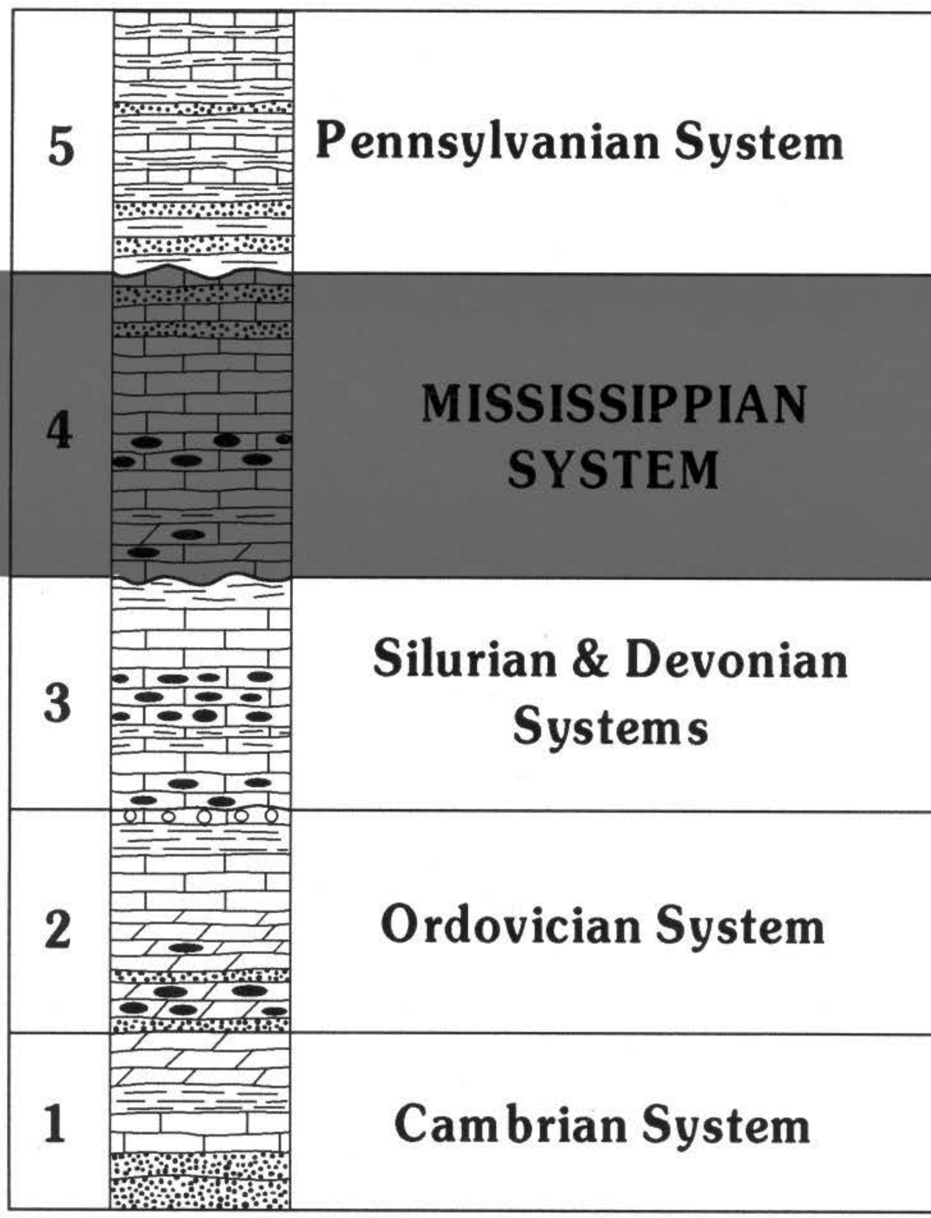
Report of Investigation No. 70

MISSOURI DEPARTMENT OF NATURAL RESOURCES
Division of Geology and Land Survey

PALEOZOIC SUCCESSION IN MISSOURI

Part 4
MISSISSIPPIAN SYSTEM



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PALEOZOIC SUCCESSION IN MISSOURI
Part 4
MISSISSIPPIAN SYSTEM

by
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Library of Congress Catalog Card Number: 86-620008
Missouri Classification No. MO/NR. Ge 8:70/4

Thompson, Thomas L., 1986, **PALEOZOIC SUCCESSION IN MISSOURI, Part 4 -- MISSISSIPPIAN SYSTEM:** Missouri Department of Natural Resources, Division of Geology and Land Survey, Report of Investigations 70 part 4, 189 p., 110 figs., 2 tbls.

