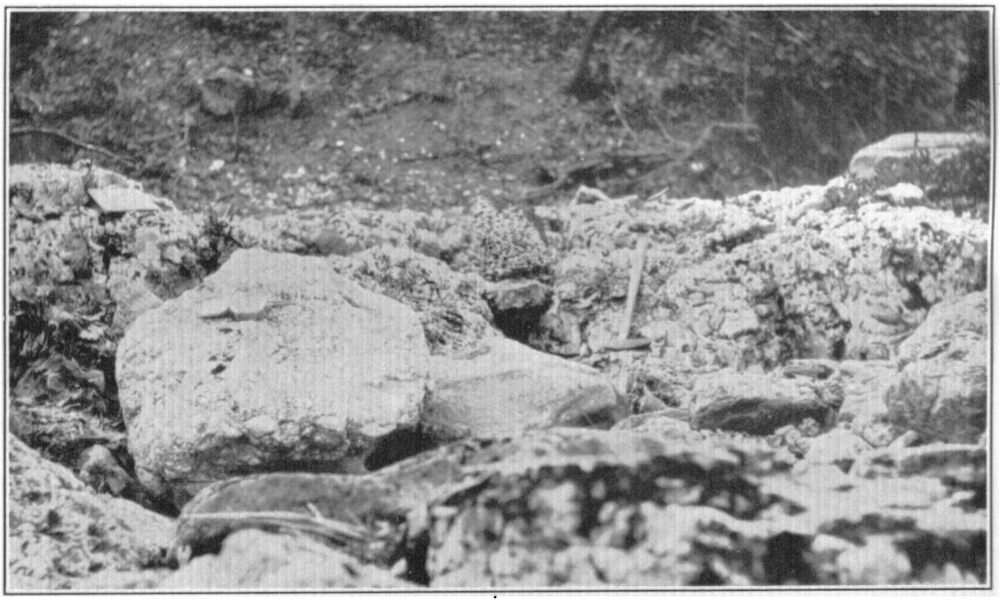
Canadian Series of Ulrich

INTRODUCTION

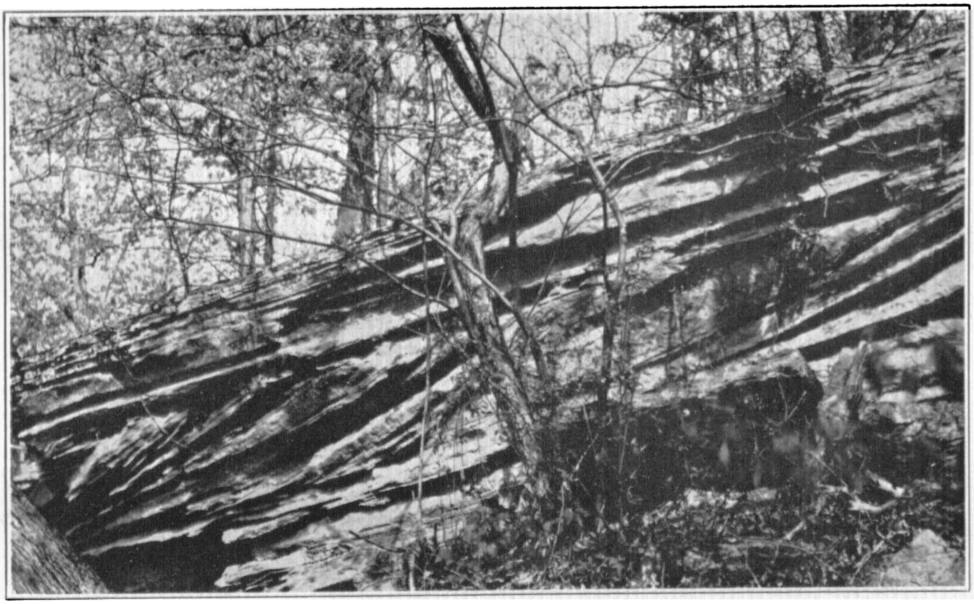
The Ordovician sediments in Ste. Genevieve County constitute a greater portion of the geologic column than those of any other single system. As interpreted by those who have made the most thorough study of the Ordovician stratigraphy and paleontology, five series are recognized within the system, as follows, beginning with the youngest or highest stratigraphically[1]: Cincinnatian, Mohawkian, Chazyan, Big Buffalo, and Canadian.

The lowermost of these series, the Canadian, has been considered as a distinct system by Ulrich[2], but he has not been gener-

[1]Maryland Geol. Surv., Cambrian and Ordovician, p. 51 (1919).
[2]Revision of the Paleozoic Systems, Bull. Geol. Soc. Amer., vol. 22, pl. 27, opposite p. 608



A. Gasconade cellular chert and boulders of Roubidoux chert conglomerate.



B. Cross-bedded Roubidoux sandstone.

ally followed by other workers, and the Canadian will be considered as a part of the Ordovician in this report. The Richmond, or upper division of the Cincinnatian Series, as it has been generally recognized in the past, also has been transferred to the basal part of the Silurian by Ulrich, and he has been followed in this respect by Bassler, but more conservative students have not followed this proceedure. The Thebes-Maquoketa and Fernvale formations in the Ste. Genevieve County section are Richmond in age, and consequently would be placed in the basal Silurian by Ulrich and Bassler, but in the present report they have been retained in the Cincinnatian Series of the Ordovician, in accordance with the more common usage.

With the exception of the Chazyan, each one of the Ordovician Series, as enumerated above, is represented by two or more formations in the Ste. Genevieve County section, and they will be considered in order in the following pages. The Ordovician formations of Ste. Genevieve County, and their grouping under the several series of the system, are shown in the following table:

5. Cincinnatian.
   - Thebes-Maquoketa sandstone and shale.
   - Fernvale limestone.
4. Mohawkian.
   - Kimmswick limestone.
   - Decorah shale and limestone.
   - Plattin limestone.
3. Chazyan.
   - (Not represented in Ste. Genevieve County).
2. Big Buffalo.
   - Joachim dolomite.
   - St. Peter sandstone.
   - Everton sandstone and dolomite.
1. Canadian (of Ulrich).
   - Powell dolomite.
   - Cotter dolomite.
   - Jefferson City dolomite.
   - Roubidoux sandstone and dolomite.

ROUBIDOUX FORMATION

Name. The name Roubidoux was first used by Nason[1] to cover the intercalated sandstones and dolomite beds which overspread the Ozark region, and which lie directly above the dolomites which he called the Gasconade formation. Ball and Smith, in their report on Miller County[2], used the term St. Elizabeth in describingthe succession of beds which was, without reasonable doubt, the same as the Roubidoux of Nason, and they also spoke of the Bolin Creek sandstone member of the St. Elizabeth forma-

[1]Report on Iron Ores, Mo. Geol. Surv., vol. 2, p. 114 (1892).
[2]Bureau of Geology and Mines, 2nd ser., vol. 1 (1903).

tion. The term Roubidoux has been adopted for this unit by the United States Geological Survey, and is used in all of the later Missouri reports.

The Roubidoux as described previously differs greatly from the Roubidoux found in the area covered by this report, a condition that is well shown by a comparison of the lithologic characters of the formation as found on the north slope of the Ozarks with those in Ste. Genevieve County.

Areal Distribution. The areal extent of the Roubidoux in Ste. Genevieve County is small. Where the formation occupies upland areas the width of outcrop varies from one-half mile to one mile. Its largest development is in the neighborhood of Weingarten and in the northwestern part of the county. Where the sandstone outcrops along the hillsides, the width of its outcrop is only a few hundred feet.

Thickness. In Miller County the thickness of the Roubidoux varies from 50 to 120 feet or more; in Phelps County it is from 115 to 150 feet, and in many other places in the Ozarks it is over 100 feet thick. Investigations by St. Clair in Reynolds County have shown at least 250 feet of Roubidoux. In Ste. Genevieve County the formation is from 50 to 70 feet thick, with an average of about 60 feet. In some of the earlier reports it is credited with 225 feet or more, but evidently some of the overlying Jefferson City horizons were included in this thickness, for recent collections of fossils have accurately established the lower and upper boundaries of the Roubidoux in this county.

Topography. Since the Roubidoux has such a limited areal extent it does not possess very important topographic features. However, many of the divides owe their width to the resistance of these rocks to weathering. The outcrops on the hillsides and in the hollows are mostly along steep slopes where they have produced very rough surfaces, due largely to the great amount of chert in the formation. Where the sandstone horizons are well developed pine trees are a characteristic growth.

Lithologic Characters. The Roubidoux is made up chiefly of sandstone and chert, with a subordinate amount of dolomite, and a little shale. The base is commonly a sandstone varying in thickness from a few feet up to 30 feet. The top is also a thin sandstone in many places, but is locally chert or dolomite. Between these horizons massive chert, conglomeratic in many places, predominates, although intercalated sandstones and dolomites are common.

The following sections and partial sections serve to bring out the irregularities of the Roubidoux formation. Where measurements of the various beds have been impractical, the general makeup of the formation is recorded, simply for use in comparison:

Section in NE. 1/4 sec. 20, T. 38 N., R. 7 E., near Fourche a du Clos Creek.

		Feet	Inches
5	Sandstone, brown, medium grains, medium bedding, porous	4	2
4	Dolomite, light-colored, crystalline. Near the bottom, quite sandy. Most of this horizon is covered by talus and details are lacking. Probably a thin sandstone horizon near upper part	35 +	—
3	Chert breccia	3 +	—
2	Siliceous horizon, probably mostly chert	3 +	—
1	Sandstone, white to red, medium sized, well rounded grains, porous	6	5

Section in south side of sec. 21, T. 38 N., R. 7 E., three miles northwest of Lawrenceton. Section taken going up creek from upper contact.

		Feet	Inches
7	Sandstone, finely conglomeratic, red in color	2 +	—
6	Dolomite, shaly, thin-bedded, cherty	7 +	—
5	Chert, dense, fine-grained, white, a little cellular in places. Many cryptozoons. Lecanospira in places	7 +	—
4	Sandstone, reddish-brown, medium-grained, porous	3	6
3	Dolomite, light, crystalline, some shale	—	—
2	Cherty horizon	—	—
1	Sandstone, reddish-brown, medium-grained, porous	4 +	—

Section in east side of sec. 29, T. 36 N., R. 9 E., along bluff, north bank of Saline Creek.

		Feet	Inches
4	Dolomite, crystalline, siliceous, light colored	2	8
3	Sandstone, white to brown, soft, medium-grained, slightly cross-bedded in places	—	—
2	Dolomite, light colored, crystalline, pitted in places, bedding from 1½ to 3 feet in thickness. In places the dolomite is siliceous, and the surface is craggy	3	—
	The rest of the section is not exposed, but the base is a sandstone several feet thick as determined a little west of the above section	—	—

Section in east side of sec. 5, T. 35 N., R. 9 E., two and one-half miles south of Minnith.

		Feet	Inches
4	Siliceous rock, partly chert, partly dolomite	5	—
3	Sandstone, heavy, cross-bedded, white, fine-grained, soft. Gray on weathered surface	20	—
2	Dolomite, shaly, argillaceous, quite platy	20	—
1	Sandstone, heavy, soft, white, cross-bedded. Bedding planes 1 to 2 feet thick	15	—

Section in south center of sec. 35, T. 38 N., R. 7 E., near Establishment Creek.

		Feet	Inches
3	Sandstone, reddish-brown, thin-bedded	2 +	—
2	Chert, with some clear, crystalline dolomite which has not been or is only partially silicified. Chert is chiefly conglomeratic, brecciated, some dense and smooth, white, fine-grained. Many cryptozoons, principally spherical variety, but some laminar	40 +	—
1	Sandstone, thin to medium-bedded, reddish-brown, porous, medium-grained	30	—

Section in sec. 17, T. 38 N., R. 7 E., west from Fourche a du Clos Creek.

		Feet	Inches
5	Sandstone, rather thin-bedded, light to brown in color. In places this horizon changes to a thin conglomerate, probably in no place more than a few inches thick	3	—
4	Dolomite. Sometimes as a ledge, again as a shaly dolomite several feet thick	4 +	—
3	Sandstone, soft, white, medium to fine, well-rounded grains. Gray on weathered surface	5 +	—
2	Horizon of alternating beds of light gray crystalline dolomite and chert, the latter being white and dense	40 +	—
1	Sandstone, light to reddish-brown, thinly bedded as a rule	3	—

Section in the Kinsey district, northern part of Ste. Genevieve County. A generalized composite section.

		Feet	Inches
5	Sandstone, gray to brown, porous, soft, medium-grained. Thickness ranges from 1 to 3 feet, the average is over 2 feet	2 +	—
4	Dolomite, shaly, irregularly bedded and fractured. In places a thin bed of argillaceous dolomite at the top. Much chert present at times. Thickness variable	10 +	—
3	Conglomerate, sandstone matrix with rounded or angular fragments of white chert, all water worn. Sandstone matrix gray to brown in color	2 +	—
2	Chert, heavy, dense. In places there are ledges of light-colored crystalline dolomite usually rather thinly bedded. Between the chert period and the original dolomite there are all degrees of alteration to be seen at various places	50 +	—
1	Sandstone, soft, porous, medium-grained, white to reddish-brown	3—	—

Sandstone. The Roubidoux sandstone is very irregular in thickness, and the most important horizon is the basal sandstone which occurs persistently over the county. This bed has an average thickness of from three to eight feet, although in a few places it reaches 30 feet. This sandstone is commonly reddish-brown, although a gray color is not uncommon. It is porous and shows abundant small red splotches in many places. The sand grains are subangular and medium-sized The sandstone at the top of the formation and the interm diate ones are similar lithologically to the basal horizon. They are in most places but a few feet thick, but in one locality, near the top of the formation, a bed 20 feet thick has been observed. All of the Roubidoux sandstones are more or less cross-bedded.

Dolomite. The dolomite horizons of the Roubidoux are discontinuous and grade into chert both laterally and vertically. Two types of dolomite occur in the formation. One closely resembles the underlying Gasconade dolomite. It is a light colored, clear, well crystallized, hard, dense variety, massively bedded in most places, the weathered surfaces becoming rough and cavernous. The other type is very distinctive in its appearance and is found most commonly near the top of the formation. It is thinly bedded with minutely thin partings of pale green shale between the beds and cutting acutely across the beds. When weathered this dolomite breaks along these shale partings, the resulting fragments being irregular in shape, but most of them have partially rounded edges. This variety of dolomite has every indication of having been formed in a much agitated sea.

Chert. Several varieties of chert occur in the Roubidoux, one of which is dense in character, and white to gray in color. Another variety is cellular, a third is conglomeratic and splintery, and a fourth is the silicified remains of the fossil cryptozoon. The dense, white to gray colored chert is found in both thick and thin beds, and was formed through the silicification of the clear, crystalline variety of dolomite. The cellular chert is found in only a few places, and it is not characteristic of the Roubidoux since similar cherts occur in abundance in the Gasconade and also in many places near the base of the overlying Jefferson City formation. This chert is fossiliferous in many localities. The conglomeratic and splintery chert occurs in massive beds but is more commonly met with in the form of residual blocks and boulders. It is believed that much of this type of chert has been formed by the silicification of the thin-bedded dolomite with thin shale partings, a conclusion which is supported by observations upon one ledge of the dolomite which has been traced into a ledge of the splintery, conglomeratic chert. The cryptozoon chert is of two varieties, concentric and laminar, the concentric species being by far the most abundant. Large beds are frequently found, the structure of the organism being extensively preserved through silification. The outlines can be seen occasionally in the dolomite, a fact which shows the original environment of the cryptozoon. Such cherts occur throughout the formation, being especially abundant near the middle. The size of the masses is variable, some being only a few inches in diameter, others three or four feet, and one specimen between eight and nine feet in diameter has been observed. The laminar variety of cryptozoon is entirely similar in structure to that which has been described as the common Gasconade type, but it is not abundant in the Roubidoux.

Stratigraphic relations of the Roubidoux. The Roubidoux formation is unconformable upon the underlying Gasconade, although there is but little evidence of pre-Roubidoux erosion. As far as observed there is no field evidence of an unconformity between the Roubidoux and the overlying Jefferson City formation in Ste. Genevieve County, but in Jefferson County there are a few localities where a small erosional unconformity exists.

Correlation. The Roubidoux formation, which is found encircling the Ozark dome in Missouri, is believed to be the equivalent of the New Richmond sandstone in parts of the upper Mississippi Valley. Its horizon is clearly indicated by its charteristic fossils in many places in the Appalachian Valley region from Alabama to central Pennsylvania. In the latter state these fossils occur in the Nittany dolomite which there attains a thickness of over 1200 feet. The same fauna is further recognized in the formation exposed at Beekmantown, New York, and also in sandy beds that rest on the pre-Cambrian floor in the southwestern angle of Quebec. Farther east it occurs in Newfoundland and, across the Atlantic, in the extreme northwestern edge of Scotland. To the west of Missouri it has been found in the Arbuckle and Wichita mountains of Oklahoma, in central and western Texas and here and there in the Cordilleran province as far north as Alberta. However, there was no direct connection at this time between Missouri and Oklahoma.

Fauna. The guide fossils of the Roubidoux by which the presence of deposits of this Middle Canadian time is recognized throughout North America and northwestern Europe consist mainly of one or more of many species of the planispiral shells of the gastropod genus *Lecanospira.* At least eight species of this genus occur in Missouri and most of these have been found in the Roubidoux as developed in Ste. Genevieve County. Specimens of *Lecanospira compacta* (Salter,) *Lecanospira conferta* Ulrich, and *Lecanospira lirata* Ulrich probably occur here more commonly than the others. Another highly characteristic and widely distributed gastropod has been called *Roubidouxia.* It is a large, broadly conical shell with a wide umbilicus. Besides these the Roubidoux contains the brachiopod *Syntrophina Campbelli* (Walcott) and near its base one or two species of the trilobite genus *Hystricurus.*

JEFFERSON CITY FORMATION

Name. The Jefferson City dolomitic limestone, as heretofore interpreted by the Missouri geologists, has included the entire series of beds lying between the Roubidoux sandstone below and what has commouly been referred to the St. Peter sandstone above, the name being in fact a geographic substitute for Swallow's old "Second Magnesian Limestone." The name was first proposed by Winslow, the typical exposures being at Jefferson City, Missouri. During the progress of his more recent field studies in the Ozark region of Missouri and Arkansas, Ulrich has come to divide the Jefferson City formation as it was originally interpreted, and to restrict the name to the lowermost division of the series of beds which occupy the interval between the two sandstones mentioned, two higher formations, the Cotter and the Powell being recognized above the Jefferson City as restricted, and below the higher sandstone. No descriptions of these formations or discussion of their relations has been published by Ulrich, but his classification of these strata has been used by Purdue and Miser in northwestern Arkansas[1], although the Jefferson City, as restricted, is not exposed in the region discussed by them. In the present report on Ste. Genevieve County, the Jefferson City formation, as restricted by Ulrich, is accepted.

The separation of the old Jefferson City into these three formations is based chiefly upon faunal change, for lithologically they are much alike, and their determination in the field is a confusing problem in many places. Lithologic criteria which mark the contacts in one locality cannot be applied in another. In some places the formations show slight unconformity, but elsewhere they are apparently conformable. Fossil remains, which are well preserved only in the chert, are not everywhere to be found where most desired, in order to make accurate differentiation of the formations.

Areal Distribution. The Jefferson City formation extends in a northwest-southeast belt through the county. The width of the belt is dependent upon the topography, being hardly more than ¼ of a mile in some places, but elsewhere it reaches a maximum of about two miles. The average width is probably about one mile.

Thickness. The Jefferson City formation in Ste. Genevieve County varies in thickness between 140 and 180 feet. In a few places it is perhaps as much as 200 feet, but the average is probably between 170 and 180 feet.

Topography. The topography of the belt underlain by the Jefferson City formation comprises areas of rounded hills and undulating plains, which are dissected by many streams. Some of the hills rise abruptly from the streams, but the slopes in most cases are somewhat gentle, and together with the upland

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[1] U. S. Geol. Surv., Geol. Atlas, Eureka Springs-Harrison folio (No. 202), 1916.

area they slope gently with the general drainage of the district. The rocks of the Jefferson City formation weather readily, and in most places the soil has accumulated on the hills faster than erosion has removed it, and as a result the outcrops in such areas are few except where the drainage has exposed bed rock or has formed narrow glades. Some of the more siliceous or cherty horizons have formed cappings and thereby produced steeper slopes and outcropping ledges of dolomite in many places.

On account of its regular topographic features, the Jefferson City area is partly adaptable for agricultural pursuits, and as a result much of the land has been cleared and is under cultivation. The larger streams have developed relatively large areas of bottom land which are occupied by farms.

Lithologic Characters. The Jefferson City is very heterogenous and irregular in its lithologic constitution. Dolomite, argillaceous dolomite, cotton rock, sandstone, chert, and small amounts of quartzite, oolite, conglomerate and shale are found in the formation.

The lithologic units of the formation do not bear systematic relations to each other throughout the county. This irregularity is due to the shallow and changing conditions of the sea at the time of deposition of the sediments. A section of the formation in one locality is rarely duplicated by the succession of beds in another locality, although in a general way there is a recognizable relation between them. In the southern part of the county the base and likewise the top of the formation contains in many places a 15 or 20-foot horizon of "cotton rock." In the central part of the county either one or both of these horizons are likely to be absent, and north of Fourche a du Clos Creek their absence is almost universal. While these easily recognized horizons are extremely useful in determining the stratigraphic contacts in some places, they cannot be entirely relied upon in even small areas, for similar horizons of "cotton rock" also occur at different stratigraphic positions within the formation. In the southern part of the county there is a sandstone horizon a few feet thick which is about 20 feet below the base of the overlying Cotter formation, and it may be used as a guide in some places, but in the central part of the county this horizon is commonly absent and farther north the same or a similar sandstone occurs in many places about 30 feet below the top of the formation. In the upper part of the Jefferson City the formation is marked in places by wavy and irregular bedding, and similar conditions are present at several horizons within the formation.

Complete sections of the Jefferson City formation are difficult to obtain and their value is minimized by the irregularities in deposition. For example, the section given below shows but little sandstone, whereas a short distance south of this locality considerable sandstone is present. Such differences illustrate the lenticular character of some of the beds. The lower part of the formation to a thickness of about 40 feet is not exposed in this section, and the upper part is covered by residual chert and sandstone, so only the middle portion of the formation is described in detail.

Section of Jefferson City Formation at railroad cut south of Minnith, in the west central part of sec. 28, T. 36 N., R. 9 E

		Thickness	
		Feet	Inches
22	Residual sandstone and chert	50 +	
21	Dolomite, light colored, fine-grained, with some "cotton rock"	6	—
20	Sandstone, white, loosely cemented	—	4
19	Dolomite, fine-grained, argillaceous	5	—
18	Dolomite, arenaceous	1	2
17	"Cotton rock," gray to white in color	5	3
16	Sandstone, white to yellow, calcareous	1	—
15	Dolomite, fine-grained, argillaceous, gray in color	9	—
14	Dolomite, heavy bedded, light-colored, crystalline	5	6
13	Dolomite, fine-grained, argillaceous	5	4
12	"Cotton rock," buff to gray in color	1	4
11	Dolomite, heavy-bedded, light-colored, crystalline	5	3
10	Dolomite, fine-grained, very argillaceous	3	6
9	Dolomite, fine-grained, argillaceous. In ledge	7	—
8	Sandstone, white, thin-bedded	—	3
7	Dolomite, fine-grained, siliceous	—	10
6	Dolomite, heavy-bedded, light colored, crystalline	5	—
5	Dolomite, fine-grained, light colored	3	—
4	Dolomite, fine-grained, siliceous	2	8
3	Dolomite, very thin bedded, granular, light colored	—	9
2	Dolomite, heavy bedded, cherty, weathering to thin beds composed of finely crystalline light-colored dolomite and argillaceous and siliceous dolomite. Irregularly bedded chert especially near the bottom. Railroad track	25	—
1	Unexposed	40 +	
		183	2

Dolomite. Dolomites and slightly argillaceous dolomites make up the greater part of the Jefferson City formation. In many places the latter grades into the typical "cotton rock" which is an earthy textured, fine-grained, argillaceous, siliceous dolomite, thin-bedded in most places with thin shale partings between the beds. The dolomites vary considerably in color. The unweathered surfaces of some of the purer beds are light gray to bluish-gray and grayish-brown, but on weathered surfaces these are usually dark gray to brown. The more argillaceous dolomite is commonly the lighter in color, the typical "cotton rock" being gray or buff. The pure dolomites weather to rough surfaces, hackly or pitted in appearance, and are both thinly and thickly bedded. The argillaceous dolomites and "cotton rock" are smoother and more even on weathered surfaces, and in many places they have a mottled or spotted appearance which probably is due to concentration of argillaceous or siliceous matter in the rocks. Locally they weather in bluffs as much as 15 to 20 feet high which stand out in prominent relief along the banks of streams. The texture of the various dolomites varies from coarsely to finely crystalline in the pure dolomites, the "cotton rock" being extremely fine and earthy. The former are hard and dense and have but little pore space, and the latter are softer, but are not very pervious to percolating water on account of their fine-grained and semi-earthy texture.

Chert. The Jefferson City chert occurs in beds and as nodules. The colors vary from dark blue to bluish-white and white, the texture from very fine-grained and dense to partly cellular, the latter being fossiliferous in most localities and occurring chiefly near the base. A few of the chert beds are conglomeratic. The chert in the "cotton rock" horizons occurs as very thin beds and as nodules, neither of which are found in quantity. Thicker beds of chert are present in the dolomite horizons, and irregular fragments are found in the pitted dolomite. A very characteristic chert is made up of silicified examples of "*Cryptozoon minnesotensis*" which occurs in irregular hemispherical masses.

Sandstone. The Jefferson City sandstones are all relatively thin, varying from an inch or two to several feet in thickness. The thinner horizons are found commonly as float on the hillsides but are exposed in place in the stream beds, but some of the thicker beds are prominently exposed in many places. In nearly all cases the sandstone is colored reddish-brown by iron oxide, but in a few places the original gray to white color is retained. Thin sandstones are in some places indurated or even altered to quartzite. The thicker and more friable sandstone horizons usually weather to rounded surfaces, locally showing a little surface hardening, but as a rule they are soft and easily disintegrated. The sandstones are fine to medium-grained, relatively porous, and are not closely cemented. The porosity of these sand beds is sufficient to permit a good circulation of water, but their outcrops cover such small catchment areas, and they are so irregular in their continuity that they cannot be considered as good water bearing horizons. Siliceous oolite and oolitic chert are found locally in very thin beds.

Stratigraphic Relations of the Jefferson City. There is no field evidence sufficient to demonstrate the presence of an unconformity between the Jefferson City and the underlying Roubidoux in Ste. Genevieve County. However, in southeastern Missouri there is a change in the character of the sediments and an almost entirely different fauna. Sedimentation during Jefferson City time was very iregular, and there were a number of oscillations which resulted in changing land and sea relations. Sun cracks occur in the dolomite which have been filled with sand and mud, and there are places which show contemporaneous erosion or slight local unconformity. There is also no pronounced evidence of an erosional unconformity between the Jefferson City and the overlying Cotter in Ste. Genevieve County, although in many places the effects of irregularity in deposition is shown in the upper Jefferson City beds. However, a study of the geological facts relating to these formations has led to the conclusion that an hiatus extending over a considerable time may separate the two.

In northern Arkansas an unconformity has been recognized between the Jefferson City and the Cotter. The invasion of both of these seas was from the south, according to Ulrich, and the presence of the Swan Creek horizon in Ste. Genevieve County near the middle of the Cotter formation, and the presence of the same horizon in Arkansas with about the same stratigraphic relations, and a thickness of 500 feet in the latter locality and only 70 feet in the former, are evidence of an overlapping, northward advancing sea followed by a corresponding southward withdrawal. As a result there was a maximum sedimentation to the south and minimum sedimentation in the northern end of the embayment. Ulrich believes that with the withdrawal of the Jefferson City sea the whole continent was land[1]. It seems evident that there must have been a long break in sedimentation at the close of Jefferson City time in Ste. Genevieve County. The absence of pronounced erosion can be explained by postulating but slight relief of the land surface during the hiatus.

On the ridge ¼-mile southwest of Kinsey and also on the hills one mile west, Cotter fossils have been found in conglomer-

[1]Ulrich, E. O., Revision of the Paleozoic Systems: Bull. Geol. Soc. Am., Vol. 22, p. 553 (1911).

atic chert boulders which may be residual. On the other hand these boulders may represent the basal part of the sedimentation in an overlapping Cotter sea, and if the latter interpretation is correct, the unconformity is a pronounced one, for the Cotter chert is found resting upon the lower Jefferson City.

Correlation. The Jefferson City sea was restricted to a comparatively small continental area, and there are consequently, but few deposits recognized at the present time with which the Missouri sediments of this epoch can be correlated. The Shakopee formation of Iowa, Wisconsin, and Minnesota is the nearest parallel of the Jefferson City, and it was probably deposited at about the same time as the latter, but at no place in the Appalachian Valley has an equivalent of the Jefferson City dolomite been recognized.

Paleontology. Fossils are comparatively very few in the Jefferson City and, excepting the cryptozoon masses, most of those found are notably of smaller sizes than those occurring in the underlying Roubidoux and overlying Cotter formations. As the visible organic remains in all of the Ozarkian and Canadian dolomites in Missouri are mainly confined to chert producing layers the relative paucity of cherts in the residual clays of the Jefferson City formation may explain, at least partly, the general rarity of unquestionable fossils of this age. The fossils so far found in the lower and middle parts of the formation consist mainly of small gastropods. The most abundant and widely distributed of these is usually less than a half inch in diameter and doubtfully referred to *Ophileta.* In another of similar size the periphery is steeper and this may be a *Helicotoma.* Less common is a thin-whorled, nearly smooth form of *Orospira;* also casts of two high spired species the larger of which seems to be related to, though distinguishable from, the Cotter and Powell species, *Hormotoma artemesia;* the smaller more like the Cotter species *Hormotoma gracilens.* Finally, of gastropods, there is a small involute shell, less than a quarter inch in diameter, that occurs also at Jefferson City, and possibly belongs to an unnamed species of *Oxydisens.* Besides the gastropods the fauna includes a number of Bathyuroid trilobites; one of them closely allied to *Bathyurus amplimarginatus* Billings; also a large annulated sponge of, or allied to, the genus *Calathium,* and even a few shells of cyrtoconic cephalapods. So far as known the Jefferson City fauna is quite different from that of the Roubidoux and also from the larger fauna of the overlying Cotter.

COTTER FORMATION

Name. The differentiation of the Cotter and the Powell dolomites has been made by Ulrich during the progress of his field studies in the Ozark region of Missouri and Arkansas from the series of beds to which he formally applied the name Yellville formation. Ulrich himself has never published descriptions of the formations, but Purdue and Miser have defined the units in Arkansas[1], and they will be used in the present report. The type section of the Cotter formation is near the town of Cotter which is situated on the White River in Baxter County, northern Arkansas. Only a portion of the Arkansas Cotter is developed in Ste. Genevieve County.

Areal Distribution. The Cotter occupies a narrow belt extending in a northwest-southeast direction through Ste. Genevieve County. In places the width of outcrop is as much as one-half mile, but it is commonly only a few hundred feet.

Thickness. In northern Arkansas the Cotter formation, as reported by Ulrich is not less than 500 feet in thickness, but in Ste. Genevieve County the maximum is 80 feet, the minimum 60, and in only a few places does it exceed 70 feet.

Topography. On account of its limited extent the topographic expression of the Cotter area is closely related to that of the overlying Powell and underlying Jefferson City formations. Where it outcrops in association with these formations it assumes to a large extent the topography of their areas. In general, the Cotter creates a rather rough country, especially where the beds outcrop along steep hillsides, with deep glades and ravines. Stream development is dependent principally on the characteristics of the overlying and underlying formations.

Lithologic Characters. The Cotter formation is made up of dolomite, sandstone, chert, and oolite, with no regular sequence of different types of beds.

In most places the base of the Cotter formation is a sandstone which varies in thickness from a few inches to five feet or more, the greatest thickness being in the extreme northern part of the county where the basal beds consist of a 10-foot horizon composed of intercalated sandstone, chert, and conglomerate, found commonly as residuum. A very characteristic feature of the Cotter is the presence of much oolitic rock, but where the formation is composed principally of dolomite, the oolite is in

[1] U. S. Geol. Surv., Geol. Atlas, Eureka Springs-Harrison folio, (No. 202), pp. 4-5, 1916).

most cases nearly absent. An horizon of white, partly oolitic chert, about 30 feet from the base of the formation in Ste. Genevieve County, contains the same fauna as the Swan Creek horizon of the Cotter in northern Arkansas, where this fauna is also found near the middle of the formation, although the formation itself is very much thicker.

The Cotter is similar lithologically to the overlying Powell formation, the separation of the two horizons being made on paleontological evidence, or on the irregular presence of a slight unconformity. Any section made must be considered as applying only to that particular locality, for the beds change in character in short distances laterally. The following section will show in a general way the make-up of the formation:

Section of the Cotter formation in the west side of sec. 8, T. 37 N., R. 8 E.

		Feet	Inches
13	Dolomite, very argillaceous, white to brownish-gray, thinly bedded......	8	—
12	Quartzite, oolitic, white to brown in color..........................	—	5
11	Sandstone, soft, white, medium-grained.........................	—	5
10	Sandstone, oolitic, hard, white................................	—	5
9	Shale, gray, argillaceous....................................	—	4
8	Dolomite, brownish-gray, argillaceous, thin-bedded, weathered surface slightly pitted..	8	—
7	Sandstone, soft, fine-grained, brown............................	9 +	—
6	Quartzite, oolitic, slightly ripple-marked........................	—	6
5	Sandstone, soft, fine-grained, brown, with thin layers of oolite. Sandstone shows small sun-cracks..................................	7 +	—
4	Limestone, magnesian, pink to brown in color, crystalline, quite thickly bedded. Small pink specks and veins running through the rock.....	7	—
3	"Cotton rock," thin bedded..................................	1	—
2	Sandstone, partly quartzitic..................................	—	3
1	Limestone, light colored, sandy, magnesian. Grades into a hard, white sandstone, the grains being well rounded. Sandstone grades downward into a white to clear gray magnesian limestone which has numerous small gray spots scattered through it..................	17 +	—

Dolomite. The major part of the Cotter is composed of dolomite intercalated with which are beds of argillaceous dolomite and "cotton rock," and a very few thin and sporadic beds of shale. The dolomite strata are commonly thinly bedded, although in the southern half of the county there are some massive beds. The color of fresh surfaces is light gray to brown which is not much changed in weathering. In texture the dolomites are crystalline or granular. Some of the massive ledges in the southern part of the county contain sugary quartz druses and in some places the surfaces of the argillaceous dolomite are pitted.

Sandstone. The sandstone horizons of the Cotter are commonly thin, except the basal one which in places is several feet in thickness. The beds are very irregular in their distribution and occur at any horizon within the formation. Normally the sandstone is white, loosely consolidated, and medium to fine-grained, but the presence of iron gives a brown color to the outcrop and indurates the surface in some places. The thinner sandstones are usually found as angular fragments of quartzite on the hill slopes.

Chert. The cherts of the Cotter formation are chiefly fine grained to dense in texture, although some are oolitic, with a brown, gray or white color. Some of the chert is conglomeratic, the angular fragments being cemented by iron in a few places, and in the various chert horizons hemispherical cryptozoons probably belonging to the species C. minnesotensis, are present. These silicified fossils are abundant in the upper ledges of the formation in a number of localities, and large specimens have been observed on Copper Mine Creek in the northeast corner of sec. 21, T. 37 N., R. 8 E., about two feet below the top of the formation.

Stratigraphic Relations of the Cotter. The Cotter formation is unconformable upon the underlying Jefferson City formation, although there is but slight field evidence of pre-Cotter erosion. The formation is likewise unconformable with the overlying Powell, and in a number of places a distinct erosional unconformity has been observed. Where this relation is found the basal Powell beds exhibit marked irregularity. The best exhibition of this unconformity can be seen in the Cuba drift of the Cornwall Copper Mine.

Correlation. The Cotter formation in Ste. Genevieve County is believed to be the equivalent of the middle part of the Cotter of northern Arkansas, a correlation based upon the relative positions of the Swan Creek fossiliferous horizon in the two localities. Beds of the same age are recognized also at many places in the Appalachian Valley and in the Arbuckle and Wichita Mountain areas by the presence of the same or only slightly modified varieties of characteristic Cotter species of fossils.

Paleontology. The residual cherts of the Cotter are often found to be more or less abundantly fossilferous. Although the fossils are largely confined to particular horizons the collector may yet find at least a few on practically every outcrop of the formation in not only Ste. Genevieve County but all around the Ozark uplift. The Cotter fauna as now known is distinctly a molluscan fauna and comprises nearly a hundred species, and very few of these are shared with adjoining formations. As most of the species are unnamed and not finally classified, the following list includes only the named species and the relatively abundant or striking of the others:

Fauna of the Cotter Formation

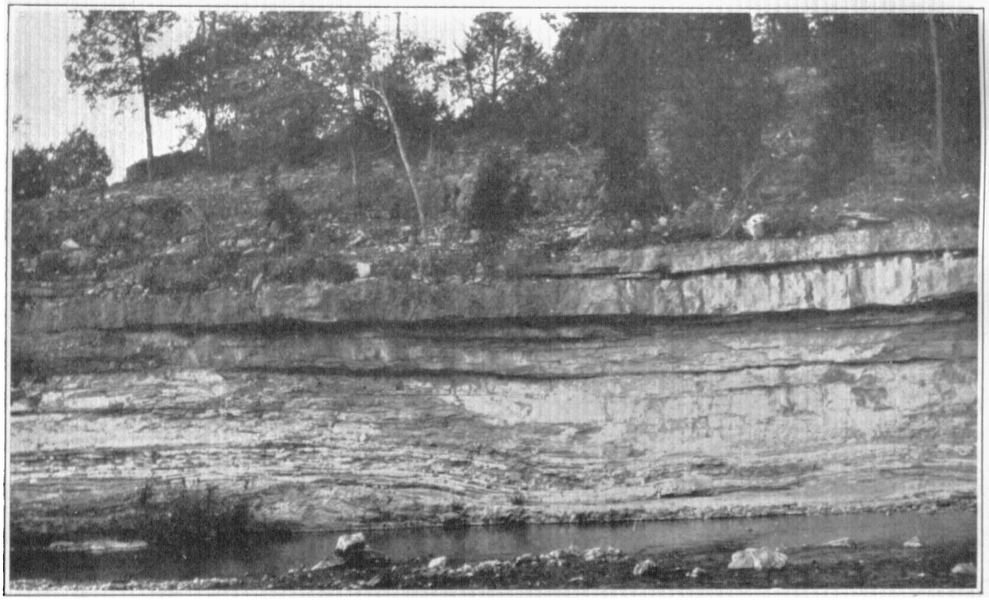
Scenella sp.
Tryblidium ? 2 n. sp., both about 2 inches in length.
Eccyliopterus planibasalis lUrich.
Eccyliopterus planodorsalis Ulrich.
Eccyliopterus cf. *volutalus* (Whitfield).
Liospira ? aff. *laurentina* (Billings).
Euconia ramseyi (Billings).
Plethospira aff. *cassina* (Whitfield).
Orospira bigranosa (Shumard).
Turritoma melaniformis (Shumard).
Coelocaulus cf. *linearis* (Billings).
Hormotoma artemesia (Billings).
Ceratopea aff. *keithi* Ulrich.
Ceratopea, 2 other n. sp.
Cameroceras genevievense F. and U.
Cameroceras missouriense F. and U.
Cameroceras ozarkense (Shumard).
Aphetoceras gyrans F. and U.
Aphetoceras subcostulatum F. and U.
Cotteroceras magnosiphonatum F. and U.
Shumardoceras complanatum (Shumard).
Pycnoceras evolutum F. and U.
Tarphyceras chadwickense.

POWELL FORMATION

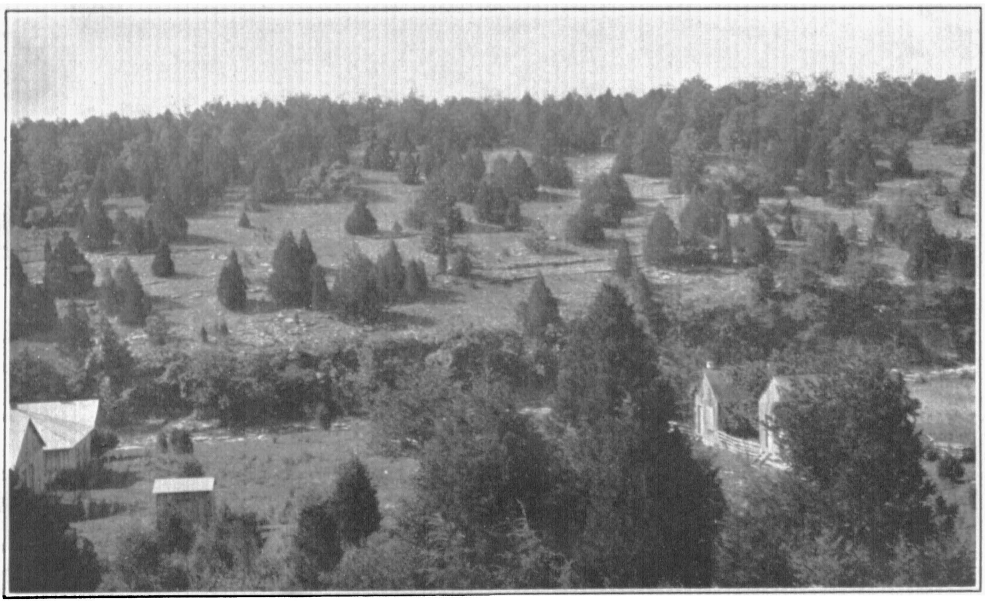
Name. The Powell formation is the uppermost division of the series of beds formerly included in the Jefferson City, as that series has been subdivided by Ulrich. The formation was named from Powell Station on the White River Branch of the St. Louis Iron Mountain and Southern Railway, in Marion County, Arkansas. Before this time it has been described only by Purdue and Miser in the Eureka Springs-Harrison Folio of the United States Geological Survey Geological Atlas. The existence in Ste. Genevieve County of both this formation and the underlying Cotter has been confirmed by Ulrich.

Areal Distribution. The belt of outcrop of the Powell formation in Ste. Genevieve County extends in a northwest-southeast direction, and varies in width from three-fourths of a mile to two miles, the greatest width being in the northern part of the county.

Thickness. In the type section of the Powell formation in Arkansas a maximum thickness of about 200 feet is exposed. In Ste. Genevieve County a detailed measurement of the formation is impractical, but from computation its thickness seems to be nearly uniform. In the southern end of the county it includes about 200 feet of strata, and in the northern part about the same thickness is present, but in a few intermediate localities the thickness is evidently not so great, there being probably not more than 170 feet of sediments. On account of the erosional unconformity between the Powell and the overlying Everton, as well as a slight unconformity at the base of the Powell, some varia-



A. Jefferson City dolomite on Fourche a du Clos Creek.



B. Typical Powell outcrop near Cornwall mine.

tion in thickness would be expected. An upper and a lower member of the formation are recognizable in Ste. Genevieve County, the line of division between the two members being near the middle of the formation.

Topography. The Powell presents some very prominent topographic features. It forms, as a rule, steep-sided ridges with long ledges of outcropping beds, a type of development so characteristic of the formation in Ste. Genevieve County, and even elsewhere, that it is a valuable criterion in the rapid recognition of the formation. Although there are many places where the above described features are not present, one cannot travel far within the Powell belt without being confronted with the striking topography of typical Powell areas. The steep slopes with outcropping ledges are particularly characteristic of the lower member of the formation which is composed almost wholly of beds of dolomite, but the upper member which is made up more largely of chert, found principally as residuum, presents a very different topographic appearance. The line of demarcation between the two members of the formation is marked by a sudden change in vegetation. The steep slopes of the lower member, with its outcropping ledges, are commonly covered by a growth of cedars, whereas the modified slope of the upper member, with a greater amount of residual soil, is suitable for the growth of deciduous trees. This vegetal break is strongly marked and when viewed from a distance the line along the hillsides is sharply defined in many places.

The Powell area is much dissected by the drainage of the region. The streams have cut relatively narrow valleys and their tributaries have formed rocky canyons, some of which have steep declivities. In some places the larger streams have developed somewhat extensive flood plains, or bottom land areas, but even in these areas the valley sides are steep in most places, a feature due chiefly to the resistant character of the rocks to the agencies of erosion. The hillsides commonly slope at an angle of between 30 and 40 degrees and in places the immediate relief is as much as 200 feet.

Nowhere does the Powell form any large areas of upland, the ridges being, as a rule, quite sharp and the divides relatively narrow. Many of the more rounded hill tops have been cleared and are under cultivation, but on the whole a relatively small part of the Powell area is suitable for agricultural purposes.

SUBDIVISIONS OF THE POWELL

The Powell in Ste. Genevieve County may be divided into a lower and an upper member, the division being made principally upon paleontological grounds, although in some localities the two members can be differentiated lithologically, and in at least one place, at the Cornwall Copper Mine, a distinct unconformity is exhibited between the two members. The base of the upper Powell is placed at the bottom of the zone of cellular, ferruginous chert, which may be termed the Minnith zone in which there is a prolific fauna in most localities where it is found, the distinguishing fossils being Trochonemoid gastropods.

Lower Powell. The lower Powell is composed almost entirely of dolomite, some of which is pitted, a feature especialy well developed in the central part of the county. There is also a very little siliceous dolomite or chert, and several sandstone horizons are present. The basal sandstone, where present, is in many places well developed, and attains a thickness of several feet. Elsewhere the base is marked by a slight unconformity or a thin conglomerate. A sandstone about 30 feet above the base is persistently present throughout most of the county, and another thin sandstone is found in places from 10 to 20 above the base. Between these sandstones and the top of the lower member, dolomite ledges prevail. A thin quartzitic sandstone or oolite occurs locally at or near the top. In the northern part of the county a sandstone in places as much as 3 feet thick, is very persistent about 50 feet above the base of the formation.

Upper Powell. The upper Powell is made up of dolomite in ledges very similar to those of the lower Powell, along with massive ledges of siliceous dolomite and chert. The basal or Minnith zone consists of intercalated beds of argillaceous dolomite, decomposed dolomite, and soft, ferruginous chert, and where this zone is absent a thin sandstone or conglomerate, or a slight unconformity, marks the contact of the two members. Dense white chert and soft ferruginous chert are abundant in the upper Powell and are features important for its recognition. Near the top a laminar variety of Cryptozoon is found in many places. Sandstone is almost absent, only a few thin lenses, usually quartzitic, being present. In a number of places the upper part of the Powell, just beneath the Everton, is composed of heterogenous beds and masses of chert, ferruginous tripoli and sandstone, and pockets of shale and clay. In at least one place the thickness of this zone is 30 or 40 feet, and the whole of it shows almost complete oxidation. It is not unlikely that deposits of this character are uneroded remnants of the residual soil formed during post-Powell emergence.

Generalized section of the Powell formation in Ste. Genevieve County.

		Thickness Feet	
Upper Powell.			
10	Dolomite. No generalized section can be given of the upper member, for owing to irregular deposition, there is no uniformity of beds in any two localities. As a rule the upper member is represented by residual chert, with here and there dolomite ledges exposed along a hillside. The dolomite where observed is quite similar to the dolomite in the lower member except that in the upper part of the upper member there is considerable argillaceous dolomite or "cotton rock," associated with which in many places are thin layers of greenish shale. The latter occur within 40 feet of the top. In most places the dolomite is siliceous and cherty and large quantities of chert are found on the surface. The red, soft, ferruginous cherts, characteristic of the Minnith zone are found at irregular horizons throughout the member, but principally at the top and near the bottom. At a few places there is an interbedding of the soft chert beds and the argillaceous dolomite ledges near the base of the member as illustrated at Cornwall Mines. Thin sandstone and oolite beds are found at irregular horizons	90–100	
9	Sandstone. This basal horizon is very variable from place to place. In the northern part of the county the sandstone is about 2 to 3 feet in thickness. Farther south the base may be a thin oolitic horizon or sandstone. At Cornwall Mines the base is unconformable on the lower Powell and the horizon is an irregular deposit of sandstone and breccia. 2 inches to	3	
Lower Powell.			
8	Dolomite, brownish, fine-grained, medium is heavy-bedded in central part of the county; light-colored and more thinly bedded in northern and southern parts of the county. In places thin oolitic horizons are present. Some of the beds may also be cherty	2–3	—
7	Sandstone, usually massive, white to light brown in color. Very persistent in northern part of county. In the southern part of county this horizon is probably represented by thin oolitic beds.	2–3	—
6	Dolomite, brownish, finely crystalline, occasionally pitted in central part of county; light-colored and more thinly bedded in southern and northern parts of county	20 +	
5	Sandstone, usually white, friable, medium-bedded; often massive. A thin green band is invariably found on rounded surfaces when sand is pure. This sandstone is an horizon marker. 3 inches to	3	
4	Dolomite, dense, fine-grained, usually dark-colored. In places pitted; often mottled on weathered surfaces	15 +	—
3	Sandstone, usually brownish in color, in some places white with thin green band on rounded edges. Not always present. 2 inches to	4	
2	Dolomite, usually hard, dense, fine-grained with dark brownish color. In central part of county it is often pitted	10–15	—
1	Sandstone, white to brownish, medium-bedded. This horizon frequently represented by sandy dolomite, irregular conglomeratic beds, or sandy beds of typical reef structure. Variable in thickness. 2 inches to	8	

Lithologic Characters. Dolomite is the principal rock of the Powell formation. In many places considerable argillaceous matter is irregularly distributed in the beds, which, upon weathering, develop a pitted surface. Where the argillaceous material is uniformly distributed, the beds present a much smoother surface and are classed as argillaceous dolomite or "cotton rock." The upper part of the lower Powell dolomite is siliceous in many places, but below this siliceous beds are not commonly present. In some localities much of the upper Powell is composed of siliceous dolomite and chert. The dolomites are light gray to dark brownish-gray in color, and the "cotton rock" is buff or gray. Weathered surfaces are not much changed in color. The bedding varies greatly, many of the siliceous horizons and argillaceous dolomites being massively bedded, while others being thin-bedded. In general the bedding is thinner in the northern part of the county than in the southern. The dolomites of the lower member are, as a rule, hard, finely crystalline, and dense in texture, and in many places they exhibit a shiny and lustrous appearance on fresh surfaces. The beds of the upper member are less uniform in their texture and composition, the dolomite commonly being softer and less dense than that of the lower member.

The Powell cherts are of two distinct types, the hard, dense variety and the honeycombed or cellular variety, although variations of these and intermediate conditions exist. The dense variety is commonly white to gray in color, in some places dark and is exceedingly hard and fine-grained. Some beds have a banded structure and many specimens are found with crystalline quartz of varying color filling cavities and interstices in the chert. Others have a surface covering of finely crystalline quartz. In a few places, notably near the top of the formation, the chert has weathered to a soft, very porous, impure tripoli, usually yellowish or tan in color, but on account of the impurities, the irregularity and the thinness of these beds they have no commercial value.

The second type of chert is best developed in the Minnith zone. It is very cellular or honeycombed, and most of it is soft. When in ledges, the cellular chert is accompanied by a red argillaceous clayey material in most localities. Modifications of this type of chert occur throughout the upper member of the Powell, and near the top in a few localities, it contains a laminar variety of Cryptozoon. Siliceous oolite occurs at various horizons, but none of the beds are more than a few inches thick and their lateral extent is irregular. Such oolites are found most commonly near the contact between the upper and lower members, and near the top of the formation, where they are associated with a red, quartzitic chert.

The Powell sandstones are composed of sub-angular to rounded, medium-sized, clear quartz grains, which are loosely consolidated in most localities, and in the thicker beds exhibit some cross-bedding. Some ledges are extremely pure and white for considerable distances. The thinner beds have been changed to quartzite locally, and the thicker horizons in places have been indurated and stained brown with iron. In some of the sandstone horizons, chiefly near the base, a fine green band is exposed on the rounded surfaces of the outcrops, this feature being especially persistent in the sandstone which occurs about 30 feet above the base of the formation in many localities. The only thick sandstone member in the powell formation is found just north of the Missouri-Illinois Railroad and about 2½ miles west from Zell Station, where for about a mile, the basal sandstone has a thickness of 10 feet, although the average thickness of this bed throughout the county is considerably less than this.

Shale occurring with any degree of persistency is present only in a thin horizon in the upper part of the Powell formation, within about 40 feet of the top. It is invariably associated with "cotton rock" and is light green in color, argillaceous and commonly fissile.

Stratigraphic Relations of the Powell. The Powell is unconformable upon the underlying Cotter formation. In some localities distinct evidence of pre-Powell erosion is exhibited, although elsewhere such evidence of unconformity is slight. A well-developed erosional unconformity between the lower and upper Powell is exhibited at the Cornwall Copper Mine, but this relation seems to be very local, for similar conditions have not been observed in any other locality in the county, although in places the basal deposit of the Upper Powell is such that a break in sedimentation is strongly suggested. Another small interruption in sedimentation is registered, at least locally, at the horizon where the copper deposits occur in the Swansea and Herzog mines on Indian Creek, about 50 feet below the top of the Powell formation. The Powell is also unconformable with the overlying Everton formation, but the pre-Everton land surface was probably not much above critical level for the amount of erosion was not enough to produce any great irregularities in the surface upon which the younger sediments were deposited.

Correlation. The presence of the Powell in Ste. Genevieve County was confirmed by Ulrich, and therefore is taken to be equivalent to the typical Powell formation in northern Arkansas. Upon a faunal basis the two formations, Powell and Cotter, may be correlated in part with the proposed Wells chert in middle Tennessee, and with some part of the middle division of the Beekmantown limestone in the Champlain Valley in New York.

Paleontology. So far as known all the fossils collected from this formation in Ste. Genevieve County came from the upper division, and most if not all of the determinable specimens were found in its lower 30 feet. The best collection was made in the fresh rock exposed in excavating the entrance to the Cornwall Mine, where the richly fossilferous and highly porous ledge lies close above the main mineralized zone. In the unweathered rock here the fossils are not silicified and occur mainly as empty moulds. However, on the surface of the hill slope the same fossils are found as siliceous pseudomorphs in the very porous residual chert that is formed where the fossilferous ledge of dolomite has been subjected to ordinary surface weathering. The following list comprises the species so far determined from collections made at this place:

Fauna of the Powell Formation

Archinacella aff. *patelliformis.*
Scenella—laterally compressed species.
Helcionopsis n. sp.
Lophonema striatellum Ulrich.
Lophonema tricarinatum (Billings).
Lophonema sp. 3.
Hormotoma artemisia (Billings).
Hormotoma aff. *artemisia*—smaller and smoother.
Coelocaulus sp.
Euconia ? sp.
Ophileta sp.
Endoceras sp.
Cameroceras yellvillense F. and U.
Cameroceras wellsense F. and U.
Isochilina n. sp.
Euchasma sp.
Bolbocephalus St. Clairi Ulrich.
Bolbocephalus unnamed sp.
Gonotelus—two unnamed sp.
Hystricurus n. sp.
Isoteloides whitfieldi Raymond.

Nearly all of these species have been found also, and in about the same position within the Powell, at Yellville, Arkansas. Associated with them at that place is a larger species of *Lophonema* to which the name *Lophonema capax* has been given. Also additional species of *Cameroceras* and two large nautiloid species of cephalopods, one a species of *Tarphyceras* the other a specifically and generically new form for which Foerste and Ulrich are proposing the name *Clytoceras capax.*

This highly and very characteristically fossilferous faunal zone was first observed by Ulrich in the vicinity of Minnith. It is of interest to note that at Minnith this zone lies directly on the Cotter with evidence of a break at the contact.

EVERTON FORMATION

Name. The Everton formation was originally differentiated by Ulrich, the type section being near the town of that name in Boone County, northern Arkansas, where it is made up of the Kings River sandstone member at the base, and the Everton limestone above. The formation was not recognized in Missouri prior to the work during the summer of 1914, before which time it had been included with the St. Peter sandstone in a single formation. The same two lithologic divisions recognized in the type area exist in southeastern Missouri, but the lower sandstone member is the thicker of the two. In the type region in Arkansas the greater part of the formation is limestone.

Areal Distribution. The Everton formation extends through the county in a general northwesterly direction, but it is offset just south of River aux Vases for several miles by reason of the faulting which passes through that district. The width of the outcropping belt is variable, being narrow to the north, where, beyond Bloomsdale, the formation occupies a position in most places in the St. Peter-Joachim escarpment. Proceeding to the south the outcrop widens gradually, due entirely to topographic relations, and at a point about a mile south of Zell Station it occupies a belt over a mile in width. With minor irregularities this development continues south to River aux Vases, beyond which, in Ste. Genevieve County, the Everton areas are discontinuous and relatively small.

Thickness. On account of the uneven surface upon which the Everton was deposited, the thickness for the formation is variable, the variation being exhibited in both the sandstone and limestone members. The minimum observed thickness of the sandstone in Ste. Genevieve County is about 40 feet, and the maximum about 65 feet, the average being less than 60 feet. The maximum development of the limestome is 30 feet, and the minimum probably 10 feet, but in most places its thickness is about 20 feet. The average thickness of the whole formation in Ste. Genevieve County is about 70 or 75 feet. In Arkansas the Everton has a maximum thickness of 150 feet, most of which is limestone, the average thickness near the type section being about 100 feet.

Topography. On account of the ease with which the Everton sandstone is eroded, a large part of the area underlain by this member has gentle slopes and a rolling surface, but in some places the topography is partly controlled by the underlying Powell formation, in which case more rugged slopes prevail. Cliffs are formed in some places where a part of the Everton is included in the St. Peter-Joachim escarpment, a feature best developed near Bloomsdale. The limestone member at many localities in the county has a characteristic growth of small cedars. Where the strata outcrop in stream beds and on very gentle slopes the cedars are absent, but where the outcrops cap small ridges or are part of an escarpment, the presence of this type of vegetation constitutes a distinct topographic feature.

Lithologic Characters. The Everton sandstone is very similar to the St. Peter and distinguishing characteristics between the two are few. The size of the sand grains, their roundness, cementation, and composition are exactly as in the St. Peter, and the origin of the two sandstones was evidently the same, although the method of deposition of the two may have differed in some degree. Aside from their stratigraphic position, probably the best criterion for differentiating between the Everton and the St. Peter sandstones is the bedding. In many places the older formation exhibits very thin bedding, especially in the lower part of the member, although massive bedding similar to that of the St. Peter is typical and is the rule where the exposure is in bluffs. Owing to its topographic position the Everton commonly contains more iron than the St. Peter, and the base of the sandstone member is, in a few places, a thin chert conglomerate, the chert fragments, so far as observed, being angular. The limestone member which separates the lower sandstone member from the overlying St. Peter has all the characteristics of an extremely shallow water deposit, and there is no evidence of any interruption in sedimentation between the two Everton members.

The composition of the Everton sandstone, or Kings River member of the formation, as that name has been used in Arkansas, varies from place to place, the most conspicuous difference being in the iron content. An analysis of an unwashed sample taken at a point three-fourths of a mile north of River aux Vases shows 99.50 per cent of silica with but .067 per cent of iron. In many other places, however, there is a higher content of iron, but it is rarely more than 0.50 per cent. The topographic position of the outcrops appears to be the primary factor governing the amount of iron present in the sandstone. Where the formation is exposed in bluffs, especially where the cap rock is the limestone member, the sand is almost free from iron impurity, but in lower outcrops the sandstone is commonly reddish-brown in color and contains varying amounts of iron. In view of these relations it is evident that the iron is not indigenous to the sandstone but comes from outside sources, although an exception to this condition may be in the basal beds which were laid down upon an unconformable and highly oxidized pre-Everton land surface.

The color of fresh exposures of the sandstone is characteristically white, but where weathered it changes to gray. In many exposures it is so incoherent that it can be crumbled readily in the fingers, although elsewhere it may be partly indurated. In some places there are a few fine, greenish bands in the white sandstone which is usually soft and friable. The softer beds weather to rounded surfaces, but the more indurated parts exhibit more angularity. Where the formation has been intersected by faults the sandstone is in part quartzitic, and the outcrops are more or less angular and irregular.

Most of the bedding in the Everton sandstone is thin, this feature being more pronounced in the ferruginous and much weathered portions of the formation, the weathering probably tending to split the thicker layers into smaller units. The bedding is commonly very wavy and discontinuous, and finely laminated cross-bedding and ripple marks are exhibited in many places, especially in the lower part of the formation, although much of the sandstone, especially where exposed in low bluffs is as massive as the overlying St. Peter.

The sand grains are fine and uniform in size. the size probably being slightly smaller than those of the St. Peter sandstone. The spherical form and frosted surface of the grains are characteristic features and are valuable criteria for distinguishing the Everton from the sandstones of any of the earlier formations upon which this sandstone may overlap.

A notable irregularity in deposition of the Everton sandstone is shown near the bridge over River aux Vases about three-fourths of a mile above the village of that name. Near the middle of the sandstone at this locality there are several thin lenses of limestone, and near the top, exposed in the cut along the main road there are thin and discontinuous lenses of conglomerate and shale.

Origin of the Sand. Much speculation has been carried on in regard to the probable origin of the sandstones of the St. Peter series. In view of the size, the perfect spherical form, and frosted surfaces of the grains, it seems highly probable that these characteristics were developed under aeolian conditions. In Ste. Genevieve County, however, the formation is undoubtedly a marine deposit, as is shown in the general character of the beds and in their relations to limestone beds containing marine fossils, with no evidence of interrupted sedimentation between the members. The highly oxidized and deeply weathered condition of the pre-Everton surface, and the absence of evidence of wind erosion upon the old land surface and rocks, are strong evidence against the theory that desert conditions prevailed in this area during this epoch. It would appear therefore, that the sand was brought to the sea from some more or less distant region where desert conditions favorable for the rounding of the sand grains obtained, but that the accumulation of the sands as they now exist was under marine conditions.

The partially dolomitic limestone at the top of the Everton formation has been the basis for recognition and mapping of the contact between the St. Peter and the Everton formations, although in faulted regions where the limestone does not outcrop continuously, the differentiation of the two sandstones is perhaps arbitrary in some places. The limestone in many localities is relatively pure, elsewhere it is magnesian, and typical rounded sand grains occur scattered through the limestone in nearly all localities, in some places the included sand being in such large proportion that calcareous sandstone would be a more applicable term for the beds than sandy limestone. In such sediments small, partly rounded limestone pebbles are occasionally found. In a few places the limestone is slightly argillaceous, and calcite is found in stringers running through it in many places.

On fresh surfaces the color of the Everton limestone is dark brownish-gray, or dove colored, but on weathering the prevailing color is dingy gray. The surface of the limestone is rough, due to the numerous sand grains together with differential weathering, and some surfaces show seams crossing nearly at right-angles, producing small rectangular elevations which are in many cases due to weathering out of calcite. The limestone has a very hackly fracture, and is fine-grained and compact in texture except where calcite is present, in which condition the limestone may exhibit some degree of crystallinity. The Everton limestone commonly shows great irregularity in bedding, both thick and thin beds being present in all localities with wavy and cross-bedding both common. The distinguishing feature of this limestone, however, is the irregularities found in the individual beds. The structure and the character of the sediments show that currents and cross-currents were operative during the period of deposition, and evidence of marine scour is present in a number of places, for pockets of sandstone and conspicuously cross-bedded sandy limestone with small amounts of shale are found within the more massive beds of limestone. In the faulted area, in the NW. ¼ sec. 11, T. 36 N., R. 8 E., near the top of the formation, there is a five-foot bed of sandy, argillaceous, semi-fissile shale interbedded with the limestone, and in the north side of sec. 29, T. 39 N., R. 7 E., a massive limestone conglomerate occurs about 12 or 15 feet below the top of the Everton.

In a number of localities a species of concentric Cryptozoon occurs in the upper beds of the Everton limestone, and very imperfect outlines of a gastropod shell were observed in a few places but they were too indistinct to permit identification. Aside from these no other fossils have been observed in the formation.

Stratigraphic Relations of the Everton. The Everton lies unconformably upon the underlying Powell formation, and there is also a small erosional unconformity between the Everton and the overlying St. Peter. The chief physical criteria for determining the Everton-St. Peter unconformity is the varying thickness of the Everton limestone member, the sudden change from calcareous to clastic sediments, and varying nature of the basal St. Peter deposits. The variable thickness of the Everton limestone may be explained either as due to pre-St. Peter erosion or to irregularity in deposition. There is ample evidence of irregularity in the deposition of these sediments, but it is not clear that there was any notable pre-St. Peter erosion. However, the Everton limestone wedges in between two typical beach sand deposits, the Kings River member of the Everton below, and the St. Peter above, and it is evident that there must have been shifting of the shore-line somewhere in this part of Missouri to bring about this change in the character of the sediments.

Correlation. The Everton sandstone and limestone members in Ste. Genevieve County are equivalent to the Everton limestone and basal Kings River member of the Everton formation in northern Arkansas, and it is probable that the formation extends continuously between the two areas.

ST. PETER FORMATION

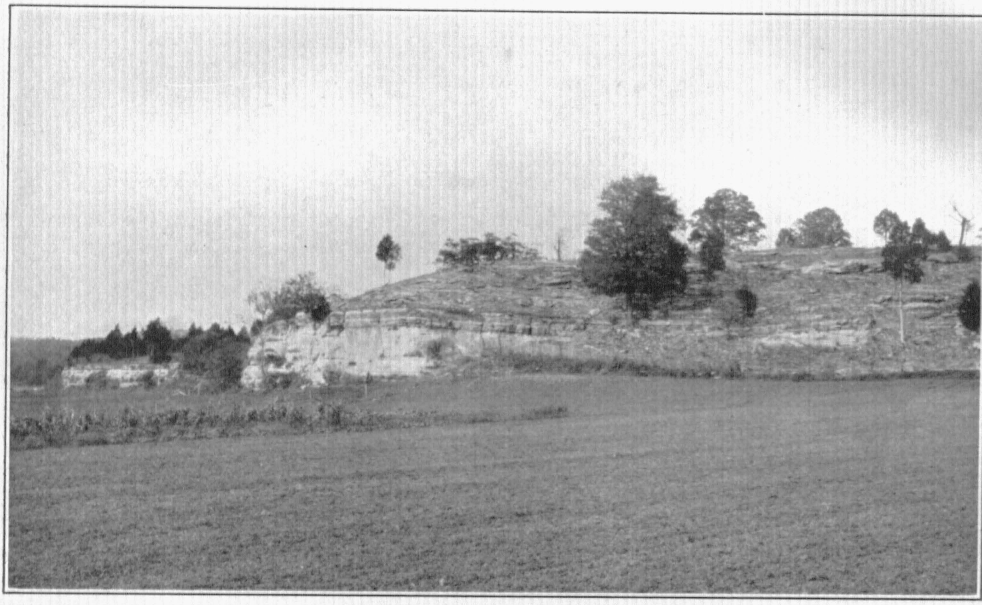
Name. This formation was originally named by Owen[1] from Minnesota as long ago as 1852, but the earlier geologists did not realize that the Missouri outcrops represented Owen's St. Peter sandstone, and consequently a number of different names came to be applied to it. In Swallow's classification of Missouri stratigraphy[2] this formation was called the "First" or "Saccaroidal" sandstone, and later writers have used the names Crystal City, Pacific, and Cap-au-Gres sandstone, and in Arkansas the name Key sandstone has been applied to the same formation. The lithologic characteristics of the formation, together with its stratigraphic position, provide unmistakable criteria for a uniform correlation throughout the Mississippi Valley and neighboring localities, and the name St. Peter, being the first one that was applied to the formation, is now universally accepted. In Ste. Genevieve County the typical St. Peter sandstone has been differentiated from the underlying Everton formation, the lower member of which is a sandstone very similar to the St. Peter in lithological character.

Areal Distribution. The St. Peter occupies even a narrower belt in Ste. Genevieve County than the underlying Everton. This is due to the fact that throughout much of its extent a large part of the formation is included in the St. Peter-Joachim escarpment. North from Bloomsdale the belt is probably narrower than anywhere else in the county where the formation is normally developed. East and southeast from Bloomsdale the outcrop widens somewhat, although there are still numerous bluff exposures, but farther south the belt again contracts. In general the breadth of outcrop of the St. Peter is dependent upon the topography which is controlled largely by the overlying Joachim formation. South from River aux Vases, faulting has offset the St. Peter and has produced very irregular outcrops.

Thickness. The thickness of the St. Peter sandstone in Ste. Genevieve County is very uniformly about 80 feet. Just south of Isle du Bois Creek an aneroid measurement showing 90 feet of sandstone has been made, and other slight variations in thickness have been observed in a few places.

Topography. Although the incoherent St. Peter sandstone is easily eroded, much of the formation is found in bluff outcrop

[1]Geol. Surv., Wis., Ia. and Minn., p. 165 (1852).
[2]First and Second Ann. Repts., Mo. Geol. Surv., p. 59 (1855).



A. Everton formation north of Bloomsdale.

B. St. Peter-Joachim contact.

and in steep slopes, a feature which is due entirely to the capping of the Joachim limestone. In many places the upper part, and locally most of the formation is included in the St. Peter-Joachim escarpment, which extends across the county, being more prominent in some places than in others. Parts of the St. Peter area, where the outcrop is broader, are gently rolling, but such areas are discontinuous, the best development of this type of topography being east and southeast of Bloomsdale and in the vicinity of Zell Station. A striking feature associated with the St. Peter topography is the occurrence of a heavy growth of cedars in many places upon the lower beds of the Joachim. A similar growth is present in many places on the Everton limestone, and the sudden vegetal change may be used as a criterion in a hasty determination of the contacts. Northwest from Bloomsdale where the St. Peter and upper half of the Everton form part of the St. Peter-Joachim escarpment, the double belt of cedars is a prominent feature. Just east of the St. Louis road about three miles southeast of Bloomsdale, there are several sink holes in the St. Peter sandstone, some of which contain water. No structure seems to be connected with these depressions, and caves lead into the hill from at least two of them, one of which has been entered for some distance. The caves appear to be old water courses, and along with the sink holes are probably due to solution in the immediately underlying Everton limestone.

Lithologic Characters. The St. Peter formation is composed entirely of sandstone. As a rule the typical sandstone rests upon the limestone member of the Everton with no definite evidence of interruption in sedimentation, and there even appears to be a complete transition between the two types of sediment in some localities. In a few places, however, a thin, irregular conglomerate composed of chert fragments in a clay and sandstone matrix occurs at the base of the sandstone. In the west side of sec. 36, T. 37 N., R. 8 E., on the main road, near the village of River aux Vases (Staabtown), the base of the St. Peter presents characteristics not observed elsewhere in the county. At this locality the initial sediment of the St. Peter, overlying the typical Everton limestone, consists of several feet of fissile, bluish-green to greenish-brown argillaceous shale which in places grades into a loosely cemented red to brown sandstone. Above this horizon is a bed several feet thick of thinly cross-bedded, yellowish-brown to red sandstone, and following this is the typical, thickly-bedded St. Peter sandstone. Near the top of the formation a thin green shale has been observed in a few places, a feature which is common in many exposures in the St. Peter in Missouri. Aside from the irregularities mentioned, the whole formation is a very homogeneous sandstone throughout.

The purity of the St. Peter sandstone is one of the striking and economically important features of the formation. Analyses of a number of unwashed samples taken from favorable localities have shown an average of 99.43 per cent silica. Bluff exposures of white sand everywhere run high in silica and contain inappreciable amounts of alumina and iron oxide, the most common impurities, but where the sandstone outcrops in lower places or on more gentle slopes, considerable iron is present. Since the amount of iron present is dependent upon the topographic position of the outcrops, it seems likely that the impurity is due to leaching, and that the iron is not indigenous to the formation. That the iron is added by a leaching process is shown in a number of places where St. Peter bluffs are directly overlain by the Joachim limestone, the upper portion as well as part of the surface of the sandstone being stained yellow by iron which has been carried down from the overlying formations, but a fresh surface of the sandstone is pure white and is practically free from iron. The natural color of the sandstone is very white, but weathering gives a gray color to the surface of the outcrops, and the presence of iron gives a yellow to brown or red color. In the iron-stained portions the formation shows varying degrees of induration, but the white sandstone is commonly loosely consolidated and very friable, although in some places the sand grains are coherent. The sandstone weathers to rounded surfaces in most places, but in faulted areas and where it is firmly cemented, it is commonly found in angular blocks and masses.

A characteristic feature of the St. Peter is the presence of vertical tubes which are the fossil burrows of a sea worm, and are known as *Scolithus*. The tubes are in many places close together and extend entirely through thick beds of sandstone. Such markings are most common in the lower part of the formation but are occasionally present at other horizons.

The bedding of the St. Peter sandstone is usually massive with little indication of stratification, although in bluff outcrops faint color bands in places mark the position of bedding planes. Cross-bedding has been observed in a few places, but this does not appear to be a persistent or characteristic feature of the formation. Ripple-markings are also occasionally present. Aside from the purity of the sandstone, the uniformity in size and the almost perfectly spherical form of the sand grains are the most distinguishing features of the St. Peter formation. These criteria are invaluable for the recognition of the formation. Although the sand grains of the St. Peter and the Everton are so similar that they cannot be easily distinguished, screening tests on a few samples have shown that the grains of the latter are in some cases slightly smaller. The St. Peter sandstone is very porous and absorbs the greater part of the water that falls in its area.

Origin of the Sand. The roundness and size of the sand grains of the St. Peter and Everton formations suggest that their origin must have been similar, and the aeolian origin of the sand is a theory held by many. In the Ste. Genevieve County area there is no evidence that desert conditions suitable for the rounding of the sand grains existed at the time the sand was being accumulated. The absence of the effects of wind erosion on the older surface, the regularity of deposition of the sandstone itself, and the presence of Scolithus, the burrow of a marine worm, are indications of not only its aqueous, but of its marine deposition, and it may be assumed that although the sand may have originally come from desert areas, perhaps far from the ocean, its final deposition in the beds in which we find it was in the sea.

Stratigraphic Relations of the St. Peter. The St. Peter seems to rest unconformably upon the limestone member of the Everton formation in some places, but elsewhere there is a complete gradation from the earlier to the later formation. The relation of the St. Peter to the overlying Joachim is generally considered to be that of conformity, the Joachim being an offshore deposit of the St. Peter. The change in character of sediment is abrupt in many places, but as a rule there is a thin transitional zone, and although local unconformities have been reported in a few localities, no such conditions have been recognized in Ste. Genevieve County.

Correlation. The St. Peter sandstone has a wide distribution throughout the Mississippi Valley. It is found outcropping as far north as Minnesota and Wisconsin, and has also been recognized in deep wells at Cincinnati and as far west as Nebraska City, Nebraska. It is known to underlie parts of Iowa, Illinois, Indiana, Missouri, and Arkansas. The continuity of this sandstone throughout this entire area is manifested both by its stratigraphic position and by its lithologic characteristics. Sediments of St. Peter age have not been recognized in any of the Appalachian basins, a fact which would indicate that this submergence began in the Mississippi Valley.

JOACHIM FORMATION

Name.—In the early reports on the geology of Missouri, the strata immediately overlying the "saccaroidal sandstone," now known as the St. Peter, were designated as the "First Magnesian Limestone." In 1894 Winslow[1] applied the name Joachim limestone to this formation from the exposures along Joachim Creek in Jefferson County, and the name has been generally used by later writers.

Areal Distribution.—The Joachim limestone occupies a belt varying in width from one-fourth to nearly three miles, and extends from Isle du Bois Creek at the northern boundary of the county to the southeastern boundary about three miles southwest of St. Marys. This belt is uninterrupted from Isle du Bois Creek to the Little Saline faulted zone where the continuity of the outcrop of the formation is considerably offset. Along this outcropping belt the formation has its greatest extent as the surface rock adjacent to Establishment Creek, immediately north of Bloomsdale, and again on the opposite side of the creek to the southeast of the same town. Another large area is in the broad valley at the head of Morrison Hollow in the northern part of the county. In northern Perry County the outcrop attains a width of four and one-half miles.

Thickness.—The upper surface of the Joachim was considerably eroded before the overlying Plattin limestone was deposited, this erosion being shown not only by the varying thickness of the formation, but by the uneven upper surface in some cases where the rocks are well exposed. In Ste. Genevieve County the range in thickness is from 50 or 60 feet up to 160 feet. The formation is thickest in the north towards Isle du Bois Creek, where it is fully 150 or 160 feet. It is thinner to the south, and in the region south of River aux Vases it rarely exceeds 60 or 70 feet, the reduction in thickness apparently being due to the removal of the higher beds of the formation.

Topography.—In Ste. Genevieve County the Joachim limestone takes part in the St. Peter-Joachim escarpment, and in only a few places does it occupy an area of any considerable

[1]Mo. Geol. Surv., vol. 6, p. 331 (1894).

breadth. Where the escarpment is most typically developed the limestone outcrops in the more or less steeply sloping southwesterly directed face, but where the formation does occupy broader areas it commonly underlies a gently rolling surface. In places, as two miles southwest of Zell Station, the Joachim is marked by scattered sink-holes, some of them being of rather large dimensions, but the sink-hole topography of the surface underlain by the Joachim has its most conspicuous development beyond the limits of Ste. Genevieve County, in northern Perry County.

Upon its weathered surfaces the Joachim is commonly dull gray in color, and its more or less porous texture gives footing for such plant growths as mosses and lichens. The formation rarely forms vertical cliffs, commonly weathering down into more or less gentle slopes covered with outcropping ledges and loose slabs of limestone. In many localities the soil upon such slopes is thin and the most conspicuous vegetation upon them consists of small cedars. In the northern portion of the county especially, the boundary of the Joachim outcrop along the hill-sides is more or less sharply defined by the growth of cedars.

Lithologic Characters.—The Joachim is a dolomite throughout nearly the entire formation, but thin non-dolomitic beds are present. It has not been determined whether the non-dolomitic strata are continuous throughout the entire extent of the formation or not, but their geographic extent is believed to be more or less local. Their position within the formation also is somewhat variable since they may be met with at any horizon from near the base to the summit, although they occur more commonly well up in the formation. The dolomitic beds which constitute 95% or more of the entire formation, are more or less variable in color, texture and bedding, but the prevailing rock is fine-grained, evenly bedded, soft, and light-brown, buff or cream colored. In many places the beds have the texture of the so-called "cotton rock" although the color is rarely or never white. These fine-grained dolomites commonly occur in even bedded strata from a foot or more in thickness down to a fraction of an inch, some of the more thinly bedded portions being almost shaly. A rather characteristic feature of many of these beds is a distinct banding parallel with the bedding planes, which is best exhibited upon freshly broken surfaces. The bands are a fraction of an inch in width, commonly being an alternation of buff or yellow with slate colored dolomite, although in some localities pinkish bands are also present, the bands but rarely exhibit any strong contrast. Thin shaly partings are present in places between the thicker beds, and minor beds of greenish argillaceous shale occur locally in the formation. Aside from the prevailing type of dolomite in the Joachim, there are locally, in some portions of the formation, harder beds of darker color and more granular in texture, which not uncommonly exhibit conspicuous fracturing upon weathered surfaces.

In the lower part of the formation, commonly from 10 to 15 feet above the base, there is a more or less persistent bed of limestone conglomerate, from less than a foot to ten feet in thickness. The included pebbles are thin and plate-like, angular in outline, with dulled edges in most places, and they range in size from a fraction of an inch to an inch or more in maximum dimension, they are for the most part fragments of dolomite darker in color than the matrix which is commonly a light gray or nearly white, soft dolomitic limestone. Above this conglomerate bed is another equally characteristic and persistent blue horizon consisting of soft, massively bedded blue dolomite of fine texture and earthy in appearance, ranging from ten feet up to twenty or more feet in thickness. These beds are rarely interrupted by fine laminae or partings; so homogeneous is the rock of this horizon that it breaks with equal facility in all directions.

In some localities numerous crystalline calcite inclusions are present in the Joachim dolomite, and in other localities masses of limonite are abundant upon the surface, presumably a residuum from this horizon. These limonite boulders have been observed most commonly about Zell, and along the Ste. Genevieve-River aux Vases (Staabtown) road.

The non-dolomitic beds, where present in the Joachim, are commonly cream-colored, gray or nearly white, very dense, hard and brittle, breaking with either a splintery or a conchoidal fracture, the texture being almost lithographic in most cases. These beds, however, constitute an inconspicuous portion of the formation. In some sections a non-dolomitic bed which weathers into a more or less vesicular limestone closely resembling certain beds of the overlying Plattin limestone, occurs as much as fifty or more feet below the summit of the formation, it being followed by other beds exhibiting the lithologic characters of the prevailing dolomite of the formation. Unlike some of the later formations, chert is rarely or never present in the Joachim formation.

The shallow water origin of at least portions of the Joachim is indicated by the mud-cracks which may be seen in many places. At some localities the surface of the rock along the bedding planes is marked off into polygonal areas from two to four inches in diameter, the centers of which are slightly depressed, the surfaces being evenly concave. The polygons are outlined by very narrow, sharply elevated ridges. That these markings were formed during the temporary exposure to the atmosphere of the Joachim sediments during the time of their deposition, is evident. During such exposure the surficial portion of the then unconsolidated calcareous mud was partially dried by evaporation, the consequent contraction causing the intersecting cracks and the slight curling up of the edges of the resulting polygons. With a later covering of the same area by the sea, and the further deposition of sediment, these sun cracks were buried and have been preserved in the consolidated rocks to the present time. Markings of this sort are especially noticeable in a quarry near Zell, about seven miles southwest of Ste. Genevieve, at a horizon about fifty feet above the base of the formation. The presence of ripple-marks upon some of the bedding planes of the formation is another indication of its shallow water origin.

Stratigraphic Relations of the Joachim.—The relation of the Joachim to the underlying St. Peter sandstone is apparently conformable, although the change from the sandstone to the dolomite is commonly abrupt with no conspicuous transition beds, although in only a few localities have good clean contacts of the two formations been observed. One of the best contacts of this sort to be seen in the county is along the St. Louis road a little less than two miles south of the crossing over the Isle du Bois Creek.

The relations of the Joachim to the overlying Plattin limestone are disconformable, a considerable portion of the Ordovician sediments which are present in some portions of the country being entirely wanting in southeastern Missouri. Notwithstanding this fact it is commonly more or less difficult to determine with absolute certainty the exact boundary line between the two formations. This difficulty is due to the rarity of uninterrupted exposures of the beds, free from talus, as well as to the fact that certain of the Joachim beds resemble some of the Plattin beds in lithologic characters, and some of the lower Plattin beds are more or less dolomitic in places, and are almost barren of fossils. Another evidence of the unconformity between the Joachim and the Plattin is expressed in the varying thickness of the Joachim from 60 to 160 feet in different parts of the county, this differing thickness being due to the varying amount of erosion to which the pre-Plattin surface was subjected before the deposition of the younger formation. Over much of the area of exposure of these formations within the county, the interval between the Joachim and the Plattin is marked by a bed of greenish shale. This shale is only rarely well exposed, but upon the hill slopes its position is commonly indicated by a slight terrace.

Correlation.—The Joachim formation has been interpreted as an off shore equivalent of the St. Peter sandstone. This sandstone is believed to be a transgressing formation which was deposited adjacent to the shore line as it advanced from a position at least as far south as northern Arkansas, to Minnesota. As the areas to the south became more remote from the shore the more calcareous sediments were initiated and continued during the submergence of the area. Under this conception the Joachim limestone of Ste. Genevieve County was deposited contemporaneously with some portion of the St. Peter sandstone farther north.

Paleontology.—Fossils in the Joachim are exceedingly rare, and have been observed in Ste. Genevieve County only in some non-dolomitic beds. The only forms so far identified are ostracode crustaceans of the genus *Leperditia.*

PLATTIN FORMATION

Name.—The Plattin limestone, named by Ulrich,[1] was commonly known as the "Trenton Limestone" in the early reports of the Geological Survey of Missouri. The name is derived from Plattin Creek in Jefferson County, near the mouth of which stream good exposures may be seen.

Areal Distribution.—The Plattin limestone occupies a belt lying immediately east of the Joachim limestone, extending from the Isle du Bois Creek at the north, to the Little Saline faulted zone on the south. Beyond this line several discontinuous areas of Plattin limestone occur within the faulted zone in Ste. Genevieve County, but the continuous outcrop extending to the south is offset far to the east in Perry County. The average width of outcrop of the formation is a mile or less, but in the northern

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

portion of the county, especially between Establishment Creek and the northern boundary of the county, long narrow tongues of Plattin extend down the deep, narrow, ravine-like valleys towards Mississippi River, in some cases for nearly three miles.

Thickness.—More or less continuous outcrops of the entire thickness of the Plattin limestone are exposed in various places in Ste. Genevieve County. In some of the ravines tributary to the Mississippi, south of Isle du Bois Creek in the extreme northern part of the county, fully 200 feet or more of the limestone is exposed, and essentially the same thickness prevails wherever any accurate measurement of the formation can be made, all the way to Little Saline Creek. In a measured section exposed in a ravine tributary to River aux Vases, mainly in the SE. ¼ sec. 3, T. 37 N., R. 9 E., the Plattin limestone beds are nearly continuously exposed through an elevation of 187 feet, but the dip of the beds would increase this amount somewhat, and the total thickness is certainly in excess of 200 feet.

Topography.—The Plattin limestone in Ste. Genevieve County exhibits no uniform topographic characteristics. In the northern portion of the county the formation occupies the tops of the ridges just northeast of the St. Peter-Joachim escarpment, at the headwaters of the drainage which flows directly into the Mississippi River, and the formation forms the floor and the steep sides of a number of the ravine-like valleys for a distance of several miles from their heads. Farther south this limestone takes part in the northwestwardly sloping plain between the St. Peter-Joachim and the Burlington escarpments, and in such situations it exhibits a gently rolling surface, much of which is under cultivation. Still farther south, from a point about three miles north of River aux Vases, to Little Saline Creek, the Plattin occupies the lower portion of the more or less abrupt slopes which constitute the Burlington escarpment. Within the faulted zone the somewhat scattered Plattin areas are gently rolling for the most part, a character presented by the area underlain by this formation wherever it occurs in comparatively broad belts. In northern Perry County a very broad area is underlain by the Plattin which is much dissected to the east, but to the west is more gently rolling with innumerable sink holes.

Lithologic Characters.—The Plattin formation consists for the most part of evenly bedded, bluish-gray or drab colored, commonly non-dolomitic limestones, of very compact texture, many beds being almost lithographic in character. The rock is very hard and brittle, giving forth a metallic ring when struck by the hammer, commonly breaking with a conchoidal or splintery fracture. The individual beds of the formation vary from two or three inches to a foot or more in thickness. In the central portion of the formation and extending well up towards the top, are conspicuous beds which are characterized by very irregular, crowded, branching, subcylindrical tubes filled with some material differing from the surrounding matrix. Commonly the material filling these tubes is softer and less resistent to the weather than the surrounding limestone, so that on weathered surfaces the rock is pierced in all directions by flexuous tubes of somewhat greater diameter than a lead pencil, where the softer material has been removed, giving to the limestone a "worm-eaten" appearance. In many places loose blocks and even whole ledges are completely honeycombed by these perforations. The material filling these tubes in the unweathered limestone is commonly lighter in color than the surrounding rock, and is apparently dolomitic. Locally, however, they may be filled with chert, limonite, or crystalline calcite, and upon the weathered surfaces of the beds where the tubes are filled with chert or limonite, the material filling them stands out in relief upon the limestone surfaces.

The origin of these softer portions of the rock which are removed in weathering is not perfectly understood, but it is commonly believed that they are of organic origin, probably from some fucoidal algae which must have existed in vast numbers in the old Plattin sea. The tubes have no definite orientation in respect to the bedding, but are branching in a most complicated manner.

Locally some beds of the Plattin are more or less coarsely crystalline, almost as much so as the Kimmswick limestone, but the color is always darker than the crystalline beds of that formation. In the lower part of the Plattin in some sections, there are dolomitic beds varying in thickness up to a foot or more, interbedded with the more characteristic limestone strata. Some of these beds are buff to nearly white in color in the more completely dolomitized layers, and vary in degree of dolomitization from an apparently pure dolomite to the prevailing non-dolomitic beds.

A limited amount of chert is present in the Plattin limestone at many localities, either as irregular concretionary masses or as irregular stringers through the limestone. At many other localities, however, the formation is apparently quite free from chert. The included fossils are silicified in many localities and not infrequently silicified coral colonies of the genus *Columnaria* are observed imbedded in the limestone or occur loose in the residuum from the formation and less commonly similar silicified examples of the sponge *Dystactospongia minor* U. & E. are met with. Locally the Plattin is conspicuously cherty, nearly the entire mass of the limestone being replaced. The most conspicuous observed occurrence of this sort in Ste. Genevieve County is the hill on the south line of SE. ¼ of SW. ¼ sec. 31, T. 37 N., R. 9 E. This hill is apparently intersected by a fault. Loose chert is not infrequently abundant in the Plattin residuum, even in localities where the limestone itself is comparatively free from it, an occurrence which suggests that under some conditions the silica included in the limestone in a disseminated form is segregated into chert as an accompaniment of the process of weathering.

Because of the hardness and close texture of the Plattin limestone, the weathered surfaces of the formation are commonly smooth except where honeycombed by the weathering out of the supposed fucoids already described, and are consequently quite free from the growth of lichens and other plants in most localities, in this respect being rather strongly in contrast to both the underlying Joachim and the overlying Kimmswick.

In places the Plattin limestone has become so completely dolomitized that it is difficult to differentiate it with certainty from some portions of the Joachim, except by observations of the stratigraphic relations of such beds, or of their fossil contents. Such a development of the formation may be seen in NE. ¼ NW. ¼ sec. 12, T. 36 N., R. 8 E., where the dolomitic beds are underlain by limestone beds which are entirely typical of the Plattin in all particulars. Along the road to St. Marys, northeast of Independence School, dolomitic beds are exposed which closely resemble some parts of the Joachim, which must be, from their situation, dolomitized beds of the Plattin, a determination which has been corroborated by the finding of the coral *Columnaria* and other Plattin fossils at this locality. The most complete dolomitization of the Plattin is commonly adjacent to fault lines, and the change is doubtless due to the deformation.

Stratigraphic Relations of the Plattin.—The Plattin everywhere in Ste. Genevieve County, rests unconformably upon the Joachim, although this unconformity is not clearly shown in every section because of the heavy talus covering which is commonly present. There are beds in the Joachim which resemble, lithologically, certain beds of the Plattin, especially in the northern part of the county, and again, not infrequently there are dolomitic beds in the lower portion of the Plattin which make the separation of the two formations somewhat difficult when good clean sections are wanting. Where fossils can be found there is no difficulty in separating the two formations, since nothing but ostracodes are known from the Joachim, but in many places fossils are rare in the basal Plattin beds. Not infrequently a bed of greenish shale is present at the base of the Plattin, locally, as in the railroad cut on the Missouri-Illinois Railroad a little less than one-half mile northeast of Zell Station, filling solution channels in the subjacent Joachim. Where this shale is present it may be taken as indicating the boundary between the formations, and in many sections where the shale is not actually exposed its presence is indicated by the terrace-like break in the topography. This unconformity is further demonstrated by the varying thickness of the Joachim, the variation being due to differential erosion of the pre-Plattin surface.

The nearly uniform thickness of the Plattin suggests the absence of any erosion interval between this formation and the overlying Decorah. Furthermore the local field relations do not indicate any discontinuity in the sedimentation in passing from the lower to the higher of these two formations.

Structure.—No notable structural features confined to the Plattin limestone alone, are recognized in Ste. Genevieve County. In general the beds dip to the northeast at an angle of two or three degrees, along with the other formations, and they are involved in the deformation exhibited in the faulted zone across the county. Adjacent to some of the faults the beds exhibit rather steep dips due to drag along the fault lines, the direction of the dip being controlled by the direction of the adjacent fault, and in places there is much fracturing and jointing of the beds near the faults of the faulted zone.

Correlation.—The Plattin limestone in southeastern Missouri is essentially equivalent to the Platteville[1] limestone of the upper Mississippi Valley in Wisconsin, Iowa and northwestern Illinois. The two formations are closely similar in both lithologic and faunal characters, and should perhaps not be designated by

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[1]Bain, U. S. Geol. Surv., Bull. No. 246, p. 18 (1905).

different names. The name Plattin, however, has priority over Platteville, and if either name is to be discontinued it will be Plattville.

In his latest correlation tables of the Ordovician formations Ulrich[1] has placed the two formations Plattin and Platteville as exactly equivalent, and in his correlation of these limestones with the Ordovician formations in New York and the Appalachian Valley, he has interpreted them as being exactly equivalent to the Lowville. The studies which have been made of the fossil faunas of the Plattin are perhaps inadequate to establish the exact limits of the formation in the terms of stratigraphic units elsewhere, but the correlation which Ulrich has suggested may be considered as approximately correct.

Paleontology.—Some beds of the Plattin limestone contain numerous fossils, among which the brachiopods are perhaps the most conspicuous forms, but in much of the formation fossils are rare or wanting. Not infrequently the specimens are completely silicified, especially upon the surfaces of outcropping ledges, and among these silicified fossils, colonies of the coral *Columnaria* are met with in many places. One of the most fossiliferous zones is present near the summit of the formation, and from an exposure of this horizon in North Gabouri Creek about five miles from Ste. Genevieve, the following species have been identified.

Plattin Limestone Fauna from North Gabouri Creek

Streptelasma corniculum Hall.
Crania trentonensis Hall.
Orthus tricenaria Conrad.
Dinorthis deflecta (Conrad) ?
Pianodema subaequata (Conrad).
Rafinesquina alternata (Emmons) ?
Rafinesquina cf. *minnesotensis* (N. H. W.).
Rafinesquina sp. undet.
Strophomena incurvata (Shepard) ?
Strophomena sp.
Camarella cf. *volborthi* Bill.
Cyrtodonta cf. *tenella* Ulrich.
Cyrtodonta sp.
Bucania ? sp.
Liospira cf. *augustata* U. & S.
Liospira obtusa U. & S. ?
Lophospira ? sp.
cf. *Eotomaria* ? sp.
Orthoceras cf. *leseuri* Clarke.
Bumastus milleri Bill.
Bumastus sp.
Illaenus americanus (Bill.).
Isotelus sp.
Ceraurus cf. *pleurexanthemus* Green.
Pterygometopus cf. *eboraceus* Clarke.
Leperditia fabulites (Conrad).
Leperditella canalis Ulrich ?

DECORAH FORMATION

Name.—As originally defined, the Plattin was made to include all of the strata between the Joachim limestone below

[1]U. S. Nat. Mus., Bull. No. 92, plate 2 (1915).

and the Kimmswick limestone above, but the higher beds in this interval consist of shales with more or less subordinate limestone layers, which contain a characteristic assemblage of fossils. A similar shale formation, with the same fauna in all of its essentials, occurs at the summit of the Platteville limestone in the upper Mississippi Valley, and has been called the Decorah shale by Calvin.[1] This shaly bed in Ste. Genevieve County is undoubtedly the exact equivalent of the Decorah of Iowa, and the same name may be applied to it in southeastern Missouri as in the more northern region.

Areal Distribution.—The distribution of the Decorah shale is essentially the same as the top of the Plattin limestone, and the formations have not been separated upon the geological map.

Thickness.—In its typical locality at Decorah, Iowa, the formation is said to range from 25 to 30 feet in thickness. In Ste. Genevieve County the maximum thickness of the formation observed, in the northern part of the county, is about 30 or 35 feet, and it ranges from this down to probably nothing in some localities in the southern portion of the district.

Topography.—The Decorah shale is too thin to exercise any notable influence upon the topography, although where it is most shaly it does give rise to a slight, terrace-like bench, in places, between the Plattin and the Kimmswick outcrops.

Lithologic Characters.—In its lower portion the Decorah is calcareous and is apparently not sharply differentiated from the underlying Plattin, the limestone layers, separated by shaly partings, being closely similar lithologically to the limestones of the Plattin. Following these more calcareous beds there are commonly 18 to 20 feet of greenish shales with lentils or thin beds of limestone, some of which are literally crowded with the shells of *Pianodema subaequata*. In the northern part of the county, between Establishment Creek and Isle du Bois Creek, this shale is followed above by about 10 feet of very hard, dense, bluish-gray, siliceous limestone, in which there are numerous silicified fossils, *Plectambonites sericeus* being the most abundant, with *Strophomena* somewhat less numerous.

Stratigraphic Relations of the Decorah.—In his correlation tables Ulrich has indicated an hiatus between the Decorah and the subjacent Plattin in southeastern Missouri, but the local

[1]Iowa Geol. Surv., vol. 16, p. 84 (1906).

field relations do not suggest any such unconformity, the sedimentation from the Plattin to the Decorah apparently being continuous. There is, however, a distinct unconformity between the Decorah and the overlying Kimmswick limestone, a part or all of the Decorah in places having been removed before the Kimmswick was laid down. In the northwest corner of sec. 29, T. 37 N., R. 9 E., the Kimmswick rests directly upon Plattin limestone with no intervening Decorah and in other places some part of the upper portion of the Decorah is wanting, that is present north of Establishment Creek.

Correlation.—The most characteristic fossil of the Decorah formation is *Pianodema subaequata.* Limestone slabs from the formation may be collected in many places which are literally covered with the shells of this brachiopod, and locally in the shale beds great numbers of complete examples of the species can be collected. This species is very characteristic of the faunas of Black River age in various parts of the country, and the Black River age of the formation can be assumed to be established. Ulrich has correlated the formation with some part of the Amsterdam limestone[1] of the New York section, but in view of the fact that there seems to be no stratigraphic break between the Plattin and the Decorah, while on the other hand there is a distinct sub-Kimmswick unconformity, it is possible that the Decorah may be somewhat older, perhaps the equivalent of the Watertown limestone in New York. In either case the formation remains as middle Black River in age.

Paleontology.—One of the most complete collections of the fossils from the Decorah formation that has been secured in Ste. Genevieve County, is from a shale bed at a locality on North Gabouri Creek, about four and one-half miles west of Ste. Genevieve. The species which have been identified in this collection are as follows:

Decorah Shale Fauna from four and one-half miles west of Ste. Genevieve.

Strepelasma sp.
Crinoid stems.
Crania granulosa N. H. W.
Orthis tricenaria Conrad.
Dinorthis deflecta (Conrad).
Pianodema subaequata (Conrad).
Pianodema subaequata var. *conradi* (N. H. W.).
Pianodema subaequata var. *perveta* (Conrad).
Strophomena incurvata Shepard.
Rhynchotrema increbescens (Hall).

[1]Bull. Geol. Soc. Amer., vol. 22, pl. 27 (1910).
U. S. Nat. Mus., Bull. No. 92, pl. 2 (1915).

Rhynchotrema minnesotensis (Sardeson).
Corynotrypa delicatula (James).
Atactoporella insueta Ulrich.
Homotrypa minnesotensis Ulrich.
Homotrypa subramosa Ulrich.
Dekayella praenuntia var. *simplex* Ulrich.
Stigmatella sp.
Eridotrypa aedilis (Ulrich).
Batostoma winchelli (Ulrich).
Hemiphragma irrasium Ulrich.
Escharopora angularis Ulrich.
Escharopora confluens Ulrich.
Escharopora subrecta Ulrich.
Stictoporella angularis Ulrich.
Rhinidictya grandis Ulrich.
Rhinidictya mutabilis (Ulrich).
Rhinidictya paupera Ulrich.
Pachydictya foliata Ulrich.
Gastropod fragments.
Endoceras sp.
Isotelus sp.
Technophorus sp.

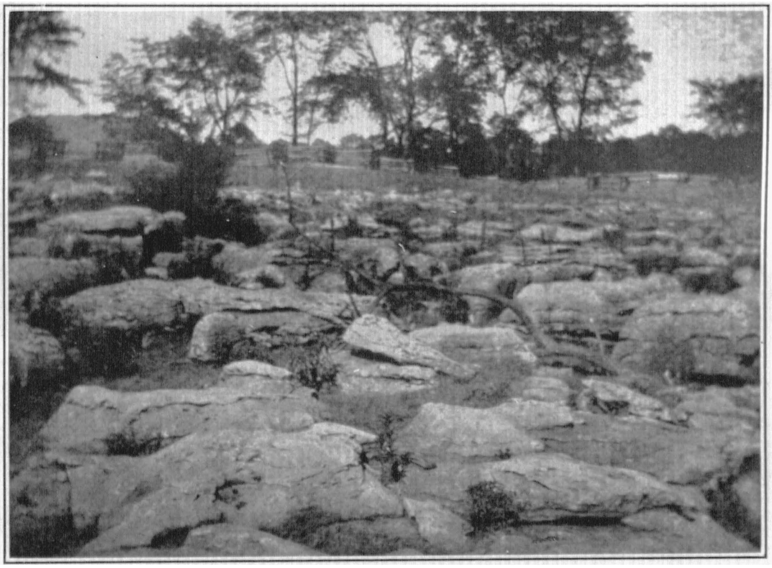
KIMMSWICK FORMATION

Name.—The Kimmswick limestone was named by Ulrich[1] from the typical exposures in the vicinity of Kimmswick, Jefferson County, Missouri, but he has never given an adequate description of the formation nor any list of fossils by which it can be identified. The name is essentially a geographic substitute for the name "Receptaculite limestone" which was used by the early Missouri geologists, a name which was first applied in Ste. Genevieve County, by Shumard.[2]

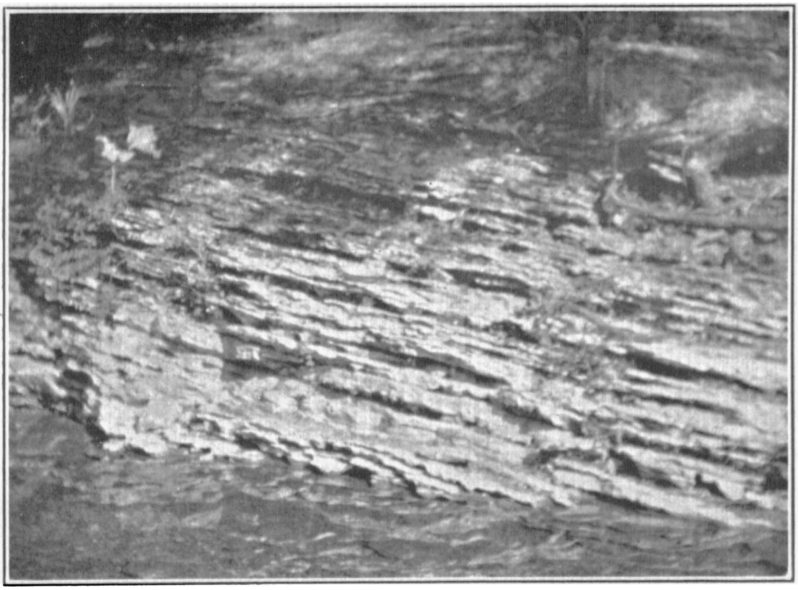
Areal Distribution.—In its areal distribution the Kimmswick limestone occupies a narrow belt adjacent to the Plattin-Decorah belt just west of it, extending from Isle du Bois Creek at the north boundary of the county to the Little Saline faulted zone. The formation is also present in some of the blocks within the faulted area, but it is not present in Ste. Genevieve County south of this zone of deformation. The width of the outcropping belt varies, but is nowhere greater than about one-fourth of a mile, and in the northern part of the county it is commonly only a few rods in width.

Thickness.—The thickness of the Kimmswick limestone in Ste. Genevieve County varies from 20 feet to about 100 feet. Unlike the Plattin and Joachim formations which are thicker to the north, the Kimmswick is thinnest in the extreme northern portion of the county in the hills south of Isle du Bois Creek, where scarcely 20 feet are present in many of the sections. Other sections in the same general region, but a little farther south and east, exhibit from 40 to 60 feet. At Brickeys 50 feet are exposed in the quarry face, and although the total thickness is somewhat greater than this, it must be considerably less than 100 feet. West of Ste. Genevieve the formation has a thickness

[1]Missouri Bureau Geol. and Mines, vol. 2, 2nd ser., p. 111 (1904).
[2]Trans. St. Louis Acad. Sci., vol. 1, p. 410 (1859).



A. Kimmswick limestone.



B. Little Saline limestone, thin-bedded phase.

of 80 to 100 feet, and this thickness continues to the southernmost outcrops in the county which are situated in the Little Saline faulted zone.

Topography.—The outcropping belt of the Kimmswick limestone is not sufficiently wide to exercise any notable influence upon the topography. Throughout the greater part of its extent the formation occupies a position in the more or less steeply sloping face of the escarpment which is capped by the Burlington chert. Where the outcrop is broader, underlying more extended surfaces, it is marked by gently rolling topography.

Lithologic Characters.—The Kimmswick limestone is a very pure, thickly bedded, rather coarsely crystalline limestone, varying in color from slightly pink or flesh colored, to nearly white. The formation is more or less fossiliferous throughout, although the fossils are fragmentary in many portions of the limestone. Bryozoan colonies can be detected in most localities, and in the uppermost beds the presence of numerous examples of the large *Receptaculites oweni* is a conspicuous feature, so characteristic is this fossil that the early geologists of Missouri named this formation the "Receptaculite limestone."

Because of its rather coarsely crystalline texture the weathered surfaces of the Kimmswick limestone are rough except in the more exposed situations, and are commonly more or less covered with lichens and mosses. In exposed places where the soil mantle is thin, the formation is locally weathered into rather smooth, rounded hummocks or knolls which are doubtless outlined by joint cracks in the limestone. Such an exhibition of the formation may be seen on the north side of Little Saline Creek one and one-half miles southwest of Ozora. Although the formation is prevailingly a thickly bedded limestone, cross-bedding within the thicker beds is clearly brought out in many places upon the weathered surfaces, showing the comparatively shallow water origin of the formation.

In most localities the Kimmswick limestone is remarkably free from chert or other impurities, but in some localities in the northern part of the county, cherty horizons of limited extent are present, and at the quarry of the Cliffdale Lime Company at Brickeys, one bed of limited thickness has been replaced by silica, at least upon the surface, in such a manner as to preserve the fossils very perfectly.

Stratigraphic Relations of the Kimmswick.—The Kimmswick limestone rests unconformably upon the subjacent formation, usually upon the Decorah, but locally the whole of the Decorah is absent, and in such places it rests directly upon the Plattin limestone. In the northern part of the county the bed immediately beneath the Kimmswick is the upper siliceous limestone member of the Decorah. Passing to the south of Establishment Creek the shaly *Pianodema subaequata* beds of the Decorah commonly immediately underlie the Kimmswick. Still farther to the south, approaching the Little Saline faulted zone, the shaly member also of the Decorah is locally absent, and the Kimmswick rests directly upon the limestone beds of the lower Decorah or the Plattin. It is not everywhere possible to determine whether or not this underlying limestone is basal Decorah or Plattin because of the talus covering, but at one locality, in the creek bed just northwest of the house near the south line of SE. ¼ sec. 1, T. 36 N., R. 8 E., a good clean section showing the contact of the Kimmswick with the underlying formation, occurs, and although the upper beds of the underlying formation are limestones with the characteristic Plattin lithologic features, still the brachiopod *Pianodema subaequata* is a not uncommon member of the fauna. At this same locality the lower portion of the Kimmswick, up to perhaps 10 feet from the basal contact, includes several interbedded layers which are more or less conglomeratic. The pebbles of these conglomerate layers do not differ materially from the surrounding matrix, and are best exhibited in the smoothly water worn ledges in the bed of the creek.

Up the hill lying to the south and east of the bend in Mill Creek, a little less than one mile south of River aux Vases (Staabtown), loose blocks of basal Kimmswick occur, some of them of a deep red color, in which numerous pebbles up to several inches in diameter are included. Most of these pebbles are of a fine grained, hard, close textured, bluish gray limestone, not unlike many beds in the underlying Plattin, from which formation they were probably derived. The red color of the formation at this locality is doubtless due to the accumulation of iron deposits of some sort in association with the unconformity, and the red color from this iron has been leached down into the underlying Plattin, and adjacent to certain fault planes even down into the Joachim, to such an extent that the beds were formerly extensively quarried in the hope of developing a good quality of marble.

At other localities, notably upon the hill slope north of Little Saline Creek one and one-half miles southwest of Ozora, there have been considerable deposits of limonite at the base of the Kimmswick, doubtless associated with the unconformity between this formation and the subjacent Plattin. These beds have been prospected for iron at some time in the past, and many masses of the ore, ranging from two feet or more in diameter down to small fragments are scattered about the surface.

An unconformity at the summit of the Kimmswick is indicated by the varying thickness of the formation, the higher beds being missing where it is the thinnest, due to erosion of the post-Kimmswick surface. Furthermore, the formation which overlies the Kimmswick throughout Ste. Genevieve County and southeastern Missouri, is very much younger than the Kimmswick, which indicates the existence of a long hiatus following Kimmswick time.

Correlation.—The fauna of the Kimmswick limestone is rich and varied, and includes many unusual forms, but the whole assemblage has not been adequately studied. This fauna must be the ultimate basis for the correlation of the formation, and until it has been studied more fully, and its relationships with other faunas worked out, the exact correlation of the Kimmswick may be considered as unsettled. The latest expression regarding the Kimmswick correlation is that of Ulrich[1] who places the formation at the top of the Black River Group of the Mokawkian. One of the most conspicuous fossils in the higher beds of the Kimmswick is *Receptaculites oweni* which is very characteristic of the Galena limestone of Trenton age, farther north in the Mississippi Valley, and if the evidence of this fossil is followed the Kimmswick might be considered as Trenton in age rather than Black River, placing it a little higher in the general section than the position assigned to it by Ulrich.

Paleontology.—Although some fossils can be found in nearly every outcrop of the Kimmswick limestone, really good specimens are not common in most localities. The most extensive collection from the formation in Missouri has been made at the lime quarries at Glen Park, in Jefferson County, rather than from any locality in Ste. Genevieve County, but the fauna is representative of the formation throughout its extent, and consequently is recorded in this place.

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[1]Bull. Geol. Soc. Amer., vol. 22, pl. 27 (1909).
U. S. Nat. Mus., Bull. No. 92, pls. 1 and 2 (1915).

Kimmswick Limestone Fauna from Glen Park.

Receptaculites oweni.
Receptaculites sp.
Streptelasma corniculum.
Dendrograptus ? sp.
Comarocystites shumardi M. & W.
Wellerocystis kimmswickensis Foerste.
Crinoid stems.
Corynotrypa inflata (Hall).
Constellaria sp.
Phylloporina sp.
Escharopora ramosa Ulrich.
Escharopora multipora (Hall).
Escharopora sp.
Rhinidictya mutabilis Ulrich.
Orbiculoidea cf. *lamellosa* (Hall).
Crania trentonensis Hall.
Crania setigera Hall.
Orthis sp.
Platystrophia precursor var. *angustata* McEwan.
Platystrophia precedens McEwan.
Platystrophia trentonensis McEwan.
Platystrophia amoena McEwan.
Dalmanella rogata (Sardeson).
Dinorthis meedsi (W. & S.).
Dinorthis pectinella (Emmons).
Dinorthis sp.
Plectambonites gibbosa W. & S.
Plectambonites minnesotensis (Sardeson).
Rafinesquina cf. *alternata.*
Strophomena septata W. & S.
Strophomena emaciata W. & S.
Saffordia sp.
Ctenodonta cf. *intermedia.*
Cyrtodonta cf. *obesa* Ulrich.
Vanuxemia umbonata Ulrich.
Ambonychia bellistriata Hall.
Ambonychia sp.
Byssonychia intermedia (M. & W.)
Cyrtolites retrorsus Ulrich.
Cyrtolites cf. *parvus* Ulrich.
Protowarthia cancellata (Hall).
Bucania cf. *halli* U. & S.
Phragmolites compressus Conrad.
Lophospira bicincta Hall.
Lophospira obtusa U. & S.
Hormotoma gracilis var. *angustata* Hall.
Cyclonema montrealense Billings.
Holopea parvula Ulrich ?
Holopea sp.
Hyolithes sp.
Pterotheca cf. *saffordi* Hall.
Conularia trentonensis Hall.
Nanno aulema Ulrich.
Orthoceras amplicameratum Hall.
Eoharpes sp.
Remopleurides missouriensis Foerste.
Isotelus sp.
Isoteloides sp.
Isoteloides sp.
Illaenus americanus Billings.
Illaenus indeterminatus Walcott.
Bumastus holei Foerste.
Bumastus rowleyi Foerste.
Goldius sp.
Proetus latimarginatus Weller.
Acrolichas cucculus (M. & W.).
Acrolichas conifrons Ruedemann.
Corydocephalus tuberculatus (Weller).
Corydocephalus sp.
Corydocephalus sp.
Calymene senaria Conrad.
Ceraurus cf. *pleurexanthemus.*
cf. *Pseudosphaerexochus* sp.
Sphaerocoryphe cf. *robusta* Walcott.
Dalmanites cf. *achates.*
Pterygometopus sp.
Pterygometopus sp.
Aparchites sp.
Ceratopsis chambersi Miller.

FERNVALE FORMATION

General Statement.—The Richmond constitutes the uppermost division of the Cincinnatian Series of the Ordovician[1] in the Ohio Valley section, where it includes six formations[2] with

[1] Ulrich and Bassler consider the Richmond as basal Silurian rather than as uppermost Ordovician.
[2] Cumings, 32nd Ann. Rep. Dept. Geol. and Nat. Res. Ind., p. 621 (1908).
Schuchert, Bull. Geol. Soc. Amer., vol. 20, p. 530 (1910).

the following sequence: 1. Arnheim, 2. Waynesville, 3. Liberty, 4. Salada, 5. Whitewater, 6. Elkhorn.

In Ste. Genevieve County two formations are clearly of Richmond age, viz, the Fernvale limestone and the Thebes-Maquoketa formation. The sediments comprising these formations, however, were deposited in a basin only indirectly connected with the typical Richmondian basin of southern Ohio and Indiana, so that the formations cannot be traced continuously from one region to the other. The similarity of the fossil faunas, however, with *Rhynchotrema capax* as the best index fossil, makes it certain that the Missouri formations were deposited contemporaneously with some portion at least, of the Ohio and Indiana formations. The two formations in Missouri do not represent a continuous sedimentary series, there being a distinct hiatus between them.

Name.—The Fernvale formation was first differentiated by Hayes and Ulrich[1] in Tennessee, in 1903. In the region where the formation was originally described it is composed largely of shales, but the characteristic Fernvale fauna has been recognized in many places in the Mississippi Valley basin, preserved in various sorts of sediments, and the name of the formation has been extended to include these various facies.

The early students of Missouri geology did not separate this unit from the underlying "Receptaculites limestone," and although they did in some cases recognize some faunal difference between this bed and the underlying limestone, they doubtless failed to recognize it as a distinct geological formation because of its limited thickness and because of the similar lithologic character of the bed to that of the underlying strata. Ulrich, however, in his definition of the Kimmswick limestone specifically excludes this bed of limestone from that formation, and points out the fact that its fauna allies it with the Fernvale.

Areal Distribution.—Some of the best exposures of the Fernvale formation in Ste. Genevieve County may be seen in the Frisco Railroad cuts along the Mississippi River bluffs about one-half mile above Brickeys. Another good exposure is beneath the railroad bridge a little less than one mile above Clement. Other exposures occur throughout the county along the upper line of the Kimmswick, some good localities being present within the Little Saline faulted zone, south of which the formation does

[1]U. S. Geol. Surv., Geol. Atlas of U. S., Columbia, Tenn. Folio No. 95, p. 2 (1903).

not occur. Because of the small thickness of the Fernvale, its outcrops must commonly be represented on the map merely as a line, and even then it must be somewhat exaggerated to show at all. Locally, however, where the formation outcrops in the beds of ravines having a gradient about equal to the dip of the strata, the surface outcrop of the formation is more extensive. Such an outcrop occurs in a ravine tributary to Little Saline Creek, about one and one-half miles southeast of Ozora. Upon the accompanying geological map the Fernvale is included with the Kimmswick limestone.

Thickness.—The thickness of the Fernvale limestone in Ste. Genevieve County probably nowhere exceeds three feet, and in some localities it is no greater than six inches. As great a thickness as three feet is rarely met with, it more commonly varying between six and eighteen inches. In places it is absent altogether, and in such situations the Thebes formation rests directly upon the Kimmswick.

Topography.—The areas in which the Fernvale is the surface rock are so narrow that they exercise no influence, apart from the Kimmswick limestone, upon the topographic development.

Lithologic Character.—The Fernvale limestone is somewhat variable in character, commonly being more or less impure. At most localities it is somewhat siliceous, sometimes highly so, but locally it is nearly free from silica. The formation is a light gray color in most localities, but in some places it has a decided brown or reddish tint, and may even be nearly white. Where free from silica it is rather coarsely crystalline and crumbles somewhat readily upon weathering. The more crystalline portion of the limestone resembles certain horizons of the Kimmswick, but are more gray in color and are commonly harder.

Stratigraphic Relations of the Fernvale.—The presence of an unconformity between the Fernvale and the Kimmswick was not suspected by the earlier geologists in Missouri. The limestone of the two formations is sufficiently alike lithologically, to make it appear in isolated sections as a continuous deposit. A study of the fossil faunas, however, shows conclusively that a long time interval elapsed between the deposition of the Kimmswick and the overlying Fernvale. Furthermore, a study of a series of sections across the Kimmswick-Fernvale interval, brings out the fact that the Fernvale does not everywhere rest upon the same bed of the Kimmswick. Commonly, in Ste. Genevieve County, the Fernvale rests upon the Receptaculite bed, but locally this bed has been removed by erosion before the deposition of the Fernvale, and the younger formation rests upon some older bed of the Kimmswick. One of the best exhibitions of this unconformable relation of the Fernvale to the Kimmswick is to be seen in Jefferson County in the sections exposed along the Iron Mountain railroad between Kimmswick and a point a short distance beyond Glen Park, where the Fernvale may be seen resting successively upon higher and higher beds of the Kimmswick. In the more southern portion of its area of outcrop in Ste. Genevieve County, the Fernvale rests unconformably upon the Receptaculites bed, but in the northern part of the county its contact is with the Kimmswick beds far below the Receptaculite horizon.

Unconformable relations also exist between the Fernvale and the overlying Thebes-Maquoketa formation, the details of which will be considered in connection with the description of that formation.

Correlation.—The correlation of the Fernvale limestone is based entirely upon its faunal characters. Its fauna has been studied by Ulrich, the original founder of the formation in Tennessee, and the correlation has been made upon his authority. The formation occurs in many localities in the Mississippi River counties of Missouri, south of St. Louis, and throughout this region it possesses uniform characters, both lithologically and faunally. In the general section of the Richmond division of the Cincinnatian, the Fernvale is placed between the Arnheim and the Waynesville, in the lower portion of the larger group.

Paleontology.—The Fernvale limestone is nearly everywhere fossiliferous, and in many places the fossils are well preserved. The most conspicuous species and the best index fossil is *Rhynchotrema capax*. One of the best collections of Fernvale fossils which has been secured in Ste. Genevieve County has been collected from an outcrop on the south bank of Little Saline Creek one and one-fourth miles southwest of Ozora, and this may be taken as being representative of the fauna as a whole.

Fauna of Fernvale Limestone one and one-fourth miles southwest of Ozora

Orthis cf. *Tricenaria*.
Plectorthis ? sp.
Platystrophia foerstei McEwan.
Hebertella insculpta (Hall) ?
Dalmanella tersa (Sardeson) ?
Dinorthis cf. *subquadrata* (Hall).
Dinorthis sp.
Plectambonites cf. *saxeus* (Sardeson).
Leptaena cf. *unicostata*.
Rafinesquina (two species).
Strophomena cf. *planodorsata* W. & S.
Strophomena planumbona.
Isotelus sp.
Sphaerocoryphe sp. (glabella).
Pterygometopus sp. (tail).

THEBES-MAQUOKETA FORMATION

Name.—The Thebes sandstone has its typical development in the vicinity of Thebes, Illinois, 60 miles down the Mississippi River from Ste. Genevieve County, Missouri. At the type locality the formation is a chocolate colored sandstone some 75 feet in thickness. The Maquoketa formation is made up largely of shale with included limestone beds, and is typically developed in the northern part of the Mississippi Valley, in Iowa, Wisconsin and northern Illinois. Farther south in Illinois, in Calhoun County, the Maquoketa, with the exception of some thin dolomitic beds at the base, is made up entirely of green shales. The two formations are considered as time equivalents by Ulrich[1], being in fact two distinct facies of contemporaneous sedimentation. Ste. Genevieve County, lying in an intermediate position, partakes of both facies, being sandstone below and shale above, and the formation is consequently indicated by hyphenating the two names. When the sandstone alone of this unit is referred to, it will be called the Thebes sandstone, and the shale alone will be designated as the Maquoketa shale.

Areal Distribution.—In Ste. Genevieve County the Thebes-Maquoketa formation may be expected at its proper horizon, from the northern part of the county to the Little Saline faulted zone. The formation is much more persistent in the southern portion of the area where it seems to be uniformly present. In much of the northern part of the county it is entirely wanting, and nowhere in that region is there any considerable thickness. In the river bluffs north of Brickeys the Mississippian formations may be seen at many places resting directly upon the Kimmswick limestone, both the Thebes-Maquoketa and the Fernvale being absent. The formation has been observed and mapped, however, at a number of localities between Establishment Creek and the north line of the county, where the sandstone member is exposed upon some prominent points. Two such exposures are shown upon the map about one mile a little north, and a little south of east from the crossing of the St. Louis road over Isle du Bois Creek. Another similar exposure, south of Establishment Creek is shown about two miles east of Bloomsdale, and three-fourths of a mile north of Bellville School. The formation is doubtless present at many points in this northern part of the county, not indicated upon the geologic map, where

[1]U. S. Nat. Mus., Bull. No. 92, plate 4.

it is wholly obscured by the talus or is too thin to be represented upon a map of the present scale. In the Brickeys quarry section, two feet of shale are present between the Fernvale and the base of the Mississippian, which resembles the Thebes, but it has apparently been reworked, and doubtless owes its present position to the waters of the advancing Mississippian sea.

Near the center of the north line of sec. 1, T. 37 N., R. 8 E., the Thebes occupies an interval of about 32 feet immediately above the Kimmswick limestone, the section at this locality being as follows:

Section of Thebes Sandstone

		Feet.
8.	Cherty limestone, Burlington.	
7.	No exposures, doubtless occupied largely by Fern Glen	35
6.	Sandstone, heavy bedded, fine-grained, more or less calcareous, yellow in color. Possibly Bushberg	4
5.	No exposure, probably the upper shale member of the Thebes	10
4.	Sandstone, fine-grained and thin-bedded, brown to yellow in color, alternating with arenaceous yellow shales	6
3.	Sandstone, fine-grained, yellow to bluish in color, somewhat calcareous, with inclusions of small rounded pebbles and phosphate nodules	5
2.	Shale, calcareous, slate to brown in color, with hard bluish or brown limestone lenses containing brachiopods and trilobites	7
1.	Kimmswick limestone, filled with *Receptaculites*.	

From sec. 7, T. 37 N., R. 9 E., southward, the formation is continuously present at its proper place in the section, although it varies somewhat in thickness, becoming more conspicuous to the south. Through most if not all of this area the two members of the formation are well developed. The last exposures of the formation are within the Little Saline faulted zone.

Thickness.—The lower sandstone member of this formation has a maximum thickness of about 20 feet in Ste. Genevieve County, but in most outcrops it is probably thinner than this. The upper shale member commonly has a thickness of from 30 to 40 feet, and perhaps as thick as 60 feet locally, but it is difficult to determine the exact thickness of this shale because it is so talus covered in most places that neither its upper or lower limits can be determined accurately. The usual thickness of the combined members of the formation is about 60 feet where the formation is fully developed, but in the northern part of the county it is much less than this and is even absent altogether in many places.

Topography.—The material constituting the shale member of the Thebes-Maquoketa formation is an exceedingly plastic clay which, on becoming wet, allows the overlying massive beds to slide down upon the shale surface. This characteristic causes the actual outcrop of the shale to be covered for the most part, but the presence of the shale gives a very characteristic topographic expression to the hill sides underlain by it, and where the shale is thick land-slide topography is clearly exhibited. This topographic feature is prominent especially along the outcrop of the formation between River aux Vases and Little Saline Creek, but it is not conspicuous north of River aux Vases because of the reduced thickness of the shale in that direction. One of the most conspicuous examples of land slide topography due to the presence of the Maquoketa shale, is in the ravine heading near the middle of the south line of sec. 29, T. 37 N., R. 9 E., running northeast and joining a tributary of River aux Vases. In this ravine masses of the overlying rock having a half acre or more of areal extent, have slumped down, in some cases as much as 20 or 30 feet. The same phenomenon is exhibited to a lesser degree at many points in the same general region between River aux Vases and Little Saline Creek.

Lithologic Characters.—The lower sandstone member of the Thebes-Maquoketa formation is a fine grained brown sandstone, in some localities distinctly mottled with small patches somewhat darker in color than the surrounding mass. In many, if not in all exposures, this sandstone exhibits an extraordinarily even bedding, the individual beds varying from two or three inches to a foot or more in thickness. The formation is also commonly intersected by regular parallel joints in one or two systems. At one locality one and one-half miles southeast of River aux Vases (Staabtown), this sandstone has been quarried for local use. The rock taken out is evenly and perfectly divided by the bedding planes and the joints, into blocks from six to ten inches thick, ten to sixteen inches wide, and with a length up to six or more feet. The blocks are pried out with little effort and may at once be laid into a wall or be used as steps with no further dressing whatsoever, except cutting to proper lengths. In many localities where the formation is not actually exposed because of the talus covering, its position may be surely detected by the presence of the subquadrangular blocks of sandstone upon the surface. Arenaceous shales locally take the place of the sandstone, or are interbedded between heavier beds of sandstone, and in most localities shaly beds of limited thickness are present at the base of the formation between the sandstone and the underlying formation. Not uncommonly a thin bed from a few inches to a foot or more in thickness, filled with irregular phosphatic nodules, occurs at or near the base of the formation.

Only rarely has this bed been observed in situ, but fragments of it are not infrequent in the talus from the basal part of the sandstone.

The upper, Maquoketa shale member of the formation, is nowhere well exposed in Ste. Genevieve County, although its presence is assured in many localities by the character of the talus, and by the slumping of the overlying beds. The shale is yellowish-green in color and very soft, and when wet it breaks down into a very plastic clay. Because of its extreme plasticity the formation gives way readily, so it is not possible to determine with accuracy its thickness.

On the south bank of Little Saline Creek, a little over one mile south of Ozora, a small quarry has been opened in the Thebes sandstone. In the midst of the quarry rock a thin, lenticular mass of carbonaceous material was uncovered which possesses all the physical properties of coal. The entire mass could not have been more than two feet, and was probably less, in diameter, with a thickness of about one-half inch. Besides this, numerous specks of black, carbonaceous matter are scattered through the sandstone at this locality. If this material is truly coal it is perhaps the oldest known occurrence of such material.

Stratigraphic Relations of the Thebes-Maquoketa.—The Thebes sandstone rests unconformably upon the underlying limestone throughout the entire area. In most localities in Ste. Genevieve County, except in the extreme northern part, the immediately subjacent formation is the Fernvale limestone, but this formation was subjected to erosion during the time immediately preceeding the deposition of the Thebes. The Fernvale, however, being a very hard and resistant limestone in most localities, was not entirely removed before the deposition of the Thebes, although in some localities a thickness of no more than six inches is present between the Kimmswick and the Thebes. In the area south of Ste. Genevieve County the Thebes also rests directly upon the Kimmswick in places[1], the Fernvale having been entirely removed. The unconformity is further indicated everywhere by the abrupt change from the Fernvale limestone to the sandstone of the Thebes.

The stratigraphic relation of the Thebes-Maquoketa with the overlying formation is also unconformable throughout Ste. Genevieve County. In much of the county the beds lying upon

[1]Savage, Amer. Jour. Sci., 4th ser., vol. 28, p. 514 (1909).

the Maquoketa shale are Mississippian in age, a succession that shows that the whole of the Silurian and Devonian, so far as they were ever represented in the region, were removed by erosion during an emergent interval preceding Mississippian time. In the Little Saline faulted belt, where the Silurian and Devonian formations are present, the Maquoketa is overlaid by the Bainbridge limestone of Middle Silurian age, or by the Brassfield limestone. The latter is the uppermost member of the Alexandrian series of southern Illinois and southeastern Missouri. The Edgewood formation and the Girardeau limestone which make up the remainder of this series are entirely absent, so that here also there is a considerable hiatus between the Ordovician Maquoketa and the succeeding formation. The presence of the Brassfield limestone was determined after the publication of the geologic map, on which it is included with the Bainbridge.

Correlation.—The basis for the correlation of the Thebes-Maquoketa, as developed in Ste. Genevieve County, is to be found in the fauna of small pelecypods, especially *Cleidophorus neglectus*, which occurs at the base of the formation. Although this fauna has not been actually observed in the county in a good state of preservation, it does occur finely preserved in the neighboring Jefferson County, and enough of it has been detected in Ste. Genevieve County to make it certain that its horizon is at the base or close to the base of the Thebes sandstone member. This fauna has a wide distribution to the north of this southeastern Missouri region, being present in Calhoun County, Illinois, and again in many localities in northeastern Iowa, northwestern Illinois and southwestern Wisconsin. Throughout this region the *Cleiodophorus neglectus* fauna everywhere occurs at or near the base of the Maquoketa shale, and is commonly, if not always restricted to a zone not exceeding four or five feet in thickness. On the evidence of this fauna the base of the Thebes in Ste. Genevieve County may be correlated, with a high degree of assurance, with the basal Maquoketa of Iowa. The name Maquoketa has been applied to a series of strata some 200 feet or more in thickness[1] which constitutes a composite formation so variable, both lithologically and faunally, that future detailed work will doubtless make necessary its subdivision. The beds under discussion in Ste. Genevieve County undoubtedly rep-

[1]Calvin, Ia. Geol. Surv., vol. 16, p. 94 (1905).
Bain, Bull. U. S. Geol. Surv., No. 216, p. 21 (1905).

resent some part of the lower portion of the Iowa Maquoketa, but certainly not the whole of it. On the other hand they are nearly, if not exactly equivalent to the Thebes sandstone of Alexander County, Illinois, and Cape Girardeau County, Missouri.

Because of the deposition of the sediments in distinct, separate basins, the exact correlation of the Thebes-Maquoketa with the formations of the Ohio Valley is not easy to determine with certainty. In his correlation tables of these formations Ulrich[1] has placed the Maquoketa between the Liberty and Saluda formations, the Thebes being shown as the equivalent of a part at least, of the Maquoketa. Such a position, near the middle of the Richmond Group, cannot be far from the correct position of the formation.

Paleontology.—Fossils have been rarely observed in the Thebes-Maquoketa formation in Ste. Genevieve County. In Jefferson County, however, at an exposure in a railroad cut on the Iron Mountain Railroad between Kimmswick and Sulphur Springs, where the arenaceous Thebes facies is wanting, a fauna consisting largely of small pelecypod shells has been collected from near the very base of the formation. The species identified from this locality are the following.

Fauna of Maquoketa Shale, one mile below Kimmswick, Jefferson County, Missouri

Lingula sp.	*Archinacella* sp.
Trematis sp.	*Scenella* sp.
Dalmanella cf. *testudinaria* (Dal.)	*Liospira micula* (Hall).
Plectambonites sericeus (Sow)?	*Gyronema* sp.
Zygospira modesta Hall.	*Holopea* sp.
Ctenodonta 4 species.	*Hyolithis parviusculus* (Hall).
Clidophorus neglectus Hall.	*Orthoceras* sp.

This fauna in which the small clam shells are the most numerous forms, is typical of the base of the Maquoketa in Iowa, northern Illinois and Wisconsin. It has also been recorded from the same horizon in Calhoun County, Illinois, and is known from the region south of Ste. Genevieve County. In Ste. Genevieve County no good collections of this fauna have been observed, but at one locality on Little Saline Creek, at the base of the sandstone member of the formation, fragments of small pelecypod shells, undoubtedly belonging to the same genera

[1]Bull. Geol. Soc. Amer., vol. 22, pl. 28 (1910).

recorded above, but too imperfectly preserved for specific determination, have been observed.

The only collection of determinable fossils from the formation in Ste. Genevieve County, has been secured from the basal bed of the section already described, in sec. 1, T. 37 N., R. 8 E., where the following species occur:

Maquoketa Fauna from four miles southwest of Ste. Genevieve

Crinoid (thick column joints with convex sides).
Strophomena sp. cf. *S. rugosa.*
Plectambonites sericeus (Sow).
Dinorthis proavita W. & S.
Isotelus (pygidium).

SILURIAN SYSTEM

Introduction.—The Silurian sediments in Ste. Genevieve County are included in a single formational unit, the Bainbridge limestone. This formation is divisible into a number of distinct parts which differ from each other more or less markedly, and with future, more detailed investigation it may prove to be desirable to subdivide it. Such procedure, however, will be largely dependent upon the discovery of more extensive fossil faunas than have yet been met with in the formation.

BAINBRIDGE FORMATION

Name.—Ulrich[1] has proposed the name Bainbridge limestone for the Silurian beds occurring in the Mississippi River bluff at Bainbridge, Cape Girardeau County, Missouri. No adequate description of the formation was given when the name was proposed, either faunal or lithological, nor has any description been published since, but inspection shows that the Silurian beds in Ste. Genevieve County are essentially equivalent to those at Bainbridge.

Areal Distribution.—In Ste. Genevieve County the Bainbridge limestone occurs only within the Little Saline faulted zone, where there are several more or less isolated areas. The formation is well exposed two miles southeast of River aux Vases (Staabtown), along the road to Little Saline Creek. A continuation of the same ledges to the southeast give good exposures in the bluffs on the east side of Little Saline. The formation is again well exposed along the road running south from Rigdon's Mill on River aux Vases, to Little Saline Creek, from one-half

[1]Mo. Bureau Geol. and Mines, vol. 2, 2nd ser., p. 110 (1904).

to three-quarters of a mile from the latter stream. Limited exposures occur in the bluffs along the south side of Little Saline, west of the crossing of the road south from Ozora, and there are other exposures east of this crossing on the north side of the creek. Extensive outcrops of the formation are present upon the southern slope of the hill three-fourths of a mile north of Independence School, along the St. Marys road.

Thickness.—The thickness of the Bainbridge formation varies notably. In the hill in the southern portion of NE. ¼ sec. 5, T. 36 N., R. 9 E.,[1] the thickness is 120 feet or more, perhaps as much as 150 feet. In the hill south of Little Saline Creek and west of the road crossing south of Ozora, the thickness is very much less, although it cannot be determined with any degree of accuracy because of the thick covering of talus. As much as 50 feet of strata may be present in this locality, but it is probably less, perhaps not over 30 feet. In the hill three-fourths of a mile north of Independence School the formation again attains a greater thickness, probably equal to that in the section first mentioned.

Topography.—Within the Little Saline faulted zone, to which the Bainbridge formation is confined, the outcropping areas of the several formations are so small that most of them exercise but little influence upon the topographic features, these being controlled largely by the structure. Where the Bainbridge is the surface formation, its more extensive outcrops are upon rather steeply sloping hill sides, with some of the harder layers locally forming low bluffs. Upon some of the hill sides more or less extensive glade-like areas occur where there is little or no surficial accumulation over the bed rock, and little or no vegetation. Where the formation underlies flatter areas the surface is rolling, and is in no way different from surfaces overlying various other formations in the region.

Lithologic Characters.—The Bainbridge is a limestone throughout, which is more or less argillaceous in most horizons, locally becoming almost shale. In color the formation varies from a light buff or yellow, through a greenish yellow, to a deep red, red being the dominant color of the formation. Many beds are distinctly mottled, the brick red portions being sharply set off from the adjacent lighter colored rock. Not infrequently, in the lighter colored beds, dendritic markings are conspicuously

[1]This locality is situated towards the western corner of a large Spanish grant, the location given being that determined by the projection of the section lines into this grant.

developed along the joints and fracture surfaces. Chert is commonly absent, and where it does occur it is present only in the lowermost beds of the formation. Nowhere are the beds thick and solid, the bedding being very irregular, changing rapidly from thicker to thinner beds vertically. Except at the very base of the formation, few if any of the beds, even the thicker ones, are free from seams, so that the rock breaks down readily in the process of weathering, and nowhere forms vertical bluffs of any notable height. Perhaps the greatest vertical exposures of the formation occur along the east side of Little Saline Creek a half mile west of Boarman School.

At the base of the Bainbridge is a bed notably different from the main mass of the formation. This bed is a very hard, tough limestone, evenly bedded for the most part. Its color is gray or pinkish gray, oftentimes the ground mass being gray or pale buff, with pinkish specks scattered through it, these pink specks being sufficiently abundant in places to give to the entire bed a distinct pink color. In an outcrop of this basal limestone member, exposed in the south bank of Little Saline Creek about 1,200 feet west of the road crossing south of Ozora, conspicuous bands of pink chert are present, these chert layers being confined to the lower five feet of the exposure. Associated with these cherts are conglomeratic limestone layers, the included pebbles being more or less irregular in form and varying in size up to six inches in diameter. In places this basal limestone resembles, more or less closely, some portions of the Kimmswick limestone, but the contained fossils at once show it to be a much younger formation.

Stratigraphic Relations of the Bainbridge.—The Bainbridge rests unconformably upon the Thebes-Maquoketa wherever it occurs in Ste. Genevieve County. As has already been indicated, the Thebes-Maquoketa is believed to occupy a position some distance below the top of the Richmond Group of the Ordovician, and the Bainbridge is clearly not the oldest Silurian, but belongs somewhere near the middle of that system. These correlations indicate that a considerable period intervened between the time of deposition of the Thebes-Maquoketa and the Bainbridge, during which the Ste. Genevieve County area was elevated above the sea level, consequently the younger formation must have been laid down unconformably upon the older. The actual contact between the two formations has nowhere been observed, so it is not possible to determine whether or not the pre-Bainbridge surface exhibits evidences of erosion.

The Bainbridge formation is also limited above by an unconformity, since it is not the youngest Silurian and the overlying formation is not the oldest Devonian.

Structure.—The Bainbridge limestone is involved in the complex faulting of the Little Saline faulted zone. In most places the strata exhibit gentle dips, the direction of the dip being dependent upon the structural relations of the particular fault block in which the outcropping beds occur. Much steeper dips are present locally, however, adjacent to some of the fault lines, the greater inclination being induced by the drag along the fault planes. There are no special structural features exhibited by the formation which are not common to the whole region.

Correlation.—All of the faunas which have been collected in the Bainbridge limestone in Ste. Genevieve County, are notably different from any of the well described Silurian faunas in America, enough different to indicate that they must have lived in a basin which was more or less independent from that in which these better known Silurian faunas flourished. The relationships of the fauna are perhaps most close with some of the Tennessee Silurian faunas which are only imperfectly known. The most prolific fauna which has been collected is from the outcrops along the St. Marys road about a mile north of Independence School, and the most conspicuous feature of this fauna is the abundance of individuals, perhaps belonging to a number of species, of the crinoid genus *Pisocrinus*. The abundance of this crinoid genus suggests some alliance between this fauna and that of the Laurel limestone of the Indiana basin, and there are other faunal relationships which suggest a similar relationship. From our present knowledge of the faunas it would be unsafe to consider that a correlation of the Bainbridge limestone of Missouri with the Laurel limestone of Indiana is established, but such a correlation may be made as a tentative suggestion. In the correlation tables published by Bassler[1] the Bainbridge limestone is shown as covering the interval from the bottom of the Waldron stage to the top of the Silurian, but any really satisfactory correlation of the formation must await much more complete Silurian faunal studies.

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[1]U. S. Nat. Mus., Bull. No. 92, plate 4.

Paleontology.—Good fossils are not present in abundance in the Bainbridge formation, except locally. At almost every locality segments of crinoid stems can be detected, commonly white in color, imbedded in the red matrix, but good crinoid bodies are exceedingly rare. By far the most complete collection of the Bainbridge fauna has been secured from the outcrops along the St. Marys road, north of Independence School, but owing to the fact that some of the species are undescribed, and that none of the material has yet been adequately studied, it is possible to record only an incomplete list of the species present. This is undoubtedly the type locality from which Rowley secured the several crinoids which he described as from "red, shaly limestone of Niagara age, near St. Marys, Ste. Genevieve Co., Mo."

Fauna of Bainbridge limestone, St. Marys road, one-half mile north of Independence School

Zaphrentis ? sp.
Favosites sp.
Strybalocystis missouriensis Rowley.
Caryocrinus sp.
Troostocrinus reinwardti var. *minimus* Foerste.
Dimerocrinus sp.
Melocrinus ? sp.
Eucalyptocrinus sp.
Cordylocrinus ? dubius Rowley.
Lecanocrinus hemisphericus Rowley.
Pisocrinus granulosus Rowley.
Pisocrinus gorbyi Miller.
Pisocrinus globosus Ringueberg.
Pisocrinus glabellus Rowley.
Cyathocrinus ? ovalis Rowley.
Fistulipora sp.
Fenestella sp.
Dalmanella cf. *elegantula* (Dal.).
Strophonella sp.
Clorinda sp.
Dictyonella cf. *reticulata* (Hall).
Atrypa reticularis (Linn.).
Atrypa cf. *marginalis* (Dal.).
Trematospira ? sp.
Nucleospira sp.
cf. *Whitfieldella nitida* (Hall).
Holopea ? sp.
Platyceras sp.
Dawsonoceras annulatum (Sow.).
Calymene sp.

Among the most characteristic members of this fauna are the species of the crinoid genus *Pisocrinus*, all the other crinoids being rare. A few of the brachiopods are somewhat common.

A peculiar member of the fauna in some localities, and one which is said by Ulrich to be very characteristic of the formation at Bainbridge, is a species of Orthoceras having exceedingly elongate chambers, the distance between the sutures being equal to or even greater than the diameter of the shell.

DEVONIAN SYSTEM

General Statement.—The Devonian System in Ste. Genevieve and Perry counties is represented by 640 feet or more of sediments, all of which belong to the Lower and Middle divisions of the System. The Lower Devonian is represented by beds of both Helderbergian and Oriskany age, and the Middle Devonian by beds of both Onondaga and Hamilton age. All of these beds are restricted to the Little Saline faulted zone. The most continuous and most complete section of these rocks is to be seen in the east bank of Little Saline Creek, along the course of that stream where it flows a little east of north in the SE. ¼ sec. 5, T. 36 N., R. 9 E., and up the slopes of the hill east of the same stream whose summit is in the SW. ¼ of the adjacent section 4.

Although the relationships of the Ste. Genevieve County Devonian are shown clearly by the fossils to be with the New York formations mentioned above, their lithologic characters are so widely different and the basin in which they were deposited is so widely separated from the New York basin, that the New York formation names cannot be used for them. Ulrich has already proposed names for some of these Devonian formations of Ste. Genevieve County, from his study of the section in the Mississippi River bluffs in Perry and Cape Girardeau counties, and these terms will be used here. Several of the formations, however, must be given new names.

BAILEY FORMATION

Name.—Meek and Worthen[1] long ago described a group of fossils said to have come from the "Lower Helderberg Group," at Bailey's Landing, Perry County, Missouri. Bailey's Landing has long since been abandoned because of changes in the channel of the Mississippi River and the name has been almost forgotten, but its former location was a short distance above the present Red Rock Landing. Ulrich restudied the Bailey's Landing section, so far as it is exposed at the present time, and proposed the name Bailey limestone[2] for the formation from which Meek and Worthen's fossils were secured, although no full description of the formation was given. The same formation with a characteristic Helderbergian fauna occurs at a number of localities in

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[1]Geol. Surv. Ill., vol. 3, pp. 368-392 (1868).
[2]Mo. Bureau Geol. and Mines, vol. 2, 2nd ser., p. 110 (1904).

Perry and Ste. Genevieve counties, and the name proposed by Ulrich will be used for it in this report.

Areal Distribution.—In Ste. Genevieve County the distribution of the Bailey limestone is essentially the same as the underlying Bainbridge limestone, the younger formation being present overlying the older, in nearly every section where the Silurian formation occurs. The most extensive area of the Bailey limestone occurs about the border of the syncline in the large synclinally folded block in the Little Saline faulted zone, lying northwest of Boarman School. This syncline is plunging to the east, so the formation occupies a horse-shoe shaped area, the open end of the horse-shoe to the east. The legs of this horse-shoe, with some offset, are continued eastward across the adjacent block of the faulted zone, lying to the northeast. Another much smaller area of the formation is present towards the eastern end of the hill on the south side of Little Saline Creek, just west of the road crossing south of Ozora. Other outcrops of notable extent are present upon the northern and western slopes of the hill north of Independence School, along whose southern and eastern sides the Bainbridge limestone is so well exposed along the St. Marys road.

Thickness.—Nowhere in Ste. Genevieve County is the total thickness of the Bailey limestone well exhibited in one continuous section, but observations upon various sections makes it certain that its thickness is not less than 200 feet, and it may be even greater. This thickness is apparently about evenly divided between the lower less cherty beds and the higher cherty beds, although the upper member may be somewhat the thicker in some places. An excellent continuous outcrop of the formation is well exposed in the railroad cuts just above Red Rock Landing in Perry County. At this locality the rocks are dipping steeply and no less than 300 feet are exposed. Other outcrops occur just below the landing which, from their contained fossils, seem to be different from any of the beds above, so that the total thickness may considerably exceed 300 feet. So far as known to the writer, the maximum thickness of the formation occurs in this locality, and probably nowhere in Ste. Genevieve County is the formation so thick as at Red Rock Landing. A measured thickness of 90 feet is exposed along the south bank of Little Saline Creek west of the road to Boarman School, all of which is in the lower portion of the formation below the fossiliferous chert beds, and it does not include a considerable thickness of the beds at the base. There may be as much as 150 feet in this section, all below the fossiliferous chert beds.

Topography.—The resistent character of the chert which constitutes so large a portion of the upper part of the Bailey formation, causes this formation to be a notable ridge maker, and each of the larger and more important Bailey areas in Ste. Genevieve County stands up in notable relief. This topographic feature is well exhibited in the horse-shoe shaped range of hills which border the large, synclinally folded block in the Little Saline faulted zone, and also in the crescent shaped hill which lies between the St. Marys road and Little Saline Creek, north of Independence School.

Lithologic Characters.—The Bailey limestone varies greatly in its lithologic character, although its most conspicuous feature is the great amount of chert present in it. These chert beds are so resistent that they commonly rise as conspicuous hills or ridges. The limestone associated with the chert is commonly dolomitic, although certain beds are nearly pure, crystalline limestone.

The lithologic succession in the Bailey limestone is not perfectly shown in clean section at any point in Ste. Genevieve County, because of the heavy covering of talus upon all the hill slopes. However, the general succession is determinable, although accurate thicknesses of the beds cannot be measured. The lower portion of the formation consists of fine-grained, yellowish-gray, thinly bedded dolomite, which is much less cherty than the higher beds, the chert present commonly being in the form of rounded concretionary masses only a few inches in diameter. Somewhat higher in the section these beds seem to pass into a more shaly member, rarely or never well exposed because of the talus covering. In the talus from this horizon in many localities, may be found numerous, irregular masses of a soft, yellow rock, probably the product of weathering of an impure chert, in which many specimens of the brachiopod *Leptaena rhomboidalis*, and the pygidia of a large *Dalmanites*, occur. Near this horizon, or a little higher up, numerous examples of *Camerocrinus*, the bulbous stem base of the crinoid *Scyphocrinus*, are commonly met with in the talus. Still higher up the formation passes abruptly into the conspicuous chert beds of the formation from which the usual talus covering of the lower beds is largely derived. The lower division of the formation, below the chert beds seem to attain a thickness of nearly or quite 100 feet in places. In the middle portion of the formation, near or at the base of the upper chert member, a layer of nearly pure, crystalline, highly fossiliferous, usually crinoidal, gray limestone has been met with at several points, and is probably a continuous bed. Where observed its thickness does not exceed five feet or so, and may be less, passing gradually into the intercalated limestone and chert beds above.

The more typical expression of the Bailey limestone is best shown in the upper member of the formation, for it is here that the most conspicuous chert beds are developed. These beds are actually exposed in clean sections at only a few localities in Ste. Genevieve County, being more commonly covered by thee chert talus which also slumps down and more or less completely obscures the lower beds. One of the best exposures is in the east bank of Little Saline Creek, about one-half mile west of Boarman School. The chert as seen upon the hill slopes, is light colored, much of it nearly white, or with a slight pinkish tint, other masses are gray. It is extremely hard and breaks into angular fragments from an inch or two to a foot in maximum dimensions. Some of it is more or less porous, especially the fossiliferous portions, but much of it is very dense. The greater portion of this chert contains very few or no fossils at all, but in the lower portion of the chert series some beds are abundantly fossiliferous, and the surface of slabs from such horizons are covered with the shells of brachiopods and some other forms.

In a few localities the fossils in some of the beds have become silicified while the surrounding matrix has not been so changed. On weathering, the fossils from such beds come out free and may be found in the talus slope below the bed from which they originate.

Stratigraphic Relations of the Bailey Limestone.—No actual contacts of the Bailey limestone upon the underlying Bainbridge are exposed in Ste. Genevieve County, free enough from talus to permit observation of the stratigraphic relations of the two formations. The Bainbridge, however, certainly is not of the age of the youngest Silurian beds known in America, and the Bailey is younger than the oldest Devonian, so that there must be a considerable hiatus between the two formations, during at least a part of which time Ste. Genevieve County must have been emergent, and if not subjected to erosion, was in such a position that no sediments were accumulating. The Bailey limestone is also unconformable with the overlying Little Saline limestone.

Correlation.—Although the fauna of the Bailey limestone in Ste. Genevieve County is somewhat different in many of its details from the Helderbergian faunas which are so well known in Maryland and New York, the similarity is sufficient to establish the Helderbergian age of the formation without any question. The fauna is more like that of the Linden formation of Tennessee[1], than any other described Helderbergian fauna, and the abundant silicified fauna which has been collected in one locality has much in common with the Birdsong member of the Linden. The Linden as a whole has been correlated by Dunbar with the New Scotland and some portion of the Coeymans formations of the New York Helderbergian section, the Birdsong member, with its very prolific fauna being New Scotland in age, and the same correlation may be accepted as satisfactory for the Bailey limestone.

Paleontology.—The more important collections of fossils which have been secured from the Bailey limestone are silicified specimens which are in places weathered out completely free from the matrix. These collections represent the fauna of the upper half of the formation. Another source of good fossils is the thin bed of gray, crystalline limestone which seems to be persistently present near the middle of the formation. These two faunas are much alike, but will be listed separately.

Fauna of the Bailey limestone, silicified specimens, from near Little Saline Creek

Hindia sphaeroidalis (Dalman).
Streptelasma strictum Hall.
Favosites helderbergiae Hall.
Favosites conicus Hall.
Pleurodictyum lenticulare (Hall).
Striatopora missouriensis M. & W. ?
Striatopora bella Swartz.
Scyphiocrinus sp.
Eridocrinus sp.
Alsopocrinus anna Tansey.
Fistulipora sp.
Fenestella sp.
Crania alsopi Tansey.
Dalmanella perelegans (Hall).
Dalmanella planoconvexa (Hall).
Dalmanella quadrans (Hall).
Rhipidomella discus (Hall).
Rhipidomella oblata (Hall).
Rhipidomella ellsworthi Tansey.
Rhipidomella carlwegi Tansey.
Bilobites varicus (Conrad).
Leptaena rhomboidalis (Wilck).
Strophonella punctulifera (Conrad).
Leptaenisca concava (Hall).
Anastrophia verneuili (Hall).
Gypidula multiplicata Dunbar.
Rhynchotrema formosum (Hall).
Uncinulus subpyramidatus Tansey.
Uncinulus angulatus Tansey.
Uncinulus nucleolatus (Hall).
Eatonia singularis (Vanuxem).
Rhynchonella bialveata Hall.
Rhynchonella transversa Hall.
Atrypina imbricata (Hall).
Atrypa reticularis (Linn.).
Spirifer cyclopterus var. *missouriensis* Tansey.
Spirifer octocostatus.
Delthyris perlamellosus (Hall).
Delthyris missouriensis Tansey.

[1]Dunbar, State Geol. Surv. of Tenn., Bull. No. 21 (1919).

Cyrtina dalmani (Hall).
Rhynchospira formosa (Hall).
Meristella bella (Hall).
Meristella melvillii Tansey.
Meristella laevis (Hall).
Nucleospira ventricosa (Hall).
Conocardium sp.
Cypricardinia distincta (Bill.) ?
Platyceras pentalobus Hall.
Diaphorostoma sp.
Dalmanites sp.
Phacops hudsonicus Hall.

Fauna of the Gray limestone of the Bailey Formation, Little Saline Creek.

Streptelasma strictum Hall.
Scyphiocrinus sp.
Dalmanella perelegans (Hall).
Dalmanella planoconvexa (Hall).
Dalmanella quadrans (Hall).
Rhipidomella oblata (Hall).
Rhipidomella discus (Hall).
Rhipidomella carlwegi Tansey.
Rhipidomella ellsworthi Tansey.
Bilobites varicus (Conrad).
Leptaena rhomboidalis (Wilck.).
Stropheodonta arata Tansey.
Leptostrophia planulata (Hall).
Strophonella punctulifera (Con.).
Leptaenisca concava (Hall).
Uncinulus nucleolatus (Hall).
Uncinulus subpyramidatus Tansey.
Uncinulus mutabilis (Hall).
Rhynchonella transversa Hall.
Rensselaerina medioplicata Dunbar.
Atrypa reticularis (Linn.).
Spirifer cyclopterus var. *missouriensis* Tansey.
Delthyris perlamellosus (Hall).
Delthyris missouriensis Tansey.
Rhynchospira formosa (Hall).
Meristella melvillii Tansey.
Pteronitella ? sp.
Aviculopecten ? *umbonata* Hall. ?
Platyceras sp.
Goldius barrandii (Hall).
Dalmanites griffoni Clarke?
Dalmanites micrurus (Green)?
Dalmanites n. sp.
Phacops hudsonicus Hall.
Phacops logani Hall.

The lower, less cherty portion of the Baily limestone contains very few fossils. Those most commonly met with are from the yellow, decomposed siliceous beds of this part of the formation, and the species most often seen are *Leptaena rhomboidalis* and the tails of *Dalmanites*. The weathered out examples of the bulbous stem bases (*Camarocrinus*) of the crinoid *Scyphiocrinus*, are not uncommonly met with in the residuum of the higher portion of the lower division of the formation.

LITTLE SALINE FORMATION

Name.—The limestone designated by the name Little Saline has not heretofore been recognized. The name is a new one and is taken from the excellent exposures of the formation at the quarries of the Ozora Marble Company, in the east bank of Little Saline Creek, just south of the abrupt bend of the stream from a northerly to an easterly direction, a little less than one and one-half miles west of the road crossing south of Ozora.

Areal Distribution.—The area underlain by the Little Saline limestone in Ste. Genevieve County, is of only limited extent, and up to the present time no occurrence of the formation is known outside of the county. The most of the area is within sections 5, 6, 7, and 8, T. 36 N., R. 9 E., but it extends a short distance to the east into the adjoining sections 4 and 9. The formation occurs in a horse-shoe shaped area in the large synclinally folded block of the Little Saline faulted area, within the surrounding border of chert hills formed by the Bailey limestone, the legs of the horse-shoe being extended, with some offset, across the block of the faulted zone next east, also folded in a syncline. Aside from these areas, the only other outcrop of the formation which has come under observation is a very small one which occurs about one and one-half miles farther east, in the hill to the south of Little Saline Creek.