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INTRODUCTION

Howe and Koenig (1961, p. 7) compiled Volume 40 (of the Missouri Geological Survey and Water Resources), *The Stratigraphic Succession in Missouri* ". . . to serve as both an expositional and graphic guide to the stratigraphic succession in the state as recognized by the Missouri Geological Survey . . ." Its purpose was to present a review and basic description of those stratigraphic units formally recognized in the State of Missouri by geologists of the Missouri Geological Survey (now the Missouri Department of Natural Resources, Division of Geology and Land Survey).

During the more than two decades since publication of Volume 40 many new concepts have developed concerning the stratigraphic succession in Missouri, and new formations have been proposed. In 1965, the Missouri Geological Survey adopted the principles in the *Code of Stratigraphic Nomenclature* (AAPG, 1961) and subsequently established a list of formal names of rock units in Missouri to serve the staff as a standard for uniform stratigraphic nomenclature. This standard was intended to be followed in all Survey publications. Adoption of the *North American Stratigraphic Code* (North American Commission on Stratigraphic Nomenclature, 1983) in 1984 further refined the concept of the formation and its components and produced the scheme of stratigraphic nomenclature included in this report.

The stratigraphic framework presented in Volume 40 is still valid. It is now believed, however, that additional information, such as authors and original descriptions, location of type sections (or inclusion of reference sections if type sections no longer exist, are unusable, or are not located in Missouri), and a listing of relevant previous stratigraphic terminology would aid geologists and others studying the geology of Missouri. The first *Supplement to Volume 40* (Thompson and Anderson, 1976) was written with the specific aim of updating formally accepted Missouri stratigraphic terminology and of presenting additional data relevant to the stratigraphic succession in Missouri. Now, with the addition of newly named units, and some new definitions of old ones, a complete revision of the stratigraphic succession in Missouri is in order.

In Missouri, Mississippian rocks crop out in an arcuate band around the northern border of the Ozark uplift (fig. 1). The region of outcrop is informally divided into six areas: southwestern, west-central, central, east-central, southeastern, and northeastern. Outside of the outcrop belt they extend throughout the subsurface, beneath rocks of Pennsylvanian age. The **Stratotype region for the Mississippian System** is the Upper Mississippi River Valley, extending from Burlington, Iowa, to southeastern Missouri and southwestern Illinois (Collinson et al., 1979; Thompson, 1984). Within Missouri are the type sections for 14 Mississippian formations and one member of a formation (fig. 2). The type regions for two of the four recognized Mississippian series, Osagean and Meramecian, are entirely within the State of Missouri, and Missouri shares with Illinois, or is immediately adjacent to, the type areas for the other two series, Kinderhookian and Chesterian. The formally recognized Mississippian stratigraphic units in Missouri are listed in table 1. Figures 3 to 8 are columnar sections of Mississippian strata present in the southwestern (fig. 3), central (fig. 4), east-central (fig. 5), southeastern (figs. 6-7), and northeastern (fig. 8) parts of the outcrop regions in Missouri.

Obviously it is beyond the limits of this report to list in synonymy all published reports describing Mississippian strata in Missouri; therefore, the historical sections list only reports considered to be of major stratigraphic import: those that originally defined, amended, reinforced, redefined, and/or stabilized the definition of Mississippian stratigraphic units in Missouri. The historical sections also list names originally proposed for formations in Missouri that have been abandoned because they are synonyms of previously proposed stratigraphic

Figure 1. *Map of Missouri showing the general boundaries of the six outcrop regions of Mississippian rocks in the state. Adapted from Spreng (1961, fig. 9).*

Figure 2. *Map of Upper Mississippi Valley region showing locations of type areas for series constituting the "standard section" for the Mississippian System. Adapted from Thompson (1984, fig. 1).*

names. Many studies have been omitted due to their limited scope, or because they repeat terminology.

In the historical sections, the parenthetical statement **upper part** means that only the upper part of that author's stratigraphic unit is within the presently accepted definition of the unit. For example, under "Ste. Genevieve Limestone" (p. 117), the present concept of Ste. Genevieve includes only the upper part of the St. Louis limestone as described by Englemann (1847). Likewise, **middle part** and **lower part** mean that only the middle or lower part of that author's stratigraphic unit is included within the present concept of the unit. The designation **part** means that some undefined portion of the author's unit is included within the presently defined unit. A statement with quotation marks in parentheses reflects the belief of a particular author, *e.g.*, Jones believed the Noel Shale (" = Chattanooga Shale").

Because the Standard Mississippian Section, or Stratotype, is within the Upper Mississippi River Valley, this region has received considerable attention in recent years in the development of a useful biostratigraphic zonation for the system, based on conodonts, correlated with the European zonation of Lower Carboniferous strata, based on conodont and ammonoid faunas. Studies, mostly by geologists