Thickness.—The entire thickness of the Little Saline limestone is well shown at the typical exposure of the formation on Little Saline Creek. At this locality the beds are dipping rather steeply to the southeast, and the successively higher beds are exposed in almost continuous outcrop in the bank of the stream, a careful measurement of which has given a thickness of 100 feet. At no other place in the area can the entire thickness be seen. In following the formation to the west, and also to the east, its thickness seems to become less. In the bank of Little Saline Creek about a mile up stream from the typical exposure, less than 50 feet of limestone which can be referred to this formation seem to be present, and in the extreme eastern outcrop, a little over one and one-half miles east of the typical locality, there are probably less than 25 feet, but both of these apparent reduced thicknesses may be due to fault relations. The two outlying exposures of the formation are both of the lower portion of the formation.

Topography.—There are no special topographic features associated with the Little Saline limestone. Along Little Saline Creek where the formation is typically exposed, it forms a low bluff. In the SE. ¼ sec. 6, T. 36 N., R. 9 E., where the greatest continuous areal extent of the formation is exposed, the surface is gently rolling.

Lithologic Characters.—The Little Saline formation is a very pure, thickly bedded, more or less coarsely crystalline limestone, nearly white in color or with a slight pinkish tint, and is filled with fossils in its lower half. One bed towards the top is decidedly crinoidal, with great numbers of fragments of crinoid stems upon the weathered surfaces. At some isolated outcrops, where fossils are scarce, it is difficult to distinguish some portions of this limestone from certain beds of the Kimmswick limestone, but usually sufficient fossil evidence can be secured to differentiate the two formations. In the upper half of the formation there are two beds of dense, hard, close-textured, nearly white limestone, with great numbers of a bryozoan resembling those forms which have been described as *Lichenalia*. The first of these beds, ten feet in thickness, lies immediately above the more coarsely crystalline, highly fossiliferous beds, the other being at the extreme summit of the formation, about eight feet thick. Between these two *Lichenalia* beds the rock is coarsely crystalline, similar to that in the lower half of the formation, but much less fossiliferous. Some beds of the Little Saline limestone have the characters of a good marble, and make a handsome ornamental stone. The formation is apparently entirely free from chert.

A detailed section of the formation at its typical exposure is as follows:

	Section of Little Saline Limestone	Feet
4.	Limestone, close-textured, hard and brittle, breaking with a splintery fracture, containing numerous bryozoans. The upper Lichenalia bed..................	8
3.	Limestone, more or less coarsely crystalline, light colored, nearly white or with a pale pink tint, some portions with pinkish blotches, the lower eight feet with numerous crinoid stems upon the weathered surface. Some portions of the bed resemble certain beds of the Kimmswick limestone..........................	25
2.	Limestone, close textured, hard and brittle, with numerous bryozoans, entirely similar to bed No. 4. The lower Lichenalia bed...........................	10
1.	Limestone, massive, heavy bedded, pure and crystalline, nearly white in color or some portions with a pale pink tint. Abundantly fossiliferous, *Spirifer murchisoni* the most conspicuous species..	60

Stratigraphic Relations of the Little Saline Limestone.—The faunas of the Bailey limestone in Ste. Genevieve County do not represent the youngest phase of the Helderbergian as developed in New York and Maryland, and the Little Saline fauna is not the oldest type of the Oriskany fauna. These conditions would indicate that an hiatus is present between the two formations, and consequently that the younger rests unconformably upon the older. Furthermore, a somewhat hasty examination of the section near the old Bailey's Landing in Perry County, seems to indicate that there are certain younger Helderberg beds in that section which are not present in Ste. Genevieve County, which would mean either that they were never deposited in Ste. Genevieve County, or if deposited they were eroded before the Little Saline limestone was laid down, the latter interpretation probably being the most likely.

The actual contact of the Little Saline upon the Bailey has been observed in only one locality, in the south bank of Little

Saline Creek near the Palmer fault, about a mile and one-half about the road crossing south of Ozora. At this locality only two or three feet of the contact is exposed. The change from the cherty beds below to the pure limestone above is abrupt, a condition suggesting an unconformity, but the relations are such at this locality as to make it possible that this contact is a fault contact rather than a stratigraphic succession.

At its upper limits the Little Saline sedimentation seems to pass without interruption into that of the overlying Grand Tower formation of Middle Devonian age.

Correlation.—The most casual observation of the fauna from the lower portion of the Little Saline limestone indicates its relationship with the Oriskany sandstone fauna of the New York section. The abundance of *Spirifer murchisoni*, *Spirifer arenosus*, *Rensselaeria ovoides*, *Plethorhyncha*, etc., stamp the fauna at once as being an expression of the same fauna, although certain forms such as *Hipparionyx proximus*, etc., are entirely wanting. One of the most surprising facts is, that while in New York this fauna, in its most typical development is preserved in a coarse sandstone, in Missouri it is in an exceedingly pure limestone. In some respects the fauna resembles that of the Grande Greve limestone of Gaspe, Quebec, more closely than that of the New York Oriskany sandstone. On the basis of the faunal evidence the formation may be correlated certainly with the Upper Oriskany. The only other similar Oriskany fauna as yet known from any part of the Mississippi Valley, has been reported by Dunbar from the Quall formation and Harriman novaculite of western Tennessee.[1]

Paleontology.—In the lower 60 feet of the Little Saline limestone some beds are crowded with well preserved fossils. In the higher portion of the formation the fossils are less abundant, but very near the summit there are a considerable number of species which do not occur below. In the following list all of the recognized members of the fauna are recorded, those which are known only from the summit of the formation being marked with an asterisk. All of the species have been collected from the outcrops along Little Saline Creek.

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[1]Tenn. State Geol. Surv., Bull. No. 21, pp. 69-77 (1919).

Fauna of the Little Saline limestone

Zaphrentis cornuformis Stewart.
Zaphrentis salinensis Stewart.
Favosites cf. *helderbergiae* Hall.
Favosites sp.
Edirocrinus sacculus Hall ?
Fistulipora acutula Stewart.
Fistulipora variolata Stewart.
**Meekopora* sp.
Heterotrypa undata Stewart.
Monotrypa cf. *tabulatum* (Hall).
**Unitrypa subcircularis* Stewart.
**Unitrypa* cf. *lata* Hall.
**Polypora* cf. *hexagonalis* Hall.
**Polypora valida* Stewart.
**Polypora media* Stewart.
**Stictopora* cf. *rigida* Hall.
Pholidops ovata Hall.
Rhipidomella emarginata (Hall).
Rhipidomella musculosa (Hall).
Dalmanella oriskania Stewart.
Dalmanella lenticularis (Vanuxem).
Leptaena ventricosa (Hall).
**Stropheodonta inequiradiata* Hall.
Stropheodonta missouriensis Stewart.
Stropheodonta ? demissa (Conrad).
Leptostrophia magnifica Hall.
Leptostrophia magniventra Hall.
Brachyprion cf. *majus* Clarke.
Brachyprion sp.
Schuchertella sp.
Anoplia nucleolata Hall.
Chonostrophia complanata (Hall).
Eatonia peculiaris (Conrad).
Eatonia plicata Stewart.
Uncinulus salinensis Stewart.
**Uncinulus parvus* Stewart.
Uncinulus welleri Stewart.
Plethorhyncha barrandei (Hall).
Plethorhyncha principalis (Hall).
**Centronella glans-fagea* (Hall).
Rensselaeria ovoides (Eaton).
Beachia suessana (Hall).
Megalanteris ovalis Hall.
**Atrypa reticularis* (Linn.).
Spirifer arenosus (Conrad).
Spirifer murchisoni Castelnau.
**Spirifer* cf. *varicosus* Hall.
Cyrtina rostrata Hall.
Metaplasia pyxidata Hall.
**Rhynchospira alternata* Stewart.
**Trematospira multistriata* Hall.
Nucleospira cf. *ventricosa* Hall.
Meristella ampla Stewart.
Meristella ovalis Stewart.
Meristella elliptica Stewart.
Meristella carinata Stewart.
Anoplotheca flabellites.
Anoplotheca cf. *dichotoma* (Hall).
Actinopteria cf. *insignis* Clarke.
Actinopteria sp.
Aviculopecten sp.
Strophostylus allani Stewart.
Orthonychia praeconicum Stewart.
Orthonychia tortuosa Hall.
**Orthonychia belli* Clarke.
Platyceras planovolvus Stewart.
Platyceras peregrinus Stewart.
Platyceras retrorsum Hall.
Platyceras depressum Stewart.
Platyceras angulare Rowe.
Platyceras newberryi Hall.
Platyceras nodosum Conrad.
Platyceras reflexum Hall.
Platyceras trilobatum Hall.
Platyceras gebhardi Conrad.
**Platyceras dumosum* Conrad.
Platyceras elongatum var. *parvum* Stewart.
Platyceras cf. *subconicum* Ohern.
Platyceras cf. *gracile* Ohern.
Platyceras cf. *magnificum* Hall.
Platyceras cf. *multisinuatum* Hall.
Diaphorostoma ventricosum (Conrad).
Hyolithes cf. *oxys* Clarke.
Tentaculites elongatus Hall.
Proetus conradi Hall.
Proetus cf. *pachydermatus* Barrett.
**Proetus protuberans* Hall.
Acidaspis sp.
Dalmanites slocomi Stewart.
Dalmanites praenuntia Stewart.
Dalmanites cf. *bisignatus* Clarke.
Dalmanites cf. *micraurus* (Green).
Dalmanites cf. *pleuroptyx* (Green).
Dalmanites cf. *aspinosus* Weller.
**Dalmanites* cf. *stemmatus* var. *convergens* Clarke.
Dalmanites sp.
**Cryphaeus* sp.
**Phacops cristata* Hall.
Phacops sp.
Phacops sp.

In a consideration of the faunas, the associations of species recognized in beds 2, 3 and 4, may be taken as a unit. The faunas of beds 2 and 4 are closely allied, and in fact express two appearances of the same faunule. Whatever one of these faunules the other must be, and the intervening beds must go with them. In this upper Little Saline fauna there occurs an interesting mingling of Oriskany types with forms which are commonly best represented in the Onondaga faunas of the more eastern region. One or two representatives of the genus *Eatonia* are present, a genus which has not been observed to extend higher than the Oriskany, but associated with them are examples of the genus *Pentagonia* which hitherto has not been recognized below the Middle Devonian. *Centronella glausfazca* is common to the higher Oriskany and the Onondaga elsewhere. The bryozoa also suggest the Middle Devonian faunas, although it can be said that the bryozoan fauna of the Oriskany is entirely unknown elsewhere. Trilobites are unusual in the Oriskany faunas generally, but in this fauna they are common and are represented by several forms, some of which strongly suggest Middle Devonian forms. This fauna is in a measure, a transition fauna between the Lower Devonian Oriskany, and the Middle Devonian Onondaga faunas.

GRAND TOWER FORMATION

Name.—Keyes[1] has proposed the name Grand Tower limestone for the strata in southeastern Missouri, "below those beds containing the fossils of the Western Hamilton," stating further that the beds had commonly been referred to the Onondaga and Oriskany by Meek and Worthen and other writers. The name was taken from Grand Tower, Illinois, in the vicinity of which town good exposures of the beds are exposed.

The section at Grand Tower has been studied by Weller,[2] and later by Savage.[3] Both these writers have shown that no part of the limestone is related faunally to the "Western Hamilton," as typified in Iowa, but rather to the formations of the east in the Ohio Valley and New York sections. It has further been shown that while the major portion of the Grand Tower limestone, as the name was originally applied by Keyes, bears a fauna with Onondaga relationships, the uppermost beds carry a

[1]Mo. Geol. Surv., vol. 4, p. 42 (1894).
[2]Jour. Geol., vol. 5, pp. 625-635 (1897).
[3]Trans. Ill. State Acad. Sci., vol. 3, pp. 116-132 (1910).

fauna having relationships with the eastern Hamilton. Ulrich[1] has used the name Grand Tower to include the local representatives in Missouri of the Hamilton and Onondaga limestones of the east, while Savage has amended the definition of the formation to include "only that portion of the Devonian strata in southwestern Illinois, and adjacent parts of Missouri, which is the western representative of the Onondaga limestone of New York." The usage of Savage is adopted in this report, although the faunal expression of the beds in Ste. Genevieve County is somewhat different from that in the Grand Tower section. Both expressions, however, are distinctly Onondagan.

Areal Distribution.—The areal distribution of the Grand Tower limestone in Ste. Genevieve County is even more restricted than the subjacent Little Saline limestone, although there are perhaps more actual outcrops of the younger formation than of the older. In the large synclinally folded block of the Little Saline faulted zone, and also in the smaller similarily folded block to the northeast, the formation occupies a belt immediately within that of the Little Saline limestone. Outside this area it has been recognized only in the hills south of the Little Saline Creek, from one-half mile to one mile east of the road crossing south of Ozora.

Thickness.—The maximum thickness of the Grand Tower limestone, approximately 250 feet, is shown in the measured section already described. A similar thickness is probably exposed along the south and east banks of the Little Saline, nearly a mile farther up stream and within the area of synclinally folded blocks of the faulted zone, the average thickness may probably be considered as between 200 and 250 feet. In the extreme eastern exposure of the formation, east of the road crossing over Little Saline, south of Ozora, the thickness seems to be less, the lower 150 feet of the formation not being exposed because of the fault relations, although some portion of these beds may be present, entirely talus covered. The maximum thickness in Ste. Genevieve County is considerably greater than at Grand Tower, Illinois, where Savage reports 155 feet altogether.[2]

Topography.—The areal extent of the Grand Tower limestone is too limited to exercise any notable influence upon the topographic features of the region. Along with that of the

[1] Mo. Bureau Geol. and Mines, vol. 2, 2nd ser., p. 110 (1904).
[2] Loc. cit., p. 117.

adjacent Little Saline limestone, this area is gently rolling, with some moderately steep slopes in places.

Lithologic character.—Although the lithologic characters of the Grand Tower are somewhat variable, the formation is a limestone throughout. A nearly complete section is exposed along the east bank of Little Saline Creek, and up the west slope of the hill in the SE. corner of sec. 4, T. 36 N., R. 9 E., immediately succeeding the section of Little Saline limestone already given. The succession of beds at this locality is as follows, the numbers of the beds being made to follow those in the section of the Little Saline limestone already given.

	Section of Grand Tower Formation	Feet
11.	Limestone, a white, finely crystalline marble; as exposed on the surface, more or less interruptedly, the beds are thin and some of them include numerous grains of quartz sand scattered more or less regularly through the limestone matrix....	15
10.	Talus covered interval........	40
9.	Limestone, fine-grained, granular, hard and tough, bluish upon freshly fractured surfaces becoming brown with weathering. Rather thinly bedded. Fossils abundant in some beds, the brachiopod genus *Schizophoria* the most common form........	55
8.	Limestone, in thin even beds, nearly pure, crystalline, white to buff in color. Fossils very scarce........	85
7.	Limestone, light colored, mostly nearly white, in rather heavy beds, the texture variable, from granular to dense. Filled with fossil corals in great variety......	25
6.	Limestone, coarsely crystalline, very pure and nearly white, similar to the Little Saline limestone in texture and appearance. Weathered surface rough, with numerous fragmental crinoid stems. The basal part contains corals in abundance	25
5.	Limestone, dense, hard, compact, and brittle, with numerous irregular chert concretions. No fossils observed........	12

In the section at Grand Tower, Illinois, the lower beds are more or less arenaceous, at first intermittently so, and then higher up including sandstone beds with as great a thickness as eleven feet.[1] In Ste. Genevieve County no such arenaceous beds occur, the succession from the Little Saline being unbroken except for the presence of the cherty limestone layer which is assumed as the base of the Grand Tower. On the other hand the higher beds of the formation in Ste. Genevieve County are more or less arenaceous, although no sandstone beds occur, the sand being present in the form of included grains in some of the limestones, varying in amount from almost none to probably 10% or more of the entire mass of the rock.

The white marble bed in the upper portion of the formation might afford a rock of considerable value if it occurred in sufficient quantities. The outcrops in the section given are much covered with talus, but these upper beds of the formation occur much better exposed in the bank of Little Saline, just east of the mouth

[1]Savage, loc. cit., p. 119.

of the tributary creek entering from Boarman School, and in these outcrops the marble beds are seen to have an insignificant development.

The brownish, granular limestone, bed No. 9, the *Schizophoria* layer, of the above section, is perhaps the most commonly exposed member of the formation, and in the hills south of Little Saline Creek, east of the crossing south of Ozora, this bed is well exposed along with some coral beds higher up on the section, which may be talus covered in the detailed section which has been described. The exposures in these hills are heavily talus covered, so no continuous sections can be studied, but the lower beds seem to be wanting, as also are the higher beds of the Little Saline limestone, allowing the *Schizophoria* bed of the Grand Tower to come immediately above, or only a short distance above the abundantly fossiliferous lower portion of the Little Saline. It is not unlikely, however, that the apparent lack of some 190 feet of sediments which are known to be present not far away, is due to the fault relations of the beds in this locality.

The coral bed, No. 7 of the section, has its best exposure in the bank of Little Saline Creek in the section described, but it occurs again, in isolated outcrop, in SW. ¼ of SE. ¼ sec. 6, T. 36 N., R. 9 E. This bed is a veritable fossil coral reef, and represents a facies of the formation which is entirely wanting in the section at Grand Tower, Illinois.

Stratigraphic Relations of the Grand Tower.—It has already been brought out in connection with the discussion of the Little Saline limestone, that there was no break in sedimentation in passing from that formation into the Grand Tower.

The relationship of the Grand Tower to the overlying Beauvais sandstone are best exhibited in the south bank of Little Saline Creek one-fourth of a mile east of the road to Boarman School. The transition from the older limestone formation to the sandstone seems to be of the sort occasioned without the intervention of an emergent interval between the two formations, so far as the Ste. Genevieve County area is involved, although there must have been some land and water changes at no great distance. The higher beds of limestone contain a considerable amount of sand below where the pure sandstone is present, but the transition does not occupy any great thickness of strata.

Structure.—Because the Grand Tower formation is restricted in its distribution to the Little Saline faulted zone, it shows a greater number of structural features than some of the formations which are widely distributed through the county. Adjacent to some of the fault lines the beds exhibit steep dips, in places 45 degrees or more, these steep dips being especially well exhibited upon the southern sides of the two synclinally folded fault blocks. Good exposures of these steeply dipping beds may be seen along the south bank of Little Saline Creek just east of the road leading to Boarman School.

Correlation.—The presence of the abundant coral fauna in the lower portion of the Grand Tower limestone in Ste. Genevieve County, containing species which are well known from the Middle Devonian limestones of the Ohio Valley, gives a basis for the correlation of the beds in the two regions. The well known fossil coral reef at the Falls of the Ohio occurs in the lower portion of the Jeffersonville limestone of Indiana. The fossil coral reef in Ste. Genevieve County is far less extensive than that at the Falls of the Ohio, but the species are all common to the two regions, and there can be no hesitation in considering them to be contemporaneous in age. In Ohio the same corals occur in abundance in the Columbus limestone, another formation with which this bed in Ste. Genevieve County may be considered as being contemporaneous in part. The presence of this coral bed in Ste. Genevieve County differentiates the Grand Tower fauna of this region rather sharply from the fauna of the same formation at Grand Tower, Illinois, where the corals constitute an almost negligible element in the fauna. This difference may be interpreted by assuming that conditions favorable for the development of coral reefs in this Middle Devonian sea were more or less local in their occurrence.

All of these formations are closely bound up with the Onondaga limestone of New York by their faunal characters, so much so that they may be considered as contemporaneous deposits laid down in distinct basins, more or less separated from each other. The Grand Tower limestone in Ste. Genevieve County is of the same age, with the relationships closest, perhaps, with the Jeffersonville limestone.

In the higher beds of the Grand Tower limestone, corals are essentially wanting in the zone with *Schizophoria striatula*, and while they are present in some abundance, locally at least, in the uppermost beds of the formation, the species occurring are different from those in the lower coral zone.

The *Schizophoria striatula* zone is characterized by the common occurrence of cephalopods belonging to species which are identical with or closely allied to those listed from the Grand Tower, Illinois, faunas. In their studies of the Grand Tower, Illinois, section, Weller and Savage both show that the cephalopod element in the fauna at that locality is limited to the upper portion of the Grand Tower beds, a fact that gives more weight to the suggestion that the coral reef development in the lower portion of the formation is a more or less local faunal expression. The *Schizophoria striatula* of this zone, which occurs far more abundantly than any other species, or in fact than all others together, is a species which is nowhere reported to be so abundant in any of the faunas of similar age farther east. Kindle[1] records the species from the Jeffersonville limestone of Indiana, but it is not listed from the Columbus limestone of Ohio by Stauffer,[2] nor is it recorded by either Weller or Savage from Grand Tower, Illinois. The member of the genus which is commonly identified in faunas of Onondaga age, is *S. propinqua Hall*, but these specimens from Ste. Genevieve County are entirely indistinguishable from *S. striatula*, which has its greatest development in faunas of Upper Devonian age.

In the highest beds of the formation *Atrypa reticularis* is an abundant species. Associated with it are some forms which are also present in the *Schizophoria zone*, and others which occur here for the first time. Among these latter *Favosites turbinatus* is a common form at the locality north of Little Saline creek, and the large gastropod from the same locality is another.

The complexion of the entire fauna from the Grand Tower beds from the several zones recognized, with the exception of the abundance of *Schizophoria striatula*, is decidedly that of the limestones of Onondaga age farther east, and this formation in Ste. Genevieve County may be correlated with these formations without hesitation.

Paleontology.—Several distinct faunal zones are recognized within the Grand Tower limestone, all but the uppermost one of which are best known from the Little Saline Creek section already described. The lowermost cherty bed has as yet furnished no fossils, the lowest distinct zone being the coral zone exhibited in beds 6 and 7, each 25 feet in thickness. In the lower of these beds the corals are well exhibited near the base upon the weathered surface of the rock, but they cannot be easily collected. The genus *Favosites* is the most common form. This

[1]25th Ann. Rep. Geol. Surv. Indiana, p. 626 (1901).
[2]Geol. Surv. Ohio, 4th ser., Bull. No. 10, p. 164 (1909).

coral fauna reaches its greatest development in bed No. 7, which is a veritable coral reef, with but few other fossils of any sort.

Fauna of the Grand Tower Limestone in Union County, Ill., furnished by T. E. Savage

Amplexus yandelli Ed. and Haime.
Aulacophyllum trisulcatum Hall.
Cyathophyllum rugosum Hall.
Cystiphyllum americanum Ed. and Haime.
Dendropora elegantula Davis.
Dendropora neglecta Rominger.
Favosites emmonsi Rominger.
Favosites cf. hemispherica Troost.
Heliophyllum sp.
Michelinia stylopora Eaton.
Zaphrentis exigua (Billings).
Zaphrentis nitida Hall?
Zaphrentis recta Meek.
Dolatocrinus sp.
Nucleocrinus verneuili Troost.
Nucleocrinus sp.
Coscinium cribriforme Prout.
Cystodictya gilberti (Meek).
Cystodictya meeki (Nicholson).
Fenestella stellata Hall.
Polypora cf. quadrangularis Hall.
Semicoscinium sp.
Amphigenia curta Meek and Worthen.
Anoplia cf. nucleata Hall.
Athyris vittata Hall.
Atrypa reticularis (Linn.).
Atrypa spinosa Hall.
Camarophoria gainesi (Nettelroth).
Camarotoechia carolina Hall.
Camarotoechia horsfordi Hall.
Camarotoechia tethys (Billings).
Centronella glansfagea Hall.
Charionella scitula Hall.
Chonetes koninckianus N. and P.
Chonetes mucronatus Hall.
Chonetes vandellanus Hall.
Crania crenistriata Hall.
Cyrtina hamiltonensis Hall.
Dalmanella lenticularis (Vanuxem).
Dalmanella sp.
Eatonia cf. whitfieldi Hall.
Eunella sp.
Eunella linklaeni Hall.
Leptaena rhomboidalis (Wilckens).
Leptostrophia perplana (Conrad).
Lingulodiscina sp.
Meristella lenta Hall.
Meristella nasuta (Conrad).
Meristella rostrata Hall.
Nucleospira concinna Hall.
Nucleospira cf. elegans Hall.
Pentamerella arata (Conrad).
Pentamerella pavilionensis Hall.
Pholidops oblata Hall.
Pholidostrophia iowensis (Owen).
Productella spinulicosta Hall.
Productella sp.
Reticularia fimbriata (Conrad).
Rhipidomella penelope Hall.
Rhynchonella cf. louisvillensis Nettelroth.
Rhynchonella sp.
Schizophoria propinqua Hall.
Schuchertella chemungensis arctistriata Hall.
Schuchertella chemungensis perversa Hall.
Schuchertella pandora (Billings).
Spirifer acuminatus (Conrad).
Spirifer duodenarius Hall.
Spirifer gregarius Hall.
Spirifer gregarius var.
Spirifer grieri Hall.
Spirifer macrothyris Hall.
Spirifer macrus Hall.
Spirifer perextensus M. and W.
Spirifer raricostus Conrad.
Spirifer segmentus Hall.
Spirifer varicosus Hall.
Strophalosia truncata (Hall).
Stropheodonta crebristriata Hall.
Stropheodonta demissa (Conrad).
Stropheodonta inaequistriata (Conrad).
Stropheodonta inaequistriata var.
Stropheodonta patersoni Hall.
Strophonella ampla Hall.
Tentaculites elongatus Hall.
Tentaculites scalariformis Hall.
Actinopteria sp.
Actinopteria boydi (Conrad).
Aviculopecten exactus Hall.
Cf. *Aviculopecten ignotus* Hall.
Aviculopecten terminalis Hall.
Aviculopecten sp.
Conocardium cuneus (Conrad).
Cypricardinia cataracta Conrad.
Glyptodesma occidentale Hall.
Leptodesma sp.
Megambonia cf. cardiiformis Hall.
Modiomorpha linguiformis Hall.
Paracyclas elliptica Hall.

Cf. Pterinopecten multiradiatus Hall.
Bellerophon pelops Hall.
Callonema lichas Hall.
Pleuronotus decewi Billings.
Loxonema sp.
Loxonema terebra White.
Murchisonia sp.
Orthonychia dentalia Hall.
Platyceras blatchleyi Kindle.
Platyceras carinatum Hall.
Platyceras conicum Hall.
Platyceras dumosum Conrad.
Platyceras erectum Hall.
Platyceras subrectum Hall.
Platyceras thetis Hall.
Platyostoma turbinata Hall.
Strophostylus varians Hall.
Gomphoceras sp.
Dalmanites calypso Hall.
Dalmanites sp.
Odontocephalus aegeria Hall.
Odontocephalus arenarius Meek.
Phacops cristata Hall.
Proetus clarus Hall.
Proetus crassimarginatus Hall.
Proetus cf. folliceps Hall.
Proetus marginalis Conrad.
Proetus sp.
Onychodus sigmoides Newberry.

BEAUVAIS FORMATION

Name.—Lying immediately above the Grand Tower limestone there is a conspicuous sandstone formation which is entirely different from any of the other formations of the Middle Devonian age in the interior of the continent. Its typical exposures are along Little Saline Creek in Beauvais township of Ste. Genevieve County, and this township name is here proposed for the formation.

Areal Distribution.—The Beauvais sandstone occurs only within the Little Saline faulted zone in Ste. Genevieve County. It occupies the central portion of the syncline in the two synclinally folded blocks, the total area underlain by the formation being less than one square mile. The formation also occurs farther east in the hills south of Little Saline Creek, on both sides of the road crossing south of Ozora. Upon the hill to the west of this crossing, the formation extends up the hill from near the road level for about one-fourth mile, and is carried by its dip down the southern slope of the hill. A prominent knoll of sandstone with the beds nearly vertical in position occurs just west of the road to St. Marys as it crosses the Little Saline. East of the road crossing this sandstone forms the north slope of the hill most of the way for one-fourth mile or more, and is again well exposed nearly a mile to the east of the crossing.

Thickness.—The most continuous outcrop of the total thickness of the Beauvais sandstone is in the bluff which has been mentioned, on the south side of Little Saline Creek, a quarter of a mile east of the junction of the Boarman School road and the creek. At this locality the beds are dipping steeply to the north, and an interval of 50 feet is present between the underlying

Grand Tower limestone and the overlying formation. The entire interval is doubtless occupied by the sandstone, although its upper part is not well exposed.

Topography.—Except where the sandstone has become more or less quartzitic along the fault lines, the Beauvais is a somewhat incoherent and soft bed which is easily weathered, and which, because of the small area occupied by it, makes but little impression upon the general topography of the region. At a number of places, however, especially just east and west of the road crossing Little Saline Creek south of Ozora, there are hard, quartzitic ledges of this sandstone which stand up in dike-like form, adjacent to some of the faults. Such occurrences, however, are very minor features in the topography.

Lithologic characters.—Many of the outcrops of this formation would be wholly indistinguishable from the St. Peter sandstone, were its stratigraphic position not determinable by the underlying or overlying beds. A bold cliff of the sandstone in the south bank of Little Saline Creek about one-fourth mile east of the junction of the Boarman School road with the creek, simulates the St. Peter so strongly, both in lithologic character, in bedding, in color, in the character of the component sand grains, and in the weathering that it has been mistaken by a number of expert geologists familiar with the St. Peter, until its stratigraphic relations were recognized. The sand comprising the formation clearly has been derived from the older St. Peter, large areas of which must have been exposed in nearby territory during Middle Devonian time. Upon the hill slope to the west in SE. ¼ sec. 5, T. 36 N., R. 9 W., other outcrops of the Beauvais sandstone occur which are remarkably like the St. Peter in all respects, and the same is true of outcrops upon the northeastern slope of the same hill in the SW. ¼ of the adjacent sec. 4. In the hills farther east the sandstone becomes harder, finer grained, and is somewhat quartzitic in places. The color of the formation varies from nearly white to brown, much as does the St. Peter, but some of the harder and finer grained portions of the formation in the more eastern outcrops have a slight pinkish tint. The weathered surfaces are commonly brown or yellow brown.

Stratigraphic Relations of the Beauvais.—In the description of the Grand Tower limestone, it has been pointed out that the higher beds contain a considerable amount of quartz sand. This sand is in the form of rounded grains not unlike those of the Beauvais sandstone, and their original source was doubtless identical, viz, exposed areas of the much older St. Peter sandstone. The change from limestone to sandstone, at the lower contact of the Beauvais is quite abrupt, suggesting the possibility of an unconformity, but in view of the fact that the sand had been introduced into the limestone, probably through twenty or more feet of the subjacent beds, it is not improbable that the sedimentation was essentially continuous across the interval without unconformable relations. There is no evidence of any unconformity between the Beauvais and the overlying St. Laurent limestone, although the actual contact between the two formations has not been observed.

Correlation.—The single fossil species which has been identified with any degree of certainty in the Beauvais sandstone, *Newberrya claypolei*, was originally described from a sandstone of Hamilton age in Pennsylvania. This occurrence apparently ties this formation up with the eastern Middle Devonian, just as the faunas of the underlying Grand Tower limestone are related to the eastern rather than to the Iowan Devonian province. This species being a Hamilton form in the east at once suggests the correlation of the Beauvais sandstone with some portion of the Hamilton, probably with the lower part, although additional faunal evidence would be desirable to establish such a correlation more firmly. The underlying Grand Tower limestone is clearly Onondagan in age, the upper portion of it being well up in that division of the Middle Devonian, so that if the Beauvais is older than the Hamilton, it can only be the extreme upper Onondagan.

Paleontology.—Fossils are rare in the Beauvais sandstone, and have been observed with certainty in only one locality, viz, the outcrop on Little Saline Creek already mentioned, one-fourth mile below the Boarman School road. In the lower part of the sandstone at this locality, a number of species of imperfectly preserved internal casts of shells have been collected. The only species which is at all common, is the shell which has been identified as *Newberrya claypolei*, and it is the only one whose identification may be said to be entirely satisfactory. At the base of the formation, at the same locality, there is a bed of calcareous algae about one foot in thickness. The calcareous masses are entirely surrounded by sand, and are so numerous as to constitute a veritable reef.

ST. LAURENT FORMATION

Name.—Succeeding the Beauvais sandstone in the section along Little Saline Creek, is a further series of Middle Devonian beds, varying in lithologic character. These strata are dominantly limestone, but some notable arenaceous beds are included. The formation is exposed not alone in Ste. Genevieve County, but also farther east in Perry County, the name here adopted being taken from St. Laurent Creek, along the course of which stream a good exhibition of the formation may be seen about three miles south of St. Marys.

Areal Distribution.—In Ste. Genevieve County the St. Laurent limestone is restricted to three small patches within the Little Saline faulted zone, the aggregate area of all three being less than one-fourth of one square mile. A limited exposure of the very base of the formation occurs immediately above the Beauvais sandstone at the outcrop of that formation in the bank of Little Saline Creek one-fourth of a mile east of the Boarman School road. The actual exposure at this locality only covers a few square yards, although the area underlain by the formation must be much more than this. The largest of the three areas is in the SW. ¼ sec. 4, T. 36 N., R. 9 W., where the formation covers the entire summit of the hill on whose lower slopes are the underlying middle and lower Devonian formations. A third small area with very limited outcrop, a mere sliver between two acutely intersecting faults, occurs along the north side of the tributary valley from the east, joining the Little Saline bottom about one mile east of the road crossing south of Ozora.

Thickness.—In the section described in one of the following pages, about 100 feet of strata are referable to the St. Laurent formation. This thickness includes only those beds actually seen in outcrop above the Beauvais sandstone, and does not include the loose sandy chert on top of the hill. On St. Laurent Creek in Perry County, three miles south of St. Marys, a more or less continuous section of 275 feet of steeply dipping beds referable to this formation may be seen. These beds resemble those on Little Saline Creek in Ste. Genevieve County in their variable lithologic character, including limestones, arenaceous limestones and sandstone.

Topography.—The St. Laurent limestone is too limited in extent to have any influence upon the topographic expression of the region.

Lithologic characters.—The St. Laurent formation is in the main a limestone, although some of the beds are highly arenaceous, and others, of limited thickness, are nearly or quite pure sandstone. The greatest exposure of the formation in Ste. Genevieve County is in the second of the areas mentioned above, where a nearly continuous section is exposed, lying immediately above the Beauvais sandstone. This section is a continuation of the sections of the earlier Devonian formations already described, and the beds are here numbered in sequence with those of the other sections.

Section of St. Laurent Formation

		Feet
19.	Chert, arenaceous, brown and porous, not observed in place but lying loose upon the surface in large quantities. Abundantly fossiliferous	??
18.	Limestone, gray in color and varying in texture, interbedded with arenaceous layers which are either sandy limestones or sandstone	40
17.	Limestone, gray, fine-grained and close textured, hard and brittle with conchoidal fracture. The lower 15 feet forms an escarpment almost continuously around the hill. No fossils observed	35
16.	Sandstone, thin-bedded, yellowish-gray in color, with conglomerate layers	10
15.	Limestone, very hard, dense and brittle, gray in color. No fossils observed	15
14.	Unexposed interval	3
13.	Sandstone, upper portion of Beauvais sandstone	7
12.	Unexposed. The upper portion of this interval is without doubt, underlain by Beauvais sandstone, probably about 50 feet. The lower portion must be the upper beds of the Grand Tower limestone, doubtless the beds with *Favosites turbinatus*	80

The limestones of the formation in this section are for the most part hard and brittle, of a gray or blue-gray color, in beds of varying thickness. Some beds are entirely free from sand, others include scattered sand grains which vary in amount from almost none to what amounts to a pure sandstone. None of these limestones in place have been observed to be fossiliferous, although a few loose blocks upon the surface have been found which contain some fossils. The loose chert at the summit of the section is abundantly fossiliferous.

In the locality one-fourth mile east of the junction of the Boarman School road with the Little Saline Creek, only the basal beds of the St. Laurent limestone are exposed. The beds at this locality are limestone conglomerates containing more or less sand, with some cross-bedding. The included pebbles are angular in form and vary in size from very small up to three or more inches in diameter. The entire thickness of the beds exposed here is only between five and ten feet. The last outcrop of the formation in Ste. Genevieve County occurs along the hillside on the north side of the small tributary valley, entering the Little Saline bottoms from the east, about one mile east of the road crossing south of Ozora.

At this locality the formation is represented chiefly by masses of highly fossiliferous, arenaceous chert, lying loose upon the hill slope but not seen in place, and by a few limestone ledges in situ, towards the eastern end of the outcrop. This limestone is of a grayish-brown color, somewhat argillaceous in places and siliceous elsewhere, with numerous fossils.

As a whole the formation is characterized by the great variability of its lithologic characters, the limestone outcrops at the several localities and the different ledges in the same locality, being unlike each other in color, texture and bedding. As yet no definite sequence, either lithologic or faunal, has been established which can be traced from place to place. The one lithologic character which ties the beds together in the several sections is the presence everywhere of the arenaceous limestones and sandstones, interbedded with limestone free from sand.

Stratigraphic Relations of the St. Laurent Limestone.—The small exposure of limestone conglomerate at or near the base of the St. Laurent limestone on the bank of Little Saline Creek, one-fourth of a mile east of the Boarman School road, suggests the possibility of a slight unconformity between this formation and the underlying Beauvais sandstone. However, there are a number of thin conglomerate beds in the lower part of the formation, and also thin sandstone and sandy limestone beds, and it is believed that the sedimentation was practically continuous from the Beauvais sandstone, with no unconformity separating the two formations.

The only place where any beds directly overlie the St. Laurent limestone in Ste. Genevieve County, is on the summit of the hill south of Little Saline Creek, a little over one mile due west from the point where the road crosses the creek south of Ozora. The overlying beds are Lower Mississippian, represented only by the residual cherts of the Burlington limestone. The entire absence of any strata of Upper Devonian age establishes the presence of an hiatus above the St. Laurent limestone, and the unconformable relations of the succeeding strata.

Correlation.—An examination of the list of species given in the following tables, shows at once the strong affinity of the fauna with that of the formations of Hamilton age in the Ohio Valley and New York, and the presence of such species as *Tropidoleptus carinatus* and *Chonetes coronatus* at once stamps the fauna as Hamilton. There is no element whatsoever in the auna connecting it with the Devonian faunas further north in the Mississippi Valley, in central Missouri and Iowa. It is the same fauna that occurs in the uppermost beds in the Grand Tower section in Illinois, but in that section the beds bearing it are not separated from the underlying Grand Tower limestone by the Beauvais sandstone.

Paleontology.—Fossil faunas have been collected from the St. Laurent limestone at several localities, and although no large number of species has been recognized at any one locality, the total list of species from all the beds makes up a fauna of no mean proportions. In Ste. Genevieve County the most prolific fauna occurs in the loose sandy cherts at the top of the section in SW. ¼ sec. 4, T. 36 N., R. 9 W.

St. Laurent limestone, Weller and Mehl, Collectors
Sec. 4, T. 36 N., R. 9 E.

Zaphrentis sp.
Cyathophyllum sp.
Cystiphyllum americanum E. & H.
Favosites cf. F. digitatus Rominger.
Undertemined coral.
Schuchertella chemungensis Con. ?
Stropheodonta demissa Con. ?
Stropheodonta perplana Con. ?
Chonetes coronatus Con.
Chonetes scitulus Hall.
Chonetes cf. C. aurora Hall.
Camarotoechia congregata Con.
Eunella lincklaeni Hall.
Tropidoleptus carinatus Con.
Spirifer pennatus Atw.
Spirifer audaculus Con. ?
Cyrtina hamiltonensis Hall.
Cyrtina alpenensis H. & C.
Pterinea flabella Con. ?

MISSISSIPPIAN SYSTEM

GENERAL STATEMENT

The Mississippian formations in Ste. Genevieve County and in the northern extremity of Perry County, between St. Marys and the Little Saline fault zone which crosses the county at Lithium, are thirteen in number. Both the Lower and the Upper Mississippian are represented, the Iowa Series and the Chester Series. The two uppermost units which will be considered in this report are not exposed in Ste. Genevieve County, but are well exhibited in the Mississippi River bluffs south of St. Marys, in Perry County.

The formations which are present in Ste. Genevieve County and northern Perry County, and their classification, are shown in the following table:

Chester Series.
- Middle Chester Group:
  - Golconda limestone.
- Lower Chester Group.
  - Paint Creek formation.

Yankeetown chert.
Renault limestone.
Aux Vases sandstone.
Iowa Series.
Meramec Group.
Ste. Genevieve limestone.
St. Louis limestone.
Spergen (Salem) limestone.
Warsaw formation.
Osage Group.
Keokuk limestone.
Burlington limestone.
Fern Glen limestone.
Kinderhook Group.
Sulphur Springs formation.

SULPHUR SPRINGS FORMATION

Name.—"At the base of the Kinderhook and perhaps top of the Devonian" Ulrich has distinguished a formation in southeastern Missouri, to which he has given the name Sulphur Springs,[1] from the town of that name in Jefferson County. This formation was divided by its author into three members, an upper sandstone member about 10 feet thick, to which the name. Bushberg sandstone was applied, below this an oolitic limestone member from one to five feet thick called the Glen Park limestone, and from nothing to fifteen feet of shale at the base for which no subordinate name was proposed.

Areal Distribution.—In Ste. Genevieve County the Sulphur Springs formation is present only to the north of the Little Saline faulted zone. It may be looked for throughout the entire distance from the Isle du Bois Creek to the faulted zone, at the very base of the Mississippian section, although through the greater portion of this distance it is either wanting or is obscured by the overlying talus. The formation has been indicated upon the geological map in only two regions where good outcrops occur. The first of these is in the northern part of the county, in Snell Hollow, whose mouth intersects the Mississippi River bluff about one mile below Brickeys. In this hollow the first of the outcrops of the Sulphur Springs formation occur about one mile from its mouth, and continues for about one-half mile in a long tributary entering from the southeast. These exposures are all referable to the Glen Park limestone member of the formation.

The Sulphur Springs formation is again represented by beds of sufficient thickness, and well enough exposed to be mapped, in the extension of the Beckett Hills to the southeast, between

[1]Mo. Bureau Geol. and Mines, vol. 2, 2nd ser., p. 110 (1904).

River aux Vases and Little Saline Creek. In this region the formation is represented by the Bushberg sandstone member and an overlying shale, outcrops being present in the heads of most of the ravines along the western and southwestern slopes of the hill, as well as in the heads of the ravines on the opposite side towards the north.

An area of the formation too limited to be shown on the map, is present in the head of a small ravine tributary to Frenchman Creek, in NW. ¼ NW. ¼ sec. 14, T. 38 N., R. 8 E. Some indication of the formation in talus slopes is also met with at a few other localities in the northern part of the county, but in the absence of both good exposures and fossils, it is impossible always to determine with certainty whether the thin sandstones present in the sections observed, are Sulphur Springs or belong to the Thebes formation, which in places occurs immediately beneath the Mississippian in the region north of the Little Saline faulted zone.

Shumard[1] reports an exposure of dark argillaceous shale on Establishment Creek a couple of hundred yards above its mouth, which must be a member of the Sulphur Springs formation. This exposure was not visible at the time the present survey was being made, but is said to have been a bed of "dark argillaceous slate" exposed in a ledge three feet high, and is reported to contain a small species of *Lingula*.

Thickness.—In the Snell Hollow locality the greatest thickness of the Sulphur Springs formation actually exposed is about five feet, although considerable more than this, perhaps as much as fifteen or twenty feet may be present beneath the talus covering. In the region between River aux Vases and Little Saline Creek, the maximum thickness of the sandstone referable to this formation is probably not more than ten feet, and in many places it probably does not exceed five feet, although where the upper black shale member is present this bed may add as much as ten feet thickness to the formation. Because of the small thickness of the formation it will be readily seen that it may be entirely covered by talus in many localities, where it might be mapped if it were uncovered, and in the areas where the formation has been mapped it has been necessary to somewhat exaggerate the width of the outcrop on the map.

Topography.—The topography of the county is in no way influenced by the presence of the Sulphur Springs formation, it

[1]Mo. Geol. Surv., 1st and 2nd Ann. Rep., pt. 2, p. 148 (1855).

being too thin, and its outcrops being too limited in extent to have any noticeable effect upon topographic forms.

Lithologic Characters.—In his original definition of the Sulphur Springs formation, Ulrich recognized three distinct members, a shale bed at the base which was not observed in all exposures, and to which no special name was attached. This shale is followed by the Glen Park limestone member, and this again by the Bushberg sandstone member.

In Ste. Genevieve County the basal shale member of the formation has not been certainly recognized, but the Glen Park limestone and the Bushberg sandstone members are well exhibited. In addition to these there is in one locality in the county, in SW. ¼ SE. ¼ sec. 29, T. 37 N., R. 9 E., another shale member lying above the Bushberg sandstone which may be included in the Sulphur Springs formation.

Glen Park Limestone Member.—This member of the Sulphur Springs formation has been observed only in the Snell Hollow locality which has been mentioned. It is represented for the most part by impure limestone beds, arenaceous in places, yellow or gray in color, cross-bedded, and in places filled with pebbles which are apparently irregular phosphatic nodules. Locally there are in this outcrop, small lenticular beds of gray, oolitic limestone, entirely similar lithologically to the typical exposures of Glen Park limestone, at Glen Park in Jefferson County, and containing the same assemblage of fossils. A much smaller number of fossil species are present in the more impure and arenaceous portions of the limestone than in the oolitic lenses, but in places the number of individuals is very great.

Bushberg Sandstone Member.—Associated with the Glen Park limestone member of the Sulphur Springs formation in Snell Hollow, a few masses of coarse, brown sandstone occur in the talus, which are lithologically like the Bushberg sandstone member of the formation in Jefferson County, and contain the same fossils.

In the hills south of River aux Vases, the Bushberg sandstone member is the lowest member of the formation which has been observed. It is a coarse, yellow-brown sandstone, not unlike some parts of the Beauvais sandstone or of the still older St. Peter. The source of the sand of which the formation is composed, was doubtless exposed surfaces of the St. Peter to the west. In most outcrops the basal portion of the sandstone is conglomeratic, the included pebbles apparently being black phosphatic nodules for the most part, and associated with the pebbles there are numerous fragments of fish teeth, among them being worn specimens of *Ptyctodus* and *Diplodus priscus*. Scattered fragments of fish teeth are also present throughout the sandstone above the conglomerate layer at the base.

Black Shale Member.—The uppermost, black shale member of the Sulphur Springs formation has been observed only in one locality, already mentioned. The shale is exposed in an outcrop only a few yards in length along the bank of the ravine, the actual thickness seen being less than two feet, although a greater thickness is doubtless present, but not more than five or ten feet as a maximum. Some years ago a shallow shaft was sunk on the adjacent hillside under the supposition that the black shale was an indication of the presence of coal.

The greater portion of the rock is a black, carbonaceous shale, similar to the exposures of the Chattanooga shale in southern Illinois, Kentucky and Tennessee. Incorporated in the shale there are a number of thin, more or less discontinuous bands a fraction of an inch in thickness, which are crowded with sand grains, and at least one sandstone lens two inches thick and perhaps two feet long, was exposed at the time the locality was visited by the writer. This sandstone is gray-brown in color, and includes concretionary masses of marcasite ranging in size from an inch and a half down to a small fraction of an inch. The sand in this lens and also that present in some of the shale layers, is quite like that which constitutes the underlying Bushberg sandstone, and although the actual contact of the shale upon the sandstone is covered, it is believed that it would show a gradual transition from sandstone to the shale rather than an abrupt change, indicating the absence of any unconformity. Imbedded in the shale there are a few examples of *Sporangites* similar to those in the Chattanooga shale, which appear as minute, discoid bodies, brown in color and only a fraction of a millimeter in diameter.

The dark shale reported by Shumard at a locality on Establishment Creek is in all probability like that exposed in the locality just described, although the possibility remains that it is the basal shale of the formation which was described by Ulrich.

Phosphatic Rock.—In the unmapped locality at the head of the small tributary of Frenchman Creek, already mentioned, the Sulphur Springs formation is represented by a bed of phosphatic nodule conglomerate, beneath which is a black, phosphatic rock containing numerous Lingulas, only a little more than one foot altogether being exposed, not reaching to the base of the formation. The black rock may be a representative of the basal shale mentioned by Ulrich, and the nodule bearing bed may be the very basal portion of the Glen Park limestone member.

Stratigraphic Relations of the Sulphur Springs Formation.—The importance of the stratigraphic break at the base of the Sulphur Springs formation, is shown by the fact that wherever it occurs, in either Ste. Genevieve or Jefferson counties, the immediately subjacent formation is Ordovician in age. In the more northern exposure in Ste. Genevieve County, in Snell Hollow, the underlying formation is apparently Fernvale limestone, while south of River aux Vases, it is the shale member of the Thebes-Maquoketa formation. Throughout this region the entire series of Silurian and Devonian formations, which attain a thickness of over 800 feet on Little Saline Creek, are entirely wanting. Along one portion of the Little Saline, about one and one-fourth miles southwest of Ozora, the section on the north side of the valley shows the Bushberg sandstone member of the Sulphur Springs formation resting upon the Maquoketa shale, while on the south side of the valley, not more than one-half mile distant, the entire section of Silurian and Devonian rocks which has been described, is present. These relations establish the pre-Sulphur Springs unconformity.

There is no reason to believe that originally the Sulphur Springs formation was not uniformly deposited over the whole surface formed by the exposed Ordovician rocks in Ste. Genevieve County, but at the present time it is represented by a few patches only, here and there. This type of occurrence establishes the fact that a period of erosion intervened between the close of the deposition of the Sulphur Springs and the beginning of the deposition of the next succeeding formation, during which time much of the Sulphur Springs was removed by erosion, the higher formation consequently resting unconformably upon the beds beneath.

Correlation.—In a paper describing the Glen Park fauna, Weller[1] has discussed the correlation of that formation with the formations in other parts of the Mississippi Valley. He has shown that the most closely allied fauna occurs in an oolitic

[1]Trans. St. Louis Acad. Sci., vol. 16, pp. 435-471 (1906).

limestone very similar in character to the Glen Park, which is present in the section at Hamburg, Calhoun County, Illinois. In the Hamburg oolite fauna as recorded by Weller, one-half of the species are present also in the Glen Park, and later studies have shown that a still larger portion of the fauna is common to the two formations. The species which do occur in both faunas include two or more peculiar genera which are unknown except in these two faunas. All the evidence at hand points to such a close relationship between the Glen Park and Hamburg faunas that the beds bearing them must be considered as being essentially contemporaneous in origin. At Hamburg the oolitic beds bearing this peculiar fauna overlie about five feet of very dense, much fractured limestone, almost lithographic in texture, whose lithologic characters are identical with the Louisiana limestone at Louisiana, Missouri, and which carries a fauna identical with that of the Louisiana limestone. On the basis of the evidence afforded by the Hamburg section, the Glen Park has been correlated with some portion of the Louisiana limestone, it being assumed to be younger than the oldest portion of that formation. This correlation may be accepted as including the whole of the Sulphur Springs formation, since such fossils as are present in the Bushberg sandstone are in the main the same as those of the Glen Park, and no fossils except *Sporangites* have been recognized in the higher black shale member.

The black shale lying above the Bushberg sandstone member of the Sulphur Springs formation may be compared lithologically with the widespread black shale of the Ohio Valley and the south and which spreads westward as far as Oklahoma, that is commonly referred to under the name Chattanooga shale in most of the more recent reports. The *Sporangites* which is present rarely in the Ste. Genevieve County shale also seems to be like that which is so abundant in places in the Chattanooga shale. In Ste. Genevieve County this shale clearly overlies the Glen Park and Bushberg members, and must be younger than either of them, and the correlation of the Glen Park fauna with that at Hamburg, Illinois, which in turn occurs in a limestone which clearly overlies beds with the characteristic Louisiana limestone fauna of lower Kinderhook age, establishes the age of the Ste. Genevieve black shale as Kinderhook. The Chattanooga black shale is the so-called "Devonian Black Shale" of many earlier writers, and its age is commonly believed to be Upper Devonian by most of those who have studied the formation.

This is the opinion held by Kindle[1] who has recently discussed the question at some length. Ulrich[2] on the other hand, believes the Chattanooga to be Lower Mississippian in age. The shale in Ste. Genevieve County must be Mississippian unless the underlying Bushberg and Glen Park, as well as the Louisiana limestone farther north in the Mississippi Valley are Devonian, and the evidence for the correlation of this shale with the Chattanooga is altogether too slender to warrant the reference of the Chattanooga to the Mississippian on this basis.

Paleontology.—From the beds exposed in Snell Hollow, the following species of fossils have been collected from the Glen Park limestone member of the Sulphur Springs formation. The locality is near the middle of the south half of sec. 24, T. 39 N., R. 7 E., about one and one-fourth miles south of Brickeys.

Fauna of Glen Park Limestone in Snell Hollow

Orthotetes ? sp.
Rhynchotetra sp. undesc.
Rhipidomella sp. undesc.
Dielasmella calhounensis Weller.
Hamburgia typa Weller.
Camarophoria hamburgensis Weller.
Rhynchonella sp. (immature specimen).
Delthyris missouriensis Weller.
Spirifer jeffersonensis Weller.
Syringothyris bushbergensis Weller.
Snellia semielliptica gen. and sp. n.
Streblopteria sp.
Modiomorpha lamellosa Weller.
Cypricardinia subcuneata Weller.
Orthonychia sp.
Platyceras glenparkensis Weller.
Platyceras sp.
Ptyctodus eastmani Weller.

The greater number of these species occur in the gray, oolitic limestone lenses exposed at this locality, the fauna in these parts of the formation being essentially the same as that of the Glen Park limestone at its typical locality in Jefferson County. In the more impure, arenaceous limestone, *Spirifer jeffersonensis* is by far the commonest species, and in some places it occurs in great numbers.

Aside from the specimens of *Ptyctodus* and other fish teeth in the Bushberg sandstone member of the formation, a poorly preserved fauna of brachiopods and molluscs has been collected at one locality in the head of a ravine about half way between River aux Vases and Little Saline Creek. The species recognized at this locality, so far as they can be determined, are as follows:

[1]Amer. Jour. Sci., 4th ser., vol. 34, pp. 187-213 (1912).
[2]Amer. Jour. Sci., 4th ser., vol. 34, pp. 157-183 (1912).

Bushberg Sandstone Fauna from near Little Saline Creek

Schuchertella ? sp. undet.
Camarotoechia sp. undet.
Delthyris missouriensis Weller.
Syringothyris bushbergensis Weller.
Spirifer jeffersonensis Weller.
Platyceras erectoides Weller ?

FERN GLEN FORMATION

Name.—The Fern Glen formation takes its name from Fern Glen, St. Louis County, Missouri,[1] where the formation is well exposed with its typical expression. In the older reports on the geology of southeastern Missouri, the beds constituting the Fern Glen were referred to the Chouteau limestone,[2] which at that time was considered to be a member of the Chemung Group, consequently Devonian.

Areal Distribution.—The area within which the Fern Glen outcrops occur in Ste. Genevieve County, reaches from the northeastern corner of the county at the mouth of Isle du Bois Creek, in a southwesterly direction to the Little Saline faulted zone, beyond which no further exposures occur. At its northern extremity this area of outcrop intersects the river bluffs, but in the south the outcrops occur about five miles back from St. Marys. Throughout this area the strata dip gently to the northeast, and the Fern Glen outcrop occupies a narrow, extremely sinuous line, extending far to the northeast along the sides of the deep and narrow valleys, and crossing the divides at the southwestern border of the area of outcrop. In the northern part of the county these outcrops extend along the sides of some of the valleys for a distance of nearly four miles, and although the formation is more or less covered with talus, it is sufficiently well exposed to establish its presence.

Thickness.—Because the exact base of the Fern Glen is rarely exposed, and because the formation passes into the overlying formation through insensible gradations, it is impossible to make exact measurements of the thickness of the formation. From a large number of observations in the field, however, it seems probable that the entire formation rarely or never exceeds 40 feet in thickness in Ste. Genevieve County, and the average thickness is believed to be between 30 and 40 feet.

Topography.—In its influence upon the topography of the region, the Fern Glen must be considered in connection with the

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[1] Weller, Trans. St. Louis Acad. Sci., vol. 16, p. 438 (1906).
[2] Shumard, Rep. Geol. Surv. Mo., 1855-1871, p. 295 (1873).

overlying Burlington. Both formations contain large amounts of chert, which is so resistent to the agencies of weathering that the beds form a conspicuous escarpment across the county, the Fern Glen being present in most places near the base of this escarpment.

Lithological characters.—The Fern Glen 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.

The very base of the formation is commonly, if not always, a shale bed from two to five or six feet thick. This shale is commonly covered by talus, and is apparently made up of reworked material from the older formations in the immediate region. One of the best exposures of this shale in Ste. Genevieve County, is above the large lime quarry at Brickeys, where the following section has been measured:

		Feet
4.	Limestone, tough and hard, evenly bedded, buff or yellowish in color, with numerous included irregularly spherical, geodial masses of white crystalline quartz, one-half to two inches in diameter. Exposed	5
3.	Shale, yellowish-green, apparently reworked Thebes	2
2.	Limestone, hard siliceous, bluish or gray in color, with numerous fossils. Fernvale	3
1.	Kimmswick limestone, exposed	50

Above the basal shale bed No. 3 the Fern Glen consists of hard, tough limestone free from chert, gray or buff in color, or locally a little blotched with red, the individual beds ranging in thickness from six inches to two feet. Some or all of these beds include a great number of subglobular, quartz geoidal bodies, varying in size from a half inch to two inches in diameter, whose white color, when broken, stands out in strong contrast with the rock in which they are imbedded. These beds are rarely observed actually in place, and at no locality have they been seen exposed throughout their entire thickness, which is probably between ten and twenty feet in most places. The underlying shale commonly gives way along the sides of the ravines and valleys where the Fern Glen outcrops, and allows these lower limestone beds to slump. In some places all that can be seen of the formation consists of loose, flag-like slabs of this limestone, from two to six feet across, lying upon the hill slopes, all the remaining portion of the formation being covered by talus. In some streams with gradient nearly equalling the dip of the rocks, that portion of their course which follows the basal portion of the Fern Glen, is commonly choked by great slabs of this limestone, such a condition of the stream bed in places persisting for a half mile or more. In those portions of the county where the Fern Glen in underlain by the Thebes shale, the basal Fern Glen limestone has slumped even more than where the bed of basal Fern Glen shale alone is present.

In their upper portion the hard, lower limestone beds of the formation become somewhat red in color, and pass with a more or less gradual transition into the red, argillaceous limestone which constitutes the following portion of the formation. 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 deep well at Chester, Illinois, red limestone and shale, undoubtedly Fern Glen, occurs at a depth of 1,656 feet and continues for 29 feet. In a deep well two miles east of Waterloo, Monroe County, Illinois, the red Fern Glen is first recognized at a depth of 795 feet, and apparently continues for 60 feet.

The characteristic red color of the formation persists throughout its entire area of outcrop in Ste. Genevieve County, from Isle du Bois Creek to the Little Saline, but in spite of its red color the marine origin of the formation is certainly established by the presence of an abundant fauna of crinoids, corals, brachiopods, etc. One of the best exposures of these beds may be seen at the mouth of Establishment Creek at Clement, where the red Fern Glen forms the lower portion of the bluff on the north side of the creek, beneath the overhanging chert and limestone beds which form the upper portion of the bluff. Other good exposures of these red beds may be seen near the base of the bluffs along the railroad between Clement and Brickeys, and at many localities in the ravines within the area of outcrop. These red beds vary in thickness from ten to twenty or more feet. They are commonly free from chert and in some localities contain numerous fossils. Because of their shaly character these beds are much softer than the overlying strata, and are commonly covered by talus, but at many localities where the beds are not exposed, the presence of this red member is indicated by the fragments of red limestone present in the talus.

The upper portion of the Fern Glen is commonly a more or less crystalline, greenish limestone, with greenish shaly partings, and conspicuous chert bands. There is no sharp demarcation between the red beds below and the overlying greenish beds, and it is probable that a considerable additional portion of these sediments was originally red, and that the ferric iron has been reduced to ferrous iron in the processes of weathering, near the surface. This supposition is supported by the varying thickness of the red horizon, by the frequent presence of red blotches surrounded by the green color near the transition between the two beds, by the retention of the red color by some of the cherts in the greenish beds, and by the fact that the red bed is commonly thicker, in some cases much thicker in deep well records which penetrate the formation, than in surface outcrops.

Stratigraphic Relations of the Fern Glen Limestone.—Everywhere, so far as known, the Fern Glen rests unconformably upon the subjacent formation. In Ste. Genevieve County the underlying formations range in age from the Kimmswick limestone to the Sulphur Springs formation. At no locality, however, in Ste. Genevieve County does it rest upon any of the middle or Lower Devonian formations, since these formations are known only in the Little Saline faulted zone, and the Fern Glen outcrops occur only north of this zone, but in Perry County the formation is known to rest upon the St. Laurent limestone at several localities. In the northern part of the county the underlying formation is Kimmswick limestone in many localities, so that an hiatus covering a large part of the Ordovician, the whole of the Silurian and Devonian, and the very basal part of the Mississippian, is present. At other localities in the same portion of the county, the underlying rock is Fernvale. Farther south the formation immediately beneath the Fern Glen is more commonly the Maquoketa.

There seems to be no doubt concerning the unconformable relations of the Fern Glen upon the Sulphur Springs formation, and if this latter formation is early Kinderkook in age, as seems to be established, an unconformity of notable importance is present between the Kinderhook and Osage stages of the Mississippian. The presence of such an unconformity is established by the patchy distribution of the Sulphur Springs formation as has already been indicated. These patches of this early Kinderhook formation can only be the remains of a formation which at one time overspread a large territory. The removal of so large a portion of the Sulphur Springs took place during an erosion interval within the Mississippian, immediately preceeding the deposition of the Fern Glen.

Correlation.—The Fern Glen has been considered to be of Kinderhook age by most of those who have studied the formation and its fauna. The early Missouri geologists referred it to the "Chemung Group," which, as used by them, was essentially synonymous with the "Kinderhook Group" of later writers. Weller[1] has considered the formation to be late Kinderhook in age, being in fact, the youngest stage in that division of the Mississippian, and Schuchert[2] has likewise placed the Fern Glen at the close of the Kinderhook epoch. Ulrich,[3] however, has considered the Fern Glen to be the oldest member of the next following Osage stage of the Mississippian. The field evidence demonstrates the fact that there is no stratigraphic break whatever, in southeastern Missouri, between the Fern Glen and the superjacent Burlington limestone, and the fauna of the lower formation includes certain elements which merge into those of the Burlington. Certain other elements in the fauna, however, are quite foreign to the Burlington limestone.

In its entirety the fauna is composed of three important elements, besides minor ones. These are the corals, the crinoids, and the brachiopods. The coral element is one of the least conspicuous parts of the Burlington limestone fauna, and there seems to be little or no relationship shown between the Fern Glen and Burlington faunas in this group of species. The crinoids and brachiopods are both abundant in the Burlington. The Fern Glen crinoids belong to the same genera that are present in the Burlington, and some of the same species pass from one fauna to the other. Some of the species, however, are more primative than their near allies in the Burlington, and may well be counted as their forerunners. The brachiopods of the two faunas belong to the same genera and some of the species are common to both. A consideration of all the data would seem to indicate that it would not do serious violence to the facts to consider the Fern Glen as the earliest member of the Osage division of the Mississippian, but the faunas do seem to indicate that it is older than any of the typical Burlington, and if it is transferred from the Kinderhook to the Osage, it may become necessary to transfer some portion of the upper Chouteau limestone also to the Osage.

[1]Bull. Geol. Soc. Amer., vol. 20, pp. 265-332 (1909).
[2]Bull. Geol. Soc. Amer., vol. 20, p. 548 (1910).
[3]Bull. Geol. Soc., Amer., vol. 22, pl. 29 (1911)

Outside of the immediate Mississippi Valley region, the Fern Glen may be correlated with some part, at least, of the St. Joe marble of northern Arkansas. The Fern Glen fauna also has much in common with the fauna of certain limestones at Lake Valley, New Mexico, and these Lake Valley beds are doubtless nearly or quite contemporaneous with the Fern Glen. Another correlative of the Fern Glen which seems to be very well established by the evidence of the fossils, is the New Providence shale which is typically developed in Jefferson County, Kentucky.

Paleontology.—In most localities in Ste. Genevieve County, well preserved fossils are not common in the Fern Glen. Fragments of crinoid stems are always present in great numbers, and at most localities a few good brachiopod shells can usually be found. From some localities in Jefferson and St. Louis counties, however, large collections of the Fern Glen fossils have been secured, which have formed the basis for a monographic study of the fauna by Weller.[1] Most of the fossils occur in the red beds of the formation, or in the greenish beds immediately above, the same species being present in both situations. The fauna is so uniform throughout, that a complete list of the species from both Ste. Genevieve and the neighboring counties will be given, and any of the species recorded may be looked for in Ste. Genevieve County.

Fauna of the Fern Glen Formation

Cyathaxonia arcuata Weller.
Cyathaxonia minor Weller.
Amplexus rugosus Weller.
Amplexus brevis Weller.
Zaphrentis cliffordana M. E. & H.
Zaphrentis wortheni Weller.
Beaumontia americana Weller.
Favosites valmeyerensis Weller.
Cladochonus americanus Weller.
Monilopora crassa (McCoy).
Palaeacis depressus (M. & W.).
Palaeacis bifidus Weller.
Synbathorcinus dentatus O. & S.
Vasocrinus macropleurus (Hall).
Barycrinus sp.
Poterocrinus sp.
Coeliocrinus sp.
Graphiocrinus sampsoni Weller.
Platycrinus stallatus Weller.
Platycrinus springeri Weller.
Rhodocrinus punctatus Weller.
Agaricocrinus praecursor Rowley.
Uperocrinus pistilliformis (M. & W.).
Actinocrinus rubra Weller.
Physetocrinus smalleyi Weller.
Mespilocrinus sp.
Metichthyocrinus sp.
Pentremites decussatus Shumard.
Fistulopora fernglenensis Weller.
Chilotrypa americana (Miller).
Cystodictya lineata Ulrich.
Evactinopora sexradiata M. & W.
Crania missouriensis Weller.
Leptaena analoga (Phillips).
Schuchertella rubra (Weller).
Schuchertella fernglenensis Weller.
Rhipidomella cf. *michelinia* (L'Eveille).
Rhipidomella jerseyensis Weller.
Schizophoria poststriatula Weller.
Chonetes multicosta Winchell.

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

Chonetes logani N. & P.
Productus fernglenensis Weller.
Productus sampsoni Weller.
Camarophoria bisinuata (Rowley)?
Rhynchopora persinuata (Winchell).
Spirifer vernonensis Swallow.
Spirifer rowleyi Weller.
Brachythyris fernglenensis (Weller).
Brachythyris chouteauensis (Weller).
Spiriferella plena (Hall).
Delthyris novamexicana (Miller).
Spiriferina subtexta White.
Cyrtina burlingtonensis Rowley.
Pseudosyrinx sampsoni (Weller).
Athyris lamellosa (L'Eveille).
Cliothyridina glenparkensis Weller.
Cliothyridina obmaxima (McChesney).
Cliothyridina prouti (Swallow).
Ptychospira sexplicata (W. & W.).
Hustedia circularis (Miller)?
Dielasma fernglenensis Weller.
Aviculopecten fernglenensis Weller.
Conocardium sp.
Platyceras paralius W. & W.
Orthoceras sp.
Cyrtoceras ? sp.
Proetus fernglenensis Weller.

BURLINGTON FORMATION

Name.—This formation was known as the "Encrinital limestone" by Shumard[1] and the other earlier geologists of Missouri, because of the great number of broken crinoid stems and the frequent occurrence of more or less perfectly preserved bodies of these organisms as fossils in the formation. Hall[2] applied the name Burlington to the limestone from the city of Burlington, Iowa, where the formation is finely exposed in the Mississippi River bluffs, and where many of the crinoids and other fossils so characteristic of it occur in an excellent condition of preservation.

Areal Distribution.—The Burlington formation, along with the overlying cherty limestone of the Keokuk, constitutes the greater portion of the Mississippi River bluffs in Ste. Genevieve County, from the northern boundary of the county at Isle du Bois Creek, to the mouth of Frenchman Creek at White Sand. From the mouth of Establishment Creek to the Isle du Bois, older formations are exposed beneath the Burlington at the foot of the bluff, the lower contact of the Burlington rising higher and higher to the northwest. The strike of the rocks is a little west of north, much more nearly north and south than the course of the Mississippi River, so that in its southern extension the outcrop of the formation leaves the river, and at the Little Saline faulted zone lies from four to five miles back from the river bluffs, south and west of Ozora. Just north of the faulted zone a narrow strip of the formation extends eastward nearly to the county line, but the formation occurs nowhere in place within or south of the faulted zone in Ste. Genevieve County. How-

[1] Rep. Geol. Surv. Mo., 1855-1871, p. 294 (1873).
[2] Geol. Surv. Iowa, vol. 1, pt. 1, p. 92 (1858).

ever, over a portion of the summit of the hill in the SW. ¼ sec. 4, T. 36 N., R. 9 E., in which all the rocks in place are of Devonian age, great quantities of residual Burlington cherts are present, which indicate that at one time the Lower Mississippian formations, including the Burlington, have extended to the south into the faulted zone, and the formation is actually present within this zone farther east in Perry County.

The total width of the outcrop of the Burlington and Keokuk together, which have been mapped as a unit, throughout the entire extent of the formations north and south, varies from less than one mile to about three miles. The widest outcrop is in the northern part of the county, northwest of Establishment Creek, where these formations cap the high hills three miles from the Mississippi, and also form the major portion of the bluffs at the river bank. In this portion of the county the formations are much dissected by the deep, ravine-like valleys which have been eroded through it into the older formations. The narrowest portion of the outcrop occurs for two or three miles south of South Gabouri Creek, where it does not exceed one-half mile for some distance.

Thickness.—The thickness of the beds that can be referred to the Burlington limestone is approximately 75 feet. In recent studies of the original Burlington section, it has been shown by Van Tuyl that the formation at that place may have a minimum thickness of 60 feet 10 inches, and a maximum thickness of 94 feet 3 inches, these figures being obtained by the addition of the maximum and minimum thicknesses of the several beds into which the formation has been divided. As a matter of fact, neither all the maximum nor all the minimum thicknesses occur in any one continuous section, and the usual entire thickness of the formation lies somewhere between the possible maximum and minimum, and is approximately 71[1] feet, being only a little greater than that exhibited in Ste. Genevieve County.

At Burlington the formation has commonly been divided into the Upper and Lower Burlington limestones, largely on the basis of the crinoidal element in the fauna, although in the stratigraphic succession a sharp dividing line between the two members has not been very definitely placed. Such a line has been established, however, by the recent field work of Dr. Van Tuyl, the approximate thickness of the lower division being 50

[1]Ia. Geol. Surv., vol XXX, p. 121.

feet and the upper 35 feet. In the Ste. Genevieve County section here given, the faunas of beds 5, 6, and 7, with a thickness of 49 feet 6 inches, are suggestive of the Lower Burlington, while the upper beds, Nos. 8 and 9, with a maximum thickness of 28 feet 2 inches, correspond with the Upper Burlington of the typical section, thicknesses which conform as closely as could be expected in sections so widely separated geographically.

Topography.—Because of the large amount of chert in the Fern Glen, Burlington and Keokuk formations, these beds are very resistant to the processes of weathering, and because of their gentle dip to the northeast the area in which they outcrop stands up as a high ridge throughout its entire length, the west face of which constitutes the so-called Burlington escarpment. This chert ridge is well exhibited in the Beckett Hills, and in the Brickey Hills lying just back from the Mississippi River from the mouth of Establishment Creek to the mouth of Isle du Bois Creek at the northern line of the county. These chert hills are all exceedingly rough and wild, being deeply dissected by narrow, ravine-like valleys separated by narrow ridges. In weathering, the limestone portion of the formation has been removed by solution, leaving the chert in sharply angular masses ranging from a fraction of an inch up to eight inches in size, which cover the steep hill slopes with a deep mantle which in places lies essentially at the angle of repose.

Lithologic Character.—The most notable feature of the Burlington formation in Ste. Genevieve County, is the extraordinary development of chert. This chert occurs as concretion-like inclusions in the limestone, its distribution commonly being along the bedding planes, either as continuous bands varying in thickness up to ten inches with very even bounding lines above and below, as horizontal bands of sublenticular, concretion-like masses varying in horizontal diameter from a few inches to several feet, or as more or less irregular stringers spreading out horizontally, varying in thickness from a fraction of an inch to six inches, with the surfaces irregularly curved. The chert masses are in all instances sharply demarked from the inclosing limestone, there being no zone of gradation from one material to the other along the contacts. In some portions of the formation many feet in thickness, the chert constitutes 50% or more of the entire mass. In other portions of the formation considerable beds of limestone occur in which little or no chert is present. The chert is light colored, in many places nearly or quite white, and in texture simulates the limestone. In those limestone beds which are fine grained and close textured, the chert also is exceedingly dense and hard, but when the associated limestone is crystalline and crinoidal, the chert, after weathering at least, is more or less porous on account of the removal by solution of the fossil fragments of crinoid stems, which apparently were not altered to silica so readily as the surrounding matrix.

The limestone in association with the chert in the Burlington formation is for the most part light gray in color, some beds being nearly white, although certain beds are pale buff and others brownish. The texture of the limestone varies considerably. Some portions of it, perhaps the greater part, is fine grained, dense and very hard, while other parts are more or less crystalline, in some beds coarsely so. The more crystalline beds are also the ones which are more conspicuously crinoidal, most or all of the calcite crystals present being nothing else than the stem fragments or other portions of crinoids which have become crystalline calcite during the process of recrystallization of the limestone.

The most continuous exposed sections of the Burlington are those in the Mississippi bluffs. Such a section has been carefully studied and measured at the mouth of Establishment Creek and down the river from that point, where the following succession of beds is recognized.[1]

	Mississippian Section at Clement	Feet.	Inches.
27.	Spergen limestone, with unbroken contact with the bed below....		
26.	Limestone, buff, fine-grained, soft, impure, magnesian, no fossils observed	5	10
25.	Limestone, gray, medium-grained, weathering to thin layers	2	3
24.	Limestone, like No. 26	5	8
23.	Limestone, gray, medium-grained, rather thick-bedded	2	9
22.	Limestone, fine-grained, grayish-black, impure, only partially exposed	31	6
21.	Clay, soft, plastic, weathering to yellowish color, filled with *Chonetes planumbona*	16	
20.	Limestone, bluish-gray, medium-grained, fossiliferous. Exposed	1	2
19.	Concealed, probably shale	4	4
18.	Shale, ash-colored to grayish-black, calcareous, with intercalated bands of bluish-gray, medium-grained limestone	41	
Top of Keokuk.			
17.	Limestone, gray to bluish, coarse-grained, crinoidal in lower portion	2	6
16.	Limestone, bluish-gray, upper portion shaly, structure less and very cherty	11	5
15.	Limestone, lower six feet fine-grained, gray, slightly shaly, very cherty, and structureless, the upper three feet more regularly bedded, bluish-gray, medium-grained, cherty	9	

[1]This section, which has been carried up to the Salem limestone, has been carefully studied by Dr. F. M. Van Tuyl, who made as full collections of fossils from each bed as the time at his disposal allowed. The lower portion of the section is exposed at Clement, the higher portion in the bluffs below the mouth of Establishment Creek, about one and one-half miles below Clement.

	Feet.	Inches.
14. Limestone, bluish-gray, tough, dense, siliceous throughout, with nodules and lentils of chert. This bed passes laterally into oolitic limestone	6	6
Disconformity.		
13. Limestone, bluish-gray, medium-grained, cherty. Middle portion structureless and with irregular patches of chert	4	7
12. Limestone, gray, crinoidal	8	2
11. Limestone, gray, compact to subcrystalline in texture, with occasional crinoidal seams, more or less structureless and bearing chert in the form of bands, nodules and patches, and in a disseminated condition, some beds with a brownish tint, becoming more regularly bedded in the upper portion and grading into the bed above 22 feet, 2 inches to	23	3
10. Limestone, gray, subcrystalline, rather heavily bedded and projecting slightly, with a few small nodules and thin bands of chert in the upper portion. *Zaphrentis* zone 1 foot, 4 inches to	2	0
Upper limit of Burlington faunas.		
9. Limestone, gray, compact, imperfectly stratified, with irregular nodules, seams and patches of gray chert 14 feet 3 inches to	18	0
8. Limestone, gray, consisting of alternating layers of compact and subcrystalline beds with occasional crinoidal seams, and with nodules and irregular bands of gray chert. The crinoid bed	10	2
Top of Lower Burlington.		
7. Limestone, gray, subcrystalline, with occasional thin crinoidal seams, some layers with a brownish tint, with nodules and irregular bands of gray chert	24	0
6. Limestone, gray, compact, regularly bedded with discontinuous seams and nodules of gray chert. A shaly parting is locally present between this bed and the one above	17	9
5. Limestone, gray, soft, slightly shaly, imperfectly stratified, with interbedded bands of gray chert	7	9
Top of Fern Glen Formation.		
4. Limestone, gray, shaly, with nodules and discontinuous bands of reddish chert	4	4
3. Shale, calcareous, red—the upper portion becoming more calcareous and mottled with seams and patches of green	12	3
2. Limestone, gray, medium-grained. Exposed	4	4
1. Concealed to level of water in creek	9	4

In this section beds 1 to 4, with a total thickness of 30 feet and 3 inches, represent the Fern Glen formation. Beds 5 to 9 with a thickness of approximately 75 feet contain faunas which are distinctly Burlington in facies. The succeeding beds, 10 to 13, through an additional thickness of from 36 to 38 feet exhibit no distinctly different lithologic characters from the Burlington, being in the main cherty limestones, but they contain a fauna with Keokuk affinities. Above bed No. 13 there is a possible disconformable contact and a change in lithologic character, but the Keokuk faunas persist with no essential modification, through an added thickness of about 30 feet, beyond which some important faunal changes occur.

Stratigraphic Relations of the Burlington.—Sedimentation from the Fern Glen into the Burlington was continuous, there being no sharp line of demarcation between the two formations. The red color of the Fern Glen gradually disappears and the cherts which are so conspicuously developed in the Burlington make their first appearance well down in the typical Fern Glen. There is also no very sharp line of demarcation between the faunas of the two formations.

The relation of the Burlington to the overlying Keokuk is similar to that between the Burlington and the Fern Glen. There is no conspicuous difference in the lithology of the two formations, both are exceedingly cherty, and the association of chert and limestone is similar, the basis for the separation of the formations being chiefly the fossils, and even the faunas are not strikingly different. These three units might perhaps fairly be considered as members of one larger formation, the Osage.

Correlation.—From the evidence afforded by the fossils, the lower portion of the conspicuous series of chert beds in Ste. Genevieve County, may be definitely correlated with the Burlington limestone of southeastern Iowa and the adjacent portions of Illinois and Missouri. Furthermore, the differentiation of the Upper and Lower Burlington limestone which has been made in Iowa, seems to be possible of extension into Ste. Genevieve County, although the fossil fauna, especially of the lower beds, is meagre. It is the Upper Burlington fauna which is most commonly met with in the county, and one bed more coarsely crystalline and more conspicuously crinoidal than other portions of the formation, seems to be very persistent throughout the area of outcrop.

Paleontology.—Fossils are poorly preserved in the Burlington of Ste. Genevieve County in most localities. In the denser beds of limestone there is little or no evidence whatsoever of the presence of fossil shells, crinoids or other forms, but in the more coarsely crystalline beds an abundance of crinoidal fragments are commonly present, although very few specimens are perfectly enough preserved to be identified. An attempt has been made to secure as full collections as possible from the several beds in the Mississippi bluff section at and below the mouth of Establishment Creek, and the following table gives the species recognized with their distribution through the several beds, Nos. 5 to 9.

Faunas of Burlington Limestone near the mouth of Establishment Creek

	5	6	7	8	9
Zaphrentis dalei E. & H. ?				x	
Zaphrentis cliffordana E. & H				x	
Zaphrentis sp. 1		x	?		x
Amplexus fragilis W. & St. J.				x	
Monilopora beecheri Grabau			x		
Eretmocrinus calyculoides (Hall)				x	
Lobocrinus aequibrachiatus (McCh.)				x	
Fenestella sp			x		
Cystodictya sp			x		
Leptaena analoga (Phill.)			x		
Schuchertella ? sp			x		
Schuchertella ? sp				x	
Chonetes illinoisensis Worthen			x		
Productus sp. 1			x	x	
Productus sp			x		
Avonia ? sp. 4			x		
Avonia sp. 5				x	
Pustula alternatus (N. & P.)			x	x	
Productella sp				x	
Rhipidomella burlingtonensis (Hall)			x	x	
Schizophoria swallovi (Hall)				x	x
Rhynchopora persinuata (Win.)			x		
Camarotoechia ? sp			x		
Spirifer rowleyi Weller	x		?		
Spirifer vernonensis Swallow	x		x		
Spirifer forbesi (N. & P.)?		x	x		
Spirifer imbrex Hall			x		
Spirifer grimesi Hall		?		x	x
Spirifer carinatus Rowley				x	x
Spirifer sp. 4			x	x	
Spirifer sp		x			
Spirifer sp			x		
Delthyris ? sp. 2			x		
Delthyris sp. 3			x		
Spiriferella plenus (Hall)					x
Brachythyris suborbicularis (Hall)				x	x
Reticularia pseudolineata (Hall)			x		
Reticularia cooperensis (Swall.)		x			
Martinia ? sp	x				
Athyris lemellosa (L'veille)	x			x	
Cliothyridina obmaxima (McCh.)	x		?		
Cliothyridina incrassata (Hall)					x
Cliothyridina sp	x				
Composita sp			x		
Composita sp					x
Edmondia sp			x		
Platyceras sp				x	
Griffithides sp	x				

The Burlington fauna in Ste. Genevieve County, as recorded in the preceding table, is indeed a meager one when compared with that at Burlington, Iowa. However, the species which have been identified are for the most part characteristic Burlington forms, and their range in the section is not unlike that in the typical Iowa section, where a lower and an upper division of the formation is commonly recognized with very different crinoidal faunas. In the Ste. Genevieve County section here recorded, bed No. 8 is more conspicuously a crinoidal bed than any other member, although only two species of these fossils well enough preserved to be satisfactorily determined have been collected at this locality. Both of these species are Upper Burlington forms, *Lobocrinus aequibrachiatus* being recorded by Wachsmuth and Springer[1] as being characteristic of the "lower part of the Upper Burlington limestone." Such brachiopods as *Schizophoria swallovi* and *Spirifer grimesi*, which are most abundant, if not wholly confined to the Upper Burlington beds in southeastern Iowa, have also been identified only in bed No. 8 and 9 in this Ste. Genevieve County section. In the lower beds in this section, Nos. 5, 6, and 7, there occur such species as *Rhynchopora persinuata*, *Spirifer rowleyi*, and *Spirifer forbesi*, which are confined to the Lower Burlington beds at Burlington. In these lower beds of the section there also occur such species as *Spirifer rowleyi*, *Spirifer vernonensis*, *Athyris lamellosa* and *Cliothyridina obmaxima*, which are common forms in the subjacent Fern Glen fauna, indicating the entire absence of any faunal as well as stratigraphic break.

Along the road-side on River Aux Vases, in SE. ¼ sec. 20, T. 37 N., R. 9 E., the Burlington is a conspicuously crinoidal limestone, and is more than usually free from chert. Fossils well enough preserved to be identified occur somewhat more commonly at this locality than is usually the case, and the following species have been met with.

Fauna of the Burlington Limestone on River aux Vases.

Zaphrentis dalei E. & H.
Zaphrentis sp.
Orbitremites norwoodi (Owen & Shumard).
Schizoblastus sayi Shumard.
Agaricocrinus sp.
Aorocrinus cf. *A. parvus* (Shumard).
Dichocrinus sp.
Lobocrinus pyriformis (Shumard).
Lobocrinus n, sp. ?
Synbathocrinus illinoisensis M. & G.
Fenestella sp. undet.
Fenestella n. sp.
Pustula alternata (Norwood & Pratten).
Schizophoria swallovi (Hall).
Spirifer grimesi Hall.
Brachythyris suborbicularis (Hall).
Athyris lamellosa L'veille.
Cliothyridina obmaxima (McChesney).

[1] N. A. Crin. Camerata, vol. 2, p. 440.

Without doubt this bed is about equivalent to bed No. 8 of the Clement section already described. The crinoids, so far as they can be determined, are Upper Burlington species, and the two Brachiopods, *Spirifer grimesi* and *Schizophoria swallovi* are also good upper Burlington forms.

Another collection from near the middle of sec. 28, T. 37 N., R. 9 E., from essentially the same horizon as the last, contains the following species.

Fauna of the Burlington Limestone south of River aux Vases

Platycrinus brevinodus Hall.	*Schizophoria swallovi* (Hall).
Dizygocrinus rotundus (Shumard)?	*Spirifer grimesi* Hall.
Schizoblastus sayi (Shumard).	*Reticularia lineatoides* (Swallow)?

This collection again is suggestive of the Upper Burlington limestone, *Dizygocrinus rotundus* being one of the most characteristic and most abundant crinoids of that horizon in the more northern portion of the Mississippi Valley. *Platyceras brevinodus* occurs typically in the Crawfordsville beds of Keokuk age, but it is also present in the Burlington-Keokuk transition beds in Iowa. *Schizophoria swallovi* and *Spirifer grimesi*, good Upper Burlington species are again present.

Still another collection from the same beds has been made from exposures in the bank of Little Saline Creek, in NE. ¼ NW. ¼ sec. 2, T. 36 N., R. 9 E., where the following species occur:

Fauna of Burlington Limestone on Little Saline Creek

Zaphrentis sp.	*Productus concentricus* Hall.
Zaphrentis sp.	*Productus* sp.
Eretmocrinus ? sp.	*Spirifer grimesi* Hall.
Schizoblastus sayi (Shumard).	*Athyris lamellosa* (L'veille).
Rhipidomella burlingtonensis (Hall).	*Cliothyridina obmaxima* (McChesney).
Schizophoria swallovi (Hall).	*Platyceras* sp.
Productus burlingtonensis (Hall)?	

KEOKUK FORMATION

Name.—In the early descriptions of the Mississippian formations of southeastern Iowa by Hall,[1] the sections at the cities of Burlington and Keokuk were selected as typical of two formations to which the names of the two cities were applied. Each formation was found to possess its own lithologic and faunal characters,

[1] Iowa Geol. Surv., vol. 1, pt. 1 (1858).

by means of which it could be easily differentiated from the other. Between the more abundantly fossiliferous portions of the two formations, is a series of conspicuously cherty beds called Montrose cherts by Keyes,[1] whose fauna is more meager than that of either the more typical Burlington or the Keokuk formation. Hall clearly included this series of chert beds in his Keokuk limestone, but Keyes apparently considered the beds as a part of the Burlington formation. Wachsmuth and Springer[2] have discussed the crinoidal fauna of these beds which they designate as the "transition beds," and these authors give expression to the opinion that the entire series of strata, including the Lower and Upper Burlington, the transition beds and the Keokuk limestone, should be combined into one geologic formation with several divisions, which in the present day usage of terms would be known as members.

In the section at Keokuk, Iowa, the type locality of the formation, the Keokuk limestone is succeeded by a series of more shaly beds characterized by the presence of numerous geodes, which have commonly been refereed to in the literature as the "geode beds." In the definition of the formation as given by Hall in his Iowa report,[3] the name Keokuk limestone was apparently restricted to the limestones below the "geode bed," although the bed was considered as a sort of appendix of the Keokuk, and in the table of formations[4] was designated as "beds of passage" between the Keokuk and the Warsaw. Later authors, however, have commonly considered the "geode bed" to be a part of the Keokuk formation or the "Keokuk Group." Recent studies have shown, however, that the faunas of the "geode bed" are more closely allied to those of the superjacent Warsaw formation than to the subjacent Keokuk limestone, in consequence it has seemed proper to restrict the name Keokuk, as Hall originally limited it, to the limestone beds between the top of the Burlington limestone and the bottom of the "geode beds," the "geode beds" themselves being added to the Warsaw formation above.

The conditions in Ste. Genevieve County are not essentially different from those in the Iowa section, in so far as the separation of the Keokuk from the Burlington is concerned, but the beds

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[1]Iowa Geol. Surv., vol. 3, p. 445 (1895).
[2]Proc. Acad. Nat. Sci. Phil., 1878, p. 224.
[3]Geol. Surv. Iowa, vol. 1, pt. 1, p. 94 (1858).
[4]Loc. cit., p. 109.

in this more southern region are much more cherty throughout, so that the fixing of dividing lines is more difficult. In the Iowa section the more calcareous series below and above are separated by the Montrose chert horizon, but in Ste. Genevieve County the entire series of beds is highly cherty. Under these conditions the dividing line between the Burlington and the Keokuk is recognizable only through observation of the fossil faunas. There is, however, a change in the lithologic character of both the limestone and chert between 30 and 40 feet above the horizon where the Keokuk faunas replace those of Burlington relationships, this change in lithologic character being associated with a local unconformity.

Areal Distribution.—The areal distribution of the Keokuk in Ste. Genevieve County conforms closely with that of the Burlington, the area of outcrop lying just east of that of the older formation, from the Mississippi River bluffs at the mouth of Establishment Creek to the Little Saline faulted zone southeast of Ozora. Since there is no marked lithologic line of separation between the Burlington and Keokuk in Ste. Genevieve County, the two formations have been mapped as a unit, and are so shown upon the accompanying map.

Topography.—The Keokuk and Burlington in Ste. Genevieve County are a topographic unit. Both are exceedingly resistant formations on account of the excessive amount of chert which is present in them, and together they are responsible for the range of high, rugged hills which extend from the mouth of Isle du Bois Creek at the northern boundary of the county, through the Brickey and Beckett Hills to the River aux Vases, and beyond to the faulted zone.

Thickness.—In Ste. Genevieve County the thickness of the Keokuk limestone is considerably greater in the region of Little Saline Creek than in the northern part of the county, due to the presence in the south of a bed in the midst of the formation which seems to be wanting in the north. In the Clement section where the most complete exhibition of the formation exists in the northern part of the county, 67 feet of strata are referable to the Keokuk, but in the region near Little Saline Creek there are about 20 feet more of limestone which belong to the formation.

From the careful work of Dr. F. M. Van Tuyl in southeastern Iowa, the maximum and minimum thicknesses of the Keokuk limestone at Keokuk, Iowa, are 80 feet 8 inches and 65 feet 5 inches, which does not differ widely from the measured thicknesses of the same formation in Ste. Genevieve County.

Lithologic Characters.—The lithologic characters of the beds of Keokuk age in the northern part of the county, are well exhibited in the Clement section in the Mississippi River bluffs at and below the mouth of Establishment Creek, which has already been described (see pp. 171-172), beds Nos. 10 to 17 of the section being referable to this formation. Beds Nos. 10 to 13 are not essentially different lithologically from those of the Burlington formation below, their Keokuk age being shown by the fossils which they contain. These beds consist of gray, more or less compact or in places subcrystalline limestone, which includes a large amount of chert in bands or concretion-like nodules. Bed 14 of the section, is separated from the subjacent stratum by disconformable contact, and besides including concretion-like nodules and lentils of chert, it contains a considerable amount of silica disseminated throughout. Furthermore, this bed changes notably in its lithologic character in a horizontal direction, and in the point of the bluff a little over one-fourth mile above the mouth of Establishment Creek, it passes into a cross-bedded, arenaceous, and oolitic limestone, very different in appearance from that shown in the measured section already recorded. The oolitic facies of this bed is elsewhere well exhibited in the bluff about one mile below Brickeys, where it is a more typical oolite than at the locality above Clement. Further south in the county, in the hills both north and south of Little Saline Creek, a conspicuous bed of oolite has been observed which is believed to be the equivalent of the bed in the northern portion of the county, one of the best exhibitions of it being nearly south of the house in NE. ¼ sec. 4, T. 36 N., R. 9 E., one-fourth mile southwest of Ozora. This oolite member is doubtless present at many intervening localities, but has been rarely observed because of the thick mantle of talus upon most of the hill slopes, and the consequent absence of good clean sections.

Above the oolite horizon cherty limestones persist for a thickness of about 23 feet in the measured Clement section, comprising beds 15, 16 and 17. Some portions of this series of beds are perhaps the most cherty limestones in the entire chert series, but the cherts tend to be somewhat darker in color with a bluish tint, although nearly white cherts are also present. Some of the cherts in these beds are more porous than most of those in any of the lower beds, and in places residual cherts of this sort, lying upon the surface of the hills, are so porous that they appear much like blocks of sandstone until they are carefully examined. The limestone too, of these beds above the oolite horizon, is somewhat more bluish in color than that of the beds below, it varies in texture from very dense to somewhat coarsely granular or crystalline, and in some places it contains some shaly material.

Another very complete section of the Keokuk and Warsaw, which may be called the White Sand Section, has been studied along the bank and in the bluffs of the Mississippi River from the mouth of Frenchman Creek at White Sand, to the mouth of Lower Frenchman Hollow, about one mile below. The succession of strata in this section is as follows:

Setion of Keokuk and Warsaw Formations, near White Sound

		Feet.	Inches.
23.	Spergen (Salem) limestone.		
	Warsaw formation.		
22.	Limestone, gray, medium-grained. 3 feet to	4	0
21.	Concealed, probably shale	3	4
20.	Limestone, bluish-gray, medium-grained, becoming shaly in upper part	4	
19.	Limestone or calcareous shale, impure, probably magnesian, dirty gray color, fine-grained	30	1
18.	Limestone, similar in character to No. 17. The *Syringothyris* zone. Exposed	1	5
17.	Limestone, ash-colored, soft, impure, probably magnesian, alternating with bluish, medium grained, cherty limestone. The *Chonetes* zone. A pelecypod zone two feet from top	6	9
16.	Concealed, probably soft shale	10	0
15.	Limestone, grayish-black, fine-grained and argillaceous. Basal member of *Productus magnus* beds	4	5
14.	Limestone, bluish-gray, crinoidal, medium to coarse-grained, filled with siliceous segregations one inch or less in diameter, some layers slightly argillaceous	7	0
13.	Concealed, probably shale	22	8
12.	Limestone, bluish-gray, medium to coarse-grained, sparsely fossiliferous, bearing siliceous segregations	10	9
11.	Concealed, probably shale	13	6
Top of Keokuk.			
10.	Limestone, gray with greenish tint, coarse-grained and crinoidal, some layers slightly argillaceous, in rather heavy layers; bearing small, irregular, siliceous geoidal nodules one inch or less in diameter, whose interiors are filled with calcite	6	0
9.	Limestone, gray with greenish tint, medium-grained, argillaceous, cherty, with green specks which are possibly glauconite	1	6
8.	Limestone, alternating layers of medium-grained bluish-gray beds, and crinoidal layers, with a bed of subcrystalline, gray, bryozoan bearing limestone two feet thick in the lower portion	10	0
7.	Limestone, bluish-gray, medium-grained, cherty, with a medium, subcrystalline, gray band locally	6	6

		Feet.	Inches.
6.	Limestone, gray, cherty, fine-grained, somewhat shaly..........	1	4
5.	Limestone, bluish-gray, dense, subcrystalline, siliceous, becoming coarser-grained in the upper portion, bearing nodules and irregularly disposed masses and seams of compact, badly shattered gray chert.	3	2
Disconformity.			
4.	Limestone, grayish-blue, medium-grained below, subcrystalline above, lower portion with occasional lentils and seams of chert, upper portion more structureless, with seams, nodules and irregular patches of light gray chert..............................	6	3
3.	Limestone, grayish, medium-grained, locally passing partially into crinoidal limestone, with discontinuous bands and nodules of chert and with occasional stylolite seams. 5 feet 10 inches to.....	6	6
2.	Limestone, brownish, subcrystalline to crinoidal, more evenly bedded than the bed below, and with chert disposed in more regular nodules and discontinuous bands............................	2	3
1.	Limestone, gray, with slight brownish tint, compact to subcrystalline, with little semblance of stratification, filled with irregular masses, nodules and bands of whitish, badly fractured chert, sparsely fossiliferous. Exposed above the river level.....	11	6

Judging from the succession below Clement, the upper limit of the Burlington limestone in the White Sand section, lies about twelve feet below the lowermost exposed beds at the mouth of Frenchman Creek. Beds Nos. 1 to 4 constitute the lower member of the Keokuk formation, the cherty limestone below the intra-Keokuk disconformity, the total thickness of this member, including the lowermost unexposed 13 feet, being 37 feet 10 inches, as compared with 37 feet 4 inches in the Clement section.

The second member of the formation, the cherty limestones above the unconformity, includes beds No. 5 to 10, with a total thickness of 28 feet 6 inches, as compared with 29 feet 5 inches in the Clement section.

The two-fold division of the Keokuk formation, as outlined in the discussion of the Clement and White Sand sections, may apparently be recognized throughout the county, although some beds are present immediately beneath the unconformity in the hills on either side of Little Saline Creek, which seem to be wanting in the northern part of the county. These two members may be briefly characterized as follows, No. 1 being the lower of the two:

Member No. 1.—Bluish-gray to nearly white, or locally brownish, crystalline or fine textured limestone, exceedingly cherty throughout in the northern part of the county, but with a maximum of 20 or more feet of pure, non-cherty limestone at the summit in the Little Saline Hills southeast of Ozora. The cherty beds are not characteristically different from those of the subjacent Burlington. The thickness of the beds of this member, in the northern part of the county is about 38 feet, near Ozora it is 60 feet or more.

Member No. 2.—Gray or bluish-gray, crystalline limestone, with much chert. The chert varies in lithologic character from very hard dense and brittle, to exceedingly porous, some of the residual masses lying upon the hill slopes having the appearance of a ferruginous sandstone until it is examined with care. The basal bed of the member is a siliceous limestone which locally passes horizontally into oolitic limestone. The silica present is either in a finely disseminated condition or is in the form of rounded quartz sand grains more or less regularly disseminated through the limestone. This arenaceous-oolitic bed varies from ten to twenty or more feet in thickness, the greater thickness being exhibited where the oolite is best developed, and the arenaceous portion lying above the oolite where both are present. This member is separated from No. 1 by a line of disconformity. The total thickness of the member is 30 or more feet.

Good Keokuk outcrops are met with in the region south of Ozora, in the hills on either side of Little Saline Creek, although no sections so continuous as those in the Mississippi River bluffs occur. The several exposures in this region may be referred to the same two members of the formation which have been recognized farther north, but the lower member includes a conspicuous limestone stratum at its summit, 20 or more feet in thickness, which is nearly free from chert and is highly fossiliferous. In the basal portion of No. 2, also, bed 4 of the following section the oolitic and arenaceous limestone beds are more conspicuous and in places portions of the bed are almost completely silicified into a very porous chert. One of the best exhibitions of the Keokuk section in the Little Saline region, is exposed in a small ravine in the northern part of the SW. ¼ SE. ¼ sec. 2, T. 36 N., R. 9 E., where the following succession occurs.

	Feet.
4. Limestone, oolitic and arenaceous, gray in color, free from chert........	15
Disconformity.	
3. Limestone, gray or nearly white, crinoidal and crystalline, free from chert, and highly fossiliferous A few inches at the base are especially full of fossils	20
2. Limestone, gray, compact, structureless, very cherty, similar to Bed No. 4 in White Sand section..	3
1. Limestone, gray in color, medium-grained, very cherty, similar to Bed No. 3 in White Sand section..	Severa

In this section beds No. 1 to 3 represent the lower member of the Keokuk, the uppermost, non-cherty limestone bed (No. 3) being wanting in the bluff sections in the northern part of the county. Bed No. 4 is the basal part of the second member, separated from the underlying beds by a disconformity.

Another good exhibition of the section occurs in the valley heading about one mile nearly due west of Ozora, running east and southeast to the point where it crosses the road south of Ozora. In the upper portion of this valley good exposures of the cherty Burlington limestone occur, these are followed by the two members of the Keokuk. Excellent exposures of the oolite bed at the base of Member No. 2 are present about one-fourth mile from Ozora, south of the farm house, where between twenty and twenty-five feet of this limestone with beds of arenaceous limestone above, are exposed. The non-cherty crinoidal limestone at the top of the lower member of the formation, which was twenty feet thick one and three-fourths mile southeast of Ozora, is here only about five feet thick, and below this are the highly cherty beds which have been met with elsewhere.

Stratigraphic Relations of the Keokuk Limestone.—The continuity of sedimentation from the Burlington into the Keokuk is clearly suggested by the succession of strata which constitute these formations in Ste. Genevieve County. The lithologic succession is continuous, and the only way to detect the line of separation between the two formations is from a study of the fossils, and even the faunal change is not abrupt or conspicuous. The upper limit of the Keokuk is more distinctly marked than the base of the formation, although there is no reason to believe that there is any line of unconformity between the Warsaw and the Keokuk. The lithologic change from the cherty limestones of the lower formation to the shales and more impure limestones of the Warsaw, takes place within a few feet so that little difficulty is met with in recognizing the line of demarcation in the field, but there are thin shaly partings between some of the limestone beds in the higher part of the Keokuk, and some of the limestones of this part of the section are less pure than those lower down. A considerable number of fossil species also pass from the Keokuk to the Warsaw.

The only distinct stratigraphic break in this part of the geologic column is recognized in the midst of the limestone which constitutes the Keokuk as here interpreted. This break is not a conspicuous one as seen in the succession of beds, and its presence is suggested more by reason of the absence of certain strata in the northern part of the county which are well developed south of Ozora, and by the change in character of the sediments above this line, especially the presence of a considerable amount of sand, locally at least, in the initial beds of the higher Keokuk member.

Correlation.—In mapping the Mississippian formations of Ste. Genevieve County it has proved to be impracticable to subdivide the Burlington-Keokuk unit which is made up of a series of remarkably cherty limestones. As mapped, this unit includes a line of unconformity below the oolitic beds in the midst of the strata referred to the Keokuk. In the correlation of the beds which constitute the higher or Keokuk portion of this unit, those strata beneath the line of unconformity are clearly shown by their fossils to be Keokuk in age, but the higher beds, beginning with the oolite and continuing to the top of the chert bearing series, includes a few fossil species which are commonly considered as being younger than the typical Keokuk of southeastern Iowa. The most characteristic Keokuk fauna of the entire section is that found in the chert-free limestone just beneath the unconformity in the region south of Ozora, but most of the Keokuk species persist into the higher beds, where they are associated with a few forms which suggest an age younger than the Keokuk. The faunal affiliations of the upper member of the Keokuk are shown in the table given on page 188, where 34 specific forms are listed from this horizon. Of these, 9 occur also in the lower member of the Keokuk but are not recorded in the Warsaw, 5 are shown to be present in one of the Warsaw beds but are not listed in the lower Keokuk member, and 12 persist from the lower Keokuk through the upper Keokuk into the Warsaw. The other 8 species are restricted to this member of the Keokuk. In the analysis of this fauna the 5 species which are recorded from the higher Warsaw beds but not from the earlier Keokuk are the really critical ones. These species are *Monilopora beecheri*, *Chonetes planumbona*, *Productus ovatus*, *Spirifer subaequalis*, and *Eumetria verneuiliana*. Of these species *M. beecheri* has been described elsewhere from the Keokuk, *P. ovatus* is a long range form which is known in faunas ranging from Kinderhook to Chester in age. *E. verneuiliana* is most commonly a higher form, but the species does occur rarely in the typical Keokuk at Keokuk, Iowa. The only remaining species, *Chonetes planumbona* and *Spirifer subaequalis*, do not afford sufficient evidence to warrant the removal of this member from the Keokuk. Furthermore both of these are unusual forms in this horizon, the great mass of the fauna being characteristically Keokuk.

In comparing these Keokuk strata of Ste. Genevieve County with the Keokuk of other parts of Missouri, the relationship of the oolite beds in the basal part of the upper member of the formation, with the Short Creek oolite of southwestern Missouri, must be considered. The Short Creek oolite is a thin bed which occurs in the midst of the more usual crystalline limestone of that part of the state, and has been shown to be rather persistent over a considerable area. The fauna of the Short Creek includes a number of forms which suggest a younger age than the Keokuk, just as the higher member of the Ste. Genevieve County Keokuk includes a number of such forms, and it seems to be reasonable to assume that this oolite horizon, in the southeastern and southwestern parts of the state are of about the same age. Both beds were deposited on the flanks of Ozarkia, and it is not unlikely that similar conditions existed at this time in these two separate regions. So far as has been reported there is no reason to believe in the presence of any stratigraphic break beneath the Short Creek oolite, such as is suspected in Ste. Genevieve County.

Paleontology.—The determination of the dividing line between the Burlington and Keokuk formations in Ste. Genevieve County, is dependant wholly upon the change in the fossil faunas which are present, both formations being represented by cherty limestones which are essentially indistinguishable lithologically. In a discussion of the faunas, the fossils from each one of the two members of the formation, which have been described, will be considered separately.

In the strata of the lowermost member of the Keokuk, fossils are in most localities rare, and are commonly poorly preserved. The only notable exception is found in the non-cherty limestone bed at the top which is so well developed south of Little Saline Creek. In the Clement section, beds 10, 11, 12, and 13 represent this member, and the fossil species which have been identified from these beds are as follows, no fauna at all having been collected from bed No. 13.

Fauna of the Lower Keokuk in the Clement Section

	10	11	12	13
Zaphrentis dalei E. & H.	x			
Zaphrentis sp. 1		x		
Amplexus fragilis W. & St. J		x		
Fenestella sp	x			
Cystodictya sp	x			
Rhipidomella dubia (Hall)	x			
Schizophoria cf. *swallovi* (Hall)			x	
Chonetes sp	x			
Chonetes shumardianus (DeKon.)	x			
Productus sp	x			
Productus sp			x	
Spirifer mortonanus Miller	x			
Spirifer rostellatus Hall ?			x	
Spirifer missouriensis Swall. ?	x			
Spirifer grimesi Hall	x			
Spirifer sp. 2	x			
Spirifer sp. 3			x	
Spirifer sp		x		
Spirifer sp			x	
Brachythyris suborbicularis (Hall)	x		x	
Reticularia pseudolineata (Hall)			x	
Platyceras sp	x			
Platyceras sp			x	
Igoceras sp	x			
Murchisonia keokuk Worthen ?	x			
Griffithides sp	x			
Griffithides sp		x		

In the White Sand section the beds of this member of the Keokuk, Nos. 1, 2, 3, and 4, have furnished much better and more complete collections than those of the Clement section. Beds 1 and 2 at White Sand are together equivalent to the upper 13 feet of bed No. 11 in the Clement section, and beds 3 and 4 are the equivalents of beds 12 and 13 at Clement. The species of fossils collected from the successive beds at White Sand, are as follows:

Fauna of the Lower Keokuk in the White Sand Section

	1	2	3	4
Zaphrentis sp. 1	x		x	?
Zaphrentis sp		x		

Fauna of the Lower Keokuk—Continued.

	1	2	3	4
Zaphrentis elliptica White			x	
Zaphrentis dalei E. & H. ?			x	x
Zaphrentis varsoviensis Worthen ?			x	
Monilopora sp. undesc. ?	x			
Cyathaxonia sp. undet			x	
Palaeacis obtusus M. & W.				x
Synbathocrinus sp	•			x
Fenestella sp		x		
Fenestella sp			x	
Fenestella sp				x
Cystodictya sp. 2				x
Cystodictya sp. 2 ?			x	x
Chonetes illinoisensis Worthen			x	
Chonetes sp. 2	x			
Productus crawfordsvillensis Weller				x
Productus setigerus Hall ?		x		
Productus sp. 1		x		
Productus sp			x	
Productus sp				x
Productella sp			x	
Productella sp				x
Productella ? sp				x
Pustula alternatus (N. & P.)				x
Pustula sp. 1			x	
Rhynchopora beecheri Greger	x			x
Rhynchonella ? sp	x			
Spirifer mortonanus Miller	x	x	x	x
Spirifer logani Hall		x	x	
Spirifer sp	x			
Spirifer sp		x		
Spiriferella neglecta (Hall)		?	?	
Spiriferella plenus (Hall)		?	?	
Brachythyris suborbicularis (Hall)	x		x	x
Brachythyris ? sp				x
Delthyris novamexicanus (Miller)	x			x
Spiriferina ? sp				x
Syringothyris sp				x
Pseudosyrinx keokuk Weller				x
Reticularia sp			x	
Composita ? sp	x			
Cliothyridina parvirostra (M. & W.)		?		x
Cliothyridina sp		?		x
Igoceras sp			x	
Conocardium sp				x
Fish teeth				x

By far the most prolific fauna collected from the lower member of the Keokuk, has been secured from the upper, non-cherty limestone bed which is well developed south of Ozora, but is wanting in both the Clement and the White Sand sections. The best observed locality for the fossils is bed No. 3 in the section already described in the northern part of SW. ¼ of SE. ¼ sec. 2, T. 36 N., R. 9 E., where the following species have been identified.

Lower Keokuk Fauna South of Little Saline Creek

Zaphrentis sp.
Cyathaxonia sp.
Monilopora sp.
Palaeacis obtusus M. & W.
Cystodictya sp.
Fenestella sp.
Orthotetes keokuk (Hall).
Rhipidomella dubia (Hall).
Chonetes illinoisensis Worthen.
Productella sp.
Productus crawfordsvillensis Weller.
Productus magnus M. & W.
Productus wortheni Hall.
Productus sp.
Pustula alternatus (N. & P.).
Camarophoria bisinuata (Rowley).
Rhynchotetra sp.
Tetracamera subtrigona (M. & W.).
Tetracamera sp.
Rhynchopora beecheri Greger.
Spirifer mortonanus Miller.
Spirifer logani Hall.
Spirifer tenuicostatus Hall.
Brachythyris suborbicularis (Hall).
Spiriferina sp.
Cyrtina neogenes H. & C.
Pseudosyrinx keokuk Weller.
Reticularia pseudolineata (Hall).
Dielasma sp.
Cranaena sulcata Weller?
Cranaena sp.
Cliothyridina sp.
Aviculopecten sp.
Cypricardinia sp.
Platyceras.

In the cherty beds beneath the highly fossiliferous noncherty limestone whose fauna has been recorded above, fossils are much less abundant and more poorly preserved. The following species only have been collected, although careful search would doubtless bring others to light.

Lower Keokuk Fauna from Chert Beds South of Little Saline Creek

Cystodictya sp.
Fenestella sp.
Schizophoria cf. *swallovi* (Hall).
Tetracamera subtrigona (M. & W.)
Spirifer logani Hall.

Another collection secured from a single block of limestone, not in place, found upon the bank of Little Saline Creek, just above the road crossing 1.3 miles southeast of Ozora, undoubtedly has come from the Keokuk. The rock contains numerous scattered, greenish specks, which are probably glauconite. The species which have been identified are as follows:

Lower Keokuk Fauna from Little Saline Creek

Zaphrentis sp.
Zaphrentis sp.
Zaphrentis sp.
Cystodictya sp.
Productus setigerus Hall (probably immature).
Productus sp.
Rhynchonella ? sp.
Rhynchonella ? sp.
Spirifer mortonanus Miller.
Spirifer mortonanus var.
Spirifer logani Hall.
Brachythyris suborbicularis (Hall).
Delthyris novamexicanus (Miller).
Spiriferella latior Weller.
Dielasma sp.
Cliothyridina sp.
Conocardium sp.
Platyceras sp.
Platyceras sp.
Griffithides ? sp.

The faunas of the beds constituting the second member of the Keokuk, are not greatly different from those of the first, although the two divisions are separated by a disconformity. In the Clement section beds 14 to 17 represent this division and have furnished the following species of fossils.

Fauna of the Upper Keokuk in the Clement Section

	14	15	16	17
Zaphrentis sp	x			
Zaphrentis sp			x	
Hadrophyllum sp			x	
Cystodictya sp			x	
Orthotetes keokuk (Hall)	x			
Rhipidomella dubia (Hall)	x			
Chonetes illinoisensis Worthen	x			
Chonetes planumbonus M. & W			x	
Chonetes shumardianus DeKon			x	
Chonetes sp			x	
Productus sp	x			
Productus sp			x	
Echinoconchus alternatus (N. & P.)			x	
Rhynchopora beecheri Greger	x			
Dielasma sp	x			
Spirifer tenuicostatus Hall	x			
Brachythyris suborbicularis (Hall)			x	
Brachythyris sp	x			
Spiriferella neglecta (Hall)	x			
Reticularia pseudolineata (Hall)	x			
Composita sp	x			
Myalina sp	x			
Cypricardella ? sp	x			
Straparollus spergenensis Hall	x			
Igoceras sp	x			

In the White Sand section beds No. 5 to 10 represent the second member of the Keokuk formation, and at this locality more extensive collections have been secured than from the Clement section, and the following species have been identified.

Fauna of the Upper Keokuk in the White Sand Section

	5	6	7	8	9	10
Zaphrentis dalei E. & H.			x	x		x
Zaphrentis elliptica White ?			x	x		x
Zaphrentis sp. 1	x		x	x		
Amplexus fragilis W. & St. J.	x		x			
Hadrophyllum sp. 1	x		x	x		x
Cyathaxonia ? sp. 1	x		x	x		
Monilopora beecheri Grabau				x		
Fenestella sp. 1					x	
Fenestella sp.					x	
Rhombopora sp. 2					x	
Rhombopora ? sp.					x	
Bryozoan (sp. 1)					x	
Cystodictya sp. 1			x		x	
Cystodictya sp. 2			x		x	
Cystodictya sp.				x		
Fenestella multispinosa Ulrich			x	x		
Orthotetes sp.				x		
Orthotetes keokuk (Hall)						x
Rhipidomella dubia (Hall)	x		x		x	x
Schizophoria cf. *swallovi* (Hall)				x	x	x
Chonetes planumbonus M. & W.					x	x
Chonetes shumardianus DeKon			?	x	x	x
Chonetes sp. 1			x			
Chonetes sp. 4			x	x		
Chonetes sp. 5	x			x		x
Chonetes sp. 6						x
Productus crawfordsvillensis Weller	x		x	x	x	x
Productus sp.				x		
Productus sp.				x		
Productus sp.				x		
Productella sp.				x		
Pustula alternatus (N. & P.)			x	x		x
Rhynchopora beecheri Greger			x			
Nucleospira cf. *N. barrisi* White	x		x			
Spirifer tenuicostatus Hall	x		x	x		
Spirifer mortonanus Miller			x	x		
Spirifer subequalis Hall					x	x
Brachthyris suborbicularis (Hall)	x		x	x	x	x
Brachthyris sp. undesc.					x	
Delthyris novamexicana Miller			x	x		
Delthyris sp. 1					x	x
Cyrtina neogenes H. & C.	x					

Fauna of the Upper Keokuk—Continued.

	5	6	7	8	9	10
Reticularia pseudolineata (Hall)				x	x	x
Syringothyris textus (Hall)					x	x
Syringothyris sp				x		
Pseudosyrinx keokuk Weller						x
Pseudosyrinx sp						x
Cliothyridina incrassata (Hall)				x		
Cliothyridina parvirostra (M. & W.)					x	
Cliothyridina sp	x					
Cliothyridina sp			x			
Cliothyridina sp				x		
Platyceras sp			x			
Platyceras sp				x		
Platyceras sp					x	
Platyceras sp						x
Orthoceras sp			x			
Phillipsia sp	x					
Griffithides sp				x		
Fish teeth				x	x	

In the hills south of Little Saline Creek, in SW. ¼ NE. ¼ sec. 2, T. 36 N., R. 9 E., near the head of a small ravine, a limestone bed about one foot thick, immediately above the oolite bed at the base of the second member of the Keokuk, is filled with fossils. One species of *Productus*, *P. crawfordsvillensis*, is by far the most abundant form, all the other species being comparatively rare. The following list of species has been identified from this locality.

Upper Keokuk Fauna from South of Little Saline Creek

Zaphrentis sp.
Zaphrentis sp.
Amplexus sp.
Cystodictya sp.
Orthotetes keokuk (Hall).
Rhipidomella dubia (Hall).
Chonetes illinoisensis Worthen.
Productus crawfordsvillensis Weller.
Productus sp.
Productus sp.
Pustula alternatus (N. & P.).
Camarophoria bisinuata (Rowley).
Rhynchopora beecheri Greger.
Dielasma sp.
Spirifer mortonanus Miller.
Spirifer logani Hall.
Spiriferina ? sp.
Pseudosyrinx keokuk Weller.
Reticularia pseudolineata (Hall).
Cliothyridina sp.
Composita sp.
Pleurotomaria sp.
Griffithides sp.

The *Productus* bed from which this fauna was collected is not over one foot in thickness, and is literally crowded with the shells of that genus. Just above this bed at the same locality, the limestone becomes more arenaceous, and although the fossils are much less numerous as individuals, the number of species present is nearly as great, and the following species have been identified.

Upper Keokuk Fauna from South of Little Saline Creek

Zaphrentis sp.
Cyathaxonia sp.
Orthotetes keokuk (Hall).
Chonetes illinoisensis Worthen.
Chonetes sp. undesc.
Productus ovatus Hall.
Productus indianensis Hall.
Camarophoria bisinuata (Rowley).
Rhynchopora beecheri Greger.
Spirifer tenuicostatus Hall.
Spirifer bifurcatus Hall.
Spirifer sp.
Brachythyris suborbicularis (Hall).
Pseudosyrinx keokuk Weller.
Reticularia pseudolineata (Hall).
Cliothyridina sp.
Orthonychia sp.
Straparollus (?) sp.
Griffithides (?) sp.

Twenty feet higher in the section, at the same locality as the last, the following species have been collected.

Upper Keokuk Fauna from South of Little Saline Creek

Rhipidomella dubia (Hall).
Schizophoria cf. *swallovi* (Hall).
Productella sp.
Productus magnus M. & W.
Productus sp.
Rhynchopora beecheri Greger.
Reticularia pseudolineata (Hall).
Eumetria verneuiliana Hall.
Platyceras sp.

At another locality in SE. ¼ of the same section, ten feet above the arenaceous limestone at the top of the oolite, the following two species have been collected.

Upper Keokuk Fauna from South of Little Saline Creek

Schizophoria cf. *swallovi* (Hall).
Brachythyris suborbicularis (Hall).

In the residual deposits from the Keokuk, blocks of porous, iron-stained, soft cherts are not infrequently met with, which are highly fossiliferous. Cherts of this nature are present in some abundance on top of the ridge extending in a northwest-southeast direction across the northeastern portion of sec. 4, T. 36 N., R. 9 E., a little less than a mile southwest of Ozora. These cherts without doubt originate from the second member of the Keokuk, and probably from the basal portion in the horizon of the siliceous and oolitic limestones. From one small block of this chert, collected from the locality mentioned above, the following species of fossils have been identified.

Upper Keokuk Chert Fauna from Southwest of Ozora

Zaphrentis sp.	*Rhynchonella beecheri* Greger.
Monilopora beecheri Grabau ?	*Dielasma* sp.
Rhipidomella dubia (Hall).	*Spiriferina* sp.
Chonetes illinoisensis Worthen.	*Reticularia pseudolineata* (Hall).
Productus crawfordsvillensis Weller.	*Pseudosyrinx keokuk* Weller.
Productus ovatus Hall.	*Nucleospira* sp.
Productus sp.	*Composita* sp.
Camarophoria bisinuata (Rowley).	*Griffithides* (?) sp.

WARSAW FORMATION

Name.—The Warsaw formation was originally named by Hall[1] from the exposures at Warsaw, Illinois, where these beds succeed the Keokuk limestone. The "geode beds" at that locality were called "beds of passage" between the Keokuk and Warsaw by Hall, but later writers have commonly included them in the "Keokuk Group." More recent faunal studies in the Iowa and northwestern Illinois localities suggest that the "geode beds" are more properly a part of the Warsaw formation, with which also they are really more closely allied lithologically, and such an interpretation of them has been accepted by the United States Geological Survey.

Areal Distribution.—The Warsaw formation in Ste. Genevieve County occupies a narrow belt lying just east of the cherty Burlington and Keokuk limestone, which extends continuously from the valley of Frenchman Creek to the Little Saline faulted zone. Another area in which the formation occurs is in the hills adjacent to the Mississippi River bluffs, just below the mouth of Establishment Creek. As the main outcrop of the formation approaches the fault zone at the south, its course changes to a more easterly direction, and a narrow belt, parallel with the zone of faulting continues eastward across the Ste. Genevieve-Perry County line into the latter county, but nowhere in Ste. Genevieve County is the Warsaw present within the faulted zone itself.

Thickness.—In the measured Clement section (page 171), there are 100 feet of strata which are referable to the Warsaw formation, and in the White Sand section (page 180) about 118 feet. In the more southern part of the county the outcrops are not of a character to permit the direct measurement of the beds, but the thickness seems to be somewhat reduced, perhaps

[1]Trans. Albany Inst., vol. 4, p. 2 (1856); also Geol. Surv. Iowa, vol. I, pt. 1, p. 97 (1858).

to as little as 80 feet in places. Throughout the county as a whole the average thickness of the formation is probably about 100 feet or a little less.

Topography.—The shaly character of the Warsaw formation makes it a much less resistant bed than the underlying Burlington-Keokuk, and in places this produces a very noticeable effect upon the topography. Valleys crossing the successive formations transverse to the strike are narrow and deep sided in the cherty limestone beds beneath the Warsaw, but where they encounter this formation they broaden out more or less abruptly. This condition is well exhibited in the valley of North Gabouri Creek west of Ste. Genevieve, the broadening of the valley being well shown at about the point where the St. Louis-Ste. Genevieve road leaves the valley. Another good example of this feature is exhibited in the valley of River aux Vases. Where this stream cuts through the chert ridge at the south end of the Beckett Hills, its valley is much reduced in width, but broadens out promptly to the east of the ridge because of the softer, shaly beds of the Warsaw.

Another topographic feature occasioned by the soft, easily eroded Warsaw formation is exhibited in the tributary valleys to some of the larger streams which flow along the strike of the Warsaw formation for considerable distances. Such tributary valleys are present on each side of the River aux Vases, the one from the north following the strike of the Warsaw for more than two miles, and the one from the south for more than a mile. At the present time these valleys have been excavated through the Warsaw, and the streams flow upon a floor of cherty Keokuk limestone with the Warsaw outcrops occupying the eastern valley slopes. The valley of Frenchman Creek, flowing south to the Mississippi River just below White Sand, was originally established in its present position along the strike of the Warsaw because of the soft character of these easily eroded beds, and it too has now been excavated through the Warsaw to the chert bed beneath, which now constitute the floor of the valley.

Lithologic Character.—The lithologic characters of the Warsaw formation are best exhibited in the Clement and White Sand sections which have been described in detail in an earlier part of this report (see pp. 171-180). Following the upper member of the Keokuk formation in these sections there is a series of beds which are dominantly shaly, and above these shales other limestone beds which are quite different in appearance from those of the Keokuk formation. These two members, the lower shaly with subordinate limestone beds, and the upper with little or no shale, constitute the Warsaw formation. In the Clement section beds Nos. 18 to 21, with a combined thickness of 51 feet and 6 inches constitute the lower member of the Warsaw. It is not made up exclusively of shales, but includes thin limestone strata at intervals, probably more than are noticed in the description of the section because of the slumping of the beds and the talus covering, and in some other sections the limestone beds are far more conspicuous than in the section here recorded. This shale member of the Warsaw is persistent throughout the county, and also extends northward across the Mississippi River into Monroe County, Illinois. The upper member of the Warsaw, beds Nos. 22 to 26 of the same section, is again limestone but the limestones of this member are very different in character from those of the Keokuk, being darker in color and more impure, with a considerable amount of argillaceous material. They also differ from the limestones beneath the shales in being more free from chert.

In the White Sand section the shaly member of the Warsaw comprises beds Nos. 11 to 14, with a thickness of 53 feet 11 inches as compared with 53 feet 6 inches in the Clement section. The upper member of the formation, made up largely of impure limestones nearly free from chert, apparently somewhat magnesian in part, and with some shale beds, includes beds Nos. 15 to 22, and is 68 feet in thickness, being 15 feet greater than in the Clement section.

The two members of the Warsaw may be briefly characterized as follows, No. 1 being the lower and 2 the higher.

Member No. 1.—Largely shale and commonly more or less completely talus covered. The color varies from bluish to yellow or buff. On weathering the shale breaks down into a somewhat plastic clay. Some limestone layers or lentils are included in the shale, the amount of limestone varying in amount in different sections. Thickness about 53 feet.

Member No. 2.—Impure limestone, nearly free from chert in some sections, but locally with a moderate amount in the lower portion. The limestone is for the most part fine-grained, gritty, argillaceous and is somewhat magnesian and siliceous. Near the top some beds of limited thickness are somewhat crystalline. In color the beds vary through various shades of gray to buff or light yellow. The thickness varies from 53 to 68 feet.

Some very excellent exposures of the Warsaw formation are present in Lower Frenchman Hollow, in sec. 12, T. 6 S., R. 8 E., especially between the wagon road and the river. Fair exposures may be seen at intervals along the belt of outcrop, especially where some of the stream valleys cut across the formation. Near Ozora good outcrops of the upper member of the formation are present at a number of localities, the shaly lower member commonly being covered with talus. One of the best of these outcrops is in the head of the valley on the east side of the Ste. Genevieve road, one and one-half miles northwest of Ozora, in NE. ¼ sec. 28, T. 37 N., R. 9 E., and another in NW. ¼ NE. ¼ sec. 2, T. 36 N., R. 9 E. At both of these localities the beds are highly fossiliferous. Southeast of Ozora there are other good exposures, especially in some of the short tributaries of Little Saline Creek from the south, where the more or less impure and somewhat shaly character of the limestone layers is well exhibited.

In a number of places the Warsaw is represented in the weathered condition by masses of a brown, porous, siliceous rock, which is the product of decay of a siliceous limestone, the calcareous content being entirely removed by leaching. Such an exposure is well exhibited in the road on the hill slope just south of the store at Ozora.

Stratigraphic Relations of the Warsaw Formation.—There is no evidence of unconformity between the Warsaw and either the underlying Keokuk, or the overlying Spergen (Salem) formations, although at both the lower and upper limits of the formation the line of separation from the adjacent formation is fairly distinct. The lower limit of the formation is more distinct than the upper, the transition from the Keokuk to the Warsaw being accomplished in only a few feet. The lithologic character of the Spergen (Salem) limestone, in its typical development, is notably different from that of the Warsaw, being made up of more pure and more crystalline beds, but thin crystalline layers begin to make their appearance at intervals in the section below the main mass of such limestone, interbedded with layers that are more typically like the Warsaw, so that the exact place to draw the line of demarcation between the two formations must be selected somewhat arbitrarily. The transition from one formation to the other, however, is commonly accomplished in a thickness of twenty feet or so.

Correlation.—The correlation of the Warsaw formation in Ste. Genevieve County with the typical Warsaw of southeastern Iowa and the adjacent part of Illinois, is based as much upon the stratigraphic position of these beds between the Keokuk limestone below and the Spergen (Salem) limestone above, as upon the fossil faunas, for the Warsaw faunas in this region, in their more conspicuous features, are notably different from those of the typical Warsaw area. Although *Productus magnus* does occur rarely in the higher Keokuk beds of the region, this shell is primarily a member of the Warsaw fauna, and locally in some beds, it is present in great numbers closely crowded together, and the Warsaw of this portion of the Mississippi Valley may be designated as the *P. magnus* zone. *Chonetes planumbona* is another species which is present in countless numbers in some of the Warsaw beds, especially in some of the lower, shale layers, but neither of these species are known in the typical Warsaw. There are other species, however, such as *Spirifer subaequalis* and *Spirifer lateralis*, which are locally common in the Warsaw of Ste. Genevieve County, and are also characteristic of the same formation in southeastern Iowa, so that the faunal connection between the two regions is established.

In its faunal relations the Warsaw of Ste. Genevieve County is more nearly like the Warsaw, formerly called Harrodsburg limestone, of southern Indiana and Kentucky,[1] which is characterized by the same *Productus magnus* fauna. In southwestern Missouri, also, the *Productus magnus* fauna is present and doubtless occurs in beds which are to be correlated with the Warsaw formation, although in that part of the state the entire succession of strata consist of limestone without the shale which is so characteristic of the Warsaw in Ste. Genevieve County and also in the typical southeastern Iowa region. From these occurrences it seems that the *Productus magnus* fauna is a more southern manifestation of the Warsaw life as a whole, and since its occurrence is nearer to the open sea of that period, which must have lain off to the south, it is not unlikely that it is the more representative faunal group of the period.

Paleontology.—The lower member of the Warsaw formation has not afforded so prolific collections of brachiopods as the

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[1]Butts, Ky. Geol. Surv., ser. 4, vol. 3, pt. 2, p. 157 (1915).

upper strata, although some of the beds do abound in bryozoans, the surfaces of some of the calcareous bands interbedded with the shales being literally covered with these fossils. Because of the soft, shaly character of the beds they are more or less completely talus covered at most localities, so that good localities for fossil collecting are not common. In the White Sand section four beds, Nos. 11 to 14, (page 180), represent this division, only two of which have furnished any collections of fossils. From these beds the following species have been identified.

Fauna of the Lower Warsaw in the White Sand Section

	11	12	13	14
Monilopora beecheri Grabau				x
Orthotetes sp				x
Chonetes planumbonus M. & W		x		x
Chonetes shumardianus DeKon		x		
Productella sp				x
Productus sp				x
Pustula alternatus (N. & P.)		x		x
Spirifer tenuicostatus Hall				x
Brachythyris suborbicularis (Hall.)				x
Delthyris novamexicanus Miller ?		x		
Reticularia pseudolineata (Hall.)				x
Pseudosyrinx keokuk Weller ?				x
Cliothyridina sp				x
Platyceras sp				x
Griffithides sp				x
Stenopora sp				x
Lioclema sp				x
Fenestella limitaris Ulrich				x
Fenestella cestriensis Ulrich				x
Fenestella compressa Ulrich				x
Fenestella triserialis Ulrich				x
Fenestella serratula Ulrich				x
Fenestella multipisnosa Ulrich				x
Fenestella funicula Ulrich				x
Fenestella rudis Ulrich				x
Hemitrypa perstriata Ulrich				x
Archimedes sp				x
Polypora sp				x
Pinnatopora sp				x
Ptilopora sp				x
Rhombopora attenuata Ulrich				x
Rhombopora sp				x
Streblotrypa cf. *major* Ulrich				x
Cystodictya sp				x
Cystodictya sp				x
Worthenopora spinosa Ulrich				x

In the section below the mouth of Establishment Creek, beds No. 18 to 21 represent this lower member of the Warsaw, and most of the fossils from the locality have been collected from bed No. 18, the upper portion of this bed being especially characterized by the great number of bryozoa. The fossils from the basal portion of the bed have been kept separate from those associated with the abundant bryozoan fauna higher up, and in the following list the distribution of the species in the two portions of the bed is indicated in the columns at the right, column A being the lower, and column B the upper division.

Fauna of the Lower Warsaw in the Clement Section

	A	B
Zaphrentis elliptica White		x
Hadrophyllum sp		x
Synbathocrinus sp		x
Pachylocrinus unicus (Ha l.)		x
Pachylocrinus sp		x
Pachylocrinus sp		x
Lingula sp	x	
Orthotetes keokuk (Hall.)	x	
Productella sp		x
Productus ovatus Hall	x	x
Productus sp	x	
Echinoconchus biseriatus (Hall.)		x
Rhynchopora (?) sp		x
Dielasma sp		x
Spirifer tenuicostatus Hall		x
Spirifer sp	x	
Brachythyris suborbicularis (Hall.)		x
Spiriferina sp		x
Reticularia pseudolineata (Hall.)	x	x
Cliothyridina parvirostra (M. & W.) ?		x
Composita sp		x
Aviculopecten sp	x	
Cypricardinia cf. *C. indianensis* Hall	x	
Griffithides sp	x	
Lioclema cf. *gracillimum* Ulrich		x
Fenestella serratula Ulrich		x
Fenestella triserialis Ulrich		x
Fenestella tenax Ulrich		x
Fenestella funicula Ulrich		x
Fenestella multispinosa Ulrich		x
Hemitrypa sp		x
Pinnatopora conferta Ulrich ?		x
Rhombopora attenuata Ulrich		x
Rhombopora sp		x

Fauna of the Lower Warsaw—Continued.

	A	B
Cystodictya sp		x
Cystodictya sp		x
Worthenopora spinosa Ulrich		x

The uppermost member of the Warsaw formation in Ste. Genevieve County is made up largely of more or less impure limestone, much of which is somewhat magnesian, with more or less important partings and thin beds of shale. Some of these beds contain great numbers of fossils. In the White Sand section, beds 15 to 22 represent this member, and from these beds the following species of fossils have been identified.

Fauna of the Upper Warsaw, White Sand Section

	15	16	17	18	19	20	21	22
Orthotetes keokuk (Hall.)	x		x	cf.				cf.
Rhipidomella dubia (Hall.)								x
Chonetes planumbonus M. & W.	x		x	x				
Productus magnus M. & W.	x		x	x		x		x
Productus altonensis N. & P.			x					
Productus setigerus Hall ?								x
Camarotoechia cf. *mutata* (Hall)			x	x				
Dielasma sp			x	x				x
Spirifer subaequalis Hall	x			x				
Spirifer washingtonensis Weller			x	x		x	x	x
Spirifer lateralis Hall								x
Reticularia pseudolineata (Hall.)								x
Syringothyris subcuspidatus (Hall.)				x				
Syringothyris sp			x					
Eumetria verneuiliana Hall	x		x					x
Hustedia ? sp	x							
Cliothyridina sp			x					
Cliothyridina sp								x
Composita trinuclea (Hall) ?	x		x					x
Aviculopecten amplus M. & W.			x	x		x		

In the Clement section beds No. 22 to 26 represent the upper division of the Warsaw, but from these beds fossil collections have been secured only from beds 23 and 25, where the following species occur.

Fauna of the Upper Warsaw, Clement Section

	23	25
Fenestella serratula Ulrich ?	x	
Fenestella multispinosa Ulrich ?	x	
Cystodictya sp	x	
Orthotetes cf. *O. keokuk* (Hall)	x	
Rhipidomella dubia (Hall.)	x	x
Productus magnus M. & W. ?	x	
Productus crawfordsvillensis Weller ?		x
Productella sp	x	
Pustula biseriatus (Hall.)		x
Camarophoria bisinuata (Rowley) ?	x	
Dielasma sp		x
Spirifer washingtonensis Weller	x	x
Spirifer lateralis Hall		x
Spiriferella neglecta (Hall.)		x
Reticularia cf. *R. pseudolineata* (Hall.)		x
Eumetria verneuiliana Hall	x	
Cliothyridina hirsuta (Hall) ?		x
Composita sp	x	

In the more southern portion of the Warsaw area two collections have been made from the very upper portion of this highest member of the formation, just beneath the Salem limestone. In the head of the valley on the east side of the Ste. Genevieve road, one and one-half miles northwest of Ozora, in NE. ¼ sec. 28, T. 37 N., R. 9 E., the following species have been identified.

Cystodictya sp.
Rhipidomella dubia (Hall).
Productus altonensis N. & P.
Productus sp.
Productella sp.
Dielasma sp. undesc.
Spirifer washingtonensis Weller.
Spirifer lateralis Hall.
Reticularia pseudolineata (Hall).

At another locality south of Little Saline Creek, one and one-half miles southeast of Ozora, in NW. ¼ of NE. ¼ sec. 2, T. 36 N., R. 9 E., the following species were collected and have been identified.

Productus magnus M. & W.
Productus ovatus Hall.
Produtella ? sp.
Delthyris ? sp.
Spirifer washingtonensis Weller.
Spirifer rostellatus Hall.
Spirifer lateralis Hall.
Reticularia setigera (Hall)
Syringothyris textus (Hall).
Syringothyris subcuspidatus (Hall).
Aviculopecten amplus M. & W.

For the purpose of making an analysis of the Keokuk and Warsaw faunas in Ste. Genevieve County, all of the forms which have been specifically identified have been arranged in a table giving their distribution in the several members of the two formations, columns I and II being Keokuk, and columns III and IV the Warsaw.

Table of Keokuk and Warsaw Faunas

	Keokuk.		Warsaw.	
	I	II	III	IV
Cyathaxonia sp	x	x		
Hadrophyllum sp		x		
Amplexus fragilis St. J. & W.		x		
Monilopora beecheri Grabau		x	x	
Palaeacis obtusus M. & W.	x			
Scaphiocronus unicus Hall			x	
Orthotetes keokuk (Hall)	x	x	x	x
Rhipidomella dubia (Hall)	x	x		x
Schizophoria cf. *swallovi* (Hall)	x	x		
Chonetes illinoisensis Worthen	x	x		
Chonetes shumardianus DeKon.	x	x	x	
Chonetes planumbona M. & W.		x	x	x
Chonetes sp. undesc.		x		
Productus crawfordsvillensis Weller	x	x		
Productus wortheni Hall	x			
Productus setigerus Hall ?	x			
Productus ovatus Hall		x	x	
Productus magnus M. & W.	x	x		x
Productus indianensis Hall		x		
Productus altonensis N. & P.				x
Pustula alternatus (N. & P.)	x	x	x	
Pustula biseriatus (Hall)	x	x	x	
Camarophoria bisinuata (Rowley)	x	x		x
Tetracamera subtrigona (M. & W.)	x			
Rhynchopora beecheri Greger	x	x		
Cranaena sulcata Weller ?	x			
Spirifer mortonanus Miller	x	x		
Spirifer logani Hall	x	x		
Spirifer tenuicostus Hall	x	x	x	
Spirifer rostellatus Hall ?	x			
Spirifer missouriensis Swallow ?	x			
Spirifer grimesi Hall	x			
Spirifer subaequalis Hall		x	x	
Spirifer bifurcatus Hall		x		
Spirifer washingtonensis Weller				x
Spirifer lateralis Hall				x
Brachythyris suborbicularis (Hall)	x	x	x	
Spiriferella neglecta (Hall)	x	x		x
Spiriferella plena (Hall)	x			

Table of Keokuk and Warsaw Faunas—Continued

	Keokuk.		Warsaw.	
	I	II	III	IV
Spiriferella latior Weller	x			
Delthyris novamexicanus (Miller)	x	x	x	
Reticularia pseudolineata (Hall)	x	x	x	x
Cyrtina neogenes H. & C.	x	x		
Pseudosyrinx keokuk Weller	x	x	x	
Syringothyris textus (Hall)		x		
Syringothyris subcuspidatus (Hall)				x
Eumetria verneuiliana (Hall)		x		x
Cliothyridina incrassata (Hall)		x		
Cliothyridina parvirostris (M. & W.)	x	x		
Cliothyridinia hirsuta (Hall) ?				x
Cypricardinia indianensis Hall ?			x	
Conocardium sp	x			
Aviculopecten amplus M. & W.				x
Straparollus spergenencis Hall		x		
Murchisonia keokuk Worthen ?	x			

SPERGEN (SALEM) FORMATION

Name.—The Spergen (Salem) limestone is widely distributed in the Mississippi Valley, from southeastern Iowa to southern Illinois and southeastern Missouri, and it again outcrops along the eastern margin of the Illinois-Indiana basin, in Indiana.

In the older reports on the Geology of Missouri this formation was referred to as the "Archimedes limestone,"[1] the name by which the beds in southeastern Iowa, later designated as the Warsaw formation by Hall,[2] were first called by Owen.[3] Shumard,[4] in his report on Ste. Genevieve County, has referred a part of the formation to the "Third Archimedes Limestone," and a part he has included in the St. Louis limestone. Other writers, however, in various places, have referred the formation to the Warsaw, or to the St. Louis Group, and not until recent years has it been clearly defined as a separate formation. Hopkins and Siebenthal[5] were the first to designate the formation by a distinctive name, in an economic report on "The Bedford Oolitic Limestone of Indiana," where they called it the Bedford

[1]1st and 2nd Ann. Repts. Geol. Surv. Mo., pp. 171, 95-96 (1855).
[2]Geol. Iowa, vol. 1, pt. 1, p. 97 (1858).
[3]Geol. Surv. Wis., Iowa and Minn., p. 92 (1852).
[4]Repts. Geol. Surv. Mo., 1855-1871, p. 294 (1873).
[5]21st Rep. Dept. Geol. and Nat. Hist. Ind., pp. 289-427 (1897).

limestone. The name Bedford, however, had long been preoccupied for a formation in Ohio, and Cumings proposed to substitute the name Salem[1] for that used by Hopkins and Siebenthal, the name being taken from the town of Salem, Indiana, one of the localities where the formation is extensively quarried for building stone. A few years later Ulrich proposed the name Spergen Hill limestone[2] for the formation, taking the name from the famous fossil locality, Spergen Hill, Indiana, which has furnished great numbers of the beautiful fossils which occur locally in the formation. The name Salem has priority over Spergen, and furthermore, Spergen Hill is not a geographic name with any standing, and is not to be found upon any map, it being merely a local collectors name, apparently derived from the name of the land owner upon whose property the fossils were collected. Because of the important papers published by Hall and by Whitfield, describing the fossils from the Spergen Hill locality, the fauna came to be known as the Spergen Hill fauna, but the name Spergen was never properly used as a formation name until Ulrich so used it. However, the United States Geological Survey has adopted Spergen as the name for the formation, and that name will be used in this place, but with Salem always added in parentheses.

Although Williams[3] and Keyes[4] had both recognized the fact that the term Warsaw had been used by authors to include two distinct formational units, Ulrich was the first to extend the usage of a formation name first applied to the exposures upon the eastern or Indiana side of the basin, to the stratigraphy along the Mississippi river, and at a later date Weller[5] established the true relation of the Warsaw to the overlying Spergen (Salem) formation in the Warsaw section and in the sections farther south along the Mississippi River.

A study of the formation in its various outcrops from southeastern Iowa to Ste. Genevieve County, Missouri, shows a wide variety in lithologic characters. In the north it is for the most part an impure limestone, in places arenaceous and very commonly magnesian. To the south it becomes more and more a pure limestone, until the impure, magnesian beds have almost or quite disappeared in Ste. Genevieve County.

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[1] Jour. Geol., vol. 9, p. 232 (1901).
[2] Mo. Bureau Geol. and Mines, vol. 2, 2nd ser., p. 110 (1904).
Prof. Paper U. S. Geol. Surv., No. 24, table opposite p. 90 (1904).
[3] Bull, U. S. Geol. Surv., No. 80, p. 169 (1891).
[4] Mo. Geol. Surv., vol. 4, pp. 69-71 (1894).
[5] Ill. State Geol. Surv., Bull. No. 8, pp. 83-88 (1908).

Areal distribution.—In Ste. Genevieve County the Spergen (Salem) limestone occupies a belt extending from the Mississippi River bluffs just below the mouth of Frenchman Creek at White Sand, in a southeasterly direction approximately parallel with the river bluffs below Little Rock, to the Little Saline faulted zone. North of White Sand, an isolated area occurs in the bluff and capping the hill a mile and one-half below the mouth of Establishment Creek. The belt of outcrop is very regular from its origin in the river bluff to the River aux Vases, with a width of approximately one mile becoming somewhat greater than that in the stream valleys where the southeastward dip of the rocks carries the outcrop some distance down stream, and being reduced in some other places. In the valley of River aux Vases, the Spergen (Salem) outcrop extends down stream to within three-fourths of a mile of the river bluffs. Beyond this stream the area within which the formation is the surface rock is much more irregular, occupying the main valley of Saline Creek to a point but little more than one-half mile from its mouth, and extending well up towards the heads of the tributaries of this stream on the north side of the great fault zone.

Thickness.—The thickness of the Spergen (Salem) limestone in Ste. Genevieve County does not vary greatly from 160 feet, this being about the maximum thickness anywhere reported for the formation. In its most northern exposures in southeastern Iowa, it is in places no more than a foot or two in thickness. In the river bluffs above Alton, Illinois, and near St. Louis, Missouri, a thickness of about 100 feet is commonly recognized. In Indiana a maximum thickness of 100 feet is reported,[1] although it varies from only a few feet to this maximum.

Topography.—The surface underlain by the Spergen (Salem) limestone in Ste. Genevieve County, occupies a portion of the eastward slope from the Burlington escarpment towards the Mississippi River bottoms. This surface is more or less gently rolling where it is broadest, but where it is adjacent to the larger streams it outcrops upon rather steep hill slopes, but in only a few places does it form precipitate bluffs. The steepest bluff and bluff-like exposures are along the valley of River aux Vases from two to three miles above the mouth of the stream. A characteristic topographic feature of much of the Spergen (Salem) area is the great number of sink holes, a feature which

[1]28th Ann. Rep. Dept. Geol. and Nat. Res. Ind., p. 53 (1904).

the formation shares with the overlying St. Louis and Ste. Genevieve limestones. These sink holes have been developed because of the solubility of the limestone and the consequent extensive development of underground drainage.

Lithologic characters.—In its lithologic character the Spergen (Salem) is dominatly an oolitic limestone, which in most localities is nearly or quite free from chert. The oolitic character of the limestone, however, varies greatly. Locally it is an almost pure oolite as in the quarry of the Western Lime Works on North Gabouri Creek, and in that of the Ste. Genevieve Lime and Quarry Company on South Gabouri Creek, each of which quarries is about two miles west of Ste. Genevieve. Elsewhere the limestone contains a less amount of oolitic material, the number of grains varying all the way from the pure oolite to beds in which only a few scattered ones are present. In some beds of the formation also, the oolitic character may be entirely wanting, in which case the limestone is commonly crystalline and medium-grained in texture. At a few localities in Ste. Genevieve County, some beds of limited thickness in the Salem are somewhat dolomitic, and possess a finely gritty texture, and locally towards the summit of the formation, beds of several feet in thickness are present, having a dense, compact texture, with a conchoidal fracture, essentially like that of much of the next succeeding formation, the St. Louis limestone. Much of the formation exhibits more or less distinctly cross-bedded structure, and in some beds this structure is very remarkably developed.

In those localities where the beds of the Spergen (Salem) are exposed in vertical faces, especially those beds which are more oolitic, these faces scale off, under the influence of weathering, in a direction across the lines of bedding, these flakes varying in width from an inch or two to a foot or more, and with a thickness varying from a fraction of an inch to two inches. This manner of weathering is very characteristic of some portions of the formation, although a similar scaling off of the beds occurs in some other of the formations in which oolitic beds are present.

The color of the Spergen (Salem) limestone upon freshly broken surfaces, is light gray to white, some beds, especially the very pure oolites, being almost pure white. The more crystalline beds have a light bluish tint. Upon its weathered surfaces the formation is of a dull gray color. Much of the limestone in the formation is comparatively soft and quite free from grit, but some of the more crystalline, bluish-gray beds, are much harder and are capable of receiving a good polish.

The lithologic characters of the formation change markedly from north to south in the Mississippi valley. Impure, gritty, more or less magnesian limestone beds, commonly yellowish, buff, or gray in color, constitute nearly the whole of the formation in southeastern Iowa and the adjacent portions of Illinois, while to the south the formation is progressively represented by more and more pure limestones until in Ste. Genevieve County the impure beds are almost wholly wanting.

Organic remains are present in abundance throughout the formation except in the very pure oolite, but in most localities they have been so thoroughly broken up before deposition that they cannot be identified. The fragmentary remains of fenestellid bryozoans are especially numerous in many of the beds. At or near the top of the formation a bed one or two feet in thickness, filled with the separated and broken plates and spines of echinoids, is a very persistent member.

Stratigraphic relations of the Spergen (Salem) Limestone.—In Ste. Genevieve County the Salem rests conformably upon the underlying formation. Sedimentation was apparently continuous from the subjacent Warsaw but with an important change in conditions. Preceeding the Spergen (Salem) the sediments were more or less impure limestones, some of them magnesian, but with the advent of the Spergen (Salem) the deposition of much purer limestone began. The transition from the older to the younger formation is accomplished in a thickness of from five to ten feet.

At the close of the Spergen (Salem) no stratigraphic break can be detected, the sedimentation being continuous into the St. Louis. The change in character of sedimentation is so gradual that it is exceedingly difficult in many localities to determine the exact position of the upper limit of the formation. The normal lithologic character of the St. Louis is quite different from that of the Spergen (Salem), but through a considerable thickness of beds, perhaps as much as forty feet in places, an alternation of beds exhibiting the lithologic character first of one formation and then the other is present. There is also an alteration and mingling of the fossil faunas of the two formations in this same zone. Because of this condition the upper limit of the Spergen (Salem) has been one of the most difficult lines to draw in making the geologic map of the county, and the position of this line may not be exactly uniform throughout its entire extent.

Correlation.—The correlation of this limestone in Ste. Genevieve County with the Salem limestone of Indiana is established, not only by its similar position in the stratigraphic column, but by the fossils which it contains. The Salem limestone in Indiana is characterized by a fauna of diminutive shells, among which the pelecypods and gastropods are very conspicuous. Even in Indiana, however, this fauna is well preserved in only a few especially favorable localities, the beds for the most part being constituted largely of finely broken fossil fragments among which the fenestelloid bryozoans are very numerous. In Ste. Genevieve County good localities for the diminutive fauna are much less commonly met with than in Indiana, but the fauna does occur here, and additional localities may be discovered in the future.

Paleontology.—As already indicated, an abundance of organic remains in a fragmentary condition are present in the Salem limestone at nearly every outcrop, but good collections of the fauna are not easily secured in Ste. Genevieve County except very locally. From a bed close to the base of the formation in sec. 31, T. 38 N., R. 9 E., on South Gabouri Creek about three miles from Ste. Genevieve, a small collection has been made in which the following species are present.

Spergen (Salem) Fauna from South Gabouri Creek

Synbathocrinus swallovi Hall.
Barycrinus (stems) two species.
Platycrinus sp.
Talarocrinus simplex Shumard.
Forbesiocrinus sp.
Pentremites conoideus Hall.
Fistulipora ? sp.
Rhipidomella dubia (Hall).

At another locality along the same creek, a little less than two miles from Ste. Genevieve, near the middle of the east half of sec. 30, T. 38 N., R. 9 E., the uppermost beds of the Salem are abundantly fossiliferous. The horizon exposed at this locality includes a very persistent bed, not alone present in Ste. Genevieve County but also further north in Monroe County, Illinois, which is characterized by the presence of great numbers of spines and plates of Echinoids. The complete list of species collected at this locality is as follows:

Spergen (Salem) Fauna from South Gabouri Creek

Zaphrentis sp.
Archaeocidaris sp. (Spines and plates.)
Cystodictya lineata Ulrich.
Fenestella tenax Ulrich.
Fenestella serratula Ulrich.
Fenestella sp.
Orthotetes keokuk (Hall).
Productus ovatus Hall.
Productus scitulus M. & W.
Productus indianensis Hall. ?
Productus sp. undesc.
Echinoconchus alternatus (N. & P.).
Echinoconchus biseriatus (Hall).
Rhipidomella dubia (Hall).
Dielasma formosa (Hall).
Dielasma sp.
Spirifer tenuicostus Hall.
Spirifer bifurcatus Hall.
Reticularia setigera (Hall).
Composita trinuclea (Hall).

Another small collection has been made from a bed in the upper portion of the formation, outcropping in a short ravine in NW. ¼ sec. 23, T. 37 N., R. 9 E. This collection includes the following species:

Spergen (Salem) Fauna from near River aux Vases

Fistulipora spergenensis Rominger.
Cystodictya lineata Ulrich.
Fenestella sp.
Orthotetes keokuk (Hall).
Productus ovatus Hall.
Productus sp.
Echinoconchus alternatus (N. & P.).
Echinoconchus biseriatus (Hall).
Spirifer pellaensis Weller.
Reticularia setigera (Hall).

Another collection from the head of a ravine just south of the locality last noted, in the same quarter section, contains a large number of the small molluscs which are so characteristic of the Salem fauna in Indiana and elsewhere where it is typically developed. The species which have been identified from this locality are as follows:

Spergen (Salem) Fauna from near River aux Vases

Pentremites sp.
Talarocinus simplex Shumard.
Stenopora sp.
Cystodictya sp.
Fenestella sp.
Schuchertella ? sp.
Spirifer bifurcatus Hall?
Eumetria verneuiliana Hall.
Athyris densa H. & C.
Cliothyridina hirsuta (Hall).
Composita trinuclea (Hall).
Modiola sp.
Cypricardella cf. *oblonga* Hall.
Cypricardinia indianensis Hall.
Conocardium sp.
Straparollus planispira Hall.
Naticopsis carleyana Hall.
Bulimorpha bulimiformis Hall.??
Loxonema n. sp. ?
Murchisonia attenuata Hall. ?
Pleurotomaria (*Mourlonia*) *piasaensis* Hall. ?
Gryphochiton parvus (Stevens). ?
Leperditia carbonaria Hall.
Phillipsia sp.

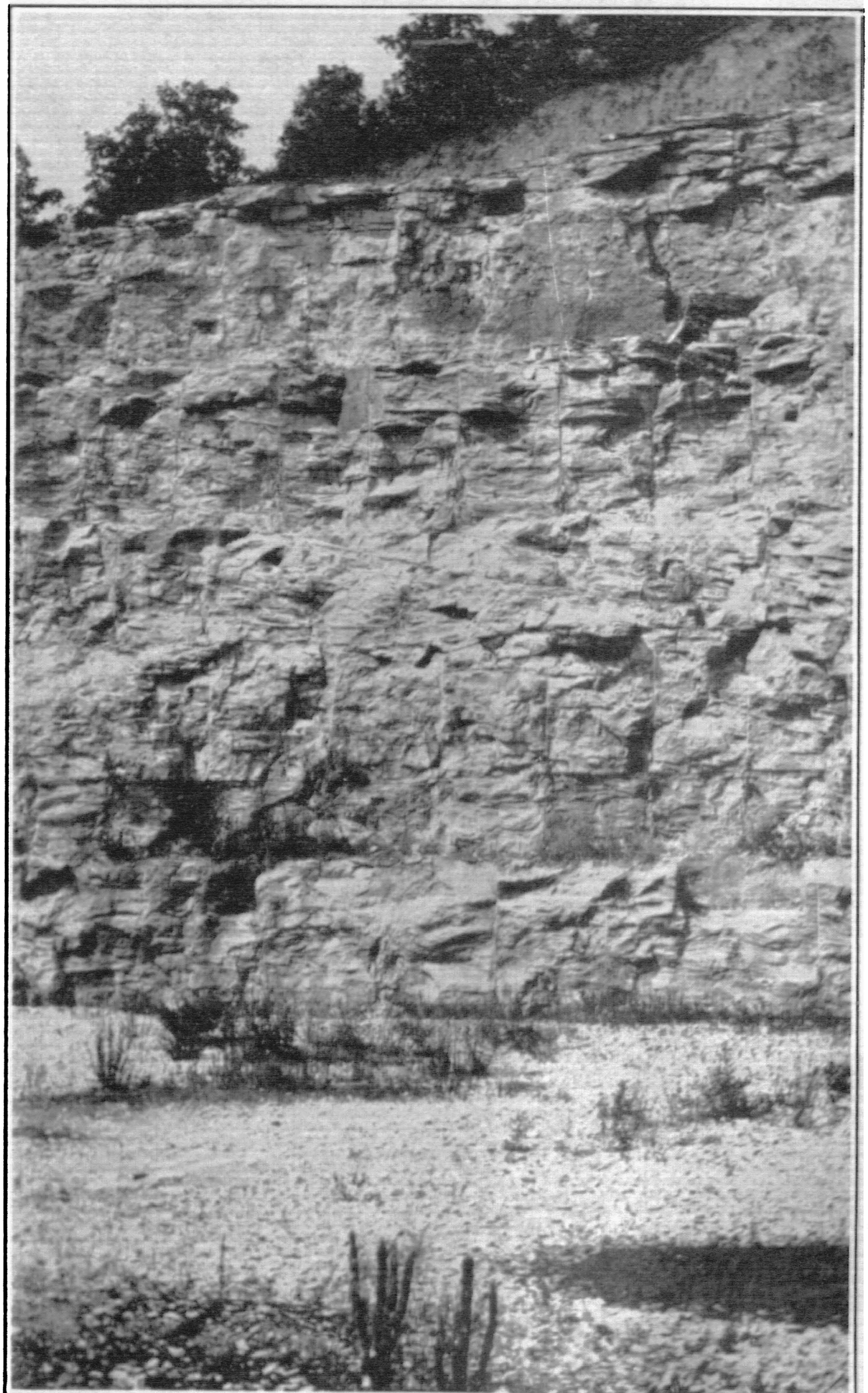
ST. LOUIS FORMATION

Name.—The St. Louis limestone was named many years ago by Engelmann,[1] the typical exposures of the formation being in the city of St. Louis. The formation has an extensive development in the Mississippi River bluffs below St. Lo is, and in the bluffs above the city of Alton, Illinois.

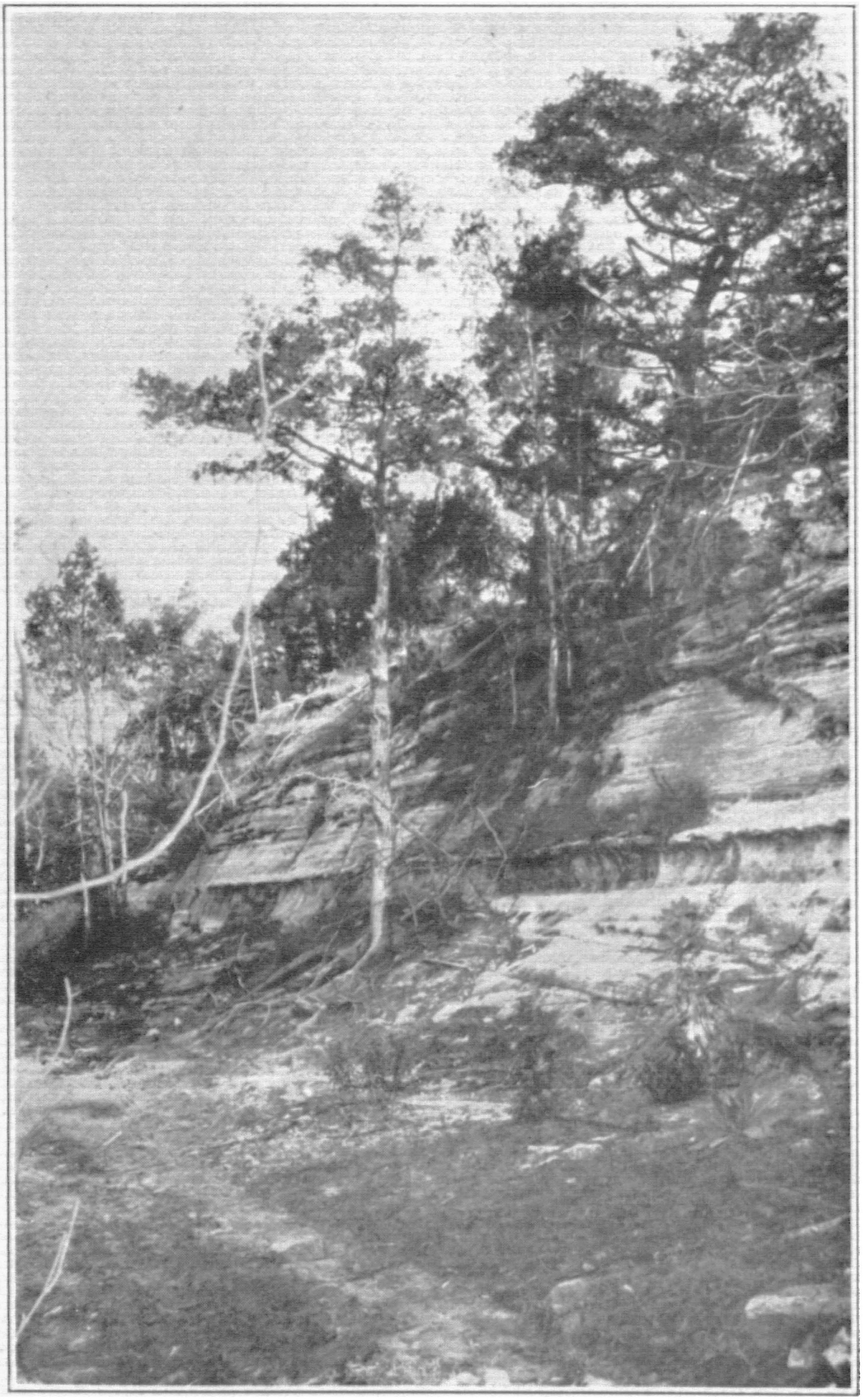
Areal Distribution.—In Ste. Genevieve County the St. Louis limestone occupies a belt lying next to that of the Salem limestone, on the east, extending from the Mississippi River bluffs just above Little Rock, to the county line about two miles southwest of St. Marys. In the southern half of this belt the area underlain by the formation is much broader and more cut up than to the north, there being some isolated areas entirely within the Salem belt, occupying the summits of some of the higher hills whose lower slopes are underlain by the Salem. Nowhere in Ste. Cenevieve County does the St. Louis limestone come in contact with the Little Saline faulted zone, but farther east, in Perry County, the formation is involved in this deformation.

Thickness.—The thickness of the St. Louis limestone as it is exhibited in the Little Rock section is between 156 and 166 feet according to the measurements recorded, and may be assumed to be approximately 160 feet. This thickness is somewhat less than the thickness of the formation in the Mississippi River bluffs above Alton, Illinois, where a measured section of 270 feet has been observed by the writer, while at St. Louis an average thickness of 325 feet is reported by Fenneman[2]. The thickness of the formation elsewhere in Ste. Genevieve County has not been so accurately determined, but in places it is apparently less than at Little Rock and does not exceed 100 feet. The reduced thickness of the formation, as compared with the sections further north, may be due to the fact that the dividing line between the Spergen (Salem) and St. Louis has been placed somewhat higher in Ste. Genevieve County, because of the persistence to a somewhat later time of the environmental conditions responsible for the lithology and fauna which characterizes the Spergen (Salem) formation, in which case the Spergen (Salem) St. Louis boundary line from St. Louis southward does not indicate one contemporaneous time plane. Some weight is given to this

[1] Amer. Jour. Sci., 2nd ser., vol. 3, pp. 119-120 (1847).
[2] Bull. U. S. Geol. Surv., No. 438, p. 23 (1911).



B. Ste. Genevieve-St. Louis limestone in quarry at Little Rock.



A. St. Peter sandstone north of Bloomsdale.

supposition by the somewhat excessive thickness of the Salem to the south. The observed differences in the thickness of the formation within Ste. Genevieve County is doubtless due to the presence of an unconformity above the St. Louis, a greater thickness of sediments having been removed by erosion in some parts than in others.

Topography.—The topographic expression of the St. Louis limestone is similar throughout the entire Mississippi Valley wherever the formation occurs, being marked by great numbers of sink holes. In Ste. Genevieve County this topographic feature is shared with the underlying Spergen (Salem) and the overlying Ste. Genevieve limestones, although the St. Louis area is perhaps more uniformly so marked than the others. The whole area of the formation occupies the middle portion of the eastwardly sloping surface from the crest of the Burlington escarpment to the Mississippi River bottoms. Considerable portions of this area are not served by surface drainage and consequently have no systematically developed valleys, all the run off of water being through the sink holes to underground channels. The general surface is rolling and much of it is adapted to cultivation.

Lithologic character.—The St. Louis formation is for the most part a very compact, dense limestone, some beds being almost lithographic in texture, with a conchoidal or splintery fracture. It includes a considerable amount of dense, compact, gray, black or rarely pink chert in some beds, which commonly occurs in definite horizontal bands which may be continuous or more or less discontinuous. Nowhere, however, is the chert so conspicuous a part of the formation as in the Burlington and Keokuk formations, lower down in the section. Some beds contain a considerable amount of argillaceous material, but nowhere, so far as observed in Ste. Genevieve County, can any of the beds be considered as shale, although thin, film-like, shaly partings are not uncommonly present between the limestone beds. Local ly some portions of the limestone have become dolomitized, but this dolomitization is not at all general, being limited to lens-like bodies a few feet in thickness, which pass laterally, usually within a few rods, into unaltered limestone. The color of the limestone is commonly light-gray, in many places bluish-gray, the dolomitized portions being light buff. Throughout most of the formation the bedding is very even, although strata are locally met with which exhibit some cross-bedding, commonly more or less obscure, but in some localities, especially towards the base of the formation, it may be quite evident.

The most continuous section of the formation exposed in the County, is the Mississippi River bluff section above Little Rock in the government quarries, where the following carefully measured succession has been made by Mr. F. M. Van Tuyl.

Little Rock Section

		Feet.	Inches.
19.	Ste. Genevieve limestone.		
18.	Limestone, dark-gray, compact to subcrystalline, weathering to a bluish tint. One continuous ledge. 5 feet to	6	0
17.	Limestone, gray, medium-grained above but compact with coarser-grained seams below, with small nodules and discontinuous bands of chert. 8 feet 3 inches to	9	4
16.	Limestone, gray, compact in the middle but with medium-grained beds below and above, with nodules and bands of black chert in the upper portion and pink chert in the lower portion. The pink chert seems to follow nearly vertical fracture lines in some places	14	7
15.	Limestone, gray, medium-grained, with obscure cross-bedding in places, and with bands and nodules of gray chert. 5 feet to	5	9
14.	Limestone, dark-gray, compact, with bands of coarser-grained gray limestone in the lower portion, with irregular nodules and thin, discontinuous bands of black chert	5	9
13.	Limestone, gray, medium-grained, in one massive ledge, free from chert. 5 feet to	5	6
12.	Limestone, gray, compact, thin-bedded, with fucoidal shale partings between the layers, and with occasional lentils, small nodules and thin, discontinuous bands of black chert	5	7
11.	Limestone, gray, massive, compact to subcrystalline, with bands and patches of gray, medium-grained limestone, and with a 2-inch layer of lighter colored, gray, subcrystalline limestone in the middle portion, lower portion locally cross-bedded. Free from chert	8	6
10.	Limestone, gray to buff, compact above, laminated, magnesian, in some places grading in part into gray, coarser grained, slightly oolitic limestone which is very imperfectly dolomitized, with thin, rather persistent bands of compact chert. 4 feet 6 inches to	5	2
9.	Limestone, gray, dense, subcrystalline, brittle, massive and structureless, with thin stylolite seam; filled with irregular nodules, lentils and thin discontinuous seams of dark gray chert. Some chert nodules exhibit concretionary structure. 5 feet 4 inches to	6	10
8.	Limestone, light gray, medium grained, rather soft, in one massive ledge; with stylolite seams and with occasional nodules of dark gray chert in the upper portion. 3 feet 8 inches to	4	4
7.	Limestone, dark gray, upper 2½ feet massive, medium-grained, and bearing *Lithostrotion proliferum;* lower three feet compact, brittle and thin-bedded with thin seams of bluish shale between the layers, passing horizontally into buff magnesian beds. With nodules and seams of gray chert. 5 feet 3 inches to	5	8
6.	Limestone, dark gray, subcrystalline to medium-grained, with bands of compact, gray limestone weathering to a lighter color; a massive 2½-foot layer at the top bears thin bands and nodules of black chert and carries *Lithostrotion proliferum;* lower portion more thinly bedded. Locally the lower portion passes laterally into magnesian beds which weather to a buff color. 8 feet 3 inches to	9	0
5.	Limestone, gray, heavily bedded, subcrystalline to medium-grained. Locally with a three or four-inch layer of gray, fucoidal limestone in the basal portion	17	0
4.	Shale parting	0	8
3.	Limestone, gray, very compact, dense, breaking with splintery or conchoidal fracture, rather thinly bedded and with undulatory stratification, with occasional nodules of gray chert; a thin-bedded member in the lower portion with small, symmetrical ripple marks. 12 feet to	14	6

	Feet.	Inches.
2. Limestone. Transition bedss from the Spergen (Salem) limestone, thin-bedded, compact, gray, with shaly partings between the limestone layers; upper and lower portions passing locally into oolitic subcrystalline to medium-grained limestone similar to the Salem lithologically, no chert observed. *Lithostrotion proliferum* ranges throughout and at the base there is a layer filled with this species. Some of the upper layers fucoidal and locally cross-bedded in part....................	41	6
1. Spergen (Salem) limestone.		

The lithologic characters of the St. Louis limestone in the Little Rock section are a good exhibition of the character of the formation as it occurs in Ste. Genevieve County generally. The successive beds are more or less uniform throughout, and unlike the sections at St. Louis and at Alton, Illinois, it contains no extensive shaly or dolomitic beds in its lower portion, nor any brecciated or conglomeratic beds which in those sections are present near the middle of the formation. At the base of the formation there is no sharp dividing line separating it from the underlying Spergen (Salem), the contact between these formations being entirely conformable, with a gradation both faunal and lithologic which may continue through thirty or forty feet. In this transitional zone a bed varying in thickness from one to five or more feet, filled with the colonies of the coral *Lithostrotion proliferum*, is met with in many localities, and it is believed that this bed occurs at essentially the same stratigraphic position wherever it is present. A bed which is entirely similar to this one, and which doubtless occupies the same stratigraphic position, is present at many localities in Randolph and Monroe counties, Illinois, in the continuation of the Missouri area of the St. Louis limestone into that state. In many localities, however, this coral bed cannot be seen, either because it is talus covered or because it is not continuously present, and in such localities it is not easy to exactly establish the line between the two formations. The genus *Lithostrotion*, however, is not confined to this horizon, and locally it has been observed some distance lower in the section, in beds here included in the Salem. The bed with abundant remains of echinoids, already mentioned in the discussion of the Salem limestone as being present near the top of that formation, occupies a position only a few feet beneath the coral zone. Ulrich[1] mentions the abundance of plates and the spines of echinoids, *Archeocidaris* and *Melonechinus*, in the basal bed of the St. Louis limestone in Kentucky, and their absence in the overlying portion of the formation,

[1]U. S. Geol. Surv. Prof. Paper No. 36, p. 35 (1905).

which seems to indicate that he has drawn the dividing line between the two formations somewhat lower than has been done in Ste. Genevieve County, a position which may be the more correct one.

The exact succession of beds which has been described in the Little Rock section is not a succession which it is practicable to follow throughout the region examined. The several beds doubtless vary as greatly in a lateral direction as they do vertically, and the dolomites and cherty horizons recognized above Little Rock may be discontinuous, and other similar beds may be intercalated.

Stratigraphic Relations of the St. Louis Limestone.—The St. Louis limestone rests with entire conformity upon the underlying Spergen (Salem) limestone in Ste. Genevieve County and elsewhere, and in places it is difficult to decide just where the line between the two formations should be placed. Wherever the conspicuous coral bed is exposed, as west of Ste. Genevieve along the old plank road just east of the lime kilns on South Gabouri Creek, the basal line of the St. Louis is placed beneath the coral zone, but in many sections it might be placed almost anywhere within a zone of 20 or 30 feet of sediments. The lithologic change from the lower to the higher formation is gradual, and many fossil species are also common to the two formations.

The upper limit of the St. Louis limestone is much more sharply defined than the lower, at least in Ste. Genevieve County, for the Ste. Genevieve limestone rests unconformably upon the St. Louis. The contact between the two formations is well shown at the base of the river bluff by the roadside for several miles below the town of Ste. Genevieve. In places the truncation of the St. Louis beds can be seen, and elsewhere solution channels in the St. Louis surface are filled with Ste. Genevieve sediments. This unconformity, however, is not widespread in its development, for in southern Illinois there is no break whatsoever in the sedimentary series in passing from the St. Louis into the Ste. Genevieve.

Correlation.—The St. Louis limestone is a practically continuous formation throughout the Mississippi Valley region, and is recognizable from Iowa to Alabama. It is of course covered by younger sediments in much of the area where it occurs, and in some other places has been completely removed by erosion. Throughout this whole region the formation is fairly uniform in its lithologic characters and contains the two coral species *Lithostrotion canadensis* and *Lithostrotion proliferum* as good index fossils.

Paleontology.—Fossils are commonly less conspicuous in the St. Louis limestone in Ste. Genevieve County, than in any of the preceding Mississippian formations, unless it be the Burlington. Certain bands are present, such as the coral zone at or near the base of the formation, where the limestone is crowded with fossil remains, and along some of the shaly partings in the upper portion of the formation, fossils are numerous in some localities. In much of the limestone of the formation, however, especially in the dense, close textured beds which occur so commonly, fossils are rarely met with. The most complete collections have been made from the Little Rock section, a collection of some sort having been secured from fifteen of the eighteen beds into which the entire succession is divided, and the species which have been identified, with their distribution in the section, is recorded in the following table, the numbers at the top of the columns corresponding with the numbers assigned to the several beds in the section.

Fauna of the St. Louis formation at Little Rock

	1	2	3	5	6	7	8	9	12	13	14	15	16	17	18
Zaphrentis spinulosa E. & H.		x					x		x				x		
Zaphrentis sp. 4..........					x						x		x		
Zaphrentis ? sp. 5.........		x									x				
Zaphrentis sp............										x				x	x
Lithostrotion proliferum Hall		x		x	x	x					x				
Syringopora sp...........				x	x		x			x	x		x		
Monilopora beecheri Grabau.					x										
Platycrinus penicillus M. & W..................											x				
Pentremites princetonensis Ulrich...............					x										
Archaeocidaris sp.........	x				x										
Dichotrypa sp............	x														
Cystodictya sp...........	x											x			
Fenestella sp............						x									x
Streptorhynchus ruginosum (H. & C.)............		x													
Orthotetes kaskaskiensis (McChes.)...............		x	x						x						
Schellwienella sp.........											x		x		
Rhipidomella dubia (Hall)..		x		x	x										
Productus ovatus Hall......		x			x		x						x		
Productus tenuicostus Hall..							x			x			x		

Fauna of the St. Louis limestone at Little Rock—Continued

	1	2	3	5	6	7	8	9	12	13	14	15	16	17	18
Productus altonensis N. & P.							x								
Productus sp. 5		?	x						x						
Productus sp. 6		x		x							x				
Productus sp.														x	
Pustula alternatus (N. & P.)					x										
Pustula biseriata (Hall)		x		x	x										
Camarotoechia mutata (Hall)	x	x													
Dielasma formosa (Hall) ?					x										
Spirifer pellaensis Weller					x		x	x	x	x	x		x	x	
Spirifer tenuicostatus Hall		x		x											
Spirifer bifurcatus Hall		x	x	x	x							x			
Brachythyris altonensis Weller	x														
Reticularia setigera (Hall)		x			x	x		x				x	x	x	
Martinia sp. undet			x												
Spiriferina ? sp											x				
Eumetria sp											x		x		
Cliothyridina lenticularis Weller									x	x		x			
Cliothyridina sp													x	x	
Composita trinuclea (Hall)	x		?	x	x	x	x			x	x	x	x	x	
Composita pentagonia Weller														x	
Composita sp		x													
Myalina ? sp													x		
Pinna sp							x								
Schizodus sp. undesc.		x													
Allorisma sp. undesc.		x						x							
Parallelodon ? sp	x														
Aviculopecten ? sp							x				x				
Conularia sp. undet			x											x	
Fish teeth							x			x					

In the preceding table some of the most commonly represented species are forms which pass over from the earlier Salem limestone fauna, this being especially true in the lower portion of the formation, where such species as *Rhipidomella dubia*, *Productus ovatus*, *Pustula biseriatus*, *Spirifer tenuicostatus*, *Spirifer bifurcatus*, *Reticularia setigera*, and *Composita trinuclea* are commonly met with. Associated with these species, however, there are others which are wholly foreign to the Salem. The appearance of the conspicuous *Lithostrotion* beds near the base of the formation marks the incursion of a new element in the faunas of the Mississippian basin from some outside region, and the slightly earlier appearance of the great numbers of Echinoids may be interpreted in the same manner. The change in the faunas, however, was no more abrupt than the change in lithologic characters of the beds, and it is necessary to adopt a position somewhat arbitrarily as the dividing line between the two formations. The conspicuous *Lithostrotion* bed is so adopted here, although there are some reasons for considering the echinoid layer as the basal bed of the St. Louis formation. In the upper portion of the St. Louis limestone some new species are introduced which seem to be characteristic of that part of the formation, *Productus tenuicostus* being the most imporatnt one in the Ste. Genevieve County collections. Another characteristic species of the formation is *Productus scitulus*. One of the brachiopods most commonly met with in the St. Louis faunas is *Productus ovatus*, specimens of which are crowded together locally to such a degree that the rock cannot be broken without uncovering numerous examples. When the species does occur in such numbers almost every other species is excluded.

STE. GENEVIEVE FORMATION

Name.—This formation was named by Shumard,[1] and although no adequate description of it was given by him, it was said to be exhibited in the bluffs of the Mississippi, commencing a mile or two below Ste. Genevieve, and from thence extending almost interruptedly to the mouth of River aux Vases. The outcrops along this bluff must therefore be considered as the typical expression of the formation. It is clear, however, that Shumard himself did not fully recognize the limits of the formation, since he specifically states that all of the outcrops in the bluffs above Ste. Genevieve belong to the St. Louis limestone, while recent investigations have shown that all the limestone outcrops between Ste. Genevieve and Little Rock lie above the beds which can be truly referred to the St. Louis, and the greater portion of the section in the first quarry at Little Rock is also above the St. Louis proper. Furthermore, Shumard referred certain outcrops in Illinois to the Ste. Genevieve limestone which cannot belong here.

In Illinois the true Ste. Genevieve limestone is well developed along Fountain Creek and elsewhere in Monroe County, and again at Alton. At the first of these localities the beds have been included in the St. Louis limestone by Worthen,[2]

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

[2]Geol. Surv. Ill., vol. 2, pp. 282-286 (1866); Geol. Surv. Ill., vol. 8, pp. 103-132 (1890).

while at the second they have been referred by the same author to the Chester.[1]

Ulrich[2] first revived the Ste. Genevieve limestone as a formation in the Mississippian section, in connection with his studies in Kentucky, and has designated three members, the Fredonia oolite at the base, the Rosiclare sandstone in the middle, and the Ohara limestone at the top, the entire formation with a maximum thickness said to be at least 245 feet. More recent field studies have shown that at least some portion of the Ste. Genevieve limestone, as the formation has been interpreted by Ulrich in Kentucky, cannot be correlated with the Ste. Genevieve limestone in Ste. Genevieve County, and that author has included in the upper part of the Ohara certain beds that belong much higher up in the section. As adopted in this report, the name Ste. Genevieve is used to include the original Ste. Genevieve limestone of Shumard, along with some other beds in Ste. Genevieve County which must be united with them. In the Kentucky section of Ulrich the summit of the Ste. Genevieve limestone lies within the Ohara member of the formation as he defined it.

Areal distribution.—The Ste. Genevieve limestone occupies a belt immediately east of the St. Louis limestone. It intersects the Mississippi River bluffs at Little Rock, and constitutes almost the entire limestone exposure in the bluffs to the mouth of River aux Vases. At a few points in the town of Ste. Genevieve and below, the underlying St. Louis is exposed to a limited degree at the very base of the bluff, but nowhere does that formation rise more than a few feet above the level of the bottoms. The width of this belt at Ste. Genevieve is about one mile, or a little more, its greatest width of about two miles being almost half way between Ste. Genevieve and the Aux Vases. Beyond the line of its greatest width the belt underlain by the formation becomes narrower, being less than one-half mile in the valley of River aux Vases. Between the Aux Vases and Saline Creek the summit of the Ste. Genevieve limestone is exposed in the base of the bluff for a short distance along the Frisco railroad track below the mouth of the Aux Vases, the main belt being in the hills at a little distance from the river. The last outcrops along the river bluffs are under the bridge near the mouth of Saline Creek, and in a small quarry by the roadside, one-half mile below the bridge. From this point on, the formation occupies a narrow

[1]Geol. Surv. Ill., vol. 1, p. 78 (1866); Econ. Geol. Ill., vol. 1, p. 61 (1882).
[2]Prof. Paper, U. S. Geol. Surv., No. 36, p. 39 (1905).

belt to the Perry County line one and one-half miles from the river bluffs.

Thickness.—In the southernmost quarry at Little Rock, two miles above Ste. Genevieve, 60 feet of Ste. Genevieve limestone is exposed in the quarry face. The total thickness at this place may somewhat exceed this amount, but the maximum cannot be more than 80 feet. Elsewhere in the county there are some beds which are evidently higher than any of the strata at Little Rock, and the total maximum thickness of the formation may be as much as 100 feet or more. On the other hand, at one locality near Lithium in Perry County, where both the upper and lower contacts of the formation can be accurately determined, there is an actual thickness of only 20 feet of Ste. Genevieve limestone. This variation in thickness is doubtless due to the erosion of the beds preceding the deposition of the next succeeding formation.

Topography.—The topographic features of the area underlain by the Ste. Genevieve limestone are not notably different from those of the underlying St. Louis and Spergen (Salem) formations. All three limestones occupy the eastwardly sloping surface from the crest of the Burlington escarpment, and all of them lack the systematically developed surface drainage in considerable portions of the area, much of the drainage being through sink holes to underground channels.

Lithologic Characters.—The Ste. Genevieve limestone as developed in Ste. Genevieve County, exhibits considerable diversity in its lithologic characters. The lower portion of the formation, as best exposed in the first quarry at Little Rock, and in the low bluffs below that point, is made up of a series of remarkably cross-bedded limestones about sixty feet in thickness, which are oolitic and arenaceous. Some layers also exhibit excellent ripple marks upon the bedding planes. This limestone is not so conspicuously oolitic as are some of the beds of the Spergen (Salem), but scattered oolite grains are present throughout the whole of it, and fine sand grains are also disseminated throughout. The cross-bedded layers are wholly free from chert, but higher in the formation there is a belt of evenly bedded limestone which includes a large amount of red chert in continuous horizontal bands or in discontinuous lentils arranged parallel with the bedding. These chert bands and lentils are commonly two or three inches in thickness and may constitute as much as 25% or more of the entire mass of the belt in which it is present. This red chert horizon is not exhibited in the quarry face at Little Rock, although there are numerous silicified fossils in the highest bed at that locality which are of a red color. At the base of the cross-bedded limestone, there is a conglomeratic bed resting upon the St. Louis, in which the pebbles, an inch or less in diameter, imbedded in a limestone matrix, seem to exhibit the lithologic characters of the subjacent formation. The thickness of the conglomerate bed is about one foot. A little higher up in the formation, about ten feet from the base, is a bed one foot or less in thickness which is filled with pebble-like remains of calcareous algae. This algae bearing bed is not continuous across the entire quarry face, but consists rather cf a series of lenses all occurring along a single horizon.

The Little Rock section of the Ste. Genevieve limestone is as follows:

		Feet.	Inches.
4.	Limestone, dark gray, compact, subcrystalline, with thin, discontinuous bands of reddish chert	1	4
3.	Shale, ash-colored, calcareous, somewhat fissile	3	0
2.	Limestone, dark gray, dense, granular to compact, passing into softer beds below, which locally grade into ash-colored shales; including red chert nodules and red silicified fossil shells. 5 feet to	5	7
1.	Limestone, granular, oolitic, and arenaceous, remarkably cross-bedded, with a zone of calcareous algae 10 feet above the base, and with small round pebbles of St. Louis limestone in the basal bed	50	

In some other localities the Ste. Genevieve limestone differs notably from the Little Rock beds in lithologic character; this is especially true of the beds which are exposed in the river bluffs below Ste. Genevieve, the locality mentioned by Shumard in his definition of the formation, which must be considered as typical of the formation. These beds are exceedingly variable in character and include both oolitic and crystalline limestones. At a locality along the road to Little Rock, a little less than one mile from Ste. Genevieve, the strata immediately above the Little Rock beds are shaly in places, the shale beds being somewhat variegated red and blue in color, and including calcareous lenses filled with fossils. At other localities the formation includes a thin sandstone stratum, but there is no continuous sandstone member. The limestones are in part evenly bedded and in part more or less distinctly cross-bedded. In color they are commonly nearly white, in some localities with a distinctly yellowish tint, and elsewhere purple and greenish colors are not uncommon especially along the bedding planes and partings in the rock. The sandstone lenses which have been observed are rather fine grained and are yellowish brown in color. Where the limestone is most cross-bedded, and especially where it is somewhat arenaceous, fossils are unusual, but in other types of sediments fossils are present in almost every locality, although they are poorly preserved in many places, or are so firmly imbedded in the limestone that they cannot be collected in condition suitable for identification.

A section about three miles below Ste. Genevieve, in the river bluff near the middle of sec. 2, T. 37 N., R. 9 E., exhibits the following succession of beds:

		Feet.	Inches.
8.	Limestone, coarsely crystalline, with weathered cups of *Platycrinus penicillus* and crinoid stems	4	
7.	Sandstone, fine-grained, yellowish brown, in thin irregular beds	3	
6.	Sandstone, fine-grained, thick beds	5	
5.	Sandstone, fine-grained, yellow, in thin beds	5	
4.	Shale, variegated in color, with limestone inclusions and pebbles	0	8
3.	Limestone, even-bedded, very sandy in upper part	5	
2.	Limestone, coarsely crystalline, with some white oolite, cross-bedded	10	
1.	Limestone, exhibiting nodular weathering	4	

Stratigraphic Relations of the Ste. Genevieve Limestone.— In the river bluffs beginning about one mile below the town of Ste. Genevieve, a distinct unconformity is clearly recognizable at the base of the Ste. Genevieve limestone. This unconformable contact is notably irregular; in places there are deep solution channels extending two feet or more into the underlying St. Louis limestone, which are filled with limestone conglomerate of the base of the higher formation. In other places the upper surface of the St. Louis is more or less undulating because of its uneven erosion preceding the deposition of the Ste. Genevieve.

In the Little Rock section the change from the evenly bedded St. Louis limestone to the remarkably cross-bedded limestone above, is very abrupt, and this condition, associated as it is with the presence of a basal conglomerate in the higher formation, may be taken as evidence of the disconformable relations between the two limestones. In the section as exposed at Little Rock, however, there is no truncation of the higher beds of the St. Louis, nor is there any evidence of the formation of solution channels in the subjacent formation which are filled with the sediments of the higher formation.

This unconformity may also be seen in the beds of both North and South Gabouri creeks in the town of Ste. Genevieve. In both of these localities joint cracks in the underlying beds were enlarged by solution before the higher beds were deposited, and were then filled with the oolitic sediments of the younger limestone. Erosion has now proceeded to such an extent that the younger formation has been entirely removed except the remnants filling the joint cracks, which, being more resistant than the enclosing limestone, stand up as distinct ridges over the exposures in the creek beds. This condition is best exhibited under the lower bridge over North Gabouri Creek.

In Perry County, not far from the Ste. Genevieve County line, in the valley of St. Laurent Creek two miles south of St. Marys, and at several localities between this point and Lithium, the base of the Ste. Genevieve limestone is more conspicuously conglomeratic than in any of the Ste. Genevieve County localities. The pebbles in the conglomerate are limestone and angular cherts, and not infrequently there are water-worn, silicified corals and some well preserved brachiopod shells belonging to Devonian genera and species, which must have been derived from Middle Devonian formations exposed at no great distance during the time of deposition of the conglomerate.

The importance of this stratigraphic break is great, and the time represented by the hiatus was sufficient for the erosion of a considerable portion of the St. Louis limestone.

Correlation.—Outside of the areas of Ste. Genevieve and Perry counties, Missouri, and Randolph, Monroe, St. Clair and Madison counties, Illinois, in which areà the typical Ste. Genevieve limestone of Shumard is more or less continuously exposed, these beds, characterized by the *Pugnoides ottumwa* fauna, have been recorded in Iowa, and in many places in the Ohio valley, in southern Illinois and Kentucky, and as far south as Alabama. The Pella beds of Iowa, originally described as a member of the St. Louis limestone, contains an abundant *P. ottumwa* fauna, and it was from these beds, in fact, that the species was first described. Another common Ste. Genevieve species is *Girtyella indianensis*. This is not so good an index fossil, however, as the *Pugnoides*, for it also occurs in higher faunas of Chester age, but it also was originally described from the Pella beds of Iowa. The other species known from the Pella beds are all good Ste. Genevieve species, and the formation may be unhesitatingly correlated with the Ste. Genevieve limestone.

The major part of the Ste. Genevieve limestone as described by Ulrich in Kentucky is truly Ste. Genevieve in age, but the higher portion of the formation, the upper beds of the so-called Ohara member, has little in common faunally with the typical limestones of the formation in Missouri, and it has been shown that these higher beds really lie unconformably upon the true

Ste. Genevieve limestone beneath. Ulrich's inclusion of the entire Ste. Genevieve formation, as he defined it, in the Chester series, has been shown to be an error.[1] The upper portion of the Ohara member, above the unconformity just mentioned, is characteristically Chester, being the equivalent of the Renault limestone of Chester age, in the Ste. Genevieve County section.

Paleontology.—The Ste. Genevieve limestone in the Little Rock section contains no fossils through the greater portion of its thickness. Near the base is a bed of calcareous algae, but the only fauna in which brachiopods and molluscs are represented, occurs at the top of the section in the quarry at Little Rock. The fossils occur in beds of limestone which pass into calcareous shales, lying entirely above the conspicuously cross-bedded series of oölitic limestones; they have been collected from beds Nos. 2, 3, and 4 of the section already described at the Little Rock locality, and the following species have been recognized.

Fauna of the Ste. Genevieve formation at Little Rock

	2	3	4
Zaphrentis spinulosa E. & H.	x		
Syringopora sp.	x		
Pentremites cf. *P. conoideus* Hall	x		
Archaeocidaris sp. (spines)	x		x
Eridopora sp	x		
Stenopora sp	x		
Fenestella serratula Ulrich	x		
Fenestella tenax Ulrich	x		
Fenestella multispinosa Ulrich	x		
Coeloconus sp	x		
Cystodictya sp	x		
Orthotetes sp			x
Productus ovatus Hall	x		x
Dielasma sp	x		x
Girtyella indianensis (Girty.)	x	x	x
Spirifer pellaensis Weller	x		x
Spirifer sp	x	x	x
Reticularia setigera (Hall.)			x
Eumetria sp			x
Cliothyridina sp	x		
Composita trinuclea (Hall.)	x	x	
Composita sp			x
Aviculopecten sp	x		
Bellerophon scissile Conrad	x		

[1]Weller, Ill. State Geol. Surv., Bull. No. 41, p. 150 (1920).

	2	3	4
Straparollus sp.	x		
Laevidentalium sp.	x		
Phillipsia ? sp.	x		x
Pleuracanthus ? sp.	x		

One of the most conspicuous members of this fauna is *Bellerophon scissile*, a large shell which attains a maximum diameter of nearly four inches. No example of *Pugnoides ottumwa*, which is so characteristic of the Ste. Genevieve limestone in most places, has been observed in these beds.

Elsewhere fossils are commonly present at most localities of the Ste. Genevieve limestone, but they are not commonly well preserved. None of the collections which have been made in Missouri contain a large number of species, but at one locality near Waterloo, in Monroe County, Illinois, a fauna with more than fifty species, has been secured.[1] This Waterloo fauna contains many small pelecypods and gastropods, in this respect resembling the fauna of the Spergen (Salem) limestone, in some places, and some of the species are common to these two horizons. Other species in the Ste. Genevieve fauna belong to genera which are present in the Salem, and are more or less closely allied to the older forms, while still other members of the fauna have no close relationship whatever to the Salem species. In the Missouri collections only the larger and less delicate members of the fauna have been preserved in the fossil localities so far discovered.

In the river bluff by the roadside, about one mile above Ste. Genevieve, the basal portion of the Upper Ste. Genevieve is represented by an outcrop of variegated red and blue shale about ten feet in thickness, with thin beds and lentils of limestone. Some of these more calcareous layers are full of imperfectly preserved fossils, and the following species have been identified.

[1]Weller, Contr. from Walker Museum, Vol. I, No. 10, pp. 239-265 (1916).

Ste. Genevieve Limestone Fauna, Shales Beds Between Ste. Genevieve and Little Rock

Zaphrentis spinulosa M. E. & H.
Platycrinus penicillus M. & W.
Polypora sp.
Girtyella indianensis (Girty).
Spirifer pellaensis Weller.
Eumetria verneuiliana (Hall).
Cliothyridina sp.
Composita trinuclea (Hall).
Platyceras sp.

In the bluff about three miles below Ste. Genevieve, from bed No. 8 above the local sandstone member in the section described on page 221, the following species have been determined:

Ste. Genevieve Limestone Fauna Three Miles Below Ste. Genevieve

Platycrinus penicillus M. & W.
Pentremites princetonensis Ulrich.
Pugnoides ottumwa (White).
Girtyella indianensis (Girty).
Spirifer pellaensis Weller.
Composita trinuclea (Hall).
Nucla illinoisensis Worthen.
Schizodus depressus Worthen.
Straparollus sp.
Phillipsia (?) sp.

In a quarry by the roadside about three and one-half miles below Ste. Genevieve, that has been recently worked for road material, the following species have been collected:

Ste. Genevieve Limestone Fauna Three and one-half Miles below Ste. Genevieve

Productus ovatus Hall.
Productus parvus Meek and Worthen.
Pugnoides ottumwa (White).
Girtyella indianensis (Girty).
Spirifer pellaensis Weller.
Composita trinuclea (Hall).
Myalina (?) sp.
Orthonychia sp.
Straparollus (?) sp.

The faunas from the last two localities have been collected from beds which may certainly be considered as being a part of the typical section of the Ste. Genevieve limestone, specified by Shumard in his original definition of the formation, and the faunas may therefore be taken as being representative of the typical Ste. Genevieve fauna. By far the best single index fossil of the fauna is *Pugnoides ottumwa*, which has been found in almost every collection which has been made in the formation in Ste. Genevieve and Perry counties, Missouri, and in Monroe and St. Clair counties, Illinois. In many of the Illinois localities especially, this species occurs abundantly and in some places is almost the only species present. Furthermore the species has nowhere been observed in any formation other than the Ste. Genevieve.

Just south of River aux Vases, at the head of a ravine tributary to the aux Vases, on the west side of the Ste. Genevieve-

St. Marys wagon road, a small collection of fossils has been secured from immediately beneath the Aux Vases sandstone. The following species are present.

Ste. Genevieve Limestone Fauna, Near River aux Vases

Fenestella sp.	*Eumetria* sp.
Pugnoides ottumwa (White).	*Composita trinuclea* (Hall).

Pugnoides ottumwa is the only one of these species which is at all common, and many well preserved examples of that species are present.

AUX VASES FORMATION

Name.—In the description of the Chester Group in Illinois by Worthen[1] a widespread "Lower Sandstone of the Chester Group" was recognized, which had been referred to as the "Ferruginous Sandstone" by the early Missouri geologists,[2] and by whom on some occasions it was confused with a basal Pennsylvania sandstone. Keyes[3] proposed the name Aux Vases for the formation, which was merely a substitution of a geographic name for the older designation, the name being selected from the outcrops which are present in Ste. Genevieve County in the neighborhood of the mouth of River aux Vases.

Long before Keyes had suggested the name Aux Vases, Engelmann[4] had used the name Cypress for an important Chester sandstone which he found in Johnson and other southern counties of Illinois, and which he believed to be the equivalent of the "lower sandstone of the Chester Group" in western Illinois. Both Engelmann and Worthen, and for a time also, the more recent students of Chester stratigraphy believed that the Cypress of Engelmann was the equivalent of the Aux Vases of Keyes, and in consequence Keyes name was dropped and Engelmann's substituted, but it has been shown that the Cypress and the Aux Vases are not equivalent,[5] and Keyes' name has again come into use. Ulrich[6] was the first recent writer to revive the name Cypress after it had been almost forgotten.

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[1]Geol. Surv. Ill., vol. 1, p. 82 (1866); Econ. Geol. Ill., vol. 1, p. 64 (1882).
[2]Shumard, Trans. St. Louis Acad. Sci., vol. 1, p. 406 (1859); also Mo. Geol. Surv. Rept. for 1855-1871 (1873).
[3]Bull. Geol. Soc. Amer., vol. 3, p. 295 (1892); also Mo. Geol. Surv. vol. 4, p. 72 (1894).
[4]Trans. St. Louis Acad. Sci., vol. 2, pp. 189-190 (1863).
[5]Weller, Jour. Geol., vol. 28, p. 286 (1920).
[6]Prof. Paper, U. S. Geol. Surv., No. 36, p. 53 (1905).

Weller's[1] earlier studies showed that the basal sandstone of the Chester series in Monroe and Randolph counties, Illinois, belong to two distinct formations, the upper one resting unconformably upon the lower, and since it was supposed that the name Cypress was applicable to the whole of the sandstone, it could not be used for a part of the beds only, and the name Brewerville was proposed for the lowermost of the two formations. The higher sandstone was included by the same author in the Renault formation, which contains, besides the sandstone, important strata of limestone and shale. The study of the Ste. Genevieve County sections has established the fact that the Renault formation as it is developed in Missouri, is essentially all limestone and shale, with only very subordinate sandstone beds in its basal portion, and that all of the massive sandstone exposed near the mouth of River aux Vases, to which Keyes gave the name Aux Vases sandstone, is the exact equivalent of the Brewerville of Weller. Because of this the name Brewerville has been abandoned.

Areal Distribution.—In Ste. Genevieve County the Aux Vases sandstone is restricted to a belt beginning about one and one-half miles below Ste. Genevieve, and extending to the Perry County line, nowhere reaching farther than one and one-half miles back from the river bluff. Above the mouth of Dodge Creek the formation occupies a very narrow strip at the top of the bluff. Between Dodge Creek and River aux Vases a larger isolated area caps the hills lying west of the former creek. Between the mouths of River aux Vases and Saline Creek, the formation is well exposed along the Ste. Genevieve-St. Marys road, and in the Mississippi River bluff along the Frisco Railroad. Below the mouth of Saline Creek the sandstone outcrops continue as a belt which gradually swings back from the river bluffs, crossing the Perry County line about one and one-half miles from St. Marys, with tongue-like extensions down the tributary valleys towards the Mississippi. In several of these tributaries narrow, isolated areas of the sandstone are present in their beds, which have been exposed by the erosion of the streams through the overlying strata.

Thickness.—The thickness of the Aux Vases sandstone varies considerably within Ste. Genevieve County, doubtless due to the unconformable relations between it and the overly-

[1]Trans. Ill. Acad. Sci., vol. 6, pp. 118-121 (1914); also Miss. Brach. of Miss. Valley Basin, p. 23 (1914).

ing formation. In the old Eads Bridge quarry, three and one-half miles below Ste. Genevieve, about 25 feet of sandstone is exposed at the present time, but residents of the neighborhood, who have been familiar with the quarry for many years, state that the bottom of it has been filled up for a considerable depth, and it is not unlikely that at least 40 feet were actually exposed there at one time. The sandstone, however, was never quarried to the bottom of the formation at this locality, so the total thickness must exceed the amount given above, and may reach a maximum of 60 or more feet.

In the old quarry below the mouth of River aux Vases, only 18 feet 6 inches of sandstone are exposed, which, with the 18 feet of shale below, makes 36 feet 6 inches for the total thickness at this point. In the continuation of the formation to the south, the outcrops are commonly more or less covered with talus, but it probably nowhere exceeds 40 feet in thickness, and may be less than that in many places.

Topography.—The non-soluble, resistant character of the Aux Vases sandstone makes it a protective covering of the underlying limestone, and consequently, throughout the greater portion of its areal extent, it caps hills or is the cause of a ridge-like elevation of the surface. North of River aux Vases, where it is the highest formation in the section, this sandstone caps one large hill and a number of smaller ones. South of this creek, where the formation is succeeded by a number of other stratigraphic units, it becomes more of a ridge maker, and from a point a little over one mile due west of St. Marys to the faulted zone, this sandstone is at least the partial cause of a nearly continuous ridge.

Lithologic Characters.—In most localities the Aux Vases sandstone is a fine grained, even textured rock, uniformly light yellow in color. Much of it occurs in massive beds which are well adapted for quarry stone, but portions of it, in some localities at least, are rather thinly bedded and locally it includes some arenaceous shale at the base. The more thinly bedded portions are commonly not cross-bedded, but upon the weathered surfaces of the more massive beds, obscure cross-bedding is commonly exhibited. One of the best exhibitions of the Aux Vases sandstone in the county is towards the top of the ridge between the Mississippi bottoms and the valley of Dodge Creek, about three and one-half miles below Ste. Genevieve, and about one-fourth mile back from the road. At this locality a large quarry was opened many years ago, from which was taken the rock for the construction of the piers of the Eads bridge at St. Louis. The rock in this quarry is perhaps somewhat finer grained and of more even texture and color than in most localities, and little or no cross-bedding is shown. Between the mouths of River aux Vases and Saline Creek, the formation has been quarried at two points along the Frisco railroad track, and in the quarries and nearby railroad cuts, excellent exposures may be seen. In the largest of the quarries, the first one below River aux Vases, the Ste. Genevieve limestone constitutes the floor of the quarry, and the following succession of beds is well exposed:

Section of Aux Vases Formation

		Feet.	Inches.
6.	Shales, evenly bedded, purple in color, with some light colored bands a few inches thick	10	0
5.	Sandstone, one massive layer varying from two to four feet in thickness, the upper surface even, the lower surface uneven.		
4.	Sandy clay, greenish in color, resting evenly upon the underlying bed but with an uneven upper surface. Thickness of beds 3 and 4 together.	6	6
3.	Sandstone, massive, fine-grained, with even texture, yellow-brown in color, with obscure cross-bedding. The quarry ledge	18	0
2.	Shale, variegated clay shales below with arenaceous bands, becoming more sandy in upper portion with less red coloration	18	6
1.	Ste. Genevieve limestone, topmost beds only exposed.		

In this section only beds 2 and 3 may be referred to the Aux Vases, beds 4 and 5 constitute an interval filling between the Aux Vases and the superjacent Renault and belong properly with the higher formation, and the shale bed No. 6, is lower Renault.

Below the mouth of Saline Creek the outcrops of the Aux Vases are more or less talus covered, and the outcrops are mostly obscure. One of the best of them is crossed by the Farmington road about one and one-half miles out of St. Marys.

Stratigraphic Relations of the Aux Vases Sandstone.—The unconformable relations of the Aux Vases sandstone upon the subjacent formation is shown by the varying thickness of the underlying Ste. Genevieve limestone, due to its uneven erosion preceeding the deposition of the sandstone. The actual basal contact of the Aux Vases is not commonly well exposed in Ste. Genevieve County, the best exposure of the sort being in the old railroad quarry about three-fourths of a mile below the mouth of River aux Vases. At this point there is no basal Aux Vases conglomerate present, but the contact with the underlying Ste. Genevieve limestone is abrupt, with no transition beds, and it is clearly an unconformable contact. At one locality in Perry County, however, in the Mississippi River bluff about one-half mile southeast of the railroad station at McBride, a good clean section across the Ste. Genevieve-Aux Vases contact shows a basal conglomerate in the Aux Vases, beneath the massive beds of sandstone, resting directly upon the Ste. Genevieve limestone. This conglomerate varies in thickness up to two feet, and is made up largely of chert pebbles from the underlying formations, showing that the Ste. Genevieve limestone had not only become consolidated, but that the chert also had been formed in essentially the same condition in which we find it at the present time, before the erosion of the Ste. Genevieve was accomplished and the sedimentation of the Aux Vases begun. In Illinois this same unconformity is well exhibited in the Mississippi River bluffs between Prairie du Rocher and Modoc, and elsewhere in Randolph and Monroe counties, and in a number of places it is characterized by a basal conglomerate in the sandstone.

The upper limit of the Aux Vases sandstone is also an unconformable contact with the overlying Renault limestone, the character of which will be discussed in connection with the description of the overlying formation.

Paleontology.—No fossils of any sort have been found in the Aux Vases sandstone.

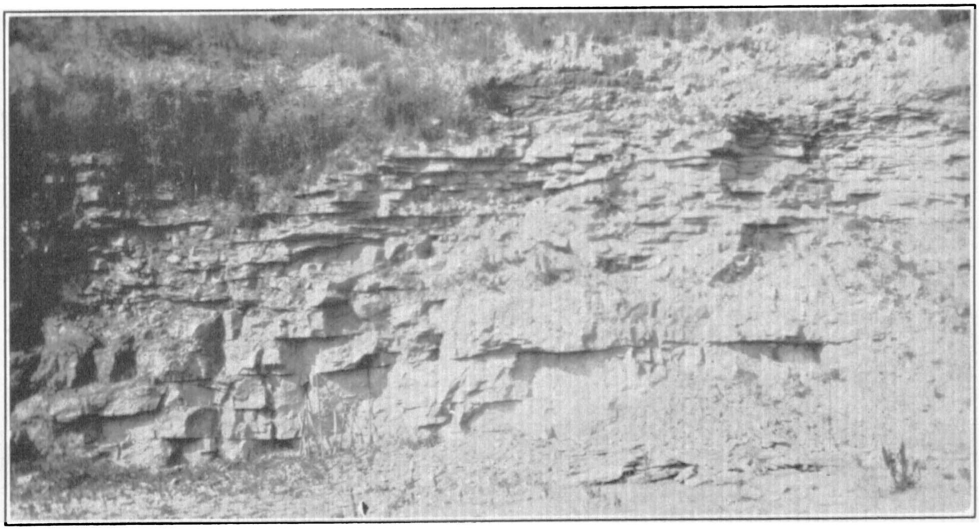
RENAULT FORMATION

Name.—The Renault formation was originally described by Weller[1] from exposures in Renault Township, Monroe County, Illinois. The formation extends into Randolph County, Illinois, and the Ste. Genevieve County exposures are a direct continuation of the Illinois beds.

Areal Distribution.—In Ste. Genevieve County the Renault formation is restricted to a small area between the mouth of River aux Vases and the Perry County line, whose maximum width of about one and one-half miles is along the county line southwest of St. Marys. In this area the formation caps the Aux Vases sandstone in the hill above the Frisco Railroad track between the mouths of River aux Vases and Saline Creek. From a point about one mile below the mouth of Saline Creek the formation outcrops almost continuously along the river bluffs, to the mouth of St. Laurent Creek at the county line, and is carried

[1]Trans. Ill. Acad. Sci., vol. 6, pp. 118-129 (1914); also Miss. Brach. of Miss. Valley Basin, pp. 23-29 (1914).

A. Keokuk limestone.



B. Renault formation.

by the dip of the beds to the tops of the hills about a mile back from the river. Within this area the larger valleys have been cut through the Renault and the underlying Aux Vases sandstone is exposed in their beds, and on the highest portions of the hill slopes remnants of a younger formation, the Yankeetown, are present in patches.

Thickness.—The section in the hillside above the Frisco Railroad track between the mouths of River aux Vases and Saline Creek, shows an interval of 46 feet that is occupied by the Renault, between the top of the massive Aux Vases sandstone and the Yankeetown formation. At no other locality in the county have both the lower and upper contacts of the Renault been so closely determined in continuous section. In this section the uppermost limestone member of the formation is only 12 feet thick, while towards St. Marys the same member increases to at least 50 feet. Where the greater thickness of limestone is present the basal contact of the formation has been carried by the dip of the strata below the Mississippi River bottoms, and none of the lower shaly and arenaceous beds are exposed. The increased thickness of the limestone, however, is not believed to be due to a corresponding thinning of the basal shaly and sandy beds, but to the differential erosion of the upper surface of the formation preceeding the deposition of the Yankeetown. The increased thickness of the limestone, therefore, probably represents an increased thickness of the formation as a whole towards St. Marys, where it is probably 80 or 90 feet. The formation may possibly have a maximum thickness of 100 feet in Ste. Genevieve County, or near by in Perry County, although no such thickness has been actually observed, and no well records are available which give any accurate data on the subject.

Topography.—The areal extent of the Renault formation is so limited in Ste. Genevieve County that its influence upon the topography is not great. The variable character of the limestone of the formation, and the presence of shale beds of some importance make the formation easily eroded, and the valley of St. Laurent Creek from Thompson School in Perry County, to St. Marys, has been determined largely by the character of the Renault formation, although the still higher Paint Creek shale is partly responsible for the position of the valley.

Lithologic characters.—In Illinois where it was first described, the Renault formation includes a great variety of sediments, limestone, sandstone and shale all being represented, and each type of rock exhibits great variation in its lithologic characters. In the Ste. Genevieve County area, the formation also exhibits much variation in its lithologic characters, although one limestone horizon is persistent throughout the area, and in the sections towards St. Marys it apparently constitutes nearly the whole of the formation. In the hill between the mouths of River aux Vases and Saline Creek, the formation includes more shaly and arenaceous beds, and in the section at the old railroad quarry already given on page 229, beds 4, 5, and 6 are believed to represent the basal portion of the Renault. Another section in the same hill about one-half mile above the mouth of Saline Creek gives the following succession of beds:

Section on Saline Creek

		Feet.
5.	Chert, quartzitic, banded, light yellow in color. Yankeetown formation.......	5
4.	Limestone, gray, more or less arenaceous..................................	12
3.	Sandstone, not well exposed, a small ledge at top and another at the base of a talus covered interval. The bed may be sandstone throughout or it may include shale..	20
2.	Unexposed, but judging from the talus and wash the interval is filled with variegated shale..	14
1.	Sandstone, massive and heavy bedded, light yellowish brown in color. The Aux Vases sandstone..	20

In this section beds 2, 3, and 4, with a combined thickness of 46 feet, compose the Renault formation.

In the gutter by the roadside[1] about half way between the mouth of Saline Creek and St. Marys, an outcrop of conglomerate is well exposed, which at this point is doubtless at the very base of Renault, only a few yards beyond the outcrop of conglomerate there being an outcrop of sandstone which is at the top of the Aux Vases. This conglomerate has a limestone matrix, with pebbles up to an inch in diameter, mostly of chert, although an occasional pebble of igneous rock is present. Above the conglomerate the beds are hidden by talus and soil, but material in the wash indicates the presence of arenaceous and shaly beds. Shumard[2] evidently observed another outcrop of this same conglomerate which is no longer exposed, he says, "About one mile above St. Marys we find, just above the water margin, an exposure of fifteen feet of quartzose sandstone, in thin layers, passing into gritstone and coarse conglomerate. The pebbles in the latter consist of milky and ferruginous quartz, jasper and

[1]Since the field work in Ste. Genevieve County was completed the road has been straightened at this point, and the conglomerate outcrop occurs along the abandoned road, several rods west of the highway now in use.

[2]1st and 2nd Ann. Repts., Geol. Surv. Mo., p. 149 (1855).

dark porphyry, varying from the size of a pea to that of a hen's egg. Above these beds is a slope of twenty-five feet, covered with soil and debris, and then succeeds the Archimedes Limestone, with its usual fossils." Changes in the position of the Mississippi River channel have caused the complete covering of this outcrop at the present time.

About one-half mile above St. Marys, the limestone in the Renault which is only 12 feet thick in the section a short distance above the mouth of Saline Creek, becomes more conspicuous, and a quarry has been opened in it for road material. At this point about 15 or 20 feet of limestone are exposed, which pass up into more shaly beds beneath the Yankeetown formation. In the bed of the creek just beyond the quarry, only a few yards from the highway, sandstone ledges belonging to the basal portion of the Renault are well exposed. This sandstone is fine-grained and yellow-brown in color, and each bed is pierced by closely crowded, vertical, Scolithus-like burrows, about the size of a lead pencil. Similar sandstone beds with burrows of the same sort have been met with at many localities in the basal portion of the Renault in Illinois, and also in Perry County, Missouri. Between this sandstone and the limestone in the quarry, the beds are not exposed. Towards St. Marys the limestone constitutes a more important portion of the Renault, and just above the town at least 50 feet of limestone is more or less continuously exposed. These limestones are commonly bluish-gray in color, becoming lighter gray in places; the texture is somewhat variable, but is rather coarsely crystalline in most exposures, and in many localities it exhibits conspicuous cross-bedding. Upon the weathered surfaces fossil fragments are abundant, especially crinoid stem plates, and bryozoans, the U-shaped bases of *Lyropora* being a common form in some of the beds. Some portions of this limestone, especially near the base, include beds which are conspicuously arenaceous.

Stratigraphic Relations of the Renault.—Several phenomena combine to establish the unconformity at the base of the Renault. The basal conglomerate, while not everywhere present, is widespread in its distribution, being present at intervals throughout the whole extent of the area occupied by the formation, from Ste. Genevieve County, Missouri, to St. Clair County, Illinois. The surface of the underlying Aux Vases is also uneven, showing that a period of erosion intervened between the close of the deposition of the Aux Vases and the initiation of the Renault.

At no point in Missouri, so far as known, has the entire thickness of the Aux Vases been removed before the deposition of the Renault, so allowing the Renault to rest directly upon the Ste. Genevieve limestone, although that has taken place in some parts of Monroe County, Illinois. This uneven Aux Vases surface, however, is well exhibited along the railroad between the mouths of River aux Vases and Saline Creek. One-fourth mile above Saline Creek the sandstone rises in an abrupt face some fifteen feet in height, beyond this for a quarter of a mile the upper surface drops below the level of the railroad and then rises again to a level similar to that near Saline Creek. The strata filling the depression are not well exposed because of the talus covering, but the character of the talus indicates that they are shales with some more arenaceous beds, essentially like the basal Renault resting upon the Aux Vases at the old quarry a short distance farther north. That the beds filling the depression in the Aux Vases are really Renault, is shown by the presence of broken trunks of a species of *Lepidodendron*, which has been observed at many localities in the Renault sandstones in Illinois, but which is nowhere known in the Aux Vases.

Correlation.—The Renault formation includes the oldest limestone of Chester age in the Mississippi Valley. As the formation is developed in Ste. Genevieve County, and in the adjacent parts of Illinois, it exhibits many characteristics which mark it as a near shore sedimentary accumulation. The heterogeneity of the beds constituting the formation, the sandstone layers and the conspicuous cross-bedding in both sandstone and limestone beds, all are indicative of shallow water conditions in proximity to the shore line. The emergent land area which was adjacent to this basin was Ozarkia lying to the west. In tracing in Renault formation to a distance from this ancient shore line, the lithologic characters of the formation change, and it becomes more completely a limestone unit, although it does continue to include shaly members which lie between the harder limestone ledges. Such a manifestation of the Renault is exhibited in the more southern counties of Illinois, where the sediments must have been accumulated 50 miles or more from the shore, but notwithstanding the changed lithologic facies, the evidence of the fossils is sufficient to fully establish the correlation of the formation from the Mississippi River to the Ohio River in Hardin County, and beyond into Kentucky. In southern Illinois and in a part of Kentucky, Ulrich has included the equivalent of the

Renault formation in his Ste. Genevieve limestone, where it constitutes the upper portion of his Ohara limestone member of that formation, and it was largely due to the Chester affinities of the fauna of this member that the whole of the Ste. Genevieve limestone was included in the Chester series by that author.

Paleontology.—The basal shaly and arenaceous beds of the Renault are commonly so covered with talus that the conditions for collecting fossils, if they are present, are unfavorable. The only fossil specimens of any sort which have been observed in these beds, are from a locality about one-fourth mile above the mouth of Saline Creek, where some fragments of trunks of a species of *Lepidodendron* have been observed. These trunks are of the same sort as others which have been collected at a number of localities in arenaceous beds of similar age in Monroe County, Illinois.

The limestone member of the Renault is fossiliferous at nearly every locality where it has been observed, although in many places the fossils are poorly preserved, or are so firmly imbedded that they cannot be satisfactorily collected. Nearly every outcrop shows an abundance of crinoid stem segments, bryozoans and brachiopods upon the weathered surfaces. Among the bryozoans the U-shaped bases of a species of *Lyropora* are particularly characteristic, and may usually be detected by careful examination upon all outcrops of any extent, and in places they occur in abundance. Among the crinoids the characteristic base, and occasionally a complete dorsal cup, of *Talarocrinus*, may be found upon nearly every weathered limestone exposure. These two forms, *Lyropora* and *Talarocrinus* are the best index fossils for the Renault, not only in Missouri, but throughout the whole extent of the formation in Illinois.

From the limestone ledges along the Mississippi River bank at St. Marys, and above the town, the following species have been collected from the Renault:

Zaphrentis sp.
Pentremites sp.
Talarocrinus ovatus Worthen.
Orthotetes ? sp.
Diaphragmus elegans (Norwood and Pratten).
Girtyella indianensis (Girty).
Spirifer leidyi Norwood and Pratten.
Spirifer increbescens Hall, var.
Eumetria vera Hall.
Composita trinuclea (Hall).
Cliothyridina sublamellosa (Hall).
Aviculopecten sp.
Cypricardinia indianensis Hall.
Nucula illinoisensis Worthen.
Schizodus sp.
Parallelodon sp.
Parallelodon sp.
Myalina sp.
Straparollus planidorsatus Meek and Worthen.
Bellerophon sp.

Bellerophon sp.
Holopea (?) sp.
Orthoceras sp.
Cephalopod (gen. and sp. undet.).
Cladodus sp.

YANKEETOWN FORMATION

Name.—The Yankeetown formation, which is the youngest hard rock formation in Ste. Genevieve County, was named by Weller[1] from exposures in Monroe and Randolph counties, Illinois, and the occurrence of the formation in Missouri is a continuation of the Illinois outcrops along the strike of the beds across the Mississippi River.

Shumard[2] observed this bed and has written of this part of the section in the following words: "Just above St. Marys we find, at twenty feet above the Mississippi, alternations of yellow and purple clay, surmounted by compact and very hard Siliceous Limestone, and, at a lower level, near the center of the town, the Archimedes Limestone." In the place where this description was published, no interpretation of the age of the "hard siliceous limestone" bed was offered, but in his later report on Ste. Genevieve County[3] the same author refers this bed with some of the underlying shale, to the "Coal Measures," or to what is now commonly called the Pennsylvanian System.

Areal Distribution.—In Ste. Genevieve County the Yankeetown formation occurs only in an area lying between the mouth of River aux Vases and the Perry County line, less than one and one-half miles back from the river bluffs. In this area the formation either caps the tops of the hills only, or occurs as a veneer upon their northeastern slopes where the angle of slope about equals the dip of the rocks. Good exposures of the formation are not met with in many localities, but its presence may commonly be detected by the fragments of the characteristic rock in the talus or upon the hill slopes. The best exposures in the county may be seen at several points along the bluff road within three-fourths of a mile above St. Marys. Just beyond the county line a good exposure may be seen in the east bank of St. Laurent Creek, in the road side near the bridge over that stream in the lower part of the town of St. Marys.

In Monroe and Randolph counties, Illinois, where the formation was first described, it is one of the most persistent

[1]Trans. Ill. Acad. Sci., vol. 6, p. 124 (1914); also Miss. Brach. of Miss. Valley Basin, p. 25 (1914).
[2]1st and 2nd Ann. Repts. Geol. Surv. Mo., p. 149 (1855).
[3]Trans. St. Louis. Acad. Sci., vol. 1, p. 405 (1859); also Mo. Geol. Surv., Repts. for 1855-1871, p. 292 (1873).

formations in the Chester Series, and it continues without interruption, except where removed by erosion, from the point where it enters Missouri to where it is carried beneath the surface by the dip of the rocks.

Thickness.—An actual thickness of no more than five feet of Yankeetown has been observed in Ste. Genevieve County, and it is believed that the formation does not notably exceed this. It may attain a thickness of ten feet, but not more. In Illinois the formation is said by Weller to have a possible maximum thickness of 20 feet, but nowhere has a greater thickness than 10 feet been actually observed.

Topography.—Although the material constituting the Yankeetown is very resistent to the ultimate processes of weathering, because of its siliceous character, it exercises but little influence upon the topography of the area where it is exposed. This is due in part to the thinness of the formation, but especially to the fact that the bed is so greatly fractured that any exposed ledge breaks into pieces which remain strewn over the surface, but does not form an upstanding ridge to protect the underlying strata.

Lithologic Character.—The rock constituting the Yankeetown formation is siliceous throughout. Some portions of it are chert, but much of it is arenaceous and quartzitic. It is light colored, usually buff or gray, locally nearly white, and very commonly it exhibits a more or less distinct banding. The bedding is more or less irregular, although locally it is even-bedded. Because of its lithologic character the Yankeetown is highly resistant, but it is brittle and easily fractured, and has been much broken up by frost action, so that masses of it from an inch to several feet in diameter are commonly met with in the ravines which head in the hills capped by the formation; in fact, on many of these hills no actual outcrops of the formation are exposed, and the presence of the formation has been determined only by the debris in the stream beds and on the hillsides.

Stratigraphic Relations of the Yankeetown Formation.—The presence of an unconformity beneath the Yankeetown has already been suggested in the discussion of the Renault formation. In Missouri such an unconformity is indicated most strongly by the varying thickness of the Renault limestone, a variation which is believed to be due to the differential erosion of the subjacent formation before the higher one was laid down. In studying the Yankeetown throughout its entire extent in

Illinois and Missouri, it is observed to rest directly upon a great variety of types of sediments in different localities, here upon limestone, there upon shale, and elsewhere upon sandstone, a condition which seems to be best explained by assuming that its relations with the subjacent beds is unconformable. The uniformity of the lithologic character of the formation from southern St. Clair County, Illinois, not more than ten miles from East St. Louis, where it passes beneath the Pennsylvanian, to beyond St. Marys, Missouri, is remarkable, when taken in connection with the great heterogeneity of the immediately underlying beds, and when the thinness of this formation itself is considered.

Correlation.—Throughout the Mississippi Valley counties in Illinois and Missouri, the Yankeetown formation is a continuous member of the section, and can be traced from place to place. In the southern counties of Illinois, however, there is no unit in the Chester section which is at all comparable, lithologically, with the Yankeetown, but its place in the section is occupied by a sandstone which has been traced from Union to Hardin counties, and continues into Kentucky. This sandstone has been named the Bethel sandstone by Butts.[1] In view of the fact that the correlation of the beds underlying and overlying the Yankeetown with the beds underlying and overlying the Bethel sandstone, has been well established on paleontological evidence, the correlation of the Yankeetown with the Bethel seems to be a safe assumption.

Paleontology.—No fossils whatever have been observed in the Yankeetown formation in Missouri, and they are exceedingly rare everywhere in the formation. The only fossils which have been seen anywhere in the formation occur in a single locality in St. Clair County, Illinois, where some ill-preserved tree trunks, probably *Lepidodendron*, have been observed.

PAINT CREEK FORMATION

Name.—The typical exposures of the Paint Creek formation occur in Monroe and Randolph counties, Illinois, where the formation was originally described by Weller.[2] The formation has been clearly recognized from southern St. Clair County, Illinois, to northern Perry County, Missouri, the Missouri exposures being a continuation along the strike, of those in Illinois.

[1]Ky. Geol. Surv., Miss. Form. West. Ky., p. 63 (1917).
[2]Trans. Ill. Acad. Sci., vol. 6, p. 125 (1914); also Miss. Brach. of Miss. Valley Basin, p. 26 (1914).

Areal Distribution.—In Missouri the Paint Creek formation is restricted to a small area in the extreme northern portion of Perry County, between the mouth of St. Laurent Creek and Lithium. The formation underlies a very narrow belt at the base of and entirely surrounding the elevated area between St. Laurent Creek and the mouth of Lithium Creek, northeast of Thompson School, except along the side next the Mississippi bottoms where the dip of the strata carries it below the surface for most of the distance. A similar narrow belt surrounds the much smaller hill, including the river bluff, northeast of Lithium.

Throughout the entire extent of the formation in Missouri, very few actual outcrops occur, the formation being covered for the most part by soil, loess or talus. The best exposure seen is in the base of the bluff about one-half mile below the mouth of St. Laurent Creek. Other exposures are present in the valley of a tributary of St. Laurent Creek entering from the northeast, and joining the main creek about one and one-half miles from its mouth, the exposures being about one-half mile up the tributary valley. The only other exposure of note is in the base of the bluff at the northwestern point of the hill just below Lithium Creek where it enters the Mississippi bottoms. At a number of other localities the wash in the small ravines or in the hillsides, has suggested the presence of the Paint Creek formation where good exposures are wanting.

Thickness.—In none of the Missouri localities are the exposures sufficient to make any close estimate of the thickness of the formation. The conditions, however, seem to be similar to those in Illinois, and the thickness of the formation in Missouri probably does not differ much, if at all, from that exhibited farther north on the other side of the Mississippi River. Wherever the relations are well shown in Illinois the top of the red clay member of the Paint Creek formation lies about 25 feet above the Yankeetown, and the basal beds below the red clay are commonly ten feet or less in thickness, giving a thickness of from 15 to 20 feet for the red clay. The total thickness of the formation, including both the lower beds and the higher, more calcareous member, is commonly about 60 feet, which is perhaps somewhat greater than can be assigned to it in Missouri.

Topography.—The influence of the Paint Creek formation upon the topography must be considered in connection with the Renault formation. These two formations together lie between the more resistant Aux Vases sandstone below, and the rather massively bedded, hard, Golconda limestone above. The siliceous Yankeetown formation which lies between the Renault and the Paint Creek is negligible because it is so completely fractured that it falls to pieces promptly wherever it is exposed. These beds are non-resistant because of the amount of shale they contain, and consequently would naturally influence the original location of valleys. The valley of St. Laurent Creek, extending southeast from St. Marys, has been determined entirely by these formations. The western wall of the valley is a comparatively gentle slope, conforming more or less with the dip slope of the formations, while the eastern wall is much more abrupt, being formed by the much more resistant Golconda limestone where the Paint Creek dips beneath the surface. Another valley determined also by the Renault and Paint Creek, lies in a nearly east west direction, with its mouth at the gap in the river bluffs just north of Lithium. These two valleys make a distinct trench which outlines the western and southern sides of the hill lying between St. Marys and Lithium, whose northeastern face constitutes the river bluffs between the two points. Another similar hill, but very much smaller in dimensions, lies just northeast of Lithium. Next to the Mississippi bottoms the face of this hill is an abrupt limestone bluff, but its western, southern and southeastern sides are limited by a trench whose position has been determined by the non-resistant Renault and Paint Creek formations.

Lithologic characters.—The most notable member of the Paint Creek formation is a remarkably persistent bed of deep red clay, which has been observed from southern St. Clair County, Illinois, where the Chester formations pass beneath the Pennsylvanian, to the neighborhood of Lithium, Perry County, Missouri. This clay is very dense and hard where it has not been subjected to weathering, as in excavation for wells, but in surface outcrops it first crumbles into irregular, angular fragments a fraction of an inch in diameter, and when combined with water it breaks down into plastic red mud. In the unchanged outcrops it exhibits no indication of lamination and is commonly entirely free from inclusions of every sort, there even being no fine grit present. The actual base and summit of this red clay has not been observed in Missouri, and is rarely well exposed in any of the Illinois localities. In the more complete Illinois sections, however, it is underlain by a few feet of shaly beds with limestone lentils and thin beds, which rest upon the subjacent Yankeetown formation, and upwards from the red bed the formation passes into more calcareous, bluish shales with thin beds of limestone which in turn pass into more continuous limestones. In Missouri the red clay bed alone has been certainly recognized, but the basal beds and also the higher ones are without doubt present in the sections, although commonly covered with talus.

Stratigraphic Relations of the Paint Creek Formation.—No exposures in the Missouri localities are of a character to permit observation of the actual contact between the Paint Creek beds and the underlying Yankeetown. Neither do the Illinois sections which have been observed exhibit this contact in a satisfactory manner, and under the circumstances it is not possible to determine whether or not the younger formation rests unconformably upon the older. There is, however, some evidence to indicate the presence of an unconformity at this horizon in the southern counties of Illinois, and it is possible that some evidence bearing upon this question may develop in future studies in the Mississippi River counties in Missouri or Illinois.

The relations of the Paint Creek formation to the overlying Golconda limestone is also obscure in the Missouri section. In Randolph and Monroe counties, Illinois, the characteristic, deep red, non-laminated shale bed of the Paint Creek is succeeded by other shale and limestone beds which are included in the formation, these beds being separated from the overlying lower Okaw or Golconda limestone by a thin sandstone unit which is the northwestern extension of the thick Cypress sandstone of the Ohio Valley. In the Missouri sections the beds overlying the red clay member of the Paint Creek, for a thickness of 30 or 40 feet, are covered by talus or other debris in every section that has been examined, but above this position there are conglomeratic layers in the overlying limestone. No representative of the Cypress sandstone, which is thin on the Illinois side of the river but becomes very thick in the Ohio Valley, has been observed in Missouri. These conditions suggest the possibility of an unconformity between the Paint Creek formation and the Golconda limestone in this part of Missouri.

Correlation.—The Paint Creek in Missouri is a continuation of the same formation of Monroe and Randolph counties, Illinois. The characteristic bed of deep red, non-laminated clay or shale is so peculiar, and so different from any other bed in the whole Chester series, that it can nowhere be mistaken, and the Missouri occurrences are entirely like those in the typical outcrops in Illinois.

In the more southern Illinois Chester section, the Paint Creek red bed is not present, but the formation is represented by shales with subordinate limestone layers, the correlation being established by the contained faunas.

Paleontology.—No fossils have been found anywhere in either Illinois or Missouri in the red clay member of the Paint Creek formation, but they do occur commonly in the more calcareous shales and limestones. This portion of the formation in Missouri, however, is entirely talus covered so far as it is known, and has consequently afforded no opportunity for making fossil collections.

GOLCONDA FORMATION

Name.—In the Chester section of the western Illinois counties, as described by Weller, the Okaw limestone[1] was named from typical exposures in Randolph County, where the formation is exposed in the valley of the Kaskaskia or Okaw River, and in the Mississippi River bluffs both above and below the mouth of the Okaw. This formation constituted the largest single formational unit in the Chester series, as described at that time. Later investigations in the more southern part of Illinois have established the fact that this unit is a complex one, made up of two distinct calcareous formations separated by a sandstone, and the lower and upper limestone units have been named respectively Golconda and Glen Dean, and the sandstone has been called the Hardinsburg. The greater part of the original Okaw limestone is now known to be the equivalent of the Golconda. The Hardinsburg sandstone is locally present in Randolph County, Illinois, but is much reduced in thickness, and above this sandstone the Glen Dean is well developed.

The limestones overlying the Paint Creek in the Missouri section are all a part of the lower division of the Okaw formation as originally described by Weller, and consequently represents the Golconda formation, and it seems to be desirable to extend this name from the Ohio Valley section to include the equivalent beds in the section exposed along the Mississippi River.

Areal Distribution.—The Golconda limestone is not present in Ste. Genevieve County, but is well exposed in northern

[1]Trans. Ill. Acad. Sci., vol. 6, p. 127 (1914); also Miss. Brach. of Miss. Valley Basin, p. 27 (1914).

Perry County, northwest of Lithium. This is the youngest of the hard rock formations in this part of Missouri, and it occupies the whole of the areas within the two encircling bands of Paint Creek, the larger one between St. Laurent Creek and the Mississippi bottoms, and the smaller one northeast of Lithium. Within these two areas the best exposures are in the Mississippi River bluffs, and in some of the ravines cutting the bluffs. The uplands within the areas underlain by the formation are deeply covered with loess, which also completely covers the hill slopes towards the St. Laurent Creek to the south, in which direction outcrops of the limestone are not numerous.

Thickness.—The maximum thickness of the Golconda limestone in northern Perry County cannot be certainly measured because of the deep covering of loess upon the hill tops, which has washed down over the upper portion of the limestone. From 100 to 120 feet of limestone, however, are actually exposed in more or less continuous section in some of the short ravines cutting the face of the bluff, and this is probably not far from the full thickness as it is here developed.

Topography.—The Golconda limestone forms abrupt bluffs bordering the Mississippi River bottoms between St. Marys and Lithium, and underlies the hills extending back from the bluffs to the Paint Creek-Renault trench which limits these hills on their southwest sides. Like most of the Mississippian limestones in this region a considerable amount of subterranean drainage has been developed which manifests itself in the presence of many sink holes scattered over the tops of the hills. It is probable that these sink holes are a relic of an earlier period, preceeding the excavation of the present Mississippi River trench, when the Golconda limestone underlaid a much larger upland area than it does at the present time. As situated now, this small area of limestone with so much relative relief, could hardly develop the underground drainage necessary to produce the sink holes which are now present in the area.

Lithologic Characters.—As represented in northern Perry County the Golconda formation is a light colored, usually gray, bluish-gray, or nearly white limestone, coarsely or rather finely crystalline in texture, some beds being conspicuously oolitic. It commonly occurs in rather massive beds which form steep bluffs rising abruptly from the river bottoms. The limestones are free from chert, and nowhere have they been observed to be dolomitic. In the full section as it is developed in Illinois, there are important shale beds interbedded with the limestone members of the formation, but in Missouri no such shale beds have been observed, although they may be present in places, hidden by the covering of mantle rock. In the basal portion of the formation some of the limestone beds include numerous, small, angular, limestone and chert pebbles. It has not been possible to determine whether this conglomerate bed occurs at the extreme base of the formation, immediately above the beds which properly belong to the Paint Creek formation, but it is certain that they are present very near the base, and it is possible that such a bed actually marks the dividing line between the two formations. The limestones are highly fossiliferous, the material constituting the rock being almost entirely organic in origin. In many localities the fossils have been much broken before deposition, and many of them are not well enough preserved to be determined, but in some localities there are many well preserved shells.

Stratigraphic Relations of the Golconda Limestone.—In the Chester section farther north, on the Illinois side of the Mississippi River, and also in the Ohio Valley, the Golconda formation is separated from the Paint Creek by the Cypress sandstone. In the Missouri section, here described, this sandstone is wholly wanting, and although the interval immediately above the red clay member of the Paint Creek is everywhere talus covered, the basal Golconda with its conglomeratic beds, is present within 30 or 40 feet of the exposures of red clay, which is just about sufficient to allow for the normal thickness of the Paint Creek. Furthermore, nowhere in the talus from this portion of the section is there any suggestion of such arenaceous beds as characterize the Cypress. The absence of the Cypress in connection with the conglomeratic basal portion of the Golconda at least suggests that an unconformity exists beneath the Golconda in the Missouri section.

Correlation.—The correlation of these "lower Okaw" limestones of the Mississippi River counties in Illinois and Missouri, with the Golconda limestone of the Ohio Valley section, is fully established by the fossil faunas which have been studied from the two regions. A very characteristic faunal group which is present on both sides of the Mississippi River in the lower beds of this formation, includes a great number of small molluscs, both gastropods and pelecypods, some of which are peculiar forms, and many of which are as yet undescribed. In the typical

Golconda limestone of the Ohio Valley section the lower part of the formation is commonly less fossiliferous than are the beds in the Mississippi Valley, and the best index fossil is the crinoid *Pterotocrinus capitalis*, which is commonly represented only by the peculiar knob-like plates which surmount the ventral side. This crinoid has not been found in the Mississippi River section, and the peculiar mollusc fauna is not common in the Ohio Valley. At one locality in southern Johnson County, Illinois, however, a bed near the base of the Golconda limestone contains great numbers of the *Pterotocrinus capitalis* plates, and also a large molluscan fauna in which many of the very peculiar basal Okaw species are present. This association in southern Johnson County, containing the characteristic elements of both the lower Okaw and the lower Golconda faunas, is sufficient to establish the correlation of these formations. The correlation of the Cypress sandstone of the Ohio Valley section with the lower Okaw of the Mississippi Valley, as has been suggested by Ulrich,[1] is not sustained by the paleontological evidence.

Paleontology.—The Golconda limestone is abundantly fossiliferous in most localities, but in many places the fossils are too incomplete or too poorly preserved to be identified. The fauna includes many typical Chester forms, but there is also an element, consisting of small pelecypods and gastropods, which is suggestive of the faunas which have been present in earlier formations, notably the Ste. Genevieve and the Salem limestones. As in those earlier formations also, the limestone beds containing this fauna in the Okaw, are commonly more or less oolitic, suggesting that the conditions which were favorable for the formation of the oolites were also especially adapted to the life of the diminutive pelecypod and gastropod fauna. In the history of this fauna, if it be considered as a single fauna, there must have been shifting here and there in the Mississippian seas, in the search for favorable life conditions, and with the progress of time continual evolutional changes must have been in progress, new species and new genera being added, and old ones being modified or lost. With each successive recurrence of the fauna it exhibits characteristics which serve easily to differentiate it from the earlier appearances, although some genera and some species do persist throughout.

One of the most prolific Okaw faunas has been collected from the lower beds of the formation, in part at least from the

[1] Ky. Geol. Surv., Miss. Form. West. Ky., pt. 2, plate D (1917).

conglomerate beds, exposed in the Mississippi River bluff about one mile below St. Marys. Another collection has been made from a locality in the same bluff between one-fourth and one-half mile above the mouth of the Lithium valley, and still a third one from the exposures in the hill east of Lithium valley, about one-half mile north of the village of Lithium. These three lists will be combined in a single one in this place, the occurrence of the species in the several collections being indicated by a x in the columns numbered 1, 2, and 3, the numbers referring to the localities in the same order as noted above.

Golconda Limestone Fauna in Northern Perry County

	1	2	3
Pterotocrinus sp	x		
Stenopora sp	x		
Fenestella tenax Ulrich	x		
Polypora spinulifera Ulrich	x		x
Polypora complanata Ulrich (?)	x		
Septopora cestriensis Prout	x		
Archimedes sp	x	x	
Lyropora (?) sp		x	
Glyptopora punctipora Ulrich	x		
Crania sp	x		
Orthotetes (?) sp	x		
Diaphragmus elegans (Norwood and Pratten)	x	x	
Productus ovatus Hall			x
Dielasmaillinoisensis Weller	x		
Dielasma shumardanum (Miller) (?)		x	
Girtyella indianensis (Girty.)	x	x	x
Girtyella brevilobata (Swallow.)			x
Spirifer pellaensis Weller	x	x	x
Spirifer leidyi Norwood and Pratten	x	x	x
Spiriferina spinosa (Norwood and Pratten)	x		
Spiriferina transversa (McChesney)	x		x
Reticularia setigera (Hall)	x		x
Eumetria vera Hall	x	x	
Cliothyridina sublamellosa (Hall)	x	x	x
Cliothyridina sp	x		x
Composita trinuclea (Hall)	x	x	x
Edmondia (?) sp		x	
Sphenotus monroensis (Worthen)	x		
Sphenotus sp	x		
Nucula illinoisensis Worthen	x	x	x
Nucula sp	x		
Leda nasuta (Hall)	x		
Leda sp		x	
Parallelodon sp	x	x	x
Conocardium sp	x	x	
Myalina sp	x		

GOLCONDA LIMESTONE FAUNA--Continued.

	1	2	3
Myalina sp	x		
Schizodus sp	x	x	
Schizodus sp		x	
Aviculopecten sp	x	x	
Aviculopecten sp	x		
Aviculopecten sp	x		
Aviculopecten sp	x		
Streblopteria (?) sp	x		
Modiola illinoisensis Worthen (?)	x		
Modiola sp	x		
Cypricardella oblonga Hall	x	x	
Cypricardinia indianensis Hall	x		
Laevidentalium sp		x	
Bellerophon sublaevis Hall	x	x	x
Bellerophon sp			x
Bucanopsis textilis (Hall) (?)	x		
Pleurotomaria sp	x		
Pleurotomaria sp	x		
Ptychomphalus wortheni Weller	x		x
Ptychomphalus sp	x		
Porcellia sp	x	x	x
Solenospira (?) sp	x		x
Solenospira (?) sp	x		
Straparollus spergenensis Hall	x		
Straparollus planidorsatus Meek and Worthen		x	x
Straparollus sp	x	x	
Straparollus sp		x	
Cyclonema sp	x		
Holopea sp	x		
Holopea sp	x		
Naticopsis chesterensis Swallow (?)	x		
Naticopsis picta Girty	x		
Naticopsis sp	x		
Naticopsis sp	x		
Loxonema sp	x		
Loxonema sp	x		
Zygopleura sp	x		
Diaphorostoma sp	x		
Platyceras sp			x
Orthonychia sp	x	x	x
Orthonychia sp	x		
Eotrochus sp	x	x	
Orthoceras randolphense Worthen		x	
Orthoceras sp		x	
Orthoceras sp		x	
Stroboceras sp	x	x	
Phillipsia sp	x		x
Ostracods	x		x

POST-PALEOZOIC ROCKS

LATE TERTIARY (?) CONGLOMERATE

There are a number of small patches of conglomerate in the southwestern part of Ste. Genevieve County, made up of angular and rounded pieces of granite, feldspar, quartz, sandstone, limestone and dolomite of several ages up to Devonian, with pieces of chert and flakes of biotite mica. The Devonian limestone fragments in the conglomerate vary in size up to several feet in diameter in at least one locality, and contain fossils characteristic of the Middle Devonian, but in some other localities no fossils have been found. These deposits are at no definite elevation, and have no distinctive topographic distribution; some outcrop in the beds of young streams, others occupy hill slopes over an elevation of as much as 60 feet, and still others are near the tops of hills. Their elevations range from 780 feet to 980 feet above sea level.

The conglomerate deposits in the NE. ¼ sec. 15, east center of sec. 15, and the NE. ¼ sec. 23, T. 35 N., R. 7 E., are similar in character, being loosely consolidated and made up of small-sized fragments. The deposit in the SW. ¼ sec. 8, T. 35 N., R. 7 E., contains pieces of the basal Bonneterre beds, along with Devonian limestone fragments, in one of which a large coral was observed. The deposit in the NW. corner of sec. 4, T. 36 N., R. 8 E., situated on a hilltop, contains some Devonian limestone with fossil corals, and also fragments of granite, chert, sandstone and mica. The best lot of fossils which have been found in any of these peculiar deposits are from the west center of sec. 2, T. 35 N., R. 7 E., in the bed of a young valley cut deep in the Cambrian formations; they are characteristic of the Middle Devonian, being chiefly brachiopods and corals. Fossils are also found in the conglomerate in the SW. ¼ sec. 18, T. 35 N., R. 8 E., where it is made up of quartz, feldspar, mica, sandstone, granite, and limestone pieces, the size of some of the latter being several feet in diameter. At this locality the deposit occupies a peculiar position along the slope of a steep hill, with a vertical range of about 60 feet, and a width of outcrop about 75 feet. A deposit in the SE. corner of sec. 1, T. 35 N., R. 6 E., contains no fossils but is characteristically made up of pieces of sandstone, quartzite, dolomite, chert, granite, and flakes of biotite mica. Along the section line between sections 1 and 12, T. 35 N., R.

7 E., there is a similar patch of conglomerate, and in the immediate vicinity there are many rounded and much weathered boulders of red granite. This occurrence has been described in the past as a granite outcrop, but upon careful examination the sedimentary character of the deposit is obvious, and the presence of the granite boulders is believed to be closely related to the formation of the small patch of conglomerate.

The age of those post-Devonian conglomerates is obscure, but from the fact that some of the patches are in the bottoms of very young stream valleys, it seems evident that they must have been accumulated after the last uplift of the region. Probably the earliest age assignable to them is late Tertiary, and Quaternary may be more nearly correct. It is possible that careful field studies over a larger area would disclose more data bearing upon a true interpretation of the beds.

CRETACEOUS (?) INTRUSIVES

A basic intrusive rock outcrops at two places in Ste. Genevieve County, whose age is at least younger than the Bonneterre, for it cuts the dolomite of that formation. The best locality for the study of this intrusive is in the SE. corner of NE. ¼ sec. 2, T. 35 N., R. 7 E., where the exposure covers an area of about 150 by 20 feet. The other outcrop is in the SE. corner of sec. 12, T. 35 N., R. 7 E., where the dike, about five feet in width, crosses Saline Creek. In both localities the rock is greenish-black in color, with prominent glassy black phenocrysts in an aphanitic ground mass. The texture under the microscope is porphyritic with a much altered holocrystalline ground mass. The important minerals are olivine, augite, titaniferous magnetite, biotite, and a little hornblende. The secondary minerals are serpentine, leucoxene, chlorite and calcite. The mineralogical composition of the rock is such as to warrant the name olivine peridotite, the prefix olivine being used to designate the large olivine phenocrysts which are characteristic, but if there should be any plagioclase feldspar in the altered and turbid ground mass, the name olivine kersantite would probably be more accurate. In describing a similar dike rock from the vicinity of Eldorado, Illinois, Johannsen has suggested that plagioclase was probably present in the ground mass, thereby classing the rock as olivine kersantite.

Just over the Ste. Genevieve County line, on the Fredericktown road, there is an outcrop of a basic rock in the Davis shale, which in some respects resembles the rocks last described, but it is coarser in texture and lacks the olivine phenocrysts.

South of Saline Creek there are several small areas where the Bonneterre rocks have a peculiar doming which may have been caused by an intrusion which has not yet been exposed at the surface by erosion. Two other small areas of rather obscure relations should be mentioned. The first of these is near the top of the divide in the SE. ¼ NW. ¼ sec. 29, T. 36 N., R. 7 E., where a small deposit of brecciated material is exposed. Under the microscope this rock is shown to be made up of quartz and feldspar phenocrysts, some of the last being microcline, and a fine-grained acid ground mass. The fragments which make up the rock are distinctly angular and broken, and the breccia may have been produced by an intrusion which is not yet exposed at the surface. The other of these two areas is a small one in the SW. ¼ sec. 33, T. 36 N., R. 7 E. The rock somewhat resembles that last described, but it is much more altered. Pounded clay gobs and brecciated fragments of acid materials are characteristic, and considerable calcite fills cavities and interstices. The origin of this rock may have been the same as that suggested for the last, by an intrusion which has not yet been exposed by erosion. However, it is possible that the rock in both of these areas may have been formed by sedimentary processes, for there is some resemblance to the pockets of the conglomerates in which Devonian limestone fragments are found.

The age of these intrusives in Ste. Genevieve County is conjectural. They are known to be younger than the Bonneterre for some of them cut rocks which belong to that formation, but a petrographic study has disclosed the fact that they are practically the same kind of rock as the intrusives which cut the Pennsylvanian coal beds in Illinois, except that the Ste. Genevieve rocks are more porphyritic. From descriptions of the basic intrusive rocks found in Kentucky and Pennsylvania, the Ste. Genevieve intrusives appear to belong to a very similar series. The basic dikes at Ithica and elsewhere in New York are also similar in some respects, and the Pike County, Arkansas, peridotite appears to be closely related mineralogically. The New York dikes cut strata as young as Upper Devonian, in Pennsylvania, Kentucky, and Illinois the similar dikes cut strata as young as Carboniferous, and in Pike County, Arkansas, the basic intrusives cut strata as young as early Cretaceous. If from a detailed microscopic study these various intrusives can be correlated mineralogically, it may be plausible to consider that all are of approximately the same age.

QUARTERNARY DEPOSITS

By E. W. SHAW

PLEISTOCENE FORMATIONS

The deposits which accumulated in Ste. Genevieve County during Pleistocene time and have not since been entirely removed by erosion consist (1) of the products of local weathering, rainwash, hillslide creek and cavern development; (2) scattered glacial boulders and small bodies of till; (3) old stream and lake deposits of at least two epochs; and (4) loess. The average total thickness is about 8 or 10 feet.

Residuum, wash, creek and cave deposits.—Although it is not possible to distinguish between the residuum, wash, creek and cave deposits of Pleistocene time and those of recent time, it is reasonably certain that a considerable part of the surficial material of these varieties reached somewhat near its present position and condition before the Recent epoch. It includes material derived from the weathering and carrying away of several hundred feet of rocks, mainly cherty limestone, for in places it is many feet thick and yet is composed largely of argillaceous matter such as constitutes only a very small fraction of the limestone.

The residuum or more or less deeply weathered rock in place consists mainly of cherty clay, the chert being in fragments ranging in size from sand grains up to blocks a foot or more in diameter. The larger fragments are generally deeply pitted because of the more ready solution of certain portions. In some parts of the county, particularly where the bed-rock is shale or sandstone, chert is scarce. The prevailing color is reddish from the concentrated and relatively insoluble iron oxides.

At the bases of many hillsides considerable bodies of material have accumulated through the action of rains, rills and sheet flood erosion. Even well up on slopes small bodies of such material are present, though such bodies are presumably for the most part Recent. The material may be recognized by its topographic position and relations, by the marks of water action in faint stratification and slight sorting, and in places by an old soil at its base, separating it from the residuum or other underlying material. It is also, on the whole, less red then the residuum. A good example of this material is found one-half mile north of Independence School which is about 10 miles south of Ste. Genevieve.

In addition to the accumulations of material through the agency of rain wash there is a good deal of more or less stony soil that has evidently crept gradually down hillsides through gravity aided by frost action, temperature changes, and soil water movements. The process is of course still in operation almost everywhere and only a part of the creep found in the county today reached its present position as long ago as Pleistocene time.

A very interesting fourth class of deposits that range in age from perhaps early Pleistocene to the present time is found in the sink holes and caves that are especially abundant in a belt 3 or 4 miles wide, comprising the hill country immediately bordering the Mississippi River bottoms. The bulk of it consists of dissolved and re-precipitated lime and other minerals, chert, gravel, and clay. There are also old pond deposits—silt and clay—in sink holes that for a time contained water. The underground or true cave deposits are inaccessible, for few of the caves are more than slightly widened joints and fissures.

Glacial till and scattered glacial boulders.—Although the surface of southern Illinois is underlain with glacial till to a line far south of Ste. Genevieve County, there is very little of this material on the west side of the river, presumably because the high and hilly country on this side kept the ice hedged away. But it is impressive, though in a way accidental, that for a long distance south of St. Louis the border of the till is close to the Illinois-Missouri boundary line. However, that the ice did override a little of Missouri along this line is shown by scattered deposits some of which occur in Ste. Genevieve County. For example, on the river bluff at Little Rock just north of Ste. Genevieve and about 150 feet above low water of the Mississippi there is a small body of till composed of a clay matrix with pebbles and small boulders of chert, quartz, quartzite, and igneous rocks.*

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*NOTES BY FRANK LEVERETT ON PLEISTOCENE FEATURES IN STE. GENEVIEVE COUNTY, MISSOURI.

At the Little Rock quarries above Ste. Genevieve several feet of a very deeply weathered till is preserved where the rock has its greatest altitude, about 140 feet above the Mississippi River, or 500 feet A. T. A short distance above (west from) where quarrying was going on in 1923 some of the old till and red sandy gravel covered the rock to a depth of 3 to 5 feet. Above this is a gummy, slightly pebbly clay, about 10 feet in thickness, of mottled brown

Pebbles and boulders of quartzite and igneous rocks have been found at points up to 3 or 4 miles back from the river, as for example, at an altitude of 520 feet, a mile and a half east and a little south of Ozora, and at 540 feet, 2½ miles southeast of this town. The character, number and occurrence of these boulders, almost if not quite excludes the possibility that they were brought to their present positions by man or any other agency except the ice, whether they are related to the Illinoian till sheet of southern Illinois or are older is not definitely known. There is apparently more quartzite and fewer granite boulders than in the Illinoian till, but this may be due to the decay of most of the granite boulders.

Older terrace deposits.—Along the lower courses of all the larger tributaries of the Mississippi in Ste. Genevieve County are scattered terraces whose tops are between 390 and 430 feet above sea or from a few feet to 50 or 60 feet above the bottom lands, the Mississippi bottoms lying mostly between 365 and 375 feet above sea. The majority of these terraces are either about 420 to 430 feet above sea or else 390 to 400 and they are evidently remnants of two old bottom lands at these levels. Such terraces have been found and studied over a broad region in Illinois, western Kentucky and eastern Missouri. The higher and older deposits rests in places on the Illinoian till and in places is covered with loess, showing that its age is between Illinoian glaciation and later loess deposition.

The tops of the older terraces are at about the same altitude, but on the whole they rise gradually upstream and disappear at the upstream points where the present alluvium reaches an altitude of 420 to 430 feet.. The thickness of the deposit also decreases upstream from 50 to 100 feet near the Mississippi

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and gray color, and much less indurated than the old till beneath it. This upper clay is probably of Illinoian age. It seems more likely to have been laid down in ponded waters along the Illinoian ice border, than a direct deposit from the ice, though the Illinoian ice may have encroached on the bluff at this point. The old till is tentatively referred to the first or Jerseyan stage of glaciation. Both deposits are connected with the Labrador center of ice dispersion.

While the ice was covering the part of the Mississippi Valley below the mouth of the Missouri, the Missouri and Mississippi drainage appears, as suggested to the writer by Dr. H. A. Buehler, to have left the present Missouri near Labadie and passed southward across a saddle at Gray Summit into the Meramec drainage. The encroachment of the ice on the hills bordering the valley above Ste. Genevieve caused the drainage to pass back of those hills and across a saddle on the divide between Indian Creek and River aux Vases at Zell, at an altitude slightly below 640 feet. This saddle carries well-rounded stones of various kinds up to 5 inches in diameter, and thus seems to have been a spillway for waters ponded to that height in the district along and west of the present Mississippi between Gray Summit and Zell. This spillway was probably in operation at the earliest glacial stage. It is doubtful if ponding reached this height in the Illinoian stage.

bottoms, indicating that the terrace is not simply an old bottom land deposit like that of the present alluvium, but is rather a back fill due to aggradation on the part of the Mississippi. It has been found from the regional study of the various stream deposits that the bottom of the Mississippi channel was once about 160 feet below the top of the present alluvium or over 200 feet below the top of the older terrace deposit and that an over supply of sediment, perhaps at the close of Illinoian time, caused it to fill its valley to this great depth. This process, of course, blocked the outlet of the tributaries, but it took place slowly enough so that the tributaries in Missouri kept their bottoms built up and lakes developed only occasionally in flood time. The evidence of this lies in the fact that the older terrace deposits are sandy, have the stratification of stream deposits, do not contain remains of lake inhabiting molluscs, and the tops rise a little upstream.

The Mississippi, being a much more powerful eroding agent and having a relatively narrow rock bound valley, has washed away almost all of the upper part of its terrace deposits, leaving only little hills, some of which have been reshaped somewhat by Indians and are now known as Indian mounds. Excellent examples of these are found three miles southeast of Ste. Genevieve.

Remnants of the tops of both deposits are found in the form of terraces from 100 to 2500 feet wide on the lower 4 or 5 miles of Isle du Bois Creek, the lower 6 or 8 miles of Establishment Creek, the lower 8 or 10 miles of River aux Vases, and the lower 10 or 12 miles of Saline Creek.

Loess.—Along the Mississippi bluffs and to some extent on the hills and gentler slopes far back from the river is a deposit of massive yellowish silty material which is believed to consist of wind transported dust. Its especial abundance and somewhat coarser texture along the river suggests that much of it at least was picked up on dry, bare, river flats. Even now great clouds of dust may often be seen rising from such flats. The relations of the deposits to others throughout considerable portions of several states indicates further that between Illinoian and Wisconsin time, dust transportation was especially active, with the result that in spite of rain wash and other erosive processes continually in operation, many thousands of square miles were covered to depths of several feet and some small areas were buried under more than 100 feet of this material.

Most of the loess and, if the above theory as to its origin is correct, all of the unmodified loess contains no particles too large to be wind transported. In some places there is loess-like material that contains small to medium-sized pebbles and small angular fragments of chert, but it seems highly probable that this minor portion of the loess-like material is either not the same sort of a deposit as the great bulk of the material or else that through some agency, such as creep or crawfish borings, true loess has become mixed with other materials.

The loess on the river bluffs in Ste. Genevieve County is commonly 20 to 30 feet thick, but at a distance of a very few miles it is generally less than a quarter as thick, and farther back it is found in only scattered patches one or two feet thick. On the bluffs it contains here and there whitened shells of snail-like, air-breathing molluscs and concretions of lime carbonate. In some places the hard seeds of the hackberry tree have been preserved in it.

Beside the main epoch of loess deposition there were evidently others and presumably more or less dust has been laid down by the wind in all Quaternary epochs, only most of the time and throughout most of the region erosive processes seem to have carried away the dust almost as fast as it was dropped. The evidence of other loess deposits consists mainly of old buried soils with loess above and below, the occurrence of leached and otherwise weathered loess under unleached loess, and the occurrence of some loess over lower terrace deposits. However, the exact ages of the loess deposits older and younger than the main loess has not been determined.

Later terrace deposits.—The later valley filling is similar to the earlier except that on the whole it is somewhat more clayey and is not capped with loess. The clay commonly contains abundant calcium carbonate nodules that may have originated as algal secretions. The deposit contains shells of snail-like and clam-like molluscs such as live in the region to-day, particularly in forested areas with calcareous soil.

Recent alluvium.—Present flood plains or "first bottoms" are found along almost all the streams of Ste. Genevieve County. It includes much chert gravel of nearby origin, some of the pebbles being scarcely rounded at all. The Mississippi River alluvium, however, and that of the lower portions of the larger tributaries consists largely of sand and silt. In addition to the ordinary flood plain deposits there are numerous alluvial fans where small streams enter the valleys of much larger ones.

CHAPTER IV

STRUCTURAL GEOLOGY

Ste. Genevieve County is divided through its central part by a belt of faulting having a general northwest-southeast direction. This belt intersects the Ste. Genevieve-Perry County line three miles southwest of St. Marys, continues in a nearly westerly direction to Mill Creek one mile south of Staabtown (River Aux Vases), and then bends more to the northwest, passing just south of Weingarten, and intersects the Ste. Genevieve-St. Francois County line about two miles northwest of Lawrenceton. Beyond the limits of Ste. Genevieve County this belt of deformation has been followed eastwardly across northern Perry County through Lithium, and then southeastwardly nearly parallel with and along the line of the Mississippi River bluffs to a little south of Wittenberg, from which point it crosses the Mississippi River into Illinois at Grand Tower. West of Ste. Genevieve County the same zone of faulting crosses northern St. Francois County where it branches, one division going southwest through St. Francois County, then northwesterly through southern Washington County; the other division continuing in a northwesterly direction through southern Jefferson County, finally branching and disappearing in southeastern Franklin County.

In Ste. Genevieve County the formations exposed at the surface north of this faulted zone, range in age from the Potosi to the middle Chester formations of the Mississippian, but with the Lower Mississippian formations resting unconformably upon those of Ordovician and Silurian age, the Devonian being entirely wanting and the Silurian being all but wanting. South of the faulted zone the formations range in age from the pre-Cambrian crystallines to the Plattin limestone. Within the faulted zone itself, at least when its extension across Perry County is also, considered, with the exception of the pre-Cambrian and the Lamotte, all the formations which are present both to the north and to the south of the belt, are represented, and in addition to these an important series of Silurian and Devonian formations at least 1000 feet in thickness. These Devonian and Silurian beds can be but a remnant of the same formations as they were origially deposited in the seas of Silurian and Devonian time, which doubtless covered the whole or a large part of Ste. Genevieve County, and the preservation of these remnants is one of the questions involved in the interpretation of the structure in the faulted zone.

In that portion of the county lying north of the faulted zone, the rock strata exhibit a gentle dip to the northeast, the general strike being about north 30 degrees west. The dip varies from one to six or eight degrees, the average being about two or three degrees. Within this area the structure is simple except locally where there has been a limited amount of deformation. Such an area of local deformation is present in a hill on the north side of Indian Creek in the NW. ¼ sec. 33, T. 38 N., R. 8 E., a little over one mile northwest of the village of Zell.

In the area south of the faulted zone the structure is again simple, except for numerous more or less isolated faults which occur in the older formations. The rock strata exhibit the same gentle northeasterly dip, but with the strike a little more westerly being about north 40 degrees west but in the western part of the county the Farmington anticline produces a reversal of dip from the general northeasterly direction, and in some places changes the general strike of the rocks. In the more southern part of the county there is another area in which the general strike and dip are markedly changed.

Within the faulted zone itself the structure is very complex. The faults belong to two distinct systems, the deformation having taken place at two different periods, one in late Devonian time and the other post-Mississippian and in all probability post-Pennsylvanian. Throughout a part of the zone of deformation the faults of the younger system intersect the older ones, and in some places it is not easy to differentiate the faults of the two systems. Through a distance of nearly four miles, however, between Staabtown (River aux Vases) and Ozora, a little south of the line joining these points, the faults of the two systems are entirely separated one from the other, the older faulting lying to the north of the younger. It is in this region that the late Devonian age of certain of the faults can be demonstrated. Upon the hills on the opposite sides of Little Saline Creek one and one-fourth miles west of the crossing of the Ozora-Minnith road, the Lower Mississippian formations rest, on the north side of the creek upon Maquoketa shale, and upon the south side upon the St. Laurent limestone of Hamilton age. The basa Mississippian contact in these hills, at points less than one mile apart, are at essentially the same elevation at the present time, approximately 640 feet, but between the two points there is a fault, well exhibited in the east bank of Little Saline Creek just south of its abrupt bend to the east, which brings the Kimmswick limestone upon the northeastern or upthrow side, against the Bailey limestone of Helderbergian age. This displacement involves the beds of Middle Devonian age, but there is no displacement in the Mississippian. This fault has been traced continuously for a distance of nearly two and one-half miles, from the eastern end of the hill south of Little Saline Creek just west of the crossing of the Ozora-Minnith road, to the road running south from Rigdon's Mill on River aux Vases. It is a normal fault, the hade being to the southwest, as can be clearly seen in a short ravine about four-fifths of a mile southeast of the point of intersection of the fault with the Little Saline bluff. A westward extension of this same fault, with a slight change in direction, continues to a point about one and one-half miles northwest of where Jonca Creek empties into River aux Vases.

This fault may be taken as typical of the faulting of late Devonian age, which is of the normal or tension type, with the upthrow to the north and east. This deformation is not represented by one simple fault, however, and in the area specified above, where it is not involved with the later faulting, it consists of two more or less parallel faults less than one-half mile apart, with the intervening area crossed by numerous oblique lines of fracture. The entire amount of throw developed in the late Devonian faulting is approximately 1000 feet. Within this zone of late Devonian tension faulting there are certain blocks of greater or less size which have been dropped down between older beds on all sides. Such an area is the small triangular patch of Kimmswick limestone which is exposed along a tributary of Mill Creek nearly one and one-half miles southeast of Staabtown (River aux Vases), which is in fault contact with the Joachim limestone on the north and with the Plattin limestone on the south. A similar small block of Beauvais sandstone has dropped down between older formations, and is imperfectly exposed along the road from Rigdon's Mill to Little Saline Creek, about one-half mile north of the creek. Farther east, in the hills south of Little Saline Creek, both east and west of the crossing of the Ozora-Minnith road, there are other blocks of younger beds which have been faulted down on all sides between older formations. Such block faulting is especially well exhibited in the northern side of the crescent shaped hill lying between the Ozora-Minnith and the St. Marys roads. Beyond this hill to the east the Devonian faulting is lost entirely, it evidently passing beneath the Mississippian formations. The direction of the older fault system beyond this locality is probably more northeastwardly, diverging from the zone of younger faulting which continues across Perry County and passes into Illinois.

West of the faulted area along Little Saline Creek which has been described above, and which lies east of the Fredericktown road, the late Devonian fault system continues as two principal faults, both of which have been a little offset by the later system of faulting at points just west of the county road. The total amount of vertical movement in this more western area is less than in the eastern part of the county, being only about 550 feet. The northern one of these two faults has been traced in a northwesterly direction for about four and one-half miles beyond the Fredericktown road, which it crosses with a small offset with overlap, one mile south of the town of Staabtown (River aux Vases). This fault crosses River aux Vases and Jonca Creek just west of their point of confluence, and dies out about one mile northwest of the last named creek. The maximum throw of the fault in this region is about 250 feet, and it has a distinct hade to the south over much of its extent, a feature that is clearly shown by the curving line of the fault plane.

The southermost of these two main faults is more continuous than the one last described, for with the exception of a distance of about a mile a little southwest of Weingarten, it has been traced from a point about three-fourths of a mile northeast of the Boarman School to the Ste. Genevieve-St. Francois county line a little northwest of the village of Lawrenceton, a distance of about 18 or 20 miles. The fault is very irregular in direction, and makes numerous angles and bends. Through a part of the distance the fault plane has a distinct hade to the south, but elsewhere it is apparently vertical. The maximum throw is about 350 feet. On Mill Creek about three-fourths of a mile west of the Fredericktown road this fault is offset with overlap for a distance of about 1300 feet, beyond which point it continues in approximately a westerly direction but follows a very irregular trend, crossing the River aux Vases five times in a little over a mile of the streams course. The largest salient is in the western part of section 5, T. 36 N., R. 8 E., where an irregularly shaped wedge is dropped down. The throw at this point is comparatively slight. One mile farther west where the fault crosses River aux Vases the last time, it may die out, but the hills are all talus covered and the fault can not be followed. A quarter of a mile north, however, a fault involving the same formations, and which is possibly a continuation of the same one, has been observed and has been traced northwest across Jonca Creek, a little beyond which it disappears. A mile to the northwest, just beyond the Missouri-Illinois Railroad tracks, the late Devonian fault has been recognized again. It follows a tortuous course to the south branch of Establishment Creek where the deformation is very complex at the pump station just west of the creek. Some of the dislocations here are so slight and so crowded that it is impossible to show them on a map of small scale. Beyond this point the fault follows a general northwesterly direction to the county line.

The most complex portion of this Devonian fault system lies between the pump house on Establishment Creek and the Potosi-Ste. Genevieve road, where the formations involved are much broken up by the numberous angles made by the main fault and its many branches. A long and sharp salient is present just northwest of the west branch of Establishment Creek (designated as Hickory Creek on the map), and the fault makes another sharp salient in the southwest corner of sec. 4, T. 37 N., R. 7 E. Within this salient or partially enclosed block, the throw is not less than 200 feet, whereas a short distance to the northwest, along the continuation of the fault, the throw is but 60 or 70 feet. Beyond here the fault is a simple one and makes only small angles and has but few minor branches, and it exhibits a maximum throw of about 350 feet. Northwest of Lawrenceton the fault dies out in a short distance, and has practically disappeared at the county line. No detailed work has been done in St. Francois County northwest of this point along the line of the fault, but the late Devonian movement probably does not continue farther in that direction.

In the post-Pennsylvanian faulting the upthrow is on the south, and the maximum displacement is about twice that of the earlier period of faulting where the upthrow was on the north. The age of this younger faulting, as indicated by the formations involved in Ste. Genevieve County, is post-Burlington, but farther east in Perry County, Mississippian beds of Chester age are involved, and still farther southeast, across the Mississippi River in Illinois, the Pennsylvanian formations are involved in what is believed to be the same zone of deformation, so it is safe to assume that the age of this faulting is post-Pennsylvanian.

The faulting which was accomplished at the later geological period is typified by the fault which crosses a tributary of Little Saline Creek about 100 yards north of Boarman School. This fault has been traced from the Little Saline crossing of the Ozora-Minnith road where it intersects the main Devonian fault which has been described, it extends in a westerly and then a southwesterly direction, past Boarman School, for a distance of two and one-half miles or more, and crosses the Little Saline where that stream flows in a northerly direction. Beyond this point the fault breaks up, and the several branches continue in a northwesterly direction, and beyond Mill Creek three of the limbs become involved with the older, late Devonian faulting and subsequently die out. East from the Ozora-Minnith road at the Little Saline crossing, the post-Pennsylvanian fault is also broken up, and is involved with the late Devonian faulting for a distance of one and one-half miles, beyond which point the entire exposed faulted zone is probably a continuation of this younger fault system.

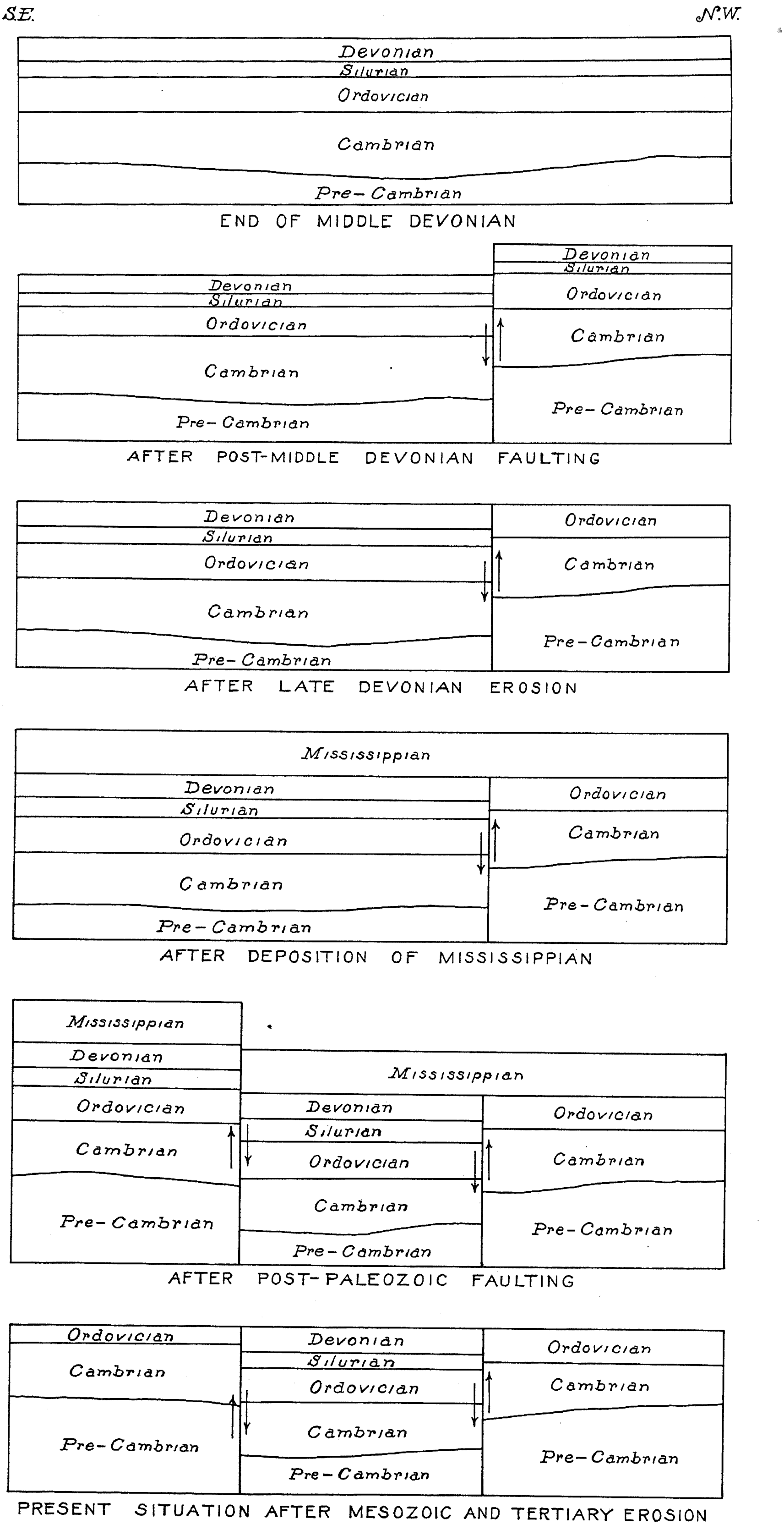
From the point where the post-Pennsylvanian fault crosses the Little Saline Creek west of Boarman School, the trend of the many branches is in a westerly direction as far as River aux Vases, a distance of about six miles. Whereas east of Little Saline Creek there is but one main fault, west of that stream and nearly to Mill Creek there are as many as six more or less parallel faults, some of which exhibit minor branching. Since these several limbs of the fault system exhibit different characteristics, they will be briefly described for a few miles of their course.

The northern most of these faults extends northwest from Little Saline Creek, crosses the Fredericktown road and intersects at Mill Creek, the older Devonian faulting which it offsets about 1300 feet. A mile beyond this point, at the top of the ridge, the fault seems to die out, but 1000 feet to the southwest a similar fault is present which at its southern end has a throw of only about 20 feet, and the two are probably connected by a small movement. Continuing in a northwestward direction to River aux Vases, this fault is joined by another one which has a throw of about 60 feet, belonging to the same system. These two intersect a small branch Devonian fault at the river, make a turn to the west and form a salient, the southern arm of which terminates at the late Devonian fault where the latter makes its first crossing of River aux Vases.

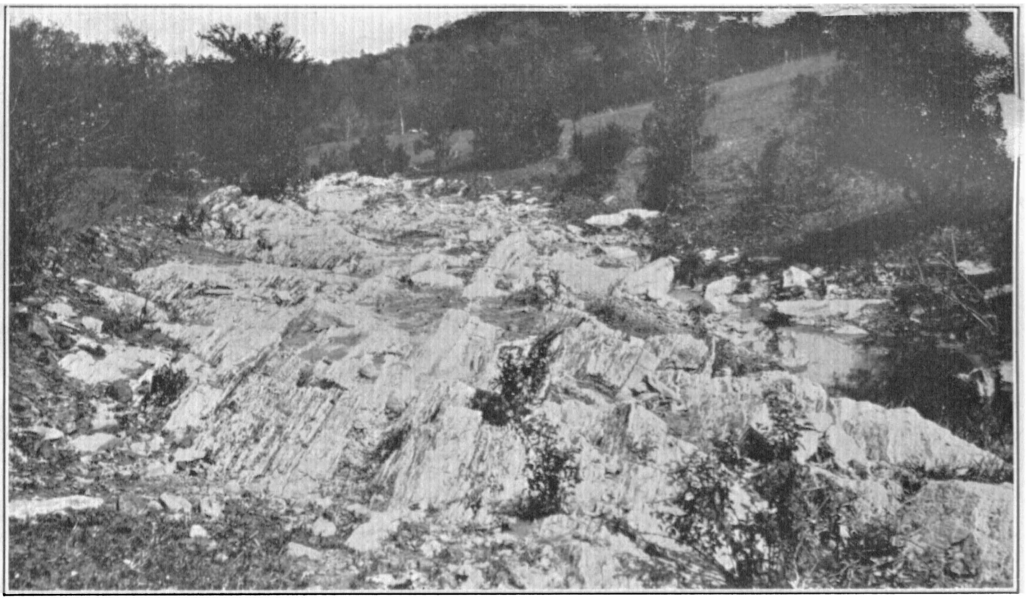
The next fault limb to the south, trends a little north of west. Half a mile west of where it crosses Mill Creek it becomes involved with the late Devonian faults. Its hade is to the south, a fact shown by the shifting of the direction of the fault plane with the topography, and it seems probable that this dislocation was due to a thrust, although the angle of hade is small.

A dislocation that starts just west of Little Saline Creek as two fault lines, is augmented between this creek and the Fredericktown road by branching, to four well defined and closely paralleling faults, all of which have south dipping hades over much of their course, although in some places the fault planes seem to be essentially vertical. One of these limbs joins the last described thrust fault at a point about half a mile west of the Fredericktown road and just south of Mill Creek, while the other three continue in a westerly direction. Just east of the Fredericktown road where the entire fault system is represented by six paralleling limbs, the total dislocation is between 1100 and 1200 feet. One mile west of the Fredericktown road the three southernmost limbs have a throw of about 700 feet. The northern one of the three makes a very sharp salient at this point, doubling upon itself for about one-third of a mile, then crosses Mill Creek and continues northwest to River aux Vases, a distance of about one and one-half miles where it terminates at the late Devonian fault. The two remaining limbs continue westward with a number of minor offshoots, and become joined in the NE. ¼ sec. 8, T. 36 N., R. 8 E., by a sharp salient which is made by the lower one, but in less than a quarter of a mile the fault again divides. At this point the throw of the single fault is only about 550 feet, but one mile to the west the throw of the whole system is about 700 feet. Just east of River aux Vases, branching produces four, more or less parallel faults, two of which join again in a short distance. An offset fault is largely responsible for the topographic feature which is presented by the pinnacle rocks on the east side of the river.

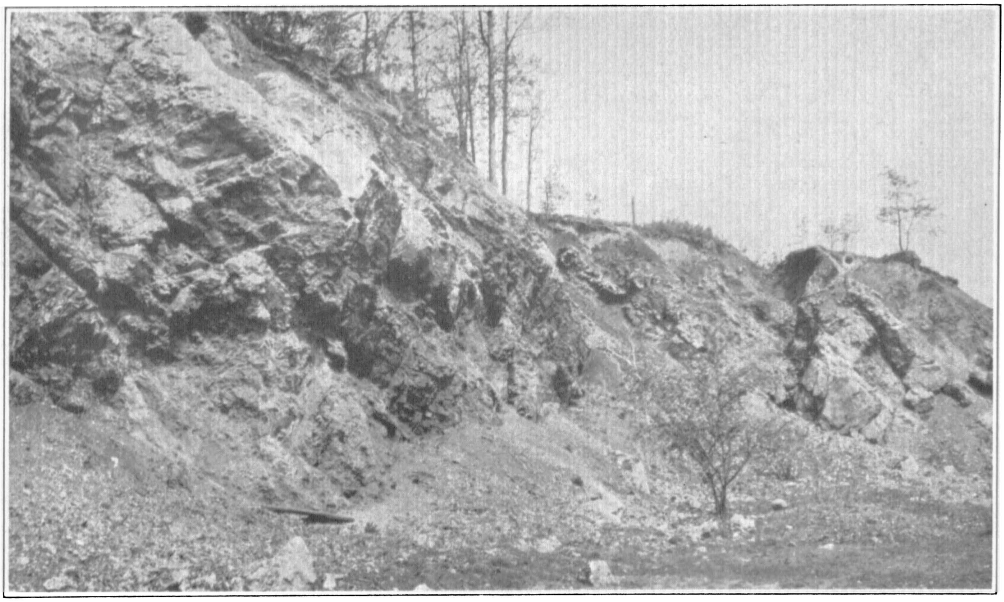
At River aux Vases the trend of the faulting changes to the northwest which direction prevails to the county line. The Lamotte sandstone is brought to the surface for the first time by the faulting and is in juxtaposition with the younger formations as far northwest as the south branches of Establishment Creek, a distance of nearly four miles. The throw of the fault



Block diagram showing age of faulting.



A. Highly dipping strata (Bonneterre) along fault in sec. 27, T. 37 N., R. 7 E.



B. Brecciated beds along fault in railroad cut southwest of Weingarten.

system through here is about 1150 feet. One mile west of Weingarten the Jefferson City formation occurs in juxtaposition with the Lamotte.

The best locality in the county to see the diastrophic effects of the younger faulting is in the railroad cut one mile southwest of Weingarten, the brecciation in a part of the fault zone at this locality being shown in the photograph on Plate XI, B. Just north of this exposure the effect of the fault is well exhibited at Establishment Creek. From here for about three and one-half miles in a northwest direction the fault zone is composed of paralleling and minor offsetting branches and block faults. The movement is very complex. Some of the salients are very sharp, and one of them brings the main fault of this system to within 200 feet of the older Devonian fault where both have approximately the same throw, about 200 feet. This locality is in the bed of the west branch of Establishment Creek (Hickory Creek on the map), and if it were not known that the two faults belong to widely different geologic ages, the formational relations could easily be misinterpreted as a narrow block of Jefferson City which had been dropped down against the Gasconade. These relations show how closely the younger faulting has followed the line of weakness which had been responsible for the earlier movement, and which undoubtedly was augmented in some measure by the Devonian faulting.

Two miles farther northwest the fault makes a sharp salient. The throw at the apex of the wedge is between 300 and 350 feet, but on the returning limb the movement dies out, probably becoming involved with the sharp salient of the late Devonian fault a short distance to the east. For a distance of one-half mile from here there is no evidence of the post-Pennsylvanian fault, but just south of the Potosi-Ste. Genevieve road in the east side of sec. 5, T. 37 N., R. 7 E., it forks with the Devonian fault and extends northwest as a simple fracture, becoming involved with the late Devonian fault beyond Lawrenceton. The combination of these two faults produces an apparent down-dropped block of the Jefferson City formation, extending for nearly three miles, with the Gasconade on both sides, the two faults being within 500 feet of each other in several places. The maximum throw within the block is in the northern and narrower half, with a displacement of about 350 feet.

One-half mile west of Lawrenceton the post-Pennsylvanian deformation is continued by the simple fault which extends northwest for about one and one-half miles to the county line. The same fault system continues northwest from the Ste. Genevieve County line one-half mile southwest of the last mentioned fault. In the south center of section 27, T. 38 N., R. 6 E., the throw is only 50 feet, but farther northwest the displacement increases. Beyond French Village in St. Francois County, the fault branches, the southern limb has been traced to the western boundary of Washington County, and the northern limb into southern Franklin County. The maximum throw observed is about 700 feet in southern Jefferson County.

Unlike the late Devonian deformation which was occasioned by a stretching or lengthening of the earth's crust to produce normal faulting, this post-Pennsylvanian faulting accompanied a shortening or compression of the crust, producing faults of the reverse or thrust type. That there was distinct compression and shortening of the crust at this time is shown by the vertical and in places overturned strata along the downthrown side, adjacent to the fault line. Such vertical and even slightly overturned beds of Burlington age are well exhibited at the point where the northernmost fault of the system crosses a short tributary of Saline Creek, two and one-half miles west of the intersection of the fault zone with the Ste. Genevieve County line. Farther east in Perry County, at the point of the bluff just south of the railroad station at McBride, beds of St. Louis limestone are overturned to the extent of 130 degrees. Again, still farther southeast, in a cut of the Frisco railroad a short distance below Red Rock Landing, the older rocks on the upthrow side of the fault, probably Canadian in age, are exposed almost in fault contact with the overturned limestone of Lower Mississippian age. West of the point where the post-Pennsylvanian fault crosses Little Saline Creek, west of Boarman School, several branches of the fault system exhibit a distinct hade to the south, as is shown by the northward swing of the fault line as it crosses the hills, this hade being in the direction to be expected with reversed faulting. South of the first line or lines of faulting, however, there are other faults which are clearly of the normal type, indicating that following the initial compression and breaking of the crust, and the consequent relief of the accumulated strains, the beds settled back to some extent, the adjustment taking place through the development of normal faults which are minor in importance as compared with the initial reversed faults.

With the recognition of the two fault systems within the faulted zone in Ste. Genevieve County, formed at two widely separated time periods, the interpretation of the large, synclinally folded, diamond shaped area northwest of Boarman School, as as well as some of the blocks farther to the northwest, is very different from what it would be if all the faulting had taken place contemporaneously. Had the faulting on both north and south sides occurred at the same time, this area would be interpreted as a down-dropped block, but under the conditions here presented it is to be interpreted as a remnant of the earth's crust in southeastern Missouri, in which has been preserved a much more complete sedimentary record than elsewhere in the region. This remnant retains to the present time more nearly the original attitude of the beds. It has never been dropped down between the crustal masses on either side, but has remained approximately stationary while the area to the north was first upthrown in late Devonian time, and then the area to the south was elevated at a much later period. The succession of events which has brought about the present relations of the strata is shown in the accompanying diagrams in which each of the two fault systems is represented as a single fault, vertical in position.

The age of the faulting which exists south and southwest of the main fault zone which has been described, is indeterminate. With one exception, which will be described later, the faults are of the normal type, and are the result of local stresses only. Most of these faults involve the Cambrian formations. Some of them may be the result of underground solution, and subsequent breaking and settling of the upper beds. Most of the solution would probably have taken place in the Bonneterre dolomite, and many of the areas of irregular dip which are so well exhibited along the larger streams are probably due to some extent to underground solution.

There are several faults of some importance on the eastern side of the Lamotte sandstone area north of the Missouri-Illinois railroad which bring the Bonneterre into juxtaposition with the Lamotte. The lines of weakness may have been induced by the stresses which produced the Farmington anticline, and the actual movement may have taken place at the same time or following the big faulting which is located but a few miles to the east.

The fault which originates near the county line in the SW. ¼ sec. 4, T. 37 N., R. 6 E., and extends for several miles northwest is evidently a thrust fault, the Lamotte sandstone being raised on the north side into juxtaposition with the Bonneterre, which outcrops on the south side of the fault. Near the southwest corner of sec. 4 the overturned beds associated with this fault are plainly exhibited. The thrust movement along this fault plane was probably caused by the faulting of post-Pennsylvanian time, which is situated only about two miles to the north.

CHAPTER V

HISTORICAL GEOLOGY

INTRODUCTION.

The historical record of geologic events in Ste. Genevieve County is the most complete to be found anywhere in the State of Missouri. The most ancient record preserved in the rocks of the earth's crust in this district carry us back to Archean time, while the latest record of the hard rock geology brings us to the late Mississippian, the Pennsylvanian only, of the whole Paleozoic era, being without any recorded history. In the unconsolidated surficial deposits some events of the Tertiary and Quaternary periods are registered.

In the discussion of the geological history of the region, the events will be considered in their logical sequence from the most remote time down to the present. The gaps in the record are numerous, some of which are of long duration, and during such interruptions many geologic events are known to have been in progress in other parts of America or in other continents. For the complete geological history, the local records of many such regions as that under consideration must be combined. This is only one sector of the great battle line of the ages, and while historical events of great importance were in process of accomplishment elsewhere, all may have been quiet here, and likewise, while there was much action here, some other regions were undisturbed.

In general the Geological history of any area in the Mississippi Valley consists of a series of alternate periods of submergence beneath the sea and emergence as dry land. These periods vary greatly in time duration, and the submergent periods differed in the depth of the waters, although at no time are they believed to have been other than shallow seas, perhaps with a maximum depth of from one hundred to three hundred feet. The geography of both emergent and submergent periods was constantly changing, and the several shore lines of the shallow seas were constantly advancing upon the land or retreating. Because of local warpings and other movements of the earth's crust, the actual topography of the solid crust was changing more or less continuously so that successive advances of the sea did not always follow the same course as those which had preceeded or which might follow them. At intervals during the succession of events in the region under consideration, more violent crustal movements took place, leading to important folding or faulting of the rock strata.

The changes in level of the sea relative to the land surface, have been occasioned either by very gentle crustal activity of the immediate region, affecting the attitude of the land, or by movements in other portions of the earth that have affected the ocean level. If the bottom of the ocean were anywhere to be notably depressed, thus increasing the capacity of the basin, the effect would be to lower the general level of the ocean throughout the world, and the consequent emergence of surfaces which had been covered by the shallower portions of the sea. In the same manner the general level of the entire ocean surface might be raised by the filling up of portions of the basins occupied by the oceans, by materials transported by streams anywhere in the world and deposited in the ocean. The phenomena observed in Ste. Genevieve County in connection with the Paleozoic stratigraphic succession may therefore be accounted for by geologic activities far distant from the immediate region under consideration. On the other hand the same stratigraphic relations may have been occasioned by local movements of the crust, or by a combination of local and more general movements. The real facts in the case can only be determined by a much broader study than is possible in such a limited area as a county or a state. If the stratigraphic breaks could be shown to be contemporaneous with similar phenomena in many portions of the world, the inference would be that the emergence producing the break was brought about by some factor that affected the ocean level generally throughout the world, but if no such correlation could be established the phenomenon would most likely be due to some local movement.

PRE-CAMBRIAN HISTORY

The oldest known rocks of the earth's crust, assigned to the Archean period, are of both igneous and sedimentary origin. This series of rocks, spoken of as the "basement complex," has its type areas in the Lake Superior region and in Canada. Intruded into the "basement complex" are the igneous rocks that have been grouped as Laurentian, and the granites and porphyries of Missouri have been assigned tentatively to this series. If the reference of these pre-Cambrian crystalline granites and porphyries of Missouri to the Laurentian is correct, then the recorded history of the rock succession of the area that is now included within the boundaries of Ste. Genevieve County, begins with a series of rocks which are associated with some of the earliest events in geologic history.

Granite is a rock which has been formed at considerable depth in the earth's crust, through the crystallization of the mineral constituents of a molten or liquid magma. The porphyry found in this region, which has practically the same mineralogical composition as the granites, has cooled more rapidly, and therefore the crystals in the greater part of the rock have not had time to grow to the size of the crystals that are found in the granite rocks. The phenocrysts of the porphyry are mineral aggregates of earlier crystallization which are included in the finer grained ground-mass at the time of solidification. Since the mineralogical compositions of the granite and the porphyry are the same, it is commonly assumed that the two rocks are differentiation products of the same general magma.

The red Missouri granite and the porphyry are evidently the oldest of the pre-Cambrian igneous rocks exposed in Ste. Genevieve County, but dikes of gray granite and finer grained red granite cut these older plutonics in a number of places. An excellent example of this relation is exposed on Pickle Creek near the Niedringhaus feldspar diggings, in sec. 11, T. 36 N., R. 7 E. The contact is sharply defined and small apophyses of the gray granite can be seen filling cracks which existed in the older red granite. At Jonca Falls, sec. 2, 36 N., R. 7 E., a finely crystalline granite dike cuts the older red granites and a small granite dike is also seen to cut the porphyry in sec. 10, T. 37 N., R. 6 E.

The basic dikes are of a later period of eruption since they fill the small fissures within the granites and the porphyry, which probably were made by the contraction of the rocks upon cooling. The pegmatite veins, which are closely related to the basic dikes, probably represent the siliceous end product of differentiation in this district.

The period of activity which produced all of these igneous rocks was completed long before the deposition of the Lamotte sandstone. The intervening time must have been long for all of the original rocks of the crust of the earth under which the granites and porphyries must have been formed were removed by erosion and the Laurentian crystallines exposed to denudation. There may have been a submergence of the land during Huronian time and the deposition of sediments that formed as much as 200 feet of conglomerate and shale in favored localities. If such a submergence did occur, the series of rocks which were accumulated during its existence has also been removed entirely except some remnants in the neighborhood of Pilot Knob, Iron County. The differential erosion of the Laurentian granite and porphyry produced the irregular floor upon which the Upper Cambrian clastics were deposited, and this also represents a long period of time. It is possible that the Pilot Knob iron bearing formations may be a terrestrial deposit, and therefore may never have been continuous over the whole district, and such an origin, of course, might eliminate the possible Huronian submergence.

Aside from the intrusion of the dikes into cracks and fissures in the granite and porphyry rocks at some time after they had cooled, and the formation of the supposed Huronian conglomerate and slate, probably in very restricted places, the geologic history of southeastern Missouri records continuous processes of degradation rather than aggradation up to late Cambrian time. Thousands of feet of rocks must have been removed, a fact which makes the uncomformity between the pre-Cambrian crystallines and the Paleozoic sediments the largest in the geologic history of the state.

CAMBRIAN PERIOD

During lower and middle Cambrian time the Ozark region was an exposed land surface. Sediments deposited during these epochs are present in the western part of the United States and in restricted areas in the Appalachian region. The nearest areas to Missouri in which sediments of this age are known are the Alabama and Tennessee basins.

At the beginning of the St. Croixan epoch of the Upper Cambrian, the sea advanced northward in the Mississippi Valley as far as Minnesota, and the first Paleozoic marine sediments in Missouri were deposited at this time. The formations which are composed of these sediments are correlated with those of Upper Cambrian age in the Alabama basin, parts of the Tennessee basin of the Appalachian Valley, and some of the Upper Cambrian formations of Oklahoma and the upper Mississippi Valley.

Lamotte Time. The encroaching Lamotte sea overspread a very uneven surface in Ste. Genevieve County. The long time during which the pre-Cambrian crystallines had been exposed to erosion had produced many depressions between adjacent areas of higher land, and the granite hills in the western part of the county represent the higher parts of the pre-Lamotte surface. The clastic sediments which make up almost the entire Lamotte formation, filled the large depressions and other irregularities, the tendency being to produce a more even surface. The sea was comparatively shallow for irregular beds of conglomerate and extensive cross-bedding are characteristic features. The conglomerates probably signify the nearby presence of granite hills which were still above the surface of the sea at the time that particular horizon was being deposited. The overlapping Lamotte sea covered all the land surface in Ste. Genevieve County, although at the end of this time there were granite and porphyry hills to the west that had not become submerged.

In the latter part of Lamotte time there was a slight change in the character of the deposits in Ste. Genevieve County and nearby areas. About 50 feet from the top of the formation there is a bed of yellowish magnesian limestone with a usual thickness of about 10 feet, but in many places it is much thinner or even entirely wanting. At Farmington this bed is 96 feet below the top of the formation, and near Doerun and Iron Mountain the dolomite is 37 feet thick and about 38 feet below the top. Following the more quiescent condition of the sea during which stage the calcareous deposits were formed, deposition of clastics continued throughout the remainder of Lamotte time. This interruption of the clastic sediments of the Lamotte formation doubtless records a short period of greater depth of the seas, during which time nearby land areas were submerged to such an extent that all sources of origin of the sand which had formed the great mass of the formation, was removed. With the subsequent withdrawal of the waters and the consequent shallowing of the seas, conditions for clastic sedimentation again returned, and the higher sandstone member of the Lamotte formation was accumulated.

Little is known of the fauna of the Lamotte sea: Clastic sediments deposited in a shallow sea which was in almost constant motion formed an unfavorable environment for the preservation of the shells of animals. However, a few species are known, and many shell fragments, probably of linguloid brachiopods, have been found.

Before the beginning of the limestone sedimentation of Bonneterre time, the Lamotte sea withdrew from Ste. Genevieve County and the immediately surrounding area, but the extent of the withdrawal cannot be determined as the sandstone is exposed only in the St. Francois Mountains region and therefore the unconformity is covered by younger formations elsewhere in the state.

Bonneterre Time. The time interval between the deposition of the Lamotte and the Bonneterre formations probably was not of great duration, geologically speaking. The irregularities produced by the erosion of the Lamotte surface are not sharp, but are undulating in character, and wind erosion may have been instrumental in the formation of such topographic forms. The advance of the Bonneterre sea changed the area from one of mild denudation, to one of calcareous sedimentation, and the fact that the greater part of the formation is non-clastic, indicates that the advance of the sea was comparatively rapid, promptly cutting off by submergence, the source of supply of sandy sediments. The basal beds of the Bonneterre are peculiar in their lithologic character, being made up of an irregular intercalation of dolomite, sandstone, and thin shale beds, although locally both sandstone and shale are absent. The most striking feature is the presence of rounded grains of glauconite which may be scattered through as much as 50 feet of the lower part of the formation, and locally constitutes entire beds. Where the unconformity is pronounced these basal beds are much thinner and in places are absent. The presence of this type of deposit at the base of the Bonneterre in other parts of the state, as shown by drill cuttings, is evidence that the peculiar chemical condition of the sea at this stage was widespread.

Although in most areas there probably was continuous deposition throughout Bonneterre time, a distinct interruption is recorded in at least a part of Ste. Genevieve County. The different types of sediments in the formation which prevail upon the opposite sides of the Farmington anticline, as has been brought out in the description of the lithologic characters of the formation (see page 41), demands consideration in this connection and some interpretation. This geographic difference in lithologic characters is not restricted to the Bonneterre alone, but is continued into the Davis and the Derby-Doerun, and is of such a nature as to suggest some sort of a barrier along the line of this structural axis. Heretofore the time at which the

Farmington anticline was formed, has been a subject of pure speculation, but the stratigraphic study of the Cambrian formations in Ste. Genevieve County has brought forth some date bearing upon the interpretation of this structural feature.

The different character of the Bonneterre sediments above the basal beds, more particularly in the lower half of the formation, especially the presence of more shaly and argillaceous dolomite on the north and west sides of the Lamotte sandstone area of Ste. Genevieve County, than in the type locality of the same formation farther west in the Flat River and Bonneterre districts, suggests the presence of a land area to the east of this locality, from which some land derived materials were carried into the sea. There is also a marked lithologic difference and variation in thickness between the Davis as exposed in Ste. Genevieve County and at the type locality near Flat River. Furthermore, the Derby and the Doerun formations in Ste. Genevieve County are notably thinner than in the type area but a comparatively few miles west. All of these facts furnish evidence bearing on the possible presence of a barrier continuing from early Bonneterre time to the close of the Doerun epoch, between the Flat River area of deposition and that of Ste. Genevieve County and the essential coincidence of this barrier with the axis of the Farmington anticline may be taken as indicative of the age of formation of the anticline, at least the initial development of the structure, in early Bonneterre time.

The earliest sediments of the Bonneterre sea were deposited across the Lamotte area, for the basal beds are found as outliers scattered over the sandstone, but the succeeding beds of the formation may never have been deposited over the present exposed Lamotte. The key to the explanation of this distribution of the sediments is found in the southern part of the county, in sections 9 and 16, T. 35 N., R. 7 E. In the SE. ¼ sec. 9, on the county road, and west center of sec. 16, at the shallow well, the basal Bonneterre beds are exposed, yet only 60 feet higher stratigraphically, the Elvins formations are present, above which is the Potosi. Exposures are few in this locality, and there is no direct evidence that faulting is responsible for the small development of the Bonneterre formation.

From a consideration of all of these data it seems reasonable to assume that the initial folding in the Farmington anticline occurred early in Bonneterre time, and that the deformation was of sufficient magnitude to form a barrier which influenced the character of the sediments on opposite sides, and that this barrier may have been emergent during at least a part of the time. The influence of this barrier upon the character of the sediments persisted through the time of deposition of the Davis and Derby-Doerun formations.

Unstable conditions prevailed throughout Bonneterre time which affected sedimentation on the eastern side of the barrier to a far greater extent than in the western basin, but since the supposed barrier was probably of small extent, the conditions which caused the differences in sedimentation were local. The shale beds may have resulted from slight uplift of land areas east of the barrier, or from change in direction or strength of the sea currents which transported sediment to this area. Meterologic changes may also have had some influence in the variation in sedimentation, but it is more probable that the irregularity in the shale beds, both stratigraphic and areal, would be the result of changing currents rather than terrestrial or climatic changes.

Davis Time. There is no well defined physical evidence of an interruption in sedimentation between Bonneterre and Davis times, although the character of the sediments is markedly different. On the west side of the Farmington anticline the Davis shows many interruptions in its depositional history due to the shifting of the strand line produced by movements of the land near at hand, or by oscillations of the sea resulting from more distant disturbances. These changes are not recorded in Ste. Genevieve County on the east side of the anticlinal barrier, for the complete Davis succession is not found in this area, the sediments which are present being more closely like the upper 63 feet of the typical Flat River Davis, that is, like the beds above the "Central" boulder horizon. Very different conditions prevailed in the two adjacent areas during at least the early part of Davis time.

During Davis time in Ste. Genevieve County, sedimentation was irregularly affected at various stages, probably by changes in ocean currents which transported argillaceous material and deposited it in eddies to form the shale beds which are found outcropping at various places in the county. Aside from these occasional influxes of terrigenous material the formation is composed chiefly of dolomite, in the lower beds of which chloritic particles are found disseminated in numerous localities.

Fossils are found in a few places in the shales of the Davis formation, but their preservation in the dolomite is of rare occurrence. In the few limestone beds of the formation the remains of trilobites are abundant.

Derby-Doerun Time. There is no evidence that the sea withdrew from Ste. Genevieve County at the close of Davis time, for no break is recorded in the rock strata. Conditions of sedimentation changed somewhat, for the small amount of argillaceous material carried into the sea was deposited along with the dolomite and not as beds of shale.

The variation in thickness of the Derby-Doerun beds in the county is thought to be due to oscillations of the sea bottom causing suspended deposition locally, rather than to any definite break in sedimentation between the Derby and Doerun stages. Obviously conditions were more unstable here than they were on the west side of the Farmington barrier. Towards the close of the epoch the rocks show that considerable argillaceous material was being carried into the sea.

Whether the original thickness of the Doerun sediments was small in Ste. Genevieve County, or whether a considerable part of the formation was removed during the stratigraphic gap between the Doerun and the overlying Potosi, cannot be certainly determined. It is believed, however, that the length of time during which the formation was exposed to erosion in the emergent interval between these two formations, was ample for the removal of the entire Doerun, a condition which obtains in the northern part of the county.

Life either was not abundant in the sea of Derby-Doerun time, or else conditions for the preservation of fossils were unfavorable, for only a few beds containing fossils have been discovered.

Pre-Ozarkian Emergence. At the close of Derby-Doerun sedimentation, the sea withdrew, leaving the whole of Missouri as a land area. This time of emergence was of long duration, for the interruption in the geologic succession in Missouri, is recorded in the sediments of the Appalachian basins, and in the thick deposits in Alabama which are older than the Potosi deposits of Ozarkian time in Missouri, but are younger than the sediments immediately beneath this formation. The physical evidence of this interruption is not recorded by a conspicuous erosional unconformity in Ste. Genevieve County, for aside from the varying thicknesses of the underlying Doerun and the overlying Potosi, no other physical evidence can be presented. The change in fauna, however, is well marked.

This stratigraphic break recorded at the top of the Nolichucky and Conasauga shales in the Appalachian basins in Tennessee and Alabama, and at the top of the Elvins in Missouri, together with a complete change in fauna, has led Ulrich[1] to make a systemic division of the Ozarkian, at this horizon. The existence of a series of formations to which the name Ozarkian is applicable cannot be seriously denied by anyone, but the advisability of recognizing this division as of systemic rank is not so clear.

The Ozarkian marks the advent in the marine faunas of this region, of many gastropods and cephalopods of types entirely unknown in the older Cambrian rocks, and at the same time the fauna retains some of the typical Cambrian trilobites, but Ulrich has not yet published any comprehensive description of the Ozarkian fauna. It is known, however, that the part of the Ozarkian succession found in Missouri contains many fossils locally.

Potosi Time. Ozarkian deposition began in the Alabama basin with the Briarfield and Ketona dolomites, which have an aggregate thickness of over 1500 feet, and are not represented in Missouri. The Ozarkian sea, therefore advanced from the south, spreading over Missouri in Potosi time. The Potosi sea was probably the most wide-spread that had yet covered Missouri, for it overlapped the older formations and deposited its sediments directly upon the pre-Cambrian crystalline rocks in numerous places.

The character of the Potosi sediments was widely different from any of those which had been deposited previously. Large amounts of silica were carried into the sea and precipitated in a disseminated form throughout the magnesian limestones which make up the formation. Part of this silica may have been supplied by organisms, for the honeycombed cherts are at least suggestive of the presence of some organic growth, but no well preserved fossils have been found in the Potosi rocks, except a species of *Cryptozoon* which has been observed in a few localities.

Sedimentation during Potosi time was very regular with no evidence of interruption at any horizon. This formation in Missouri is closely simulated by the Potosi in the Cahaba Valley

[1]Bull. Geol. Soc. Amer., vol. 22, p. 548 (1911).

of Alabama, and the deposition is supposed to have been contemporaneous in the two regions.

Post-Potosi Emergence. An unconformity exists between the Potosi and lower Eminence at places where the contact has been observed, a condition which shows that in Ste. Genevieve County there was withdrawal of the sea, permitting the land to be exposed to subaerial erosion during the intraformational time, and also during lower Eminence time. Under the description of the Potosi formation (see page 57), it has been shown that the Potosi siliceous druses were formed either just before or during this emergence.

Eminence Time. So far as can be observed sedimentation was continuous from Potosi through Eminence time, and the younger seas seem to have been of much the same character and extent as the older. Silica was apparently abundant in both. Evidences of life in the waters of Eminence time are more abundant than in the preceding seas, but this may be more apparent than real, since we know very little about the conditions favoring preservation.

Gasconade Time. The next submergence of Ste. Genevieve County was probably the most widespread that had yet covered southeastern Missouri. A study of the stratigraphy of the Ozark region seems to show that the incursions of the sea during Upper Cambrian, including Ozarkian, time, were a series of progressive overlaps. When the Gasconade sea advanced it is believed that the Ozark region, with the possible exception of the highest peaks of the St. Francois Mountains and perhaps some isolated granite hills in a few other places within the state, was completely covered for the first time.

The beginning of Gasconade time was marked by a complete change in the character of the sediments in Ste. Genevieve County and in some other parts of central Missouri. During the initial stage, as much as 40 feet of white sandstone, the Gunter member, composed of well-rounded quartz grains, was deposited in depressions in the pre-Gasconade surface, but elsewhere the sandstone is much thinner or even entirely absent, this varying thickness of the Gunter sandstone member being an expression of the uneven surface upon which the Gasconade was deposited.

The character of sedimentation changed abruptly at the close of the Gunter stage, and calcareous material was deposited during the remainder of this time. There were, however, oscillations of the nearby land surface, for there are a few very local intraformational unconformities in the Gasconade, a relation which shows either subaerial erosion or marine scour, and also a few irregular but sharply defined sandstone horizons.

The Gasconade sea was evidently teeming with life for the casts of gastropods, cephalopods, trilobites, and some brachiopods are found well preserved in the cherts of the formation, and less so in some siliceous dolomite beds. The sea was shallow during most of the epoch, for species of *Cryptozoon* are found widely distributed throughout the formation, in places occurring in reefs. The vermicular or honeycombed cherts which are typical of the Gasconade may be the silicified remains of some plant life which thrived in the shallower parts of the sea.

Post-Gasconade Emergence. Gasconade time was brought to a close by orogenic movements which caused the land to emerge from beneath the sea. In some parts of Missouri the upper beds of the Gasconade show by their character the changing conditions of sedimentation, but in Ste. Genevieve County the break was probably more abrupt, for calcareous sediments appear to have been deposited up to the close of the epoch. According to Ulrich the retreat of the late Ozarkian sea affected the greater part if not all of the North American continental area that had been subjected to sedimentation during the period, but in Ste. Genevieve County the direct evidence of a post-Ozarkian erosional unconformity is not plainly shown, although indirect evidence confirms the existence of a considerable break in the sedimentary succession at this horizon.

ORDOVICIAN PERIOD

The lowermost or Canadian series of the Ordovician has been considered as a separate System by Ulrich[1], but it seems wiser for the present, at least, to pursue the more conservative course and consider the Canadian as the oldest subdivision of the Ordovician. In Ste. Genevieve County Canadian time was brought to a close by the post-Powell emergence.

The oldest known Canadian sediments are found in the Mississippi Valley, for the Roubidoux and Jefferson City formations of the Ozark region, and the New Richmond and Shakopee of Minnesota and vicinity, have no known equivalents in the Appalachian basins. It is obvious, therefore, that the Canadian

[1]Bull. Geol. Soc. Amer., vol. 22, p. 647 (1911).

submergence of the land area began in the middle and western part of North America, and proceeded eastward to the Appalachian basins of Alabama, Tennessee, Pennsylvania, and New York.

Roubidoux Time. The Roubidoux sea is believed to have covered the whole of the Ozark region, and outcrops and drill records show a thickness of sediments varying from 50 to 250 feet. The conditions of sedimentation differed greatly from those that were in existence during the preceding submergence. Although there was much calcareous material in the sea water at that time, there were also large quantities of fine argillaceous material in suspension, and at irregular intervals sand was brought into the sea and was deposited in beds of varying thickness over the entire region. In addition to these, large quantities of colloidal silica were brought into the sea water from some source. The resulting deposition of such an heterogenous mixture of sediment was a complex formation composed of intercalated beds of sandstone, dolomite, argillaceous dolomite, and chert.

Repeated oscillations of the land and sea level seem to have taken place during Roubidoux time, a condition that is expressed in the sun-cracked surfaces of sandstones and dolomite, in the local unconformities, and in conglomerates and breccias composed of Roubidoux material, at various horizons within the formation.

The Roubidoux fauna is small in comparison with the life which existed in preceeding and succeeding seas, but some of the species at least, are exclusively diagnostic of the formation.

Jefferson City Time. There is no evidence of a prolonged break between the Roubidoux and the Jefferson City epochs, although in some localities unconformable relations do exist, and the oscillatory earth movements which were continuous throughout most of Roubidoux time, extended into the Jefferson City, but with less pronounced vigor, and in general deeper water conditions prevailed.

Conditions of sedimentation during Jefferson City time were unstable. Sandstone, shale, conglomerate, and dolomite beds have no uniformity in their relations over even small areas, and changes from clastic to calcareous sediments are abrupt in many places. Much argillaceous material was brought down into the sea during most of this time, for beds of argillaceous dolomite or "cotton rock" are especially characteristic of the formation, and colloidal silica must have been abundant in the sea water. Parts of Ste. Genevieve County rose above the sea for at least a brief time at several intervals, for local unconformities exist as well as sun-cracked surfaces upon the argillaceous dolomite beds. The organism *Cryptozoon minnesotense*, a lime secreting plant, thrived in the shallow waters of the Jefferson City sea. Animal life also must have been abundant, although the fossils are found only in certain chert horizons in which casts of their shells have been preserved.

The Jefferson City sea was probably coextensive with that of the Roubidoux, and covered the whole Ozark region, and it was doubtless continuous into the upper Mississippi Valley, for the New Richmond and Shakopee formations of Minnesota are believed to be essentially contemporaneous with the early Canadian formations of Missouri, the Roubidoux and Jefferson City. The sea may also have extended over a part of Oklahoma, but the Ozark and upper Mississippi Valley regions contain the best evidence of the sedimentary record of the early part of the Canadian period. There is no record of early Canadian sedimentation in any of the Appalachian basins.

Post-Jefferson City Emergence. At the close of Jefferson City time the sea is thought to have withdrawn from the Mississippi Valley, and it is believed that continental conditions were in existence over most of the central and eastern parts of the country. Canadian sedimentation in the Appalachian basins began at a time after the close of the Jefferson City in Missouri, the Theresa, Tribes Hill, and Stonehenge formations of New York and Pennsylvania, and the Jonesboro of Tennessee being typical of the earliest Canadian sediments in the east.

In Missouri there is no well defined evidence of an unconformity between the Jefferson City and the overlying Cotter. In the area covered by this report there are certain irregularities at the contact between the two formations, but they are apparently of no greater magnitude than might have been produced by the numerous oscillations which are shown to have taken place during the period of Canadian deposition in Missouri. The position of the Swan Creek horizon in the overlying Cotter formation is strong evidence, however, of the retreat of the Jefferson City sea from Ste. Genevieve County, the subsequent readvancement from the south, and the retreat of the Cotter sea. If such an oscillation of the sea occurred during the intraformational time, the emergent land surface was not much elevated above the critical level, for erosion was not notably effective, or stronger evidence of unconformity would be presented. The observed variation in thickness of the Jefferson City formation may be due in some measure to erosion before Cotter time. The hiatus between the Jefferson City and Cotter formations in Ste. Genevieve County is represented by the deposition of over 200 feet of lower Cotter sediments in northern Arkansas, lying below the Swan Creek horizon.

Cotter Time. The Cotter sea encroached upon the Ozark region from the south. The northward advance was relatively slow, as is shown by the decreasing thickness of the sediments from the type area in northern Arkansas to the probable northern limits of the Cotter embayment in central Missouri. Additional evidence confirming this interpretation in some degree, is supplied by the position of the Swan Creek horizon of the Cotter in southern Missouri and northern Arkansas, and in Ste. Genevieve County, for in both districts this highly fossiliferous zone is approximately in the middle of the formation, although the thickness of the whole formation is much less in Ste. Genevieve County. That there was a coextensive retreat of the Cotter sea, at least from the Ozark region, is expressed by the erosional unconformity that is present between the Cotter and the overlying Powell formation in both Missouri and northern Arkansas.

Study of the whole Ozark region has not been in sufficient detail to show the probable boundaries of the Cotter sea, but it is believed that embayment conditions prevailed rather than a widespread sea like that in Roubidoux and Jefferson City times, and probably only the flanks of the Ozark dome in Missouri were areas of sedimentation during Cotter time. Sedimentary conditions in Ste. Genevieve County were similar to those that had prevailed during Jefferson City time. The land areas were unstable and their oscillations apparently caused shallowing of the sea and probably slight emergence at various stages. Slight local unconformities and oxidized horizons mark the latter condition, and sandstone, conglomerate and probably some of the oolite reflect the former. Argillaceous material and colloidal silica in abundance were carried into the sea at this time, for much of the formation is made up of argillaceous dolomite and chert, the latter secondary formed by the segregation of the silica.

The slow retreat of the Cotter sea exposed the sediments in Ste. Genevieve County to subaerial erosion while Cotter sedimentation was proceeding uninterruptedly father south, and that part of the formation found in Ste. Genevieve County represents the northern end of a wedge which has its base in Arkansas where the thickness is at least 500 feet. The hiatus below the Cotter is measured, therefore, by the length of time required for the deposition of the sediments south of and not represented in Ste. Genevieve County, and the hiatus above is measured by the accumulation of sediments farther south, plus any hiatus which exists between the Cotter where fully developed and the overlying Powell formation.

Post-Cotter Emergence. From what has been written above it is obvious that there was a considerable time break in the upper Canadian sedimentary record in Ste. Genevieve County at the close of Cotter time. This break is marked by an erosional unconformity, but the low relief of the surface prevented any but slight irregularities from being produced by erosion.

Powell Time. The Powell sea advanced from the south much more rapidly than had the preceeding Cotter sea. It is believed that the Powell embayment was somewhat restricted in Missouri, and that it did not cover the entire Ozark dome, although this interpretation is the result of negative rather than of positive evidence. Conditions were much more stable in Ste. Genevieve County during early Powell time than at any preceding time during the Canadian period, and aside from a few sharp defined influxes of clastic sediments, deposition was almost entirely calcareous during lower Powell time, neither was there any considerable amount of colloidal silica present in the sea water of this time. Near the close of lower Powell deposition conditions changed somewhat, and deposition became more irregular, and the purely local crustal movements culminated with at least a partial withdrawal of the sea from Ste. Genevieve County.

The duration of time in which certain parts of the area were exposed to subaerial erosion during the progress of Powell time, may be measured-in a degree by certain phenomena exhibited at the Cornwall Copper Mine. The hardening of the calcareous and calcareo-argillaceous sediments of the lower Powell, was followed by weathering and partial disintegration, after which the returning sea deposited sandy and conglomeratic sediments in the depressions, the conglomerate being composed of pieces of the dolomitic rock which lay partially disintegrated upon the surface. The intraformational unconformity so well exhibited at this locality is almost, if not entirely lacking at other places in Ste. Genevieve County, but at this horizon a change in the conditions of sedimentation in Powell time took place, and a distinct fauna which is found only in the upper Powell made its appearance.

The upper Powell sea had an abundance of colloidal and argillaceous material supplied to it, since the formation, as now exhibited, contains large quantities of chert, at least in southern Missouri, and there are also present numerous beds of soft, ferruginous chert, and soft, much decomposed dolomite. The characteristics of these horizons may be due to weathering by atmospheric waters, or they may have been formed by repeated and irregular emergence of the land, and subsequent weathering, in each instance followed by resubmergence. At the Swansea-Herzog mines a distinct unconformity is exhibited at one of these horizons. The unstable conditions during upper Powell time may have been a forerunner of the epirogenic movements which brought Canadian sedimentation to a close in Missouri, Arkansas, and elsewhere.

Post-Powell Emergence. The withdrawal of the Powell sea brought the Canadian period in Missouri to a close, but in a few of the Appalachian basins in New York, Pennsylvania, and probably Maryland and Virginia, Canadian sedimentation continued for a short time.

The unconformity which exists between the Canadian and the next succeeding series in the Ordovician System in Missouri, is shown by the differential weathering and erosion to which the Powell rocks were subjected. The amount of erosion which took place is small when the length of the interruption is considered, but it is considerably more than the erosion that took place between the Ozarkian and Canadian. The surface relief was slight and consequently the stream action was unimportant, and since there is no angular unconformity between the formations of any of the series, the uplift of the land, or conversely, the withdrawal of the seas, was the result of harmonious and gentle orogenic movements. The depth to which oxidation extended, in a degree, measures the length of time of the emergence of the land following Powell sedimentation. In a few places the weathering of the dolomites and cherts has been effected to a depth of 40 or 50 feet, but in other places the resistance of the siliceous dolomite permitted but slight change.

Everton Time. The deposition of the formations of the Big Buffalo Series of the Ordovician began in the Mississippi Valley, and the sea in which they were laid down never extended into the eastern portion of the continent, for the equivalents of these formations have not been found in the Appalachian basins. The St. Peter sandstone which is the most widely distributed of the sediments of this series, is found only as far east as the Cincinnati dome, where it has been encountered in deep wells.

In the Mississippi Valley the first Big Buffalo deposition of which we have record, occurred in northern Arkansas, and the sea which advanced from the south extended into Missouri but probably did not reach farther north than the center of Jefferson County during Everton time. In Arkansas the Everton was laid down upon an irregular surface, the basal sediments being conglomerate and sandstone which have been called the Kings River member. Following these clastic sediments with no evidence of an interruption, the deposition of as much as 150 feet of calcareous sediments was accomplished, the limestone in numerous places containing considerable numbers of floating sand grains which are rounded and uniform in size.

As the Everton sea transgressed northward into Missouri, sedimentation changed. In Ste. Genevieve County the basal Kings River clastic member increases in thickness and is almost entirely sandstone. The limestone, on the other hand, decreases in thickness. It is obvious that the sea advanced upon a well developed beach, reworking the sand and depositing it in shallow water which was much agitated by cross currents, and while beach conditions prevailed in Ste. Genevieve County and vicinity, farther south in Arkansas, deeper water conditions prevailed and calcareous sedimentation proceeded, but a certain amount of sand was transported southward by wind and currents from the shallow water shore area to the region where the calcareous sedimentation prevailed, and was scattered through the calcareous ooze, the resulting deposit being a more or less arenaceous limestone.

The sand grains of the Everton have the same rounded and frosted characteristics as those of the often described St. Peter sandstone, and the origin of one must hold for the origin of the other. The roundness and size of the grains, and their frosted and pitted surfaces have been interpreted as being the result of formation under aeolian conditions.

Everton deposition was brought to a close by a southward withdrawal of the sea.

Post-Everton Emergence. Upon the withdrawal of the sea to a point at least as far south as northern Arkansas, the Everton limestone was exposed to subaerial erosion, a fact which is expressed in the differential erosion to which the surface of the formation was subjected.

Conditions of active erosion probably did not obtain for long before the wind blown sands from the north advanced southward, extending into northern Arkansas and probably Oklahoma and later the northward advancing St. Peter sea reworked the beach sands as the preceeding Everton sea had done, and produced the same sort of sedimentation but under slightly deeper water conditions.

St. Peter Time. The character of the grains of the St. Peter sandstone is almost unique among the sandstones of the Mississippi Valley. They are more uniform in size than in most sandstones, being very perfectly assorted, with a minimum of foreign material. The larger grains are commonly very perfectly rounded, and the smaller ones less perfectly, but in all cases the surfaces have a frosted or pitted appearance. The peculiar characteristics of these sand grains have commonly been ascribed to the work of the wind, since the same sort of pitted surface is frequently present upon modern, wind-blown, desert sands, and the aeolian origin of the entire St. Peter sandstone has been suggested by some authors. The more commonly accepted interpretation of the formation is, that it is a marine deposit laid down by a transgressing sea, the sand being wind-worn upon the beach and upon the land, in advance of its final aqueous deposition.

During St. Peter time the advancing sea gradually spread across Ste. Genevieve County from south to north, the old shore line slowly shifting to the north, either by reason of the gradual sinking of the land, or the slow rise of the sea level, or perhaps more likely by reason of a combination of crustal movement and rising sea level. Along this advancing beach line the waves of the ocean worked upon the sands which had been blown southward by the wind, and redeposited them as water laid deposits with their characteristic ripplemarks and cross-bedding. For a long distance southward from the beach, at any given time during this deposition the waters were shallow, and the sands of the sea bottom were constantly moving about by the action of the waves. The broad stretches of the shallow St. Peter sea, with its bottom of shifting sands, was not a congenial habitat for marine life, and nowhere in Ste. Genevieve County have fossils of any sort been observed in the formation. The absence of fossils is almost everywhere characteristic of the St. Peter sandstone, and only near the northernmost extension of the formation, in Minnesota, have they been recorded.

Joachim Time. As the shore-line of the St. Peter sea advanced northward, the sea covering Ste. Genevieve County became gradually deeper, and at last there came a time when the depth was sufficiently great so that the sands of the bottom were not constantly stirred up by the action of the waves. With the coming of these conditions the calcareous sediments now known as the Joachim limestone began to be deposited. Far to the north of Ste. Genevieve County, adjacent to the shore-line of this ancient ocean, the St. Peter sandstone was still being deposited, while the Joachim limestone was being laid down in the deeper waters.[1] In its present condition the Joachim limestone is, in a large measure dolomitic and unfossiliferous, but locally there are beds of non-magnesian limestone which are fossiliferous. The dolomitic beds were either barren of fossils originally, or the originally contained fossils have been destroyed or obscured during the process of dolomitization, so that almost nothing is known of the life that inhabited the sea which covered Ste. Genevieve County during the epoch.

Although it is believed that in the main the Joachim limestone was being formed off shore, contemporaneously with some part of the St. Peter sandstone further north, there are evidences that parts of it at least, were deposited in very shallow waters, and that at times some portions of it must have been temporarily above the surface of the sea. Evidence of shallow water conditions are found in the presence of ripple-marks upon some of the beds, although nowhere are the strata cross-bedded as is so commonly true in the underlying St. Peter sandstone, and in some beds there are well defined mud cracks impressions which could only have been formed during temporary emergence, perhaps only an emergence between tides.

Post-St. Peter Emergence. Succeeding the period of deposition of the Joachim limestone there was a withdrawal of the sea from Ste. Genevieve County and the surrounding area. From the evidence at hand this withdrawal left an area of dry land

[1]Ulrich, Bull. Geol. Soc. Amer., vol. 22, p. 480.

extending from the Ozark region of Missouri northward to where it was connected with the permanent land nucleus of the continent. In a southeast direction from Missouri, in a sea occupying the Appalachian basin, formations of Stones River age were being deposited during the emergence of the Ozark region. The elevation of the post-Joachim land was not great, so that vigorous erosion was not possible, but the difference in thickness of the Joachim is passing from north to south, suggests that either a considerable portion of the original sedimentary material was removed from the more southern portion of Ste. Genevieve County, or that the thickness was never so great in that direction. In places distinctly unconformable relations between the Plattin and the underlying Joachim are exhibited, but elsewhere it is not in all cases possible to determine the exact line of demarcation between the two formations.

Plattin Time. With a return of the sea in Plattin time, a type of sediment different from that of the Joachim sea was deposited. The physical characters of the Joachim sediments were such that they have become almost completely dolomitized if they were not originally deposited as dolomite, while the Plattin sediments have withstood such changes except very locally. The waters of the Plattin sea were exceptionally free from all clastic materials, and the original source of the material which has made the limestone was doubtless the calcareous secretions of organisms which were living in the sea. The fossil remains of these organisms have been preserved at many places, and among them there are represented many brachiopods, pelecypods, gastropods, cephalopods, among which are gigantic Orthoceratites, trilobites, corals and crinoids. Although these several types of organisms are only locally well preserved as fossils, they doubtless flourished in great numbers over the whole of Ste. Genevieve County, throughout the entire period of deposition of the Plattin limestone.

Besides the varied animal life of this sea, it must have been inhabited by vast numbers of fucoids, a form of sea-weed, whose stems became buried in the calcareous mud of the sea bottom. When these stems decomposed the casts left by them were filled with sedimentary material which seems to have been a little different in character from the surrounding material, perhaps because of the decomposed vegetable matter with which it was mingled, so that in the weathering processes of modern times, the material filling these cavities has been removed in many places, and locally the rock is filled with branching, tube-like cavities which penetrate it in every direction.

The length of time during which the Plattin sea occupied the Ste. Genevieve region must have been of great duration. The thickness of the formation varies from 150 to 250 feet, and 200 feet may be taken as about the average. It has been estimated that some limestones are deposited at the rate of one foot per century[1], which would mean approximately 20,000 years for the deposition of the Plattin limestone. Other estimates, however, allow a much slower rate of deposition for limestone sediments, as low as one-tenth of one foot per century,[2] which would make the time interval ten times as long, or 200,000 years. The factors upon which such estimates as those given above are made are so uncertain, that the actual time value of such a formation as the Plattin limestone is extremely uncertain, but the time was very long, and the longer estimate is probably more nearly correct than the shorter.

Decorah Time. It is not clear from the observations in Ste. Genevieve County, that the Plattin sea was withdrawn preceding the deposition of the Decorah formation, but in any event the physical conditions were changed to some degree, and the life also was somewhat different. No longer was the material being deposited so pure a limestone as it had been previously, for there are argillaceous shale beds in the Decorah, indicating that the rivers draining the lands adjacent to this sea were carrying fine mud which was being deposited, and later spread out over the sea bottom. Limestone formation still continued, however, for interbedded with the shales there are thin limestone bands, and in the higher portion of the formation somewhat siliceous limestones are present to the exclusion of the shales.

The life of the Decorah sea consisted largely of brachiopods and bryozoans, for the most part specifically different from those of the Plattin sea, although some of them are allied forms. The duration of the epoch was much less than that of the Plattin time, as is suggested by the limited thickness of the formation, although this is not an altogether safe criterion, because a considerable amount of the formation, and in places all of it, was removed by erosion subsequent to its deposition and preceding the deposition of the next higher formation, the Kimmswick limestone.

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[1]Chamberlin and Salisbury, Textbook of Geology, vol. 2, p. 275.
[2]Williams, Geol. Biol., p. 57.

Post-Decorah Emergence. In the interval between the deposition of the last of the Decorah formation and the first of the Kimmswick limestone, Ste. Genevieve County was again a portion of a more or less extensive dry land area. This withdrawal of the sea is clearly indicated by the unconformable relations which are everywhere present at the base of the Kimmswick. The dry land surface of post-Decorah time was subjected to degradation to such an extent that in places the entire thickness of the Decorah formation was removed, while elsewhere the maximum thickness of 35 feet are present.

Kimmswick Time. The sedimentation of the Kimmswick sea was notably different from that of the Plattin, as is indicated by the difference in character of the limestones. The Kimmswick is the purer limestone and is much the lighter colored, and the fragments of the shells of organisms of which the rock is built up have not been so finely ground to powder as must have been the case in the formation of the dense Plattin limestone. The rock itself is for the most part a rather coarsely crystalline limestone, in sharp contrast with the compact and dense Plattin. These differences in the lithologic characters of limestones of different formations are indicative of the varying physical conditions which prevailed in the seas during the time of their deposition, but it is not always easy to determine with certainty just what the varying factors have been. That the formation was deposited in a shallow sea is shown by the fact that cross-bedding is not an infrequent phenomenon in the limestone, and although well preserved fossils are only locally present, the entire mass of the limestone is clearly composed of broken fossil fragments. The sea in which the formation was laid down must have been teeming with life in great variety. As in most of the ancient faunas of the earth, brachiopods constitute a notable portion of the life, but associated with these organisms there were many bryozoans, numerous trilobites, and a considerable number of molluscs, especially gastropods. The pelecypods and cephalopods were less numerous than in the Plattin, and the corals, which were not uncommon in the Plattin, are only rarely met with. One of the most conspicuous members of this old fauna, especially during the later portion of the epoch, was the peculiar organism commonly considered as an unusual sort of sponge, which is known under the name *Receptaculites.* Just what these creatures looked like when they were living is problematical, but they must have existed in enormous numbers in this old Kimmswick ocean.

It is known that the Kimmswick sea, with essentially identical conditions, stretched northward at least as far as Lincoln County, Missouri, and eastward beyond the Mississippi River into Calhoun County, Illinois. To the south it stretched beyond the limits of Missouri into northern Arkansas, and doubtless occupied an extensive embayment of the present Mississippi Valley.

Post-Kimmswick Emergence. Following the occupation of Ste. Genevieve County by the Kimmswick sea, there was a period of emergence of much greater duration than of the previous dry land epochs of the Ordovician. This is shown by the unconformable relations of the formations overlying the Kimmswick with the upper surface of that formation. The geological age of the Kimmswick, as shown by its fossils, is early Mohawkian or Middle Ordovician, while the formations which rest upon it belong to the uppermost division of the Ordovician, formations which some recent authors consider as being early Silurian in age. This lapse of time is represented in the unconformity recorded in the stratigraphic succession. It is of course conceivable that certain formations younger than the Kimmswick may have been deposited and later have been entirely removed, as a considerable portion of the Kimmswick has been in places, during the erosion period preceding the later Ordovician deposition, but if that had been true it is almost certain that some remnants, at least, of the younger formation would somewhere be left, and no such remnant has been found.

Fernvale Submergence. The Fernvale limestone of Richmond or Upper Ordovician age, is commonly found resting upon the Kimmswick limestone. In places the younger formation rests upon the uppermost beds of the Kimmswick, as we know that formation, upon beds carrying great numbers of specimens of the peculiar sponge *Receptaculites*, but elsewhere one-half or more than one-half of the Kimmswick had been removed by erosion before the deposition of the Fernvale, and in such places the younger formation rests upon limestone beds belonging low down in the older formation.

The lithologic character of the Fernvale is in general a coarsely crystalline limestone similar in texture to that of the underlying Kimmswick, but it is somewhat darker in color and is not so pure as the older limestone. Although there are these differences it would be very difficult, in many places, to separate the two formations were it not for the great difference in the fossils which the two limestones contain. This life of the Fernvale sea was fully as abundant as that of the preceding Kimmswick, and consisted largely of brachiopods, with some other forms, such as bryozoans, molluscs and trilobites, but the assemblage of species was very different from that of the earlier period.

The duration of the Fernvale submergence was short, compared with either that of the Kimmswick or the Plattin, if the thickness of the formation is a criterion, for the Fernvale probably exceeds ten feet nowhere in Ste. Genevieve County, nor elsewhere in Missouri or Illinois, and in many places is less than two feet.

Post-Fernvale Emergence. The emergence of Ste. Genevieve County and the adjacent portion of the Mississippi valley following Fernvale time, was much shorter in duration than the emergence preceding the period. Some erosion of the Fernvale was probably accomplished, as is shown by the varying thickness of the Fernvale, although this difference in thickness may be accounted for by assuming a greater accumulation of Fernvale sediment in certain localities than elsewhere.

Thebes-Maquoketa Time. With the resubmerfence of Ste. Genevieve County after the post-Fernvale interval, a type of sedimentation was initiated, so different in character from anything that had preceded it for a long time, that notable changes in the geography of the continent must have been accomplished, perhaps in the Appalachian region. The initial sediments of this Thebes-Maquoketa period, consisted of fine brown sand. In Ste. Genevieve County this sandstone is not thick, rarely if ever exceeding 20 feet. In a northward direction it becomes thinner, disappearing from the section entirely, south of St. Louis. To the south, on the other hand, it is much thicker, being over 70 feet thick at Thebes, Illinois, the type locality of the Thebes sandstone. With this distribution and variation in the thickness of the sandstone, it does not seem probable that the source of the material could have been a land area occupying the position of the present Ozark dome. The sand, however, was undoubtedly land detritus which was transported to the sea by stream activity, and the thickening of the formation to the south would seem to indicate that its source was somewhere from that direction or from the southeast.

The upper portion of the formation, and in Ste. Genevieve County much the thicker portion, is a fine, olive-green, plastic, argillaceous shale. Like the underlying sandstone, the source of clay must also have been from some land surface adjacent to the sea which covered Ste. Genevieve County, although it is not possible to determine from our present knowledge, the true location of the land area from which the material was derived. This change in the nature of the sediments in the midst of this time, from sand to clay, is ample proof of changing outlines of unsubmerged areas somewhere within the region of which Ste. Genevieve County was probably a subordinate part.

The life inhabiting the Thebes-Maquoketa sea which covered Ste. Genevieve County, was very meager as compared with that of several of the preceding epochs of submergence. A very few fossil brachiopods and trilobites have been found in the county, but in adjacent areas in Missouri and Illinois there are some graptolites and bryozoans. One of the most persistent Thebes-Maquoketa faunas occurs at the very base of the formation, and consists largely of small molluscs, mostly pelecypods. This fauna has been found in Jefferson County, Missouri, and in Monroe County, Illinois, but only fragments of it have as yet been detected in Ste. Genevieve County. The same fauna, identical in every respect, continues northward as far as southwestern Wisconsin, indicating that the sea which covered Ste. Genevieve County at this time reached at least as far north as that. In other directions it probably extended to the south and southeast, but its westward extension was probably limited. The final Ordovician emergence of the region occurred subsequent to the deposition of the Thebes-Maquoketa formations.

SILURIAN PERIOD

The Silurian history is much less fully recorded in the sedimentary series of Ste. Genevieve County than is that of the Ordovician. A single formation of Silurian age is known in the county, the Bainbridge limestone, which records a single submergence of the area, as contrasted with the several periods of submergence during Ordovician time.

Pre-Bainbridge Emergence. Preceding the period of deposition of the Bainbridge limestone, Ste. Genevieve County had been part of an area of dry land whose extent during some portion of the interval may have been nearly coextensive with the North American continent. At other times, however, the sea reached to within a short distance of the county, for the Alexandrian formations of southern Illinois and Cape Girardeau County, Missouri, intermediate in age between the Maquoketa-Thebes and the Bainbridge, have a total thickness of over one hundred feet. In Alexander County, Illinois, Savage[1] has recognized three formations in the Alexandrian, the Girardeau limestone, Edgwood limestone and Sexton Creek limestone, each of which lies unconformably upon the one subjacent to it, showing three submergences of that region, with withdrawal of the sea during intermediate stages. If any one of these submergences extended as far north as Ste. Genevieve County, no record of it has been preserved, either no sediments were laid down, or if they were deposited they were again removed by erosion before being buried beneath younger formations.

Bainbridge Time. When the county was submerged beneath the Bainbridge sea, the conditions of sedimentation differed from any that had preceded. The formation is in the main a limestone, but it contains a considerable amount of argillaceous or clayey material. The lime was doubtless furnished by various lime secreting organisms which lived in the sea, but the associated clays must have been brought in from neighboring land areas. The clay which was carried into the sea was of a deep red color for the most part, and it imparted its color to much of the formation. The original source of the red clays was doubtless the accumulated residuum from the older limestones, similar in all respects to the red residual clays of the Ozark region which are so widespread at the present time. The mottled red and greenish coloring of much of the Bainbridge at the present time, is believed to be due to the reduction of the red oxide of iron to the green, in recent times, and that originally much of the formation was red throughout.

The extent of the Bainbridge sea cannot be determined with any degree of accuracy, but it must have reached far beyond the limits of the present area in which the formation is known, both to the north and to the south. To the west it is believed that the sea was limited by Ozarkia, but to the east it probably extended for a long distance.

The red muds which were being deposited in this Silurian sea over Ste. Genevieve County, seem not to have been favorable for the development of an extensive fauna, although locally the fossils are fairly common. The assemblage of life which has

[1]Ill. State Geol. Surv., Bull. No. 23 (1913).

been recognized included numerous crinoids, some corals, brachiopods and bryozoans.

Post-Bainbridge Emergence. The emergence of Ste. Genevieve County following the Bainbridge submergence, endured for a long time. The Bainbridge fauna indicates the age of that formation as being about Middle Silurian, and either there was never any deposition of sediments representing the late Middle and Upper Niagarian, and the whole of the Upper Silurian or Cayugan, or if any of them were ever present they were entirely removed by erosion before the deposition of the oldest Devonian beds which are now present in the section.

DEVONIAN PERIOD

The Devonian period is represented in Ste. Genevieve County and Perry County, its neighbor on the southeast, by approximately 1,000 feet of sediments. The formations, however, are much restricted in their present geographic distribution, and are not sufficient to tell the whole of the Devonian story. The history of the period was similar to those which had preceded it, namely a succession of emergences and submergences of the area, and not until near the close of the period was there any crustal movement other than these gentle oscillations of the land, or perhaps oscillations of the sea level.

Bailey Submergence.—The earliest submergence of Ste. Genevieve County during Devonian time was in the Helderbergian epoch of Lower Devonian time. The sediments laid down were largely limestones, but mingled with the deposits of calcareous mud which probably had its origin from lime secreting organisms, there must have been quantities of silica, probably brought into the sea in a colloidal condition by the inflowing rivers from surrounding lands. This silica was intimately mingled with the calcareous mud during the period of accumulation, but during more recent times it has been segregated in bands and nodules of chert.

It is not possible to determine the extent of the submerged basin in which the Bailey limestone was laid down, from the fragments of the formation which have been preserved, but a formation of such importance, with an original thickness of at least 300 feet, must have covered a considerable area in all directions. No estimate whatever of the northern extension of the sea can be made, because of the complete removal of the beds in that direction subsequent to the late Devonian faulting which crossed Ste. Genevieve County. In a southwesterly direction, however, there are formations of the same age in the Arbuckle mountains in Oklahoma, and it is not unlikely that the waters covering these two widely separated areas were parts of a continuous sea which formerly stretched across or around the southern part of Ozarkia. It is also believed that this same sea or embayment stretched across southwestern Illinois, western Kentucky and Tennessee, because beds carrying a similar fauna are known to be present in the last named State.

Post-Helderbergian Emergence.—Following the Bailey submergence there was an emergence of southeastern Missouri, including Ste. Genevieve County, during which the land surface formed by the Bailey limestone was subjected to a considerable amount of erosion, which is now shown by the varying thickness of the formation, and by the presence in some localities, especially in Perry County, of beds in the upper part of the formation which are wanting elsewhere. The duration of this emergence is not known, but the fossil faunas of the Bailey limestone show that the age of that formation is about equivalent to the New Scotland formation of the New York basin, the higher beds of the New York Helderbergian, and the Lower Oriskany being unrepresented in Ste. Genevieve County.

Oriskany-Onondaga Submergence. Succeeding the emergent stage of Post-Helderbergian time, the area under consideration was again submerged beneath the sea, and a new formation, the Little Saline limestone, was laid down. This formation is a remarkably pure, white, crystalline limestone, which is quite free from clastic materials of any sort. The natural contact of the formation upon the underlying Bailey limestone has nowhere been observed, and in consequence the very basal beds of the formation have not been seen, and it is not known whether or not the pure calcareous sediment continues from the initiation of the deposit. An apparent contact of the Little Saline upon the Bailey limestone is exhibited in the south bluff of Little Saline Creek a few rods above the crossing of the Palmer fault, where the very pure limestone rests directly upon the cherty Bailey limestone, but this contact is in reality a fault contact and does not represent the true depositional junction of the two formations.

The Little Saline limestone has a maximum thickness of nearly or quite 100 feet, and such a body of limestone must have been laid down in a basin of considerable extent. This basin must have continued to the north for an unknown distance, and also to the southeast and southwest, but how far can only be a matter of conjecture. The sea in which the limestone was formed teemed with life, judging from the great number of fossils which are present in the limestone. The lower half of the formation especially, is for the most part crowded full of large brachiopod and gastropod shells, with an occasional pelecypod, trilobite, coral and bryozoan. A large portion of the species of fossils in the fauna are identical with those of the Oriskany formation of New York and southwestward along the Appalachians, and there can be no doubt in regard to the equivalent age of the two formations. The fauna, however, is representative of that of the higher portion only of the Oriskany of the east, a fact which again falls in line with the evidence for unconformable relations between the Little Saline and Bailey limestones, the lower Oriskany as well as the higher Helderbergian formations being missing in the Ste. Genevieve sequence, because of the emergent condition of the area during that interval.

The Oriskany sea that covered Ste. Genevieve County merged into that of Middle Devonian time without any interruption by emergence. The sedimentation was continuous and was similar in character, although the earliest limestone beds which have been referred to the Grand Tower formation are somewhat cherty in character, indicating that a considerable amount of silica was being carried into the ocean at this time by the inflowing waters from the adjacent lands.

The life of this Devonian ocean also changed somewhat gradually from that which characterized the earlier period, to faunas of Middle Devonian type. There was no abrupt disappearance of the Oriskany life, followed by the sudden introduction of forms characteristic of the new fauna. In the higher beds of the Little Saline limestone fossil forms are present which alone would be considered as indicative of Oriskany age, but associated with these are other fossil forms which by themselves are more indicative of early Middle Devonian time. These transition faunas, however, persisted for only a brief time, for shortly after the beginning of Grand Tower sedimentation the sea became peopled by great numbers of corals. These creatures lived in such numbers that they constituted a veritable coral reef. This reef habit of the corals was common at this time in the Ohio valley, in New York and in Canada, and many identical species lived in all these localities, indicating that all these widely separated areas were submerged during this period beneath one continuous shallow sea.

As time progressed the conditions in the portion of the Middle Devonian sea that covered Ste. Genevieve county, became unfavorable for the life of the coral animals. For a considerable thickness of the strata of the Grand Tower formation above the fossil coral reefs no fossils of any sort have been observed. This absence of fossils must not be interpretated as meaning that the sea was devoid of life during this time, but rather that the conditions for the preservation of fossils were unfavorable in the limited area which has been available for examination. In the higher portion of the formation fossils are again abundant, but the assemblage of species living in the sea at this time was quite different from that which was present earlier. There were still many corals present, but of different sorts than those of the early portion of the period, but the corals of the fauna were overshadowed by the brachiopods, cephalopods, pelecypods and trilobites.

During the closing stages of Grand Tower time, and continuing into the Hamilton, there is evidence in the rocks of Ste. Genevieve County that crustal movements were in operation at no great distance. These movements are indicated by the presence of a considerable amount of sand which is intimately associated with the limestone. The sand does not constitute beds of sandstone at first, but is disseminated through the limestone. Later, however, it becomes a continuous and massive sandstone formation, the Beauvais sandstone of this report. The sand grains of the Beauvais sandstone are identical with those of the St. Peter sandstone, and the expression of the formation so closely simulates this earlier sandstone formation, in many localities, that it would be extremely difficult, if not impossible, to differentiate the two beds except where their stratigraphic position can be determined, or where fossils can be secured in the younger formation. As a matter of fact, the source of the Beauvais sands was without doubt from some nearby exposures of the St. Peter sandstone in the Ozark region, and an uplift of Ozarkia at this time doubtless rejuvenated the streams draining the area and caused them to transport great quantities of disintegrated St. Peter sand, and redeposit it along the shore of the Middle Devonian ocean.

The life of this sandy shore which probably crossed Ste. Genevieve County in a more or less north-south direction, during this period in Middle Devonian time, was meager, if we are to judge from the number of fossils which have been preserved. Such life as was present was represented by brachiopods and by a few gastropods, which belong to species that are known elsewhere in rocks of Hamilton age, and for this reason it is concluded that the sandy shore line represented by Beauvais sandstone is of early Hamilton age. The land surface of the time doubtless lay to the west, and may have included some portion of the western part of Ste. Genevieve County. The sea stretched to the east, and was doubtless continuous through the Ohio valley to New York, since the fossil faunas of all the Hamilton rocks of Ste. Genevieve County are similar in type from southeastern Missouri to New York. The sandy shore facies of the Hamilton sedimentation, however, did not extend for any great distance to the east since the beds of Hamilton age in Jackson County, Illinois, are all limestones.

The disturbed condition of Ozarkia continued throughout the whole of Hamilton time, including the periods of deposition in Ste. Genevieve County of the Beauvais sandstone and the St. Laurent limestone. The disturbances consisted, in the main, of interrupted emergence of the Ozarkian land, which renewed at intervals the erosive activity of the streams draining into the sea to the east. Following the deposition of the shore sands represented by the Beauvais formation, a limestone conglomerate was deposited over much or all of the area where the formations are exposed in Ste. Genevieve County. Whether this limestone conglomerate is indicative of unconformable relations between the Beauvais and the St. Laurent, is not clear, but it certainly does indicate disturbed conditions of some sort, and the unconformity, if present, can represent only a comparatively short time hiatus, since both formations are included within the Hamilton period.

The disturbed conditions which existed during the deposition of the St. Laurent limestone are exhibited by the alternately arenaceous and calcareous nature of the sediments. Limestones predominate, but at intervals there are beds with considerable amounts of sand, and even some beds of pure sand. This mingling of the sand with the dominant calcareous sediment is doubtless a comparatively near-shore feature, the greater amount of sand being deposited during the stages of interrupted emergence, immediately following the slight uplifts. After the first influx of sand, as the gradient of the streams became gradually reduced, the normal accumulation of calcareous sediments became re-established.

Late Devonian Faulting and Peneplanation. The comparatively slight disturbances which recurred at intervals during the latter portion of Middle Devonian time, finally culminated in a period of faulting that doubtless took place early in Upper Devonian time, and probably immediately after the close of the Hamilton epoch. The faulting was of normal type, due to tension strains in the earth's crust. The breaks followed in general an east and west direction across Ste. Genevieve County, with the upthrow side on the north. The maximum differential movement along the fault line was about 1,000 feet, or about the total thickness of the Devonian rocks of the region. The area to the south of the fault line must have remained near sea level in elevation, since little or no erosion of the Devonian surface was accomplished before the deposition of sediments of Mississippian age, but the uplifted area to the north was cut down before the close of Upper Devonian time to a base level, and in the course of this erosion the entire accumulation of Devonian sediments north of the fault line, as well as the underlying Silurian beds which had been deposited in the basin of which Ste. Genevieve County was a part, were removed, and the exposed land surface consisted of the Ordovician Maquoketa shale formation, or formations still older. Off shore from Ozarkia, to the east, the younger formations on the north side of the faulted zone, were probably not wholly removed, but if this northward extension of the Devonian formations still persists, the beds are now covered by the younger Mississippian and Pennsylvanian formations, and under these conditions their presence could only be detected in deep well drillings.

MISSISSIPPIAN PERIOD

Earliest Mississippian Submergence. By the close of Upper Devonian time, the relief of the surface of Ste. Genevieve County which had been brought about by the Devonian faulting, had been reduced essentially to a plane. This plane extended far beyond the confines of the county, to the north, south and west, and probably included much or all of the Ozark land area. Early in Mississippian time this plane was partially submerged, perhaps by reason of the gradual rise of the surface of the ocean which surrounded the island Ozarkia. There is no evidence to show that the whole of Ozarkia was submerged at this time, but the sea must have transgressed upon the land on all sides, and the area of the island must have been much reduced.

The sediments associated with this earliest Mississippian submergence are limestones, sandstones, and shales of the Sulphur Springs formation. Nearly black or dark brown phosphatic nodules, more or less irregular in form but always with rounded surfaces, and varying in size up to an inch or more in diameter, are commonly present in greater or less abundance in the lowermost beds deposited at this time. These phosphatic nodules are without doubt a residual product from the disintegration of the older rocks of the Ozarkian lands.

The shoal waters bordering the diminished Ozarkia, abounded with life, and many species of brachiopods, gastropods, and pelecypods, with some corals and crinoids, have been preserved as fossils in some of the beds. One of the most characteristic members of this fauna was a lung fish, *Ptyctodus*, only known from its teeth, which have been preserved locally in enormous numbers. The remains of this Ptyctodus fauna have been observed not only in Ste. Genevieve County and elsewhere along the eastern shore of this ancient island, but off the southwestern shore of the same Ozarkia in Greene County, in the Phelps sandstone, and off its northern shore at Providence on the Missouri River. The *Ptyctodus* bed at the base of the Sweetland Creek shale in Iowa, and the *Ptyctodus* bed whose remnants are preserved in solution channels in the Silurian dolomites of northeastern Illinois, both of which were deposited as the initial sediments in a shoal sea following a long period of emergence, may belong to this same submergence. The Sylmore sandstone of northern Arkansas may also be a contemporaneous deposit. All of these facts go to suggest that the emergent land area of late Devonian time was widespread in the Mississippi Valley region, and that it was succeeded by a broad, shallow sea, in whose fauna the lung fish, *Ptyctodus*, was a conspicuous member. In this sea Ozarkia was a low lying island occupying a considerable portion of southern Missouri and northern Arkansas.

At one locality in Ste. Genevieve County the upper beds of the Sulphur Springs formation consist of fine black shales with streaks and pockets of sand in its basal part, and with pyrite nodules. These shales also contain examples of *Sporangites*, the fossil spore cases of an ancient plant. These shales resemble in all their physical characteristics, the Chattanooga black shales of the region east and southeast of Missouri, but the Sulphur Springs formation is probably younger than the typical manifestation of this formation.

Post-Sulphur Springs Emergence. The submergence of the shores of Ozarkia during the time of deposition of the Sulphur Springs formation, was not permanent. Another one of the periodic elevations of the island mass brought these sediments in Ste. Genevieve County, and elsewhere around its borders, above sea level and subject to erosion. In many places the formation was entirely removed during this emergence so that only more or less discontinuous patches of it were left in Ste. Genevieve County.

Fern Glen Submergence. The emergent condition just described continued through the greater portion of the Kinderhook epoch of the Mississippian period, but at or shortly before the close of this epoch, the sea again transgressed from the east and spread over Ste. Genevieve County, and the sea in which the Fern Glen formation was deposited occupied the region and doubtless surrounded completely the island Ozarkia. The red color of the Fern Glen beds is doubtless due to the transportation to the sea of red residual clays that had been accumulating from the weathering for a long period of time, of the limestones which constituted the surface rocks of Ozarkia, or by the action of the waves of the slowly advancing seas upon the residual deposits. The amount of this red material carried into the sea was not sufficient to interfere with the development of the abundant animal life which inhabited the sea, but it was sufficient when mingled with the accumulation of the calcareous remains of the organisms, to give a distinctly red color to much of the limestone, and to make some of the beds distinctly argillaceous or shaly in character.

Life abounded in the waters which covered Ste. Genevieve County at this time, and the crinoids were perhaps the most conspicuous members of the fauna. It is here that we find the beginning of what is perhaps the most wonderful crinoid fauna that has ever existed upon the earth, and whose remains have been preserved in the Burlington and Keokuk limestones throughout the upper Mississippi Valley basin. Besides the crinoids, corals were abundant, many brachiopods and some bryozoans were present, with an occasional trilobite, pelecypod, gastropod and cephalopod.

The Fern Glen submergence continued with the shores of the sea surrounding Ozarkia slowly transgressing the land, until finally the entire island was submerged, and Ste. Genevieve County, probably along with the whole of Missouri was covered by a widespread, shallow, interior, epicontinental sea. With the complete submergence of the island, which is proven by the presence of residual cherts of Lower Burlington age in the north-central portion of the Ozarks at the present time,[1] the source of land derived sediments was removed, and the red color of the sediments was no longer present. From this time on the accumulation upon the sea bottom was almost entirely organic, and was largely composed of the calcareous stems and broken bodies of crinoids. So abundant are the remains of crinoids in the limestones deposited at this time, that the formation was named "Encrinital Limestone" by the earlier Missouri geologists. Associated with the crinoids there were many brachiopods and a few other types of life, such as corals, molluscs and trilobites, all of which now occur as fossils in the limestones. Along with these lower types of life there were numerous fishes allied to the sharks, whose presence is made known by their teeth which are found fossil in the limestones.

Although there was no land detritus in the form of mud or sand being carried into the waters covering Ste. Genevieve County at this time, the streams from more distant lands were carrying in solution great quantities of silica, which was precipitated in a colloidal or gelatinous condition on coming in contact with the sea waters. Such finely disseminated, colloidal silica was conveyed long distances in the shallow epicontinental seas, and accumulated over the sea bottom along with the calcareous organic accumulations. On the consolidation of the sediments a limestone with abundant, disseminated silica was the result. More recently this silica has become segregated into the concretionary masses and beds of chert which are now so characteristic of the limestones. The apparent excessive amount of chert in much of the limestone as we know it, is probably not a proof of an excessive amount of silica in the ocean at the time of accumulation of the limestone, but rather an indication of the extreme slowness of accumulation of the limestones.

The clear water sea which covered Ste. Genevieve County and much of the upper Mississippi basin at this time persisted

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

with little or no change, so far as southeastern Missouri is concerned, through the time of deposition of the Burlington and Keokuk limestones. In the northern portion of the basin, as exhibited in southeastern Iowa, a limited amount of mud was carried into the sea, probably from lands to the north, during the latter part of Keokuk time, but Ste. Genevieve County was too far distant to be affected by any changed conditions which may have been initiated in the north, but at the close of Keokuk time there were changes which have been recorded in the sedimentary record of Ste. Genevieve County. Probably one of the periodic uplifts of Ozarkia occurred at this time, and there are some facts to suggest that Ste. Genevieve County may have been a portion of an emergent area, probably the Ozarkian island at this time. Twenty feet or more of limestone at the top of the Keokuk, with a characteristic fauna, are present towards Little Saline Creek, which are apparently wanting in the northern part of the county, a condition which suggests an unconformity at this position, produced by the erosion of some of the higher Keokuk beds before the initiation of further deposition. This supposed erosion removed a greater thickness of the Keokuk in the northern portion of the county then further south, if any at all were removed in the latter region. This interruption in the succession of events at this time, however, was in no wise comparable to that preceding the Fern Glen, for instance, for many of the same species of brachiopods and other forms of life, continued to live throughout the period of change, and now occur as fossils in the limestones on either side of the unconformity representing the interrupted sedimentation.

The initial deposits following the temporary interruption in the accumulation of sediments, were commonly oolitic beds, and in some places there was a limited amount of sand, not as a distinct sandstone bed, but merely as disseminated grains in the limestone. The conditions occasioning the formation of such an oolite bed, only a few feet in thickness, as occurs at this horizon, are not clear, but that the conditions were not confined to the eastern shore of Ozarkia, but were more general, is shown by the presence of a similar oolite in southwestern Missouri, known as the Short Creek oolite, which is about equivalent in age with the oolite in Ste. Genevieve County, so far as can be determined by a study of the faunal succession.

The interruption of sedimentation just preceding the deposition of the oolite, is considered as a line of division within the Keokuk formations. During the late Keokuk time, in Ste. Genevieve County, the conditions were not unlike those during the earlier Keokuk and Burlington epochs, for the sedimentary record consists of essentially pure limestone with an abundance of chert. Gradually, however, conditions changed, and large quantities of mud and clay were carried into the sea, so that in Warsaw time the sedimentary record consists of shales associated with strata of limestones. The source of the clays which gave origin to these shale beds may have been in part, at least, the Ozarkian land, although there are some facts which suggest that the island was submerged at this time. If this submergence was a fact, the source of the material must have been from a distance, perhaps far to the north or east. That some of these clays were not from Ozarkia is suggested by the fact that the deposits of similar age in southwestern Missouri are wholly limestone, and if Ozarkia had been emergent at the time, it is not likely that all the clay transported by the streams draining the island, would have been deposited off the northern and eastern shores, with none to the southwest.

The life of the Ste. Genevieve County seas of Warsaw time was different from that of the preceding Keokuk time, although many fossil species are common to the formations of the two periods. The bryozoans constitute a far greater element in the fauna of this time than during any of the preceding Mississippian epochs, the fenestellid forms, with their delicate, lace-like colonies being especially abundant. Not only were these creatures represented by innumerable individual colonies, but the variety of genera and species was very great. Associated with these bryozoans there were many brachiopods and crinoids, with some corals, molluscs and trilobites. Inhabiting these waters also, there were the same sorts of strange, shark-like fishes which had been present in the earlier periods of the Mississippian.

Following Warsaw time, during which quantities of mud were deposited in the seas covering southeastern Missouri, there was a long period of clear water conditions during which very pure limestone with practically no land derived sediments, were deposited. The sedimentary record exhibits no break in Ste. Genevieve County in passing from the Warsaw to the Spergen (Salem) formations, although there is a distinct stratigraphic break and unconformity exhibited between these two formations in the northern portion of the Mississippian basin, especially in southeastern Iowa. The facts suggest that the shore line on the northern side of the Mississippian basin lay far to the north during Burlington time, so far away, in fact, that no land derived sediments were deposited south of some point north of southeastern Iowa. With the progress of time the land to the north was slowly elevated and the northern shore line of the Mississippian basin slowly shifted to the south. Accompanying this elevation the streams were rejuvenated and great quantities of residual clays which may have been accumulating for a long period of time, were transported into the basin. In southeastern Iowa these clays, in the form of shaly beds, make their appearance first in Keokuk time, but are not conspicuous until during the Warsaw, which contains much shale. There is no break within the Keokuk, between the Keokuk and Warsaw in Iowa, the possible disconformity observed in Ste. Genevieve County being due to local conditions connected with Ozarkian movements. The maximum southward advance of this north shore line was in Warsaw time, during the latter part of which period the sea border occupied a position south of the southern boundary of Iowa, and north of St. Louis. At this time the area of deposition of the land derived clays was pushed at least as far south as Ste. Genevieve County. Following this maximum southern position of the shore line, the land to the north was again slowly depressed, and the shore line again migrated to the north. With this depression of the land surface at the north, the supply of land derived sediments was cut off and clear water conditions were again inaugurated in the Mississippian basin, the shore line migrated northward again, and the Spergen limestone was deposited as far north as southeastern Iowa, where it is separated from the underlying Warsaw formation by an erosion unconformity, the erosion of the Warsaw surface having taken place while the shore line occupied a position south of Iowa. During this shifting of the shore line Ste. Genevieve County was continually covered by the sea from the beginning of Warsaw time, and the higher Warsaw beds of this County are younger than any of the Warsaw beds in the typical section of southeastern Iowa and the adjacent portion of Illinois.

During the Spergen transgression described in the last paragraph the life of the Mississippian sea had much in common with the preceding Warsaw fauna, as might be expected from the continuity of the submergence in the south. This similarity of the faunas is especially brought out in the great abundance of the delicate fenestellid bryozoans in both the Warsaw and the Spergen faunas, but there were many forms of life which disappeared at the close of Warsaw time, and others which are known for the first time in the Spergen.

Following the Spergen transgression there was again a withdrawal of the waters of the more northern portion of the Mississippian basin by reason of the elevation of the land at the north, and the shore line again migrated to a position south of Iowa and north of St. Louis, a position essentially the same as that between the Warsaw and Spergen epochs, but in Ste. Genevieve County the sedimentary record is again unbroken, and the St. Louis limestone follows the Spergen with no break whatsoever. In southeastern Iowa, however, the St. Louis rests unconformably upon the Spergen, and in places the whole of the Spergen was eroded during the period of the southermost position of the shore line, so that the St. Louis limestone rests directly upon the Warsaw.

Post-St. Louis Emergence. The two temporary southward migrations of the northern shore line of the Mississippian embayment, at the close of the Warsaw and again at the close of the Spergen epochs, were but the forerunners of a much more extensive withdrawal of the waters of the basin, which succeeded the period of deposition of the St. Louis limestone. This withdrawal was sufficient to leave the whole of Ste. Genevieve County above the sea, and the Ozarkian land at this time became continuous with the continental land to the north and east, and much of the interior basin of the continent may have been drained. During this emergence of the land much erosion was accomplished over the surface of the county. The St. Louis limestone, which is three hundred or more feet thick at St. Louis, and doubtless was of equal thickness originally over Ste. Genevieve County, was cut away to such an extent that commonly less than 100 feet are now present. Solution channels were also developed in the surface of the limestone which were later filled with a younger formation. During this emergent stage the erosion in some nearby area, perhaps southern Ste. Genevieve County, was carried sufficiently far to expose limestones of Middle Devonian age, as will be shown later.

Ste. Genevieve Submergence. Following the emergent epoch just described, the waters again advanced in the Mississippian embayment, and the deposition of a new formation, the Ste. Genevieve limestone, was inaugurated. The northward extension of the submerged embayment covered essentially the same area that had previously been occupied by both the Spergen and the St. Louis submergences, and its sedimentary record has been recognized as far to the northwest as Fort Dodge, Iowa. Throughout the entire distance from Ste. Genevieve County to Fort Dodge, Iowa, the Ste. Genevieve sediments were laid down upon a surface that had just previously been dry land subject to the processes of erosion. In many localities the basal beds of the formation are conglomeratic, due to the washing in of fragments of the limestone and cherts from older formations, and locally, in northern Perry County, just east of the Ste. Genevieve County line, many of the fragments in the basal conglomerate are cherts from Middle Devonian limestones, and among them are fragments of silicified Middle Devonian corals and brachiopods, showing that these beds must have been exposed at the time, at no great distance from the spot where they were redeposited. At other places, in Ste. Genevieve County, old solution channels in the St. Louis limestone of the pre-Ste. Genevieve land surface, may be seen filled with the basal conglomerate of the Ste. Genevieve limestone. That the waters of the Mississippian embayment at this time were shallow, is conclusively shown by the extraordinary amount of cross-bedding exhibited in the limestones, and by the ripple-marked surfaces. In places some of the lower beds of the Ste. Genevieve formation are slightly arenaceous due to the presence of rather evenly disseminated sand grains through the more calcareous beds. Locally also, in the midst of the formation, there is a thin bed in which the sand predominates, and on weathering takes on the appearance of a pure sandstone.

The life of the waters of the Ste. Genevieve submergence was varied, but the fossil record of it has been well preserved in only a few localities within the region that has been studied, doubtless due to the fact that the waters were shallow and much disturbed, so that the shells were commonly broken to fragments before being finally deposited in the sediments of the sea bottom. The fauna, as it is known, includes many small pelecypod and gastropod shells, besides some brachiopods, corals, crinoids, and perhaps other things.

Post-Ste. Genevieve Emergence. After the deposition of the Ste. Genevieve limestone, the waters of the Mississippian basin were more completely withdrawn than at any other previous time since the Kinderhook. From the Keokuk time onward there had been oscillatory movements with recurrent withdrawals of the sea, each withdrawal being more complete than the one just previous to it, but with each re-advance the sea returned to essentially the same area it had occupied before, and continued its deposition of lime sediments, with some shale in Warsaw time. No sandstone deposits are present in the whole series of beds, save in the Ste. Genevieve formation, where they are of very minor importance, and in many sections are wanting altogether. The final withdrawal after the close of Ste. Genevieve time was of a different sort. It was more complete than any of the previous retreats, and must have been accompanied by much more general diastrophic movement, for with the next advance the waters did not occupy the same basin as they had done previously, and the streams draining into the basin were loaded with great quantities of sand so that sandstones comprise a notable portion of the later sedimentation.

The younger series of Mississippian sediments is much more heterogeneous in character than are those of the earlier Mississippian, for they include notable sandstone and shale formations as well as limestones. The history of events during Chester time in Ste. Genevieve County, and the adjacent portions of the Mississippi Valley, is not simple. There were repeated shiftings or withdrawals of the waters occupying the Chester basin, and changing conditions upon the surrounding lands which supplied the land derived sediments of the time, as is indicated by the varied types of sediments that have been preserved.

During the Post-Ste. Genevieve emergence the region now occupied by Ste. Genevieve County was a part of an extensive land surface, probably stretching from Appalachia on the east for a long distance west of Ozarkia, and continued northward to the Arctic regions. To the south it may have occupied much or all of the lower Mississippi Valley. This land surface was doubtless drained by many rivers and river systems, and their activities eroded the surface to a notable degree. In the immediate portion of the Mississippi Valley with which we are concerned, this erosion, in places, removed the whole of the Ste. Genevieve limestone and cut into the St. Louis limestone, so that when the next epoch of sedimentation was inaugurated the Chester beds were laid down unconformably upon the St. Louis.

Aux Vases Submergence. The first of the Chester invasions to occupy any portion of Ste. Genevieve County, and the earliest one of which we have any record, has left its record in the Aux Vases sandstone. The source of this sand cannot be determined at the present time, with entire certainty, but it probably came from Ozarkia, the land which formed the western border of the basin in which it was deposited. It may have been transported to the position of its final resting place by streams which drained areas in which the St. Peter sandstone, or other more ancient sandstones were exposed. It is a very pure sand, free from either calcareous or argillaceous material, which suggests a different topographic attitude of Ozarkia than that which it had presented through the whole of the preceding Mississippian time, when the area had supplied no clastic sediments of any sort. The older sandstones which could furnish the Aux Vases type of sediments had probably been wholly or in large part buried beneath some of the earlier Mississippian sediments, but at the time of the post-Ste. Genevieve emergence, Ozarkia probably experienced one of its recurrent periods of uplift, so that much of the Mississippian accumulation of calcareous sediments were removed before Chester time, while only a much less amount was removed in Ste. Genevieve County, on the flank of the uplift.

The distance eastward to which the Aux Vases sandstone was deposited is unknown, and consequently the width of this earliest Chester embayment is uncertain. No record of the life of the sea in which the Aux Vases sandstone was deposited has been preserved, although a bit of evidence bearing upon the character of the flora of the lands adjacent to the basin in which the sands were deposited, is preserved in a few fragmentary tree trunks which have been observed at one locality in Illinois, these trunks being members of a species of *Lepidodendron.*

Post-Aux Vases Emergence. The first Chester submergence was not permanent, but was followed by an emergent condition which seems to have been greater to the east, perhaps in the Cincinnati axis, than in Ozarkia. The erosion which took place during this emergence cut into the surface of the Aux Vases sandstone, and seems to have removed it entirely to the east, if it was ever present to any distance in that direction, since it is now restricted to a narrow belt reaching but a short distance east of the Mississippi River.

Renault Submergence. The submergence which followed the temporary emergence after the deposition of the Aux Vases sandstone, was more enduring than the earlier one had been. The Renault formation which has preserved the record of this submergence, is exceedingly heterogeneous in character, indicating that the conditions of sedimentation in the basin at this time were exceedingly variable. At the beginning of Renault time much chert gravel was spread over the newly submerged area. The pebbles are well rounded, showing that they were much worn by stream transportation or by rolling upon the beach. Such a basal conglomerate is well exhibited in Ste. Genevieve County between St. Marys and the mouth of Saline Creek, and at many localities in Illinois. From eastern Ozarkia the streams carried various sorts of sediments into the Renault sea, in places sand, elsewhere fine clays, some of which were distinctly red in color. In other localities the sediments were made up largely of calcareous organic remains, although all of the limestones include more or less of argillaceous material. In southeastern Ste. Genevieve County, where alone the Renault sediments have been preserved in the county, a limestone bed with shale partings makes up a considerable portion of the formation, this limestone exhibiting a maximum thickness of 50 feet. Two miles distant from the section exhibiting this maximum thickness, however, the limestone is only 12 feet thick, and even that is conspicuously arenaceous.

The life of the Renault sea was abundant and varied, the fauna being the first of the distinctly Chester faunas which continued to live in the Mississippian basin, with greater or less modification, for a long time. The brachiopods were well represented in the fauna, and associated with them were numerous bryozoans, simple corals were present, as were pelecypods, gastropods, and some cephalopods. Crinoids must have been abundant, judging from the great numbers of fragmentary stems, although the bodies are only rarely preserved, and the pentremites, which are highly characteristic of most of the Chester faunas, are not uncommon. Associated with all these types of invertebrates, there were numerous fishes allied to the sharks, whose presence has been recorded by their teeth.

Yankeetown Time. The last sedimentary record of Paleozoic time in Ste. Genevieve County is the Yankeetown formation. This is a most peculiar siliceous formation, so different from other beds that its origin is difficult to interpret. It is a thin bed, rarely if ever more than ten feet in thickness. Its relation to the underlying Renault is not clearly shown in Missouri, but when studied throughout its entire extent in Illinois, its relations seem to be unconformable upon the Renault, which would indicate that the sea withdrew following Renault time, to return later, this peculiar, siliceous, Yankeetown bed being the initial deposit of the readvancing sea.

Later Chester History. No record of the later Chester history has been preserved in Ste. Genevieve County, although it can probably be asserted with much certainty, that the western shore line of the Chester sea, which bathed the eastern slope of Ozarkia, crossed the area now included in Ste. Genevieve County during much of the time. The records of these submergences, however, have been completely destroyed through the agency of the processes of erosion which have been active for so long a period over the entire county.

PENNSYLVANIAN PERIOD

Whether or not strata of Pennsylvanian age were deposited in Ste. Genevieve County has not been positively determined. Remnants of strata of this age occur over a large part of the Ozark region, indicating that the Pennsylvanian Sea encroached over much of the area and deposited an unknown thickness of strata. In the St. Francois mountain region, and in the river counties on the east, including Ste. Genevieve County, no deposits of the Pennsylvanian have been found. It is believed, however, that this portion of the Ozark region was covered by the Pennsylvanian Sea and that whatever strata were deposited were removed by subsequent erosion.

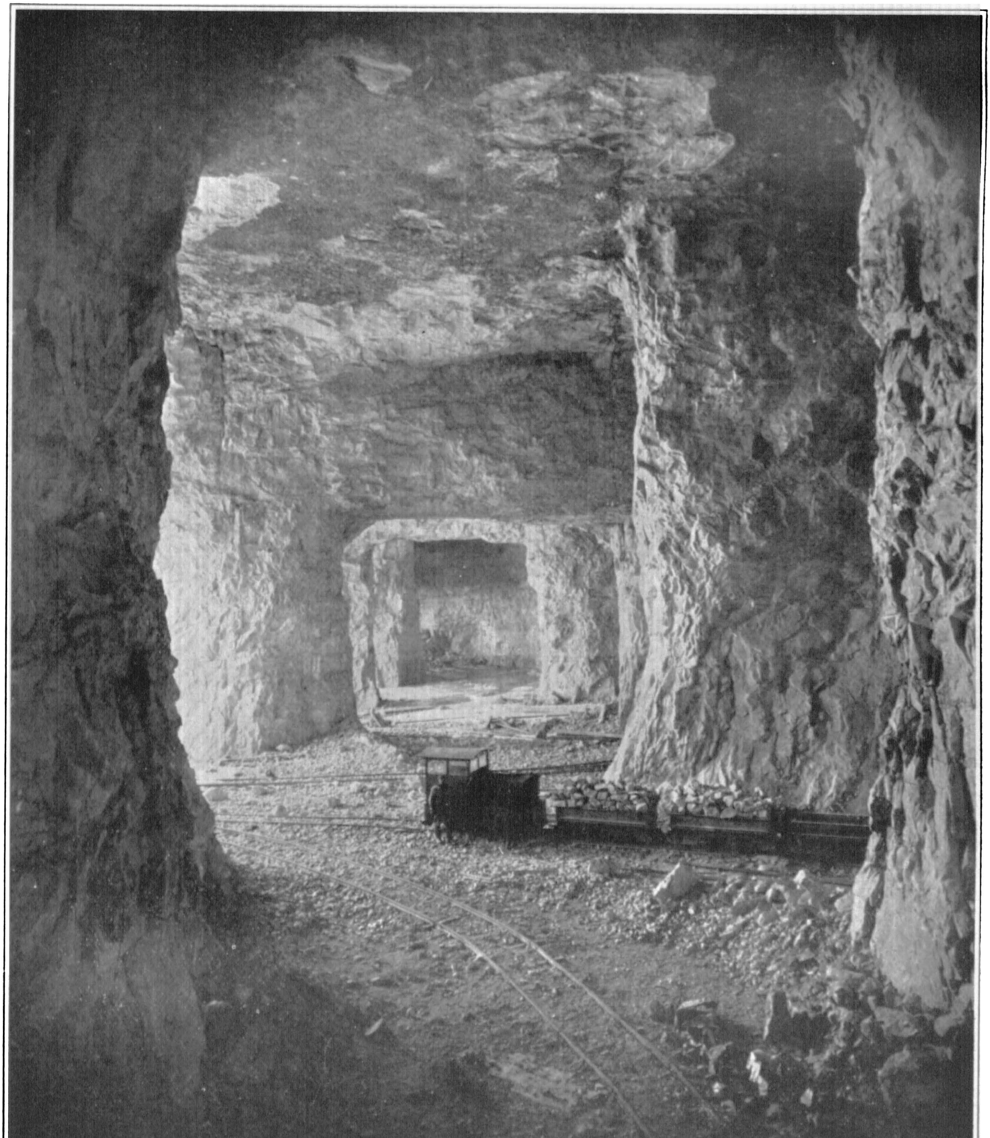
Post-Pennsylvanian Emergence. The area comprising Ste. Genevieve County has been above sea level since Pennsylvanian time, and subject to continual erosion. The present strong topographic expression has been the result of continuous denudation since the Pennsylvanian.

Post-Pennsylvanian Faulting. At a later period than any that is now represented in the sedimentary record of either Ste. Genevieve or Perry counties, the rocks constituting the earth's crust in southeastern Missouri were disturbed by a much more violent diastrophism than any which had occurred since the period of faulting in late Devonian time which had served to ease the accumulated stresses. Like the earlier deformation this diastrophism exhibited itself in crustal breaking or faulting. The exact time of this faulting is not determinable from observations in Ste. Genevieve County, it can only be shown to be later than any of the Mississippian sediments which have been preserved, but by following the same line of deformation eastward into Illinois, where formations of Pennsylvanian age are involved, it can be shown to be post-Pennsylvanian in age. It probably occurred during the period at the close of Paleozoic time when crustal movement was very general throughout the whole world.

Through much of the distance across Ste. Genevieve County this younger faulting followed closely the line of the earlier Devonian movements, but it differed from the earlier deformation in that the upthrow of the faulting was all on the south. The maximum displacement was approximately 2000 feet. During the period of peneplanation which accompanied and followed this faulting, the entire surface of the county and the adjacent region was cut to a common level, and in consequence very much of the sedimentary record of the uppermost formations was destroyed. In the case of the Devonian and Silurian records, all that portion which had extended northward from the line of late Devonian faulting had been swept away in the course of the peneplanation which followed that movement. The southward extension of the beds, however, must have been still in existence during the whole of Mississippian time, and indeed until this later faulting was accomplished, but after the peneplanation which followed this diastrophism the southern extension also of the Devonian and Silurian, as well as of the Mississippian records was destroyed. In consequence of these two periods of faulting and peneplanation, a large part of the sedimentary record in Ste. Genevieve County has been destroyed except in a small area with a maximum width of scarcely more than one mile, where for the distance of three or four miles the later faulting occupies a position south of the older.

PLEISTOCENE EPOCH

As shown by Shaw and Leverett, evidently the ice during at least one period reached Ste. Genevieve County and shifted for a time the course of Mississippi River. Detailed work throughout southeast Missouri will be necessary before definite conclusions can be reached concerning the regional effect of glaciation.



Underground limestone quarry, Peerless White Lime Co., Ste. Genevieve.

CHAPTER VI

ECONOMIC GEOLOGY

INTRODUCTION

The comparatively wide range of geological formations occurring in Ste. Genevieve County is reflected in its mineral resources. Present industrial developments are largely non-metallic, the chief output being marble, lime and limestone, obtained from the various horizons chiefly near railroad transportation. Formerly copper ore was mined; and lead ore was produced to some extent near Avon, where the Bonneterre formation outcrops over a considerable area. Some prospecting has been carried on in the vicinity of the granite areas for gold and silver, but neither of these metals have been found. There are possibilities for the production of glass sand and feldspar, this county being probably the most favorable one in the State for the production of the latter. Although much iron ore and barytes have been produced in other areas of southeast Missouri, there seems but little evidence favorable to the occurrence of commercial deposits in this county.

LIME INDUSTRY

The manufacture of lime is the most important mineral industry in the county. The industry centers in the eastern part, particularly around the town of Ste. Genevieve, where there is an abundant supply of high-grade limestone. Rail connections are good to the north, south and east, where there are large markets; and with the nearby coal fields of Illinois economic conditions are quite favorable for this industry.

Four plants with a total of 34 kilns are burning limestone at, or in the vicinity of, Ste. Genevieve; the raw material being obtained from the Spergen limestone of Mississippian age. The fifth plant is located at Brickeys, the material being obtained from the Kimmswick limestone of Ordovician age.

The burning of lime in Ste. Genevieve County dates from 1840,[1] the product being hauled to Ste. Genevieve and shipped

[1]Buehler, H. A., Lime and Cement Resources: Missouri Bur. of Geology and Mines, Vol. VI, 2nd Ser., p. 207, 1904.

by boat to points along Mississippi River. Vertical stone kilns were in operation until about 1904, when the present plant of the Western Lime Works was constructed at Ste, Genevieve. Two kilns of stone and steel constituted the first unit; but with continued development the company has grown until now six steel kilns are in operation. The plant of the Ste. Genevieve Lime and Quarry Company (Plate XIV, B) was constructed a short time later, about two miles west of Ste. Genevieve. Seven vertical stack kilns are now in operation. The Peerless White Lime Company started on the site of the old Boyer kiln about 1908. At present 9 vertical stack kilns are fired, with a 10th kiln in process of construction. This kiln, together with kiln No. 9, embody several features that produce a more uniform product, and a reduction in operating costs. The Bluff City plant was constructed west of the Peerless plant in 1925, and consists of 12 vertical stack kilns.

The raw material for the plants at Ste. Genevieve is obtained from the Spergen limestone, previously described on page 203 of this report. As shown on the geological map of the county, it extends in a belt approximately one mile wide from the mouth of Frenchman Creek south to the faulted area on Saline Creek, a distance of 16 miles. The general easterly dip has resulted in outcrops along River aux Vases for a distance of 2 miles and along Saline Creek for a distance of 3½ miles. Outcrops of the formation also occur along the down-thrown side of the belt of faulting in Perry County. It is also exposed in the bluffs north and south of McBride in the same county. The formation has a maximum thickness of 160 feet in Ste. Genevieve County, the upper half of which produces a white to light gray or bluish-gray, very pure, oolitic to slightly oolitic crystalline limestone. A generalized section compiled from studies of the quarries follows:

Generalized section Spergen limestone, Ste. Genevieve, Mo., lime district.

	Thickness Feet
St. Louis Limestone: Hard, compact, dense, bluish-gray or gray in color, with nodules and lenses of chert	0–160
Spergen limestone:	
1. Limestone, light blue-gray, slightly oolitic, crystalline, fossiliferous	40
2. Limestone, magnesian, buff-colored, fine-grained to finely crystalline	1–2
3. Limestone, very white, extremely oolitic, soft, sometimes marked by crystals of calcite, in cross bedded portions of this member	15–20
4. Limestone, magnesian, buff-colored, dense	1–3
5. Limestone, light bluish-gray, crystalline, somewhat oolitic	30 +

These major divisions are shown in the photograph of the Bluff City Lime and Manufacturing Company's Quarry (Pl. XIII, A).

The oolitic member, No. 3 of the above section, is valued because of the purity and color of the burned product, which makes it particularly suited for chemical lime. The magnesian limestones, of the above section, appear to be persistent over the district, although perhaps locally absent. The stone from these thin beds is not suitable for high-grade lime, and it is discarded in quarrying. The rock underlying and overlying the slightly magnesian beds is of good quality, and is quarried and burned to high-grade lime.

QUARRIES AND PLANTS

Western Lime Works. This company operates two quarries in the upper part of the Spergen formation, on the north side of North Gabouri Creek, about two miles west of Ste. Genevieve. The new quarry is 300 feet long in a north-south direction and 260 feet wide in an east-west direction. The maximum height of the limestone face is 47 feet, capped by cherty clay and loess overburden up to 12 feet in thickness. The upper 10 feet of the face consists of gray, crystalline, slightly oolitic limestone, underlain by approximately 20 feet of more oolitic limestone, containing fine crystals of calcite, beneath which is a gray, hard, crystalline, slightly oolitic limestone having a thickness of 15 feet. No beds of yellow magnesian limestone were noted in the face at the time of the examination. However, large pieces were seen on the dump, and beds of this stone are no doubt locally present.

The upper 15 to 20 feet of the quarry, particularly the west face, is cut by many vertical joints and solution channels along bedding planes. These openings are filled with dark red, sticky, joint clay, which is troublesome in quarrying, and results in some waste rock. The lower part of the face appears to be solid, except in the south part, where it slopes toward the valley and is less than 10 feet high. The general dip of the strata in this quarry is to the southeast. This property is worked as an open quarry, the cherty clay overburden being removed, at the time of the examination, by shoveling into small dump cars. As the face is extended into the hill, additional facilities will probably be required for handling the increased thickness. Holes are drilled by means of a small churn drill, and shot with black powder and dynamite. The larger pieces are block-holed by compressed air drills and reduced to desired size by shooting. The stone is loaded by hand and trucked to the plant, located in the town of Ste. Genevieve.

This company also operates a quarry just south of the one described above. It has been in operation for a number of years, and until recently furnished all the stone required at the plant. The quarry has been developed in a northeast and southwest direction, and measures 600 feet long by 150-175 feet wide. About 40 feet of the upper part of the Spergen limestone has been worked. The formation is similar to that described in the new quarry. Jointing is present under the overburden, and solution channels are present, one near the floor of the quarry being quite persistent.

The plant is located east of the St. Louis-San Francisco Railroad in the town of Ste. Genevieve. It consists of six vertical stack kilns, four of which are fired by producer gas from individual units, the other two being equipped with Ward patented semi-producer gas machines.

The kilns are charged from an inclined railway running up to the charging floor at the top of the kilns. The burned product is removed through end draws at the base of the kilns. The plant has a capacity of 120 tons per day. It is equipped with a hydrator for the manufacture of hydrated lime.

Ste. Genevieve Lime and Quarry Company. The plant and quarry of this company are located at Mosher Station (Macy on the County Map) on the Missouri-Illinois Railroad, about two miles west of Ste. Genevieve. The quarry is in the upper part of the Spergen formation, a few feet of the overlying St. Louis formation being exposed at the top of the face. This property was formerly worked only as an open quarry, but with an increase in the thickness of the overburden, and the demand for high-grade, oolitic limestone, tunnels have been driven in the face on the main oolitic bed. Production is also being maintained from the open quarry. As developed it measures about 600 feet long in a northeast-southwest direction; 150 feet wide and 80 feet from top to the bottom of the face. The beds of magnesian limestone overlying and underlying the oolitic limestone serve as parting planes in quarrying. The following general section is exposed along the north face of the quarry.

Section Upper Part of Spergen Formation in Quarry of Ste. Genevieve Lime and Quarry Company.

	Thickness, Feet
Overburden, red cherty soil	6–11
St. Louis formation	
Limestone, cherty	
Spergen formation	
Limestone, light bluish-gray, crystalline, slightly oolitic	35–38
Limestone, buff, finely crystalline, magnesian	3
Limestone, white, soft, very oolitic, cross-bedded, marked by well-defined stylolites, crystals of calcite common in cross-bedded portions	18–22
Limestone, magnesian, buff, slightly crystalline	1–3
Limestone, gray, crystalline, slightly oolitic	25

The upper part of the face shows mud-filled joint planes and solution channels. Occasionally these extend down some 40 feet into the tunnels from which the white oolitic limestone is being removed. The underground workings are at present confined to the high-grade oolitic limestone. The headings are driven 22 feet high.

The plant is equipped with seven vertical stack kilns capable of producing 185 tons of lime per day. Five kilns are fired by producer gas manufactured in individual units, and two by Ward type machines. The hydrator for the production of hydrated lime is the Clyde type machine. A Raymond pulverizer is used for grinding the quicklime, after which, the product is dumped, and conveyed to a blower which sizes the material to the desired fineness. The larger and heavier particles are sold for agricultural lime. The company has recently installed a Webster Hammer Mill for crushing limestone not suited for burning into high-grade lime. The crushed stone, 95 per cent of which passes through 10 mesh, is sold for agricultural limestone. The unit is rated at 25 tons per hour of crushed limestone. Storage bins for uncrushed rock, and bins for crushed rock are a part of the mill. The product is sold under the trade name of "Agstone." The company has under consideration plans for adding certain features to the present kilns to insure a more uniform product and a decrease in operating costs.

Peerless White Lime Company. This plant, a subsidiary of the Hunkins Willis Lime and Cement Company of St. Louis, was started in 1908. It is located at Mosher Station about 2¼ miles west of Ste. Genevieve.

As in other parts of the district, the upper part of the Spergen formation furnishes the stone for this plant. Quarrying operations were formerly confined to an open quarry. The overlying St. Louis formation increased in thickness as the face was extended into the hill and tunnelling was resorted to in 1921. At present the bulk of the stone is obtained by underground operations although some stone is now obtained from a new opening in the quarry from which the overburden has been removed by hydraulic stripping.

In tunnelling, the original headings are driven 40 feet wide by 16 feet high. This permits the removal of the bed of white oolitic limestones which is usually burned separately as it yields a high-grade chemical lime. In some parts of the mine the oolitic limestone is overlain by a layer two to four feet thick which is adapted for certain purposes and is removed separately. The stone above this rock for a vertical distance of 25 feet is next removed, and finally 35 feet of rock below the base of the oolitic limestone is removed, making the final stope 75 feet in height. The arrangement of the pillars is such that a rock recovery of 86 per cent is reported from the underground operations.

The open quarry shows mud-filled joints in the face, which are particularly noticeable just under the overburden. Joints are also present in the underground workings, but are confined chiefly to the ground at or near the mouths of the tunnels. Occasional mud-filled cracks are encountered, but are taken care of to prevent mud and gravel from entering the mine during wet seasons. Holes are drilled with rock drills and shot with dynamite, care being taken to reduce the percentage of spalls. In this connection it is interesting to note the use of red flares in the mine which warn the workmen of the location of impending "shots."

The rock is hauled in mine cars by gasoline motors over a well arranged system of tracks to the plant located north of the quarry. Ten kilns have been constructed, and 9 are being fired at present, the plant having a maximum daily capacity of 225 tons.

The kilns are fired by gas furnished by Woods type producer gas machine. The last two kilns constructed by the Company are 84 feet in height. They are charged with stone by means of a five-ton skip hoist loading from rock storage bins. These kilns have been the subject of much experimentation by the company and considerable attention has been paid to features that will insure a more uniform product, plus efficiency in operation at lower costs. The plant has a continuous hydrator of the Kreitzer type for the manufacture of hydrated lime.

Bluff City Lime and Stone Company. This plant is located just west of the Peerless plant, on the north side of the Missouri-Illinois Railroad, about 2¼ miles west of Ste. Genevieve. It is the most recent plant in the district, being put in operation in 1925.

The quarry is located a short distance east of the plant and on the north side of State Highway 25. The stone is taken from an open quarry in the upper part of the Spergen formation, where the following section was measured.

Section Upper Part Spergen Formation, Quarry Bluff City Lime and Stone Company.

	Thickness, Feet
Overburden, red clay—average	5
Limestone, bluish-gray, finely crystalline, thin-bedded, weathers gray to buff. Beneath overburden shows much jointing and the results of subsequent solution, which has produced rounded knobs	0–7
Limestone, dark buff, magnesian, finely crystalline	2
Limestone, white, very oolitic, soft, cross-bedded	15
Limestone, dark buff, magnesian, dense to crystalline, crystals of calcite common	2 +
Limestone, gray, crystalline, somewhat oolitic	25

The overburden is removed by scrapers and dumped into the valley north of the quarry. The face is shot by holes 22 feet deep from the top of the face, 25 per cent dynamite being used. Compressed air drills are used in sinking the holes. The rock is sorted on the quarry floor and hauled by gasoline locomotives to the plant. The extensive system of tracks to the quarry is shown in plate XIII, A. The company has diamond core drilled property near the western limits of the town of Ste. Genevieve. Because of the thickness of the overlying St. Louis limestone, plans are being made to remove the limestone from the Spergen formation by underground mining methods.

Twelve vertical stack kilns with a reported maximum production of about 200 tons of lime per day are in operation at the plant. Coal is used for fuel and fed by hand to the kilns. The rock is loaded into the kilns from a charging platform which is virtually a continuation of the incline from the quarry. A spur from the incline permits the loading of waste rock, and rock not suited for high-grade lime, directly into open cars below. This material is used for various purposes from agricultural limestone to flux and whiting.

Arrowhead Manufacturing Company. This plant is located in the NW. ¼ NW. ¼ sec. 24, T. 39 N., R. 10 W., in Brickeys Hollow, about one-fourth mile southwest of the town of Brickeys on the main line of the St. Louis-San Francisco Railway, with which the plant is connected by a spur.

The stone was formerly obtained from an open quarry, the Kimmswick limestone being utilized. At this place it is light gray to light buff crystalline limestone, marked by many stylolites. Chert nodules are common near the top. It is overlain by shales and red-gray limestones of the Fern Glen formation, which are not suited for the manufacture of lime, and as the thickness of this formation increased open quarry work was abandoned and the stone recovered by underground methods. The headings are in the upper part of the Kimmswick limestone and are driven from the face, twenty-two feet high, the workings in the main being to the southeast. Thirty-foot pillars are left to support the roof, which in general appears to be solid. In one place it is cut by a vertical joint through which much debris has come down onto the floor of the tunnel, during recent rains.

The stone is hauled from the underground workings over an elevated track to the top of the kilns, the elevation of which is the same as the floor of the tunnels.

The plant is equipped with four vertical stack kilns, and has a capacity of 36 tons per day. The kilns are fired by hand with coal. The product is a high-grade strong lime, darker colored than the lime burned at Ste. Genevieve, and for some purposes is in greater demand than lime made from the Spergen formation.

Composition and Uses. The limestones burned in Ste. Genevieve county are very pure, being high in calcium oxide. The product resulting from burning the Spergen limestone is white, that from the Kimmswick formation being somewhat darker and gray in color. Analyses of the limestone and lime are given in the table below:

Analyses of Limestone and Lime, Ste. Genevieve County, Mo.

	1	2	3	4	5	6
Calcium Carbonate ($CaCO_3$)	98.79	....	97.75	86.81	98.50	
Calcium Oxide (CaO)	....	98.82	....	....	....	98.52
Magnesian Carbonate ($MgCO_3$)	0.32	....	1.40	8.84	0.50	
Magnesium Oxide (MgO)	....	0.30	....	....	....	0.39
Silica (SiO_2)	0.27	0.31	0.25	1.91	0.21	0.32
Iron and Alumina (Fe_2O_3—Al_2O_3)	0.22	0.21	0.16	0.96	0.21	0.40
Totals	99.60	99.64	99.56	98.52	99.42	99.63

No. 1. Average analysis of oolitic limestone, Spergen formation, Ste. Genevieve district.

No. 2. Average analysis of lime burned from Spergen formation, Ste. Genevieve district.

No. 3. Analysis of limestone overlying oolitic limestone, Spergen formation, Ste. Genevieve district.

No. 4. Analysis of magnesian limestone, one to two feet thick overlying oolitic limestone, Spergen formation, Ste. Genevieve district.

No. 5. Analysis of Kimmswick limestone, near Brickeys, Ste. Genevieve County.

No. 6. Average analysis of lime burned from Kimmswick limestone, Jefferson and Ste. Genevieve counties, Missouri.

The analyses given above do not show the presence of phosphorus or sulphur. A study of analyses of the oolitic limestone from the Spergen formation indicates a low phosphorus content, usually less than .01 per cent, and an average sulphur content of .02 per cent or less.

The finished product is used in building, for agricultural lime, in glass works, in paper mills, in sugar refineries, for water purification, and many other industries requiring high-grade chemical lime.

Production and Future. In 1913 the production of lime from Ste. Genevieve County was 38.500 tons, valued at $151,913. Since that time the growth has been steady and in 1927 the total produced was 159,405 tons valued at $1,113,738, the amount and value being more than one-half of all the lime produced in Missouri.

The industry should continue to grow, with increased demands for lime and with scientific research to determine new uses for this material. The industry does not face any lack of raw material. The extensive development and distribution of the Spergen limestone and also the Kimmswick limestone is such that raw materials will be available for many years to come. It is probable, however, that the development of the lime industry two miles west of Ste. Genevieve, in the immediate vicinity of Mosher will be confined to the expansion of plants located in this district at present.

North of Little Rock landing at the mouth of Frenchman Creek, and also at the mouth of Lower Frenchman Hollow, the Spergen is exposed. Transportation facilities are at hand, and these points offer possible sites for future development.

The Spergen formation outcrops on River aux Vases and Saline Creek, and within one-half to two miles of the main line of the St. Louis-San Francisco railway. The formation also outcrops in the bluffs north and south of McBride, Perry County, but as shown on the geologic map the formation is limited in extent and involved in complex faulting. It is quite possible that excessive joints and openings would be encountered in the rock in this locality.

There is also the possibility of obtaining the Spergen limestone from deep mines, in the future. Shafts could reach the main oolite at a depth of approximately 330 feet at Ste. Genevieve, but to the west, due to the rise of the formation, it could be reached at a shallower depth. The cross section (fig. 4) is drawn along a line from the plant of the Ste. Genevieve Lime and Quarry Company to that of the Western Lime Works in the town of Ste. Genevieve.

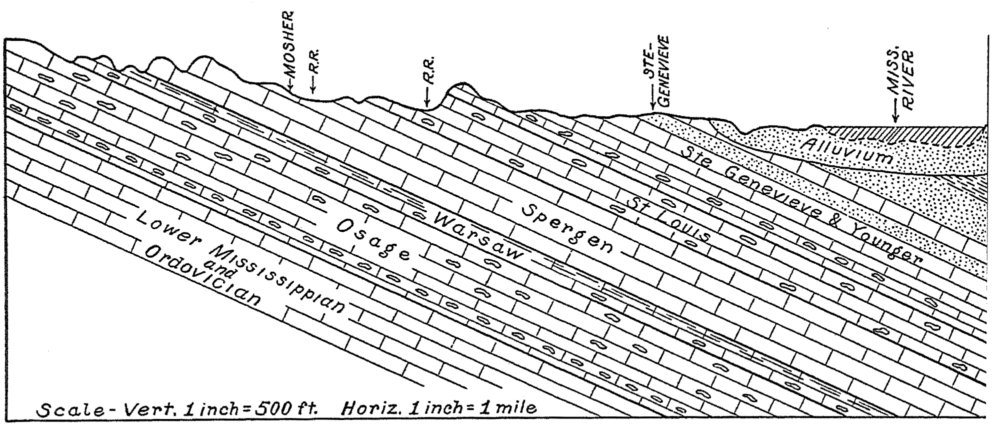


Fig. 4. Generalized cross section showing depth to Spergen limestone.

The Kimmswick outcrops in the valleys tributary to Mississippi River from Clement Station north to the Jefferson County line. It is also available where the Missouri-Illinois Railroad crosses the belt of outcrop in the SW. ¼ sec. 36, T. 38 N., R. 8 E. The limestone is accessible to transportation facilities and the distribution is such as to insure sufficient stone for the manufacture of gray lime for many years.

QUARRYING INDUSTRY

Ste. Genevieve County has a wealth of stone suitable for many purposes, and the quarrying industry as a whole is second in value to the production of lime.

Extensive quarries have been developed in various parts of the county, the production being chiefly limestone and marble, although sandstone has been quarried in the past, and there are granite deposits in the western part of the county which are at present undeveloped.

The Kimmswick, Little Saline, Grand Tower, Spergen, St. Louis and Ste. Genevieve formations are being worked at present. Sandstone has been quarried from the Roubidoux formation, and was used in the church at Weingarten; the Joachim has also been quarried to some extent, and was used in the church at Zell. Stone has also been taken from the Plattin formation, and the sandstone beds in the Aux Vases formation were formerly worked south of Ste. Genevieve. It is probable that other formations have been quarried locally.

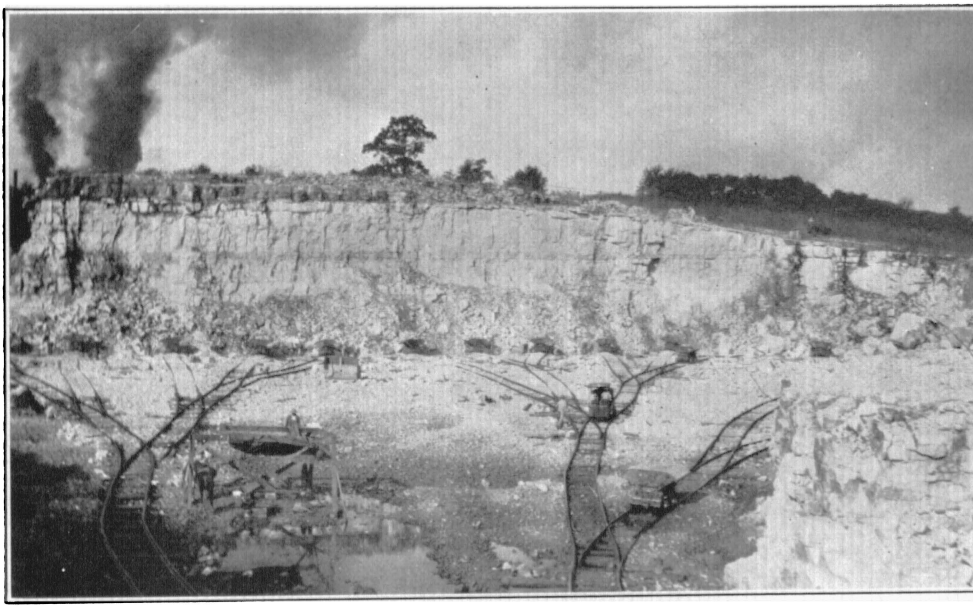
The opening of marble quarries in recent years has been one of the important developments of the natural resources of this county. The quarries are described below.

Ozora Marble Quarries Company. The quarry of this company opened in 1920; is located on the southeast bank of Saline Creek, in the east part of SE. ¼ sec. 5, T. 36 N., R. 9 E., about two miles south of Ozora. This property is situated in a highly faulted zone and the formations producing the marble, the Little Saline and Grand Tower of Devonian age, have been slightly metamorphosed.

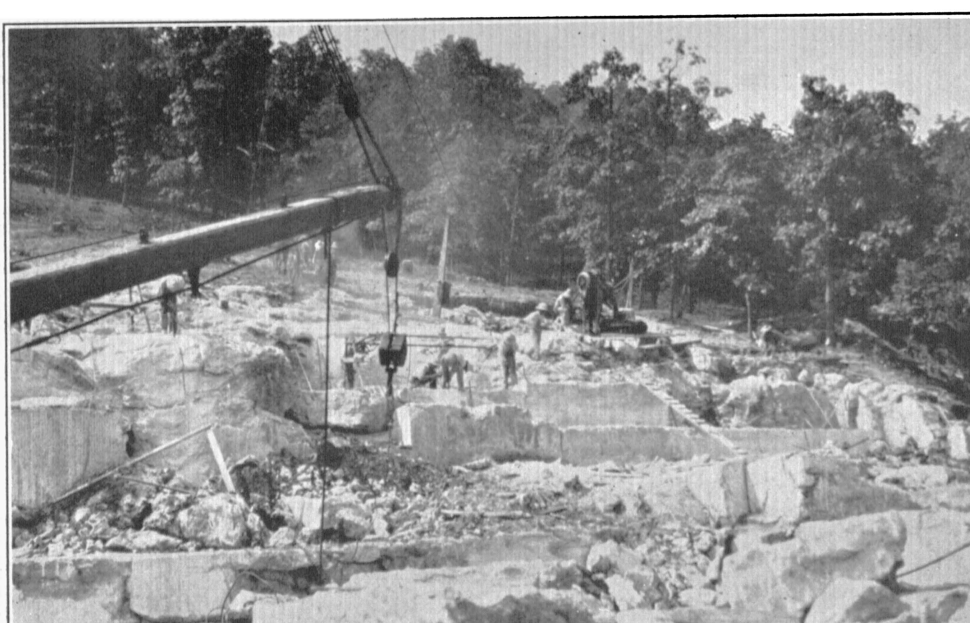
The Little Saline formation is white, slightly pinkish, highly crystalline, chert-free limestone. The marble from this formation is marketed under the name of "Ste. Genevieve Clear." It is locally very fossiliferous. As exposed in the quarry openings, the overlying Grand Tower formation is a very variable limestone. Light-colored beds of crystalline limestone are present in the basal part; higher in the formation brownish-gray to dark red, slightly magnesian limestones are common. The red limestone is dense to finely crystalline, and even textured. It appears to be slightly argillaceous. Gray to pink and red crystalline limestone is also found in this part of the formation, the stone being marketed as "Ste. Genevieve Rose." The overlying beds are white, crystalline, and very fossiliferous, corals being particularly abundant. The succeeding beds are brownish-gray, finely crystalline, hard limestone, marked by small veins which vary from fine lines to one-half inch in width. These are filled with buff to pink-colored limestone, more crystalline than that of the matrix. Small areas of gray crystalline limestone are interspersed in the veining. Fossil corals, which are present in abundance in this part of the formation, are also crystalline, being marked by fine crystals of calcite. The light buff-colored veining has resulted in the trade name of "Ste. Genevieve Golden Vein" being applied to this stone. Polished slabs of this marble are light gray in color, with a light brownish cast. The color of the irregular veining, and the darker colored fossils stand out in pleasing contrast to the lighter gray of the rock. Light colored, finely crystalline marble is being produced above the "Golden Vein" Marble. These beds are even-grained and uniform in color. The stone is hard. Chert is not common in the Little Saline or Grand Tower formations, but occurs locally near the base of the latter.

The quarries are in the north central part of a heavily faulted block, the structure within the planes of the faults being that of a sharply folded syncline. North of the quarry and on the north side of the fault, the cherty limestones of the Bailey formation of Devonian age outcrop. South of the fault, the Little Saline and Grand Tower limestones are exposed, the beds showing considerable drag along the fault plane. The structure is shown by cross section D-D on the geologic map.

The general structure is reflected in the quarries. Back of the company's office, an opening 50 feet long by 40 feet wide by 40 feet high shows brown to gray, red-mottled metamorphosed limestone dipping 23 degrees southeast. The stone quarried is marketed under the trade name of "Ste. Genevieve Rose." Some of the rock has light greenish-colored stains, which appear on the surface or filling small veins in the rock. The face in this opening which is in the lower middle part of the Grand Tower formation is considerably jointed. Near the surface these show enlargement from solution and are filled with red mud. Mud-filled solution channels were also noted along bedding planes in the upper part of the face. Southeast of the above, another opening has been made in brownish-gray crystalline metamorphosed limestone, carrying the buff-colored veining characteristic of the so-called "Ste. Genevieve Golden Vein" marble. The width of the quarry face measured along the strike is about 165 feet, the depth of the opening being about 50 feet. The lower part of this opening is now in gray fine-grained, slightly fossiliferous metamorphosed limestone or "Monotone" marble. The beds in this opening dip 18° S. 75° E. In the northeast corner, the face shows solution channels, which are filled with clay. The rock appears to become more solid as the face is extended in depth or east into the hill.



A. Quarry, Bluff City Lime and Quarry Co., Mosher.



B. Quarry, Ozora Marble Co., near Ozora.

About 25 yards east and at a higher elevation a new opening has recently been made in a light gray to light bluish-gray, hard, dense limestone. The beds exhibit approximately the same dip as in the other workings. A mud-filled solution channel was noted near the base of the opening. In developing the property a diamond drill hole was put down and the following record was kindly furnished from memory by Mr. Kelley, the General Manager.

Record of Diamond Drill Hole, Ozora Marble Quarries.

	Thickness, feet	Depth, feet
Grand Tower formation:		
Marble, gray, crystalline, "Monotone"	30	30
Marble, brownish gray, streaked with light colored veins, "Golden Vein"	30	60
Marble, gray crystalline, "Monotone"	21	81
Marble, pink red, brownish-gray, mottled, crystalline "Ste. Genevieve Rose"	11	92
Little Saline formation:		
Marble, white to gray, mottled pink, crystalline	97½	189½
Bailey formation:		
Limestone, cherty	—	—

The stone from the upper part of the workings is often discarded, due to the presence of solution channels which prevent the quarrying of sound blocks of considerable size. As the quarries are extended in depth solid blocks can be obtained, and one block was reported quarried that measured 60 by 5 by 4 feet.

The quarries are equipped with air drills, electric and compressed air channelling machines, and derricks (Pl. XIII, B). Electric power is generated in a plant on the property.

The lack of adequate transportation facilities has been a factor in the development of the property, as it is necessary to transport the blocks quarried by truck to Hick's siding, on the St. Louis-San Francisco railway, a distance of 12 miles.

Consolidated Marble Quarries Company. This quarry is located at Marlo Switch, on the Missouri-Illinois Railroad, in the SW. ¼ sec. 36, T. 38 N., R. 8 E., on the farm of Peter Weiler. Prior to the beginning of operations in 1922, a diamond drill hole was put down, penetrating the Kimmswick limestone of Ordovician age. The Kimmswick at this place is white to light gray, very crystalline, and fossiliferous. Along joint planes and solution channels the stone has a light brown color. It is reported to take a good polish. The face developed is 18 feet high. Just below the red, cherty clay overburden the rock is cut by many joints and cracks, enlarged by solution, and the rock has been weathered into knobs. Jointing is a prominent feature in this quarry, the directions being northeast-southwest and northwest-southeast; the former are the most prominent, and with the other set have cracked the stone into rectangular blocks. The limestone has undergone considerable solution along these openings, which vary in width from one foot to five feet, the last mentioned being a prominent solution channel in the south part of the quarry.

As a result of the jointing and subsequent solution of the limestone along these structures, a considerable quantity of stone was discarded as waste, and after operating about one year the quarry was closed. The property is equipped with a power plant, channelling machines, and a steel derrick. Attempts have been made recently to reopen the quarry.

The Southeast Missouri Quarries Company. This quarry, now abandoned, is located on the river bluff about two miles above Little Rock on the north side of Lower Frenchman Hollow. Actual stripping operations were started here in April, 1914. Some fifteen to twenty-eight feet of loess and residual clay were removed, chiefly by hydraulicking. The plant was equipped with Worthington hydraulic pumps that supplied a four-inch stream with one hundred and seventy-five pounds pressure at the nozzle. This was not found altogether satisfactory, however, and the process was aided by shooting.

The quarry was opened from the top and was remarkable in the small amount of waste rock, as but little preliminary work was necessary before stone of commercial value was obtainable. The upper portion of the exposure, the horizon last worked, is approximately ninety-four feet above the St. Louis and San Francisco railway tracks, or about that distance above the base of the formation. The floor of the quarry is broken by solution channels along old joint cracks, but this in no wise damages the surrounding rocks. The limestone at this horizon is a light buff in color, highly oolitic, with an abundant admixture of finely broken fossil remains. When first quarried the rock is rather soft, but rapidly hardens on exposure. Below the floor of the quarry at a depth from twenty to thirty feet the lithology is slightly different; it grades into harder, more crystalline texture, slightly darker in color, sometimes with a bluish tint. Some of these lower beds take a beautiful polish. While the company had an opening in these crystalline beds they were operating almost entirely in the upper, more oolitic portions. The quarry was equipped with a thirty-ton, stiff-leg, all-steel derrick of the most modern pattern, and two Wardwell channelling machines. The product of the company was shipped chiefly to St. Louis. Blocks of any desired size up to thirty tons, the capacity of the hoisting apparatus, were obtainable.

The stone has a uniform color and texture, is easy to work, and is free from "crows feet" or stylolites. The quarry has not been operated for a number of years.

Undeveloped Prospects. Possible marble quarry sites are reported in the E. ½ NW. ¼ SE. ¼ sec. 6, NE. ¼ sec. 7, NE. ¼ sec. 8, and NW. ¼ of sec. 5, T. 36 N., R. 9 E. These areas are underlain in part by the Little Saline and Grand Tower formations, and the limestones appear to be similar in character to those obtained at the quarries of the Ozora Marble Company.

A diamond drill hole is reported to have penetrated 187 feet of marble beds near the house of A. J. Thomure in the NE. ¼ NW. ¼ sec. 8, T. 36 N., R. 9 E. No development has been done at these sites.

Bussen Quarry. This quarry is located in the NE. ¼ sec. 12, T. 38 N., R. 9 E., on the north side of Lower Frenchman Hollow. The lower part of the Spergen and the upper part of the Warsaw formations are exposed in the working face, 125 feet long by 60 feet high, where the following section was measured:

Section exposed in Bussen Quarry, NE. 1/4 sec. 12, T. 38 N., R. 9 E.

	Thickness, Feet
Overburden, red cherty soil	1
Spergen formation:	
1. Limestone, light gray, crystalline, fossiliferous, heavy and cross-bedded, weathers light-gray and in thin beds	10–25
2. Limestone, yellow, crystalline, fossiliferous, argillaceous, in west part of face appears to be absent, the position being represented by 3-5 feet of red mud, apparently filling solution channel	3– 5
3. Limestone, bluish-gray, finely crystalline, fossiliferous	8
4. Limestone, yellow, fine-grained, fossiliferous	3
5. Limestone, light bluish-gray, to brown, fine-grained to finely crystalline, fossiliferous. Heavy bedded but weathering in thin beds. Some phases show thin darker colored streaks of crystalline calcite parallel to bedding	12
6. Limestone, yellow, crystalline soft, called "sand" by workmen	5
Warsaw formation:	
7. Shale, dark blue-gray, calcareous, thick-bedded but weathers into thin platy slabs, and to a buff colored clay. 1 foot exposed in face; and at least 5 feet, west of quarry in hollow	1– 5

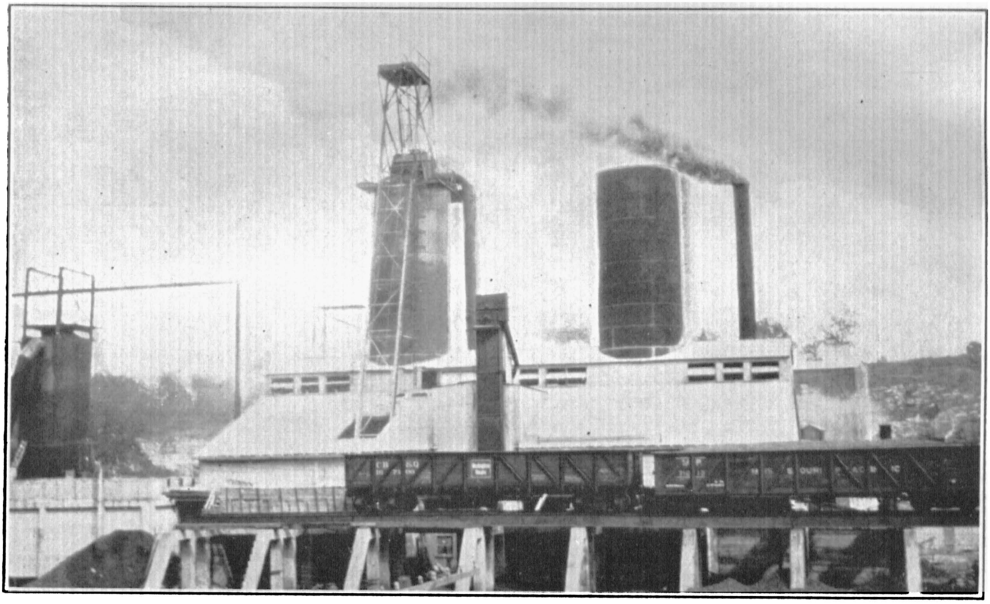
The top of the quarry face slopes rapidly to the west from the bluff facing Mississippi River toward the small valley joining the hollow from the north. As a result the workings which have been continued west and into this valley are in the lower limestones of the above section. Higher up the valley, shales of the Warsaw formation are well exposed, the southeast dip, however, results in exposing only one foot in the main working face. Joints are prominent in the upper part of the face, some of these have been enlarged by solution, and filled with mud. Along the east end of the quarry, for a distance of five feet, the face is marked by a series of vertical joints, giving the rock a sheeted appearance.

Drilling is done with pneumatic jack-hammer drills, the holes being loaded and shot with dynamite. Care is exercised in shooting to eliminate spalls, for which there is no sale. All the rock quarried is used in improvement work along the Mississippi River, the chief use being for riprap. The stone is hauled by trucks to the barge landing on the river.

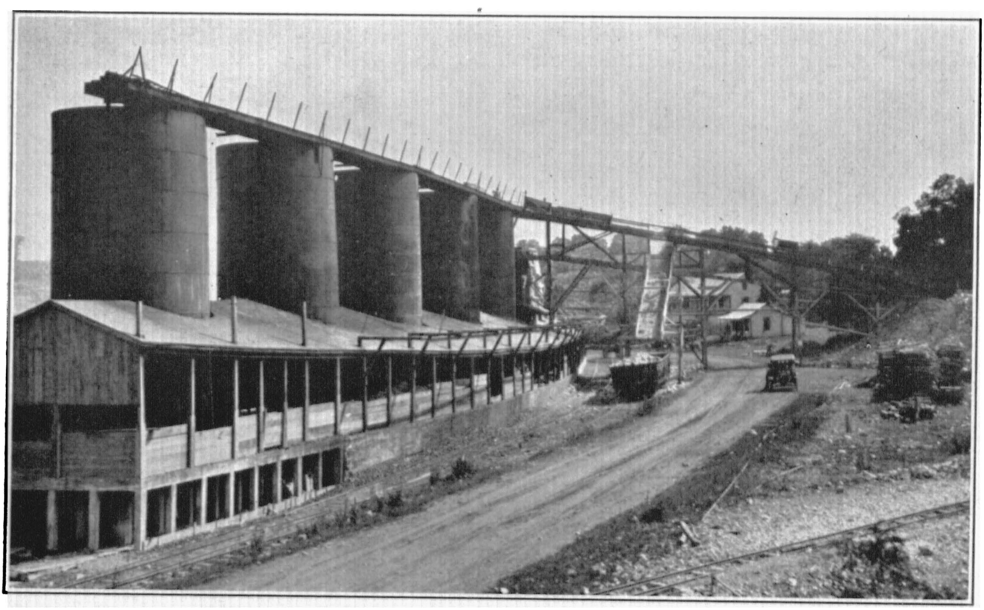
Arnold Stone Company Quarry. One of the largest stone quarries in this county is operated by this company, one-fourth mile north of Little Rock. Operations were begun many years ago, and a large quarry was formerly worked just south of the present one. The quarry now operated has a working face 700 feet long. The height of the face varies somewhat but ranges from 120 to 140 feet.

The St. Louis and Ste. Genevieve formations are exposed in this quarry, the former furnishing the bulk of the stone. The overburden is glacial clay and loess varying in thickness from 10 to 30 feet. This material is described in detail in the footnote on page 252. It is removed by hydraulicking. The beds exposed rise gently to the north and in the north face the overburden has a thickness of 10 feet. It is underlain by 20-25 feet of relatively thin-bedded limestone forming the lower part of the Ste. Genevieve formation, the base of which appears to be marked by a thin green argillaceous sandstone only a few inches in thickness. This part of the face is cut by many clay-filled joints and bedding planes, and in general has the appearance of "boulder ground." The rock is finely crystalline, slightly sandy, and dark gray in color.

The underlying St. Louis limestone forms roughly the lower 90 feet of the quarry. It is composed of dense to fine-grained, fossiliferous limestone. The characteristic "lithographic stone" is present. In color it varies through shades of gray. Fossils are common. Nodules and lenses of dense, live, fossiliferous



A. View of new kilns, Peerless White Lime Co.



B. View of Ste. Genevieve lime plant, Ste. Génevieve.

chert are common, particularly in the upper part. The chert varies in color from blue-black, through blue-gray, brown and red. Some of this material has evidently replaced the limestone, for some specimens examined show the original structure of the limestone and also a gradation between the two.

After removal of the loess overburden, holes are drilled with compressed air drills and shot with low strength dynamite to eliminate spalls and to insure large pieces. The stone is loaded by hand onto small box cars and trammed to a hoist located on the river bank. The cars are lowered over barges, and the stone dropped through hopper bottoms. All the output is consumed in improving the Mississippi River, the chief use being for riprap.

Forty or more men are employed, many of whom live on the property. A commissary is maintained for the convenience of the workmen.

Cliffdale Quarrying and Manufacturing Company. This quarry, locally known as Carron's Quarry, the name of the operator, is located one-half mile north of Brickeys in sec. 13, T. 39 N., R. 7 E. The quarry on the north side of the valley was formerly worked as an open quarry, but in recent years all work has been done by tunnelling. The formations exposed are given below:

Section Measured in Carron's Quarry, North of Brickeys.

	Thickness, Feet
Burlington formation	
Limestone, gray, thin-bedded, with nodules, lenses and beds of chert. Top of formation not exposed	30
Fern Glen formation:	
Limestone, thin-bedded, gray, green and red with shaly limestones, and red shales	20
Kimmswick formation:	
Limestone, brown to light brownish gray, darker colored and softer near weathered face. Occasional lenses of chert in very upper part. Base not exposed	50

The stone quarried is from the Kimmswick formation. As shown in the tunnels, it is brown in color near the old quarry face, but becomes light colored as the workings extend into the hill. The underground workings extend back into the hill for 300 feet. The room and pillar method is used, the pillars being 20 feet in diameter on the floor, but 25 feet under the roof. The headings are 30 feet high, the top being about three feet below the Kimmswick-Fern Glen contact. The dark colored rock is broken up into blocks suited for riprap and general construction work on Mississippi River. The stone is hauled by truck and dumped directly on barges. A part of the output is used for flux in the manufacture of glass at the plant in Crystal City, Missouri. For this purpose the lightest colored stone is used. It is hauled in trucks to a loading platform located on the St. Louis-San Francisco Railway.

Sandstone Quarries. About five miles south of Ste. Genevieve in and near the NE. ¼ sec. 11, T. 37 N., R. 9 E., there are several old sandstone quarries from which much stone was taken years ago. The formation quarried is the massive bedded Aux Vases sandstone of Mississippian age. In color it is light buff, weathering to light brown. The quarries are large, one being over 400 feet long and having been worked into the hill for a distance of 200 feet or more. The weathered face shows 12 feet of massive sandstone from the floor up. The upper part shows some seaming from weathering. It was apparently possible to get very large blocks from the face as only one vertical joint was seen. An old water tank, made of slabs about 11 feet by 5½ feet by 6 inches thick, and in perfect condition, shows the large sizes obtainable, and the resistance to weathering. From its appearance in the quarry the stone should resist weathering very well. This stone was used in the abutments of the Eads Bridge at St. Louis, and in the old Iowa State Capitol Building. The quarry has not been worked for many years, due to the Mississippi River meandering away from the bluff line with consequent loss of cheap transportation. The stone is light buff in color, weathering to light brown.

Granite. The areas in Ste. Genevieve County where granite is at the surface are shown on the geologic map of the county. The deposits are confined, in the main, to the valley and tributaries of Jonca Creek from the village of Jonca east to near the Weingarten fault zone, a distance of five miles. Smaller areas are present on Pickle Creek in the central part of T. 36 N., R. 7 E. Red and gray granites are present, the former predominating. It is medium to coarse-grained, and contains in places large crystals of feldspar, which in contrast with the colorless quartz gives the rock a spotted appearance. Pegmatite dikes of orthoclose feldspar and quartz cut the granite in several places; and dikes of dark green to gray, basic igneous rock were observed cutting the granite on Jonca Creek.

The outcrops are usually marked by an extensive and irregular system of joints. Faults along which shearing was noted were also observed. The nearest deposits to transportation are those on Jonca Creek, 1½ miles from Miller's switch, on the Missouri-Illinois Railroad. No quarries have been opened in this county, and so far as is known, no development work has been done.

COPPER DEPOSITS

Copper ore was discovered in Ste. Genevieve County in 1863, and for the following twenty-five years sporadic operations produced a considerable tonnage of fairly high grade ore. A brief outline of the early history of operations on the various properties as published by Frank Nicholson[1] is given below.

"The discovery was made by a German farmer named Simon Grass, who had occasion to make a road from his farm down the hill into the neighboring valley, and while so engaged noticed pieces of a green-colored mineral, some of which he collected. Not knowing the character of the ore he had found, and supposing it to be valuable for its brilliant green color only, he carried a piece with him into the town of Ste. Genevieve and showed it around the various barrooms as a curiosity. No special attention was paid to the matter until nine years later, when Mr. O. D. Harris sent a specimen of the ore to Dr. Theodore Fay, of St. Louis, for analysis. This analysis, which was the first ever made of Ste. Genevieve copper ore, showed the specimen to contain 17.75% metallic copper. . . . .

In 1868 explorations under the direction of Mr. Harris were begun on the section where the croppings had been noticed; but after a short period of unsuccessful prospecting the work was abandoned. In 1872, four years previous to the death of Simon Grass, Messrs. Harris, Rozier & Co. obtained a lease on the property for twenty-five years, paying 10 per cent royalty. In 1876 work was begun on the hill opposite that on which copper was first discovered, by a Chicago firm styled Hitchcock, Wilson & Co. After one year's unprofitable working this firm failed. The Chicago mine—this was the name applied to the old workings of the Chicago Company—was bought in by O. D. Harris, who now owns both the Grass and Chicago mines and operates them under the name of the Cornwall Copper Mines. In 1876 Mr. Leon Jokerst discovered another outcropping of copper ore, about four miles north of the Cornwall mines, and took out considerable ore, running from 20 per cent to 27 per cent of metallic copper. Following the lead taken by Mr. Harris, Mr. Jokerst called his property the Swansea Copper Mine.

In 1879 a third property was opened near the Swansea mine, and was named the Herzog Copper mine. . . . .

From 1877 to 1880 the mines were operated by contractors, who agreed to work under the supervision of the mine-boss, and to deliver to him the ore at one cent per pound, irrespective of its content of metallic copper, the only desideratum to them being that it be accepted by the mine-boss under whose inspection it must pass before it was paid for. This method of working, though it secured the company controlling the mines from actual loss, had its disadvantages. Men who carefully dressed their ore were naturally displeased at seeing others that were exceedingly careless about the matter receive the same amount per ton for their ore. The necessary consequence was that all hands soon adopted the plan of dressing the ore as little as possible, the less the better, so long as it was accepted. Nevertheless, during the three years mentioned, the mines paid their owners well.

The system of valuation adopted in 1880—in fact, the only sensible one where contract mining prevails—was to pay the contractor a certain amount per ton for each unit of copper contained in the ore, the price paid being regulated, of course, by the market quotations for ingot copper. Under this system, each lot of ore is assayed and its market value determined before the ore is paid for. Under the old system, contractors delivering 12 per cent ore, received the same per ton as others whose ore contained 25 per cent of copper. The injustice

[1]Nicholson, Frank, "Review of the Ste. Genevieve Copper Deposits, Tran. A. I. M. E., Vol. 10, p. 444.

of the system was manifest, and as above indicated resulted in a sort of race to see who could deliver the poorest ore and have it accepted.

In 1880 the Cornwall mines, which so far had shipped ore to Baltimore, Boston and Phoenixville, erected works for making raw matte, and in 1881 refining works were added."

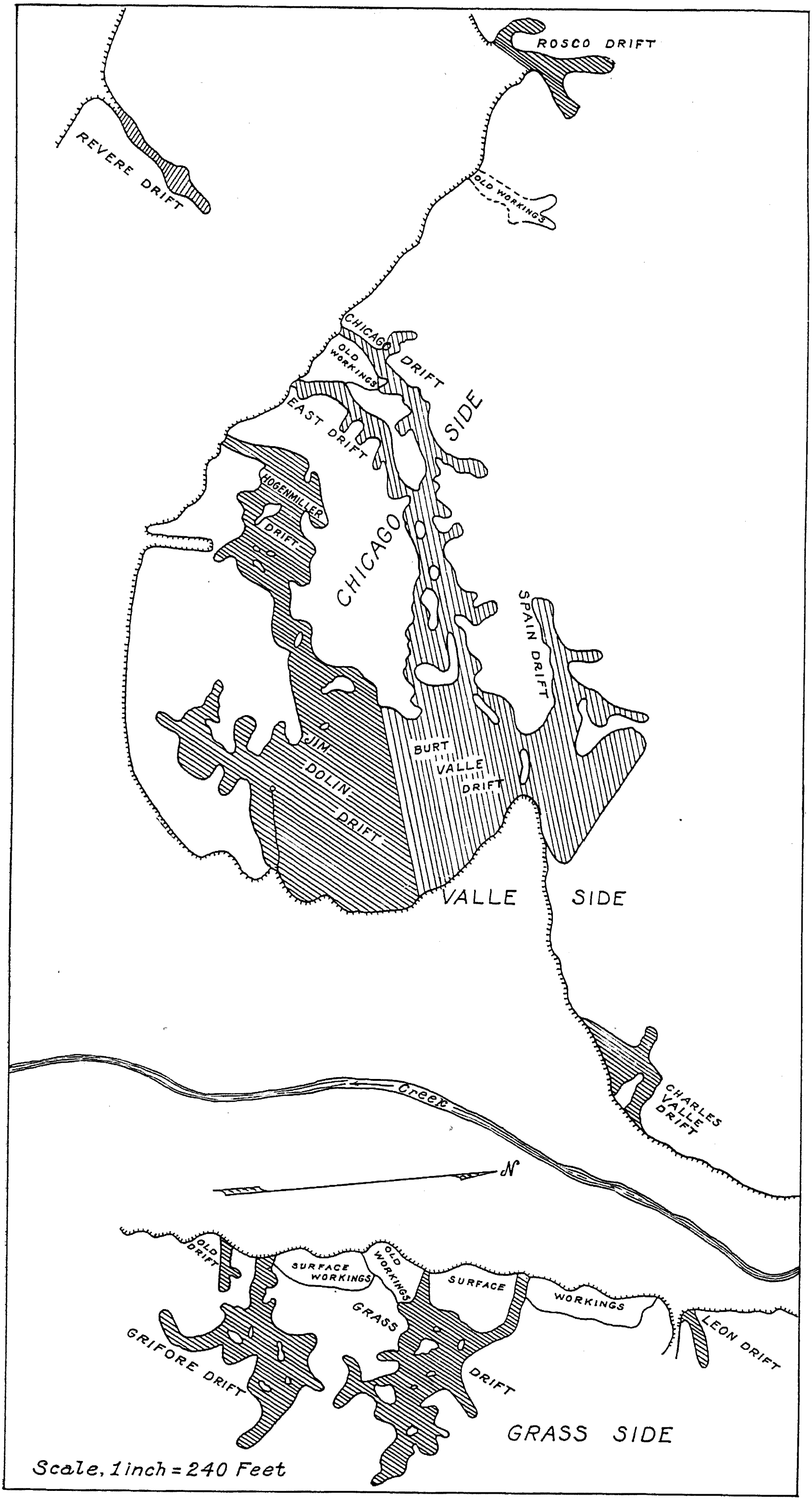
The various mines have since been operated at intervals, the latest production being from the Cornwall property, about 1916. There are no figures available from which the total production of these properties can be determined. The map of the Cornwall mine (page 332), shows that a considerable area was productive.

The copper deposits occur in sedimentary rocks which belong to the Powell formation. There are three ore-bearing horizons, the lowest being at the contact of the Powell with the underlying Cotter formation; the middle or chief copper horizon occurs at the division of the lower and upper Powell members; and the upper horizon about 50 feet below the top of the formation. In each case the ore is associated with unconformable relations, the most pronounced being at the upper Cornwall horizon. The most continuous unconformity is that at the base of the Powell, and very small and limited occurrences of copper are to be found in several places at this horizon. The two upper unconformities were noted at no other localities in the county except at the Cornwall and Swansea-Herzog mines.

The ore occurs as a replacement and impregnation of soft, porous chert beds, as a cement in sedimentary breccia, in small chimneys at vertical fractures, and irregularly filling erosion depressions in the dolomite. A little lean copper ore also occurs in small areas of crush breccia which has resulted from solution. The main ore bodies, therefore, occur as irregularly bedded deposits which have the general dip of the enclosing formation.

The ore is made up of several of the minerals of copper of which chalcopyrite is the most important. Evidently chalcopyrite was the primary copper mineral and its alteration has produced some of the oxidized and enriched minerals. The minerals of secondary importance are bornite, chalcocite, malachite, azurite and cuprite. A few specimens of tenorite and chrysocolla have been reported.

The principal associated minerals are marcasite, iron oxide, and calcite. The marcasite is of no value, but the soft oxides of iron usually contain some copper, probably in the form of cuprite. Calcite is usually found as "dogtooth spar" crystals and not closely associated with the ore bodies although locally some calcite occurs in the ore pockets.



Map of underground workings, Cornwall Copper mine.

DESCRIPTION OF THE MINES

Cornwall Group. The Cornwall group of mines is located in the adjoining quarters of Sections 15, 16, 21 and 22 T. 37 N., R. 8 E. There are two levels upon which drifts have been run into the hillsides. All of the drifts on the upper horizon are on the north side of Copper Mine Creek (Valle Creek), and on the lower horizon there is one drift on the north side and one on the south side of the same creek. A north-south branch divides the workings of the upper horizon. The property to the east of this branch is known as the Grass side; that to the west and facing the branch, the Valle side; that facing Copper Mine Creek, the Chicago side. The map shows these positions. (p. 332).

The upper level was the main producing horizon and was the one being worked when the mines were last visited by the writer in June, 1916. The lower horizon never has proven to be of much economic importance and but little work has been done at this level. Both copper horizons dip with the strata in a general northeast direction, a fact shown by the elevations at the mouths of the drifts which are based upon an assumed bench mark of one hundred (100) feet at the office building.

The drifts on the Chicago and Valle sides are connected so they will be described together. The main drifts are the Chicago, Hogenmiller, Dolin, and Bert Valle. From these the bulk of the best copper was removed in the early days of the mines. The ore was chiefly the soft and breccia type.

The entrance to several of the drifts show the general relations clearly. The roof is a fine-grained, argillaceous dolomite of a yellow to buff color. Below is the bed of soft, porous chert, which was such a valuable producer where impregnated with the copper minerals. Above the roof in several places may be seen other beds of soft, porous chert, but none have been found that contain copper deposits. Just east of the Chicago drift entrance, may be seen an outcropping ledge of sedimentary breccia filling erosional depressions in the soft chert horizon.

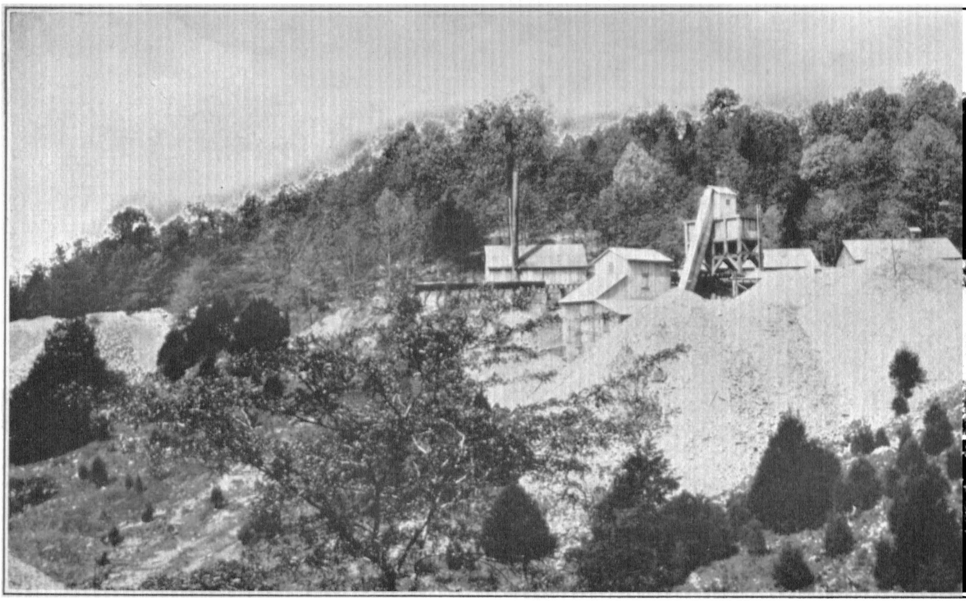
The system of working, which has been employed inside the mine, shows clearly the character of the ore horizon. The numerous large and small pillars left in mining indicate the location of the barren spots, and also that a large part of the ore was in pockets. The Dolin and Bert Valle drifts, however, show a large and nearly continuous area, which was mined almost entirely, only small pillars being left. The support for the roof was furnished by the waste rock.

A small fissure starts in the Chicago drift near the entrance and runs in a nearly east direction through the Bert Valle drift and across to the Grass side. The movement increases going east and at the junction of the Dolin-Valle drifts the displacement is three feet, the north side being downthrown. Just west of this point along the fissure is the "mud" drift, a rift in the roof which has been enlarged by solution. The opening extends upward for 30 or 35 feet and was nearly filled with red clay. Cnly a little copper was found in this fissure. Another small fissure runs N. 75° W., through the south end of the Dolin drift near Pearson blowout. The displacement is to the north with but little movement. There are several other places in the mine where there has been little movement resulting in brecciation. They are, however, of no importance. A seven-foot fault crosses the Chicago-Valle drifts at this junction causing a sudden rise in the mine.

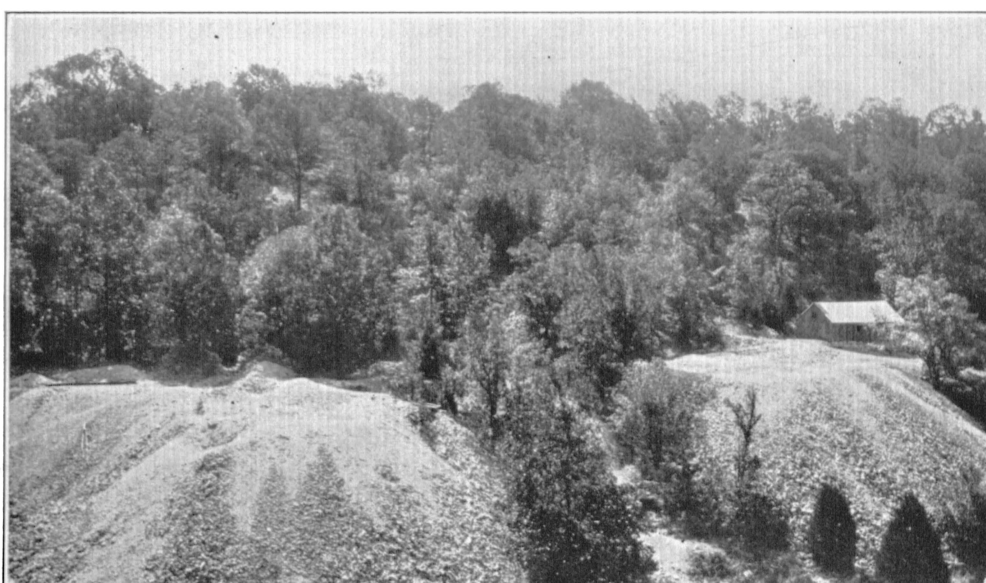
The Spain drifts are the most northern workings in the mine. Practically all the work done during the operation of 1913 was confined to these drifts. From their present appearance the copper ore was probably rather lean. Although the barren rock shown in these drifts may prove to be horses only, it is the opinion of the writer that the ore bodies are very limited in their northern extent. In Spain No. 5, a winze was started with the intention of connecting with the lower level about 125 feet below, but it was never completed.

Several other smaller drifts and workings are on the Chicago-Valle side, but none of them proved productive as far as the work was carried.

There are but two main drifts on the Grass side, although there are several other smaller ones. The ones being worked at the time examined were the Grass and Griffard. Both drifts show very similar conditions to those found on the Chicago-Valle side, except that there is considerable more sulphide minerals on the Grass side. The sedimentary breccia is well shown near the extreme eastern faces. The sulphide minerals have suffered very little change. The best ore showing in the mines is at the present faces of these drifts which were being pumped out preparatory to beginning work upon them when visited in June, 1916. The walls and roofs of these two drifts are in many places covered by a film of bluish-green copper sulphide. Their appearance suggest large deposits of malachite, but the true character is revealed upon close examination.



A. Mill and drifts, Cornwall Copper Mine.



B. Waste dumps at Grass and Griffard drifts, Cornwall Copper Mine.

In the Grass drift, the fissure, which crosses from the Valle side, shows considerable brecciation. The fractured zone has been partially filled with iron sulphide and some copper minerals. Apparently this mineralization is younger than the copper mineralization of the main horizon. A large room has been opened at this point which is over 20 feet in height. Off from this room is a chamber about 12 feet above the floor of the drift in which a small and irregular vein or body of copper was opened. It proved to be of little value, being apparently a small offshoot from the brecciated zone.

The Griffard drift shows nothing essentially different in the character of the main copper horizon.

There is an old shaft on top of the hill on the Grass side; since much of it has caved, but little information could be gathered.

An interesting feature present in the drifts of the upper horizon is the solution pockets in the dolomite which have been filled with large and small crystals of dog-tooth spar. These calcite crystals belong to the latest period of mineralization. Some of the solution pockets contain a red, waxy clay.

The Cuba and Revere drifts are small entries on the lower horizon which is at the base of the Powell formation, and about 125 feet below the upper horizon. A little exploitation has been done on this level, but from a study of the occurrence and size of the mineralized portions shown at the present time, the probability of developing a rich horizon is not very good.

Swansea Mine. The Swansea mine is in the SE. ¼ Sec. 32, T. 38 N., R. 8 E., on a small tributary of Indian Creek, and about one-fourth mile south of it. There are drifts on both the east and the west sides of the branch, about 20 feet above the bottom. On the south side the drift is not more than 250 feet long and has been run on an irregular bedded horizon along which there has been some mineralization. The conditions presented are those of a slight local unconformity in a soft bed of chert. In the depressions are deposits of sandstone, bedded dolomite, and shale. The mineralization has been along these irregularities. Nothing of value was observed.

On the other side the drift has caved to such an extent that access to the old working was possible for only a short distance from the entrance. Conditions were quite similar to those which have already been presented for the other copper deposits. The presence of the horizons of soft, porous chert is conspicuous.

The irregularity or unconformity, however, appears to be very limited in extent.

Herzog Mine. The Herzog mine is located on Indian Creek in the NW. ¼ Sec. 32, T. 38 N., R. 8 E. The drift is about 30 feet above the creek on the south side. Work was done here during the fall of 1914 when a car of picked ore was shipped on which assays ran a little less than 10 per cent copper. The writer has not been at the mine since, but the intention was to begin operations again in June, 1916, when the Cornwall mines were opened.

The Swansea and Herzog are at the same horizon and have similar conditions of ore occurrence. The irregularity or local unconformity is plainly exhibited within the mine. The irregular surface upon which the ore rests has but a relief of a foot or two at the most, the ore occurring in pockets or seams and varies from a few inches to 18 inches in thickness. The ore often pinches out where the bedding is more regular. At the mouth of the drift the unconformable relations are also shown with a bed of soft chert above and one below the roof.

The Swansea-Herzog copper horizon is higher than the upper Cornwall horizon, being only about 50 feet from the top of the Powell formation.

UNDERGROUND WATERS

The question of a large supply of water has not been an important one in Ste. Genevieve County. For this reason very little deep drilling has been done and little is therefore known of the possibilities of the different horizons.

The belt of outcrop of the geologic formations is in general, northwest-southeast although locally, as in some of the more intensely faulted areas, the strike or direction of outcrop has been changed. The formations dip to the east and as shown by structure section A-A, on the geologic map, the entire succession of beds making up the geologic column may be crossed in going from the western to the eastern part of the county.

The columnar section in this county is composed of limestone, magnesian limestone, dolomite, sandstone, shale, granite, and porphyry. The last three mentioned are not dependable water producers, any obtained being from bedding planes in the shale or from fractures in the granite and porphyry. The other rocks mentioned offer far greater possibilities of yielding supplies of ground water, and in this county the dip of the strata permit surface waters to enter the rocks along the belt of outcrop or through fractures in the overlying beds, and to flow down the strata, which may be reached at increasing depths from west to east. This is particularly true of the formations in the lower part of the section.

The sandstone beds in the Lamotte, Roubidoux, St. Peter and Everton formations are the most dependable and persistent aquifers in the county and drilling for water supplies in those parts of the county underlain by these formations should in general be successful. The limestone formations are sometimes marked by crevices and solution channels, which often furnish, when encountered in drilling, varying quantities of water. Over most of the county, particularly in the eastern part, small supplies should be found at rather shallow depths in openings in the limestones. The surface of this part of the county is marked by a great many sinkholes. These are connected with underground drainage systems, the outlets of which are marked by numerous springs. Wells drilled into these openings would, no doubt, yield quantities of water sufficient to supply dwellings or towns and villages in the county. In some cases this water might be contaminated due to the disposal of refuse into the sinkholes. However, the distribution of the population at present, with regard to the occurrence of sinkholes is such that this factor in general does not appear to be a serious one.

The alluvial deposits in the flood plain of Mississippi River, or along the major streams of the county offer excellent possibilities of yielding adequate supplies of water. The supply for the town of Ste. Genevieve is derived from these deposits. The water is hard and requires softening before use in boilers. From the sanitary standpoint the water is satisfactory for human consumption.

Flowing Wells. A few flowing wells have been noted in this county. One is located on the farm of Lee Herman, west of Brickeys. It is 115 feet deep and was reported dry until the shale (Fern Glen) was penetrated when the well started flowing. The water apparently comes from an opening in the underlying Kimmswick formation.

At Lawrenceton there are two flowing wells, at an elevation of approximately 600 feet. The well at the store is 113 feet deep, the other, about 700 feet north, is 200 feet deep. These wells start in the lower part of the Gasconade formation, but the water was probably found in channels in the underlying formations.

There are several small flowing wells near Avon which start in the lower part of the Bonneterre formation and go into the Lamotte sandstone. The highest of these is on land owned by C. A. Boyd, NW. cor., SE. ¼ NE. ¼ sec. 11, T. 35 N, R. 7 E, a quarter of a mile north of the store, at an elevation of 750 feet. There is also a weak flowing well on the land of Wm. Blackledge on the left bank of the creek, in the S. ½ sec. 12, T. 35 N., R. 7 E. Two others are reported in the same region. It is probable that future drill holes in this area at no higher elevations will also flow if drilled deep enough into the Lamotte sandstone.

The well of the Perry Oil Company, in the bottoms of St. Laurent Creek at St. Marys is at an elevation of about 390 feet. It flows a feeble stream from around the casing and at times flows over the top of the casing 12 inches above the ground. The first water was reported to have been struck at 50 feet on top of the bed rock and a good flow came in at about 700 feet. The mineralized waters probably came from near the bottom of the well. The diameter of the well is 10 inches to 150 feet deep; 8 inches to 500 feet; then 6 inches, and 4 inches at the bottom which is 1600 feet. The well probably finished in the Joachim formation. Sand points driven in the alluvial deposits in the creek bottoms in the same locality will occasionally yield flowing water.

Deep Wells. The deepest well in the county located at the plant of the Schaff Milling Company in St. Marys, has a total depth of 1930 feet. The elevation is 390 feet. The hole was drilled by J. M. Hahn, of Perryville, Missouri, in 1915. Cuttings were received and examined by this Bureau from 840 feet to the bottom of the hole, and the following log prepared. No cuttings were saved above 840 feet and the log above that depth has been compiled from the general section.

Condensed Log, Schaff Milling Company's Well, St. Marys, Missouri

	Thickness, Feet	Depth, Feet
Surface	30	30
Mississippian system:		
Chester series:		
Lower Chester group:		
Renault formation:		
Shales and limestones, with sandstone locally present near base	60	90
Aux Vases formation:		
Sandstone, yellow and brown, fine-grained	70	160

	Thickness, Feet	Depth, Feet
Iowa series:		
Meramec group:		
Ste. Genevieve formation:		
Limestone, gray, crystalline, with some reddish chert. Sandstone member locally present	110	270
St. Louis formation:		
Limestone, hard, compact, dense, evenly bedded, bluish-gray or gray in color, with thin shaly partings and local chert layers	170	440
Spergen formation:		
Limestone, white, very pure, with little or no chert, including thick beds of very pure massive oolite	160	600
Warsaw formation:		
Upper part, limestone often cherty; lower part, shales with limestone beds	150	750
Osage group:		
Keokuk and Burlington formations:		
Limestone, grayish to white, highly crystalline, with irregularly distributed masses of gray to white chert	197	947
Fern Glen formation:		
Limestone, gray and darker than above, with much light blue, chert and some pinkish, apparently ferruginous limestone	47	994
Limestone, reddish and gray, very fine-grained, with much chert	21	1,015
Limestone, gray, fine-grained and argillaceous with a few quartz sand grains, a little reddish shale, but no chert	10	1,025
Limestone, light-gray and fine-grained, with gray shale, some very fine, dark, shaly sand, some white chert	20	1,045
Kinderhook group: (?)		
Sulphur Springs formation: (?)		
Limestone, sandy and somewhat argillaceous, with dark shaly sand (Glen Park member ?)	18	1,063
Shale, light to dark bluish-gray, slightly calcareous, slightly sandy and in part fissile	43	1,106
Cincinnatian series:		
Richmond group:		
Thebes-Maquoketa formations (?):		
Shale, blue to dark blue, sandy and slightly pyritiferous	73	1,179
Shale, with some limestone	6	1,185
Ordovician system:		
Mohawkian series:		
Kimmswick formation:		
Limestone, gray to white, very crystalline and free from chert	69	1,254
No cuttings	69	1,323
Plattin formation:		
Limestone, fine-grained, light brownish gray, with calcite veins	23	1,346
No cuttings	172	1,518
Limestone, gray to drab and very fine-grained, with fossil fragments (Orthis ?), large per cent of dolomitic limestone	42	1,560
Limestone, gray, fine-grained, much green to gray pyritiferous shale	11	1,571
Limestone, gray, drab, blue and brownish, dense to finely crystalline, in part lithographic	89	1,660
Big Buffalo series:		
Joachim formation:		
Limestone, gray, fine-grained, slightly dolomitic	13	1,673
Dolomite, light to dark gray, finely crystalline and somewhat argillaceous; some bluish-black shale, some "cotton rock"	137	1,810

	Thickness, Feet	Depth, Feet
Dolomite, light to dark bluish-gray, dense, few fragments of gray shale	10	1,820
Dolomite, light to dark gray, very fine-grained	7	1,827
St. Peter formation:		
Sandstone, rounded to angular, etched, colorless to slightly iron-stained, quartz grains of medium to coarse texture, with a little light gray, fine-grained, dolomite	103	1,930

The well reached bed rock at a depth of 30 feet. At a depth of 860 feet water stood within 8 feet of the top of the hole, but was easily bailed dry; the depth at which it came in is not known. This water was of good quality. The second supply of water was obtained from the St. Peter sandstone, the top of which was reached at a depth of 1827 feet. The quantity was said to be large, but unfortunately the water was highly mineralized. The upper water was not cased off so that the analysis on page 343 represents a mixture of the waters obtained in this well. The water from the St. Peter probably predominates as the well was pumped for 10 minutes before the sample was collected.

In connection with this well, the deep well at St. Mary's Seminary, Perryville, Mo., drilled by the late E. H. Klump of Perryville, and completed in 1927 is of particular interest. It started at an elevation of 615 feet in the Joachim formation, and 95 feet above the St. Peter sandstone, in which the Schaff well was completed. It was drilled to a depth of 3033 feet, the hole being bottomed in the transition beds between the Bonneterre and Lamotte formations. The difference in elevation of the St. Peter sandstone in the two wells is 1947 feet, and is due to faulting which has lowered the formation at St. Mary's.

The St. Peter, being near the surface in the Perryville hole, furnished but little water. The Roubidoux formation was drilled from 1105 to 1240 feet, and furnished about 30 gallons per minute from thin sandstone beds at the top and bottom of the formation. At the latter depth the water stood 190 feet from the top of the well. Additional water was reported by the driller near the bottom of the hole, particularly from the sandy beds in the transition zone between the Bonneterre and Lamotte formations.

Upon completion of the hole, the static water level remained 190 feet from the top. The quantity had increased, and bailing and pumping tests indicate at least 75 gallons of water per minute. The water is of good quality as shown by the analysis on page 343

A condensed log of this well is given below. It has been prepared after examination of a good set of cuttings and indicates the character of the formations below the St. Peter. It also shows thickening of the Cambro-Ordovician formations in Southeast Missouri.

Condensed Log, St. Mary's Seminary Well, Perryville Mo.

	Thickness, Feet	Depth, Feet
Surface	12	12
Ordovician System:		
Big Buffalo Series:		
Joachim formation:		
Dolomite and magnesian limestone light gray, fine-grained, slightly argillaceous, some black shale	53	65
Sandstone, white and dolomite	5	70
Dolomite, dark gray	5	75
Sandstone, white and dolomite	5	80
Dolomite, gray, fine-grained	15	95
St. Peter formation:		
Sand, white, rounded frosted grains	120	215
Everton formation:		
Dolomite, gray, fine-grained	20	235
Sandstone, white	10	245
Canadian series (of Ulrich):		
Jefferson City formation undifferentiated (includes Jefferson City, Cotter and Powell formations):		
Dolomite, light to dark gray, fine-grained to finely crystalline, some sand	105	350
Chert, white to dark gray, dense, banded, some sand	10	360
Dolomite, light gray, dense; white to gray chert, some sand.	5	365
Sandstone, clear and frosted quartz grains, some blue-gray finely crystalline dolomite; some gray chert	5	370
Dolomite, light to dark gray, dense to finely crystalline, light gray chert, small amount green shale; pyrite	465	835
Dolomite, light to dark gray dense to finely crystalline; gray chert, some quartz sand and green shale	85	920
Dolomite, light gray to brownish-gray, dense to finely crystalline; white to gray chert, small amount of sand, few fragments of shale	110	1,030
Sand, fairly well rounded grains cemented with dolomite; some dolomite and chert	5	1,035
Dolomite, light gray to gray, generally finely crystalline; light gray chert, some sand	70	1,105
Roubidoux formation:		
Dolomite, light colored, more crystalline than above, with quartzitic sandstone	10	1,115
Dolomite, gray, finely crystalline; white chert, some sand..	120	1,235
Sand, well-rounded grains; some dolomite and chert	5	1,240
Ozarkian System (of Ulrich):		
Gasconade formation:		
Dolomite, light gray to bluish-gray, finely crystalline, granular; light to blue-gray chert, argillaceous and sandy near base	375	1,615
Eminence formation:		
Dolomite, white, light gray, light brownish-gray, finely crystalline, somewhat argillaceous and siliceous; pyritiferous; light gray to blue-gray, dense to slightly oolitic chert. Some sand, grayish-green shale; glauconitic near base	350	1,965

	Thickness, Feet	Depth, Feet
Potosi formation:		
Dolomite, light grayish-brown to brown, finely crystalline, siliceous, pyritiferous, with angular, crystalline, and rounded grains of sand, gray and brown dense and drusy chert	335	2,300
Cambrian System:		
Upper Cambrian Series:		
Elvins group (includes Davis and possibly Derby-Doerun formations. Lower beds in Potosi formation, given above, may belong to this group):		
Dolomite, light gray, fine-grained, siliceous, pyritiferous, with increasing amount of shale at base	35	2,335
Bonneterre formation:		
Dolomite, white to light and dark-gray, finely crystalline, siliceous, glauconitic, pyritiferous; some chert, some dark shale; some sand in lower part	590	2,925
Shale and sand; former green, micaceous, pyritiferous; latter medium sub-angular to rounded grains, a few fragments or rhyolite porphyry (?) and granite (?)	1	2,926
Sand, fine to medium-grained, subangular to rounded, with fragments of porphyry (?) and granite (?), some green shale	1	2,927
Dolomite, gray, finely crystalline, argillaceous, siliceous, glauconitic, pyritiferous; much fine to medium, angular to frosted grains of sand; green shale; much glauconite; some dense and drusy chert	106	3,033

Another deep hole in this county was drilled in 1919-1920 just north of River aux Vases, in the NE ¼ sec. 26, T. 37 N., R. 8 E. The total depth was 1240 feet. Water was found at a depth of 80 feet, in the St. Peter or Everton formations, but below that depth the hole was dry. Unfortunately no log is available. There is also another deep well near St. Marys which has been described under flowing wells.

Springs. Water flows or seeps from openings in the limestones or from the sandstones in many parts of the county. Several springs were noted during the course of the field work, and are listed below.

Partial List of Springs in Ste. Genevieve County.

Name of spring.	Location.	Geological formation.	Remarks.
Valle.	½ mi. S. of Ste. Genevieve.	Ste. Genevieve limestone.	Spring probably drains many sink holes to the west. Flow estimated in fall of 1924 at approximately 4,000,000 gallons per day.
Blue Spring.	SE ¼ sec. 24, T. 38 N., R. 6 W.	Potosi or Eminence.	Elevation about 750 feet; spring may be due to folding in rocks at and near this point.
Saline Creek Salt Springs.	On north bank Saline Creek, from the mouth to 2 miles west.	Spergen-St. Louis, Ste. Genevieve and Renault.	At one time important as source of salt. Relics collected indicate springs were once frequented by Indians.

PARTIAL LIST OF SPRINGS—Continued.

Name of spring.	Location.	Geological formation.	Remarks.
Name unknown.	¼ mile north of Saline Creek on Ste. Genevieve-St. Marys road.	St. Louis.	Small flow of water from cave, undoubtedly connected with sinks to the north. Indian petroglyphs found (see page 18).
Names unknown.	Secs. 16 and 17, T. 37 N., R. 7 E.	Bonneterre to Roubidoux.	A number of small springs along Hickory Creek, probably issue, in main, from faults in this area.
Fallert Spring.	Zell.	Top of St. Peter sandstone.	Flows four to five gallons per minute.
Names unknown.	Secs. 1 and 2, T. 37 N., R. 6 E.	Upper part of Bonneterre.	Small springs. Not uncommon in upper part of Bonneterre, at or near contact with overlying Davis shale, where structure is favorable.
Pickle Spring.	SW. corner sec. 20, T. 36 N., R. 7 E.	Lamotte sandstone.	Supplies most of water in Pickle Creek. Springs common in Lamotte formation, especially in coarse sandstone at or near contact with granite and porphyry.
Name unknown.	S. W. ¼ sec. 33, T. 46 N., R. 7 E.	Lamotte sandstone.	Appears to be connected with slight faulting.
Nations Mill Spring.	NW. ¼ sec. 27, T. 35 N., R. 8 E.	Potosi formation.	Supplies a large part of flow of Coldwater Creek at this point.

Analyses of Water from Ste. Genevieve and Perry counties.

(Expressed in parts per million).

	No. 1.	No. 2.	No. 3.
Silica, SiO_2	24.6	11.2	8.8
Iron, Fe	0.50	0.56	0.25
Aluminum, Al	2.2	1.4	1.4
Calcium, Ca	143.5	122.8	43.7
Magnesium, Mg	28.9	61.5	22.6
Alkalies, Na. & K, as Na	39.8	308.1	13.8
Carbonate, CO	15.3	13.2	None
Bicarbonate, HCO_3	317.0	282.1	243.2
Sulphate, SO_4	123.3	46.3	12.1
Chloride, Cl	68.2	682.0	5.4
Nitrate, NO_3	9.95	None	Trace
Totals	773.2	1,529.2	351.2
Volatile susp. matter	11.0	12.4	15.6
Non-Volatile susp. matter	0.0	7.2	16.2
Totals	11.0	19.6	31.8
Total hardness, calculated as $CaCO_3$	477.5	559.0	202.0
Alkalinity, calculated as $CaCO_3$	285.5	253.5	199.2

No. 1—Ste. Genevieve city water, analyzed August, 1926.
No. 2—St. Marys Milling Co. deep well, analyzed August, 1926.
No. 3—Perryville, St. Mary's Seminary, deep well, analyzed August, 1926.

City and Village Supplies: Ste. Genevieve (population 2046) is the only town with an extensive water system. It is supplied with water by the Missouri Power Company which has three wells in the alluvial deposits in the river bottom east of town. These wells are 8 inches in diameter and 75 feet deep, going to bed rock or boulders. The wells have been pumped 24 hours without lessening the supply. The pumps are set at 25 feet, and 12-foot brass screens to exclude sands are used. The plant was installed in 1906-7, and it was not necessary to clean the screens until 1923. A stand-pipe of 50,000 gallons capacity, located on a hill west of the city, gives 60 pounds pressure at the plant. The consumption averages 2,000,000 gallons per month. There are about 5 miles of 8, 6 and 4-inch mains with 124 connections and 40 hydrants. The water is softened for use in the boilers at the power plant, but no treatment is necessary from the sanitary standpoint. An analysis of the water is given on page 343.

Public wells dug on springs or seepages, and shallow dug wells and cisterns supply the town of St. Marys. Shallow drilled wells are in use at Brickeys, Bloomsdale, Lawrenceton, Kinsey, New Offenburg, River aux Vases, and Avon. Cisterns and shallow dug wells are in use in some of the towns mentioned above, and also at Zell, Weingarten and Minnith. Drilled wells could obtain supplies of water in the last mentioned towns at shallow depths.

A number of wells have been drilled in this county and the available information is summarized in the following table. Accurate logs are not available and the producing formations shown are in some cases approximate.

Table of Wells Drilled in Ste. Genevieve County.

Owner	Location	Depth in feet	Formation bottomed in	Depth of water horizon	Level of water in well	Remarks
Thomas Whitledge	St. Marys, Missouri	1600	Joachim			Water salty, flows feebly
St. Marys Milling Co.	St. Marys, Missouri	1930	St. Peter	860′-1827′+	8′	Water salty
Harris Brewer	St. Marys, Missouri	915	Fern Glen			Water good
Saline Creek M. & S. Co.	St. Marys, Missouri	213	Ste. Genevieve			
Saline Creek M. & S. Co.	St. Marys, Missouri	188	Ste. Genevieve			
Saline Creek M. & S. Co.	St. Marys, Missouri	441	Spergen			
Saline Creek M. & S. Co.	St. Marys, Missouri	418	Spergen			
Vogt	NE. ¼ sec. 2 T. 35 N. R. 7 E.	49	Lamotte			
Wm. Blackledge	SW. ¼ sec. 12 T. 35 N. R. 7 E.		Lamotte			
C. A. Boyd	NE. ¼ sec. 11 T. 35 N. R. 7 E.		Lamotte			
Issac Coffelt	NW. ¼ sec. 9 T. 35 N. R. 9 E.	140	Gasconade			Water flows feebly
Chas. Hopkins	NE. ¼ sec. 14 T. 36 N. R. 6 E.	80	Lamotte			Flows small stream
Joseph C. Loida	NE. ¼ sec. 16 T. 36 N. R. 6 E.		Lamotte			Good amount of water
Davis	NW. ¼ sec. 21 T. 36 N. R. 6 E.		Lamotte			
James Bowling	sec. 3 T. 36 N. R. 7 E.	150	Lamotte			
	NW. ¼ sec. 4 T. 36 N. R. 7 E.		Lamotte			
	SE. ¼ sec. 35 T. 36 N. R. 7 E.	83	Lamotte			Well shows plenty of water
	SW. ¼ sec. 36 T. 36 N. R. 7 E.		Bonneterre	40′	Near surface	Good flow from 40′ when drilled
	NE. ¼ sec. 17 T. 37 N. R. 6 E.	120	Lamotte	35′		Water at contact of lime and sand
Frank Hoover	sec. 29 T. 37 N. R. 7 E.	150	Lamotte			
	sec. 2 T. 37 N. R. 8 E.	1240	Gasconade or older	80′		
	SW. ¼ sec. 18 T. 37 N. R. 8 E.		Gasconade	135′-175′	35′	Can pump 1″ stream
Laurence Huech	SW. ¼ sec. 34 T. 37 N. R. 8 E.					
	NE. ¼ sec. 35 T. 37 N. R. 8 E.	210	Cotter or Powell			Water hard and scales boiler
Henry Werner	sec. 34 T. 38 N. F. 6 E.	80	Cambrian	25′	19′	Water hard
D. F. Loida	sec. 36 T. 38 N. R. 6 E.	113	Cambrian	19′		Flowing well
Frank Misplay	sec. 6 T. 38 N. R. 7 E.	105	Jefferson City or Roubidoux			
	sec. 13 T. 38 N. R. 7 E.	40	St. Peter or Everton		10′-15′	Water soft

TABLE OF WELLS DRILLED—Continued.

Owner	Location	Depth in feet	Formation bottomed in	Depth of water horizon	Level of water in well	Remarks
Anton Kemper	sec. 20 T. 38 N. R. 7 E.	56	Roubidoux	36′	16′	Water hard
Joseph Werner	sec. 20 T. 38 N. R. 7 E.	75	Roubidoux	40′	2′	Water hard
Kalligor and Schillig	sec. 13 T. 38 N. R. 7 E.	160	Powell		120′	2/3 miles south of Bloomsdale
Cornwall Cu. M. & S. Co.	sec. 16 T. 38 N. R. 8 E.	14	Powell	10′	10′	Water hard
Peter A. Weiler	SW. ¼ sec. 36 T. 38 N. R. 8 E.	95	Kimmswick (?)			Water hard
Ste. Genevieve Lime Works	Ste. Genevieve, Missouri	200	Warsaw (?)			2 miles west of town
	Ste. Genevieve, Missouri	75	Ste. Genevieve			Water hard
Peerless White Lime Co.	Ste. Genevieve, Missouri	40	Spergen			2 miles west of town
	sec. 24 T. 39 N. R. 7 E.		Kimmswick (?)			Deposits some scale
Lee Herman	T. 39 N. R. 7 E.		Kimmswick			Flows

extensive deposits may be found in the heavily faulted areas. The Gasconade, Eminence and Potosi formations should be the most favorable ground. An example of this type of deposit is in the north-center of sec. 34, T. 37 N., R. 8 E., where a shaft has been sunk about 35 feet. The shaft started in the lower Cotter, and probably bottomed in the Jefferson City formation. Local solution and settling had developed small fissures in which galena and calcite have been deposited. There are also small deposits of lead in the form of pockets. Calcite and barytes are the usual gangue minerals, with limonite altered from pyrite, and zinc minerals occasionally present. In the east-center of sec. 22, T. 36 N., R. 8 E., a shaft 30 to 35 feet deep was sunk in the Potosi formation, and is reported to have found a little lead, zinc, copper, and iron. Numerous other pits may be seen in various parts of the county, which were probably sunk on deposits of this kind, or on masses of residual chunk lead which has weathered out of either small pockets or fissures. Residual deposits are not always indicative of workable deposits in the underlying rock as they may be concentrated by weathering.

ZINC

Small amounts of zinc ore have been found with lead ores in the county, but no commercial deposits have been developed. To the northwest, at Valles Mines, in Jefferson County, considerable zinc has been mined, and some has been found in other places in the Potosi formation.

SAND

The St. Peter sandstone, the distribution of which is shown on the geologic map, furnishes an excellent grade of sand for the manufacture of glass, for use as molding sand, general foundry practice, and in the manufacture of pottery. There are no quarries operating in this county at present, although north in Jefferson and Franklin counties large quarries have been developed. The sand is reported to have been worked many years ago in the northwest part of T. 38, R. 8 E., this county, and hauled to Whitesand, the name of the village being derived from the color of the sand. The sand was loaded on barges and shipped down the Mississippi, and up the Ohio to glass factories in Pittsburgh, Pennsylvania. This is believed to have been the first use of Missouri sand for this purpose, and the discovery eventually lead to the establishment of glass works at Crystal City, Jefferson County.

The sand from the St. Peter and underlying Everton formation is of exceptional quality as indicated by the analyses given below:[1]

Analyses of Sand, Ste. Genevieve County.

	No. 1.	No. 2.
Silica (SiO_2)	99.50	99.54
Alumina (Al_2O_3)	0.09	0.20
Iron (Fe_2O_3)	0.06	0.10
Lime (CaO)	0.12	0.02
Magnesia (MgO)	Trace	0.02
Ignition loss	0.20	0.14
Totals	99.97	100.02

1. Everton sandstone, ¾ miles north of village of River aux Vases (Staabtown).
2. St. Peter sandstone, NE. ¼ NE. ¼ sec. 10, T. 38 N., R. 7 E.

The St. Peter sand is generally white in color, although locally iron stained on weathered exposures. The grains are well rounded and moderately fine, but fairly uniform in size. The sandstone is poorly cemented and friable except in the intensely faulted zone east of River Aux Vases (Staabtown) where it is indurated to a hard iron stained quartzite. Perhaps the most favorable locality for the production of sand from the St. Peter formation in this county would be from the outcrops west of Zell station, on the Missouri-Illinois Railroad. This area was favorably considered at one time by a large plate glass manufacturing company, but no work was done and the plant was located elsewhere.

The Lamotte sand has been worked on a small scale in the NW. ¼ NW. ¼ sec. 4, T. 36 N., R. 7 E., about 200 yards west of Miller's switch, on the Missouri-Illinois railroad. Two car loads were shipped from this place in 1925 by the Silica White Sand Company of Festus, Missouri, the material being used for molding sand. The sand was satisfactory for this purpose, but freight rates were too high to permit competition with the molding sand shipped from areas closer to the foundry industry in the St. Louis district.

[1] C. L. Dake, Mo. Bureau of Geol. and Mines, Vol. XV, p. 140, 1918.

FELDSPAR

Three deposits of feldspar have been worked in the past in Ste. Genevieve county—the Dobschutz pit, opened about 1880, the Niedringhaus deposit and the Pratte deposit, which is probably the largest. The feldspar mineral is orthoclase, deep red in color, and nearly pure as shown by the analysis given below. It occurs in pegmatite-like dikes, or as segregation from the main granitic mass. These pegmatites are a mixture of feldspar and quartz with the former predominating. The veins vary in width from a few inches to several feet, but apparently are not persistent in length. Thorough prospecting or test pitting is necessary to determine the extent of the deposits. In two of the deposits, as noted below, basic dikes are present. These may or may not be connected with the genesis of the veins. Other places were noted where there is a tendency toward segregation of the feldspar and the possibility of finding other deposits of perhaps larger size should not be overlooked.

The Pratte deposit is located in the south-center of sec. 2, T. 36 N., R. 7 E. A shallow pit, on the south side of Jonca Creek, is 150 feet long by 8 to 10 feet wide, and strikes N. 75° E. The vein varies in width, measuring 8, 10, 16, 18, 24 and 26 inches in different places, but could not be found on the opposite side of the creek. A basic dike cuts the vein and the best feldspar is apparently on the west side of the dike. Near the vein and on the south side of the creek is a small segregation of coarse crystals of feldspar and quartz, and near the falls a four-inch vein shows mico-pegmatitic characteristics. The feldspar has little quartz or other impurities. and being only three or four miles from Miller's switch deserves further prospecting to determine its extent and grade.

The Dobschutz deposit is located in the north-center sec. 10, T. 36 N., R 7 E. This deposit was opened in the early eighties, and furnished all the feldspar for the Belleville, Illinois, pottery during its short life. The pit is now nearly filled with wash, but pieces of good feldspar were found on the dump. Wheeler[1] described the property as being opened by a pit 35 feet deep showing an eight-foot vein tapering to one and one-half feet at the northern end, and quite free from quartz and ferromagnesian minerals.

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[1]Wheeler, H. A., Clay Deposits, Mo. Geol. Surv., 1st ser., Vol. XI, 1896.

He gives the following analysis furnished by Mr. Dobschutz:

	Per cent
Silica	64.80
Alumina	18.00
Potash (trace of soda)	15.90
Water	0.70
Iron	0.60
Total	100.00

This deposit is less than three miles from Miller's switch, and would seem to warrant further exploration.

The Niedringhaus deposit in the north-west corner, sec. 14, T. 36 N., R. 7 E., is on the north side of Pickle Creek. The condition of the deposit was such that no examination could be made when visited. Micro-pegmatite and a basic dike cut across the pit. It is reported that some feldspar was shipped years ago.

A small prospect excavation in the granite on the north bank of the creek, in the NW. ¼ NE. ¼ sec. 9, T. 36 N., R. 7 E., shows a small segregation of feldspar which contains considerable quartz. Although the surface showings do not indicate workable material, it is possible that higher grade feldspar would be found with additional prospecting.

IRON

Up to the present time no iron sulphide or iron oxide deposits have been found that would warrant commercial development. However, there are several small prospects in various parts of the county. The iron occurs as pyrite, marcasite, and as limonite, the latter in most cases being an alteration from the sulphides. In addition to the prospects, pieces of limonite, derived from various formations can be found as surface boulders or "float ore" in many places.

Near the center of sec. 10, T. 35 N., R 7 E., large chunks of pyrite and marcasite have been found, many of which are fresh and unweathered. The dip of the rocks toward the hill suggests the presence of a sink structure which may be filled with iron sulphides. About three-fourths of a mile southeast, in the SW. ¼ sec. 11, a shaft was sunk to a depth of about 75 feet. Some finely divided iron sulphide is present on the dump. The shaft was put down some 45 years ago in prospecting for lead and zinc.

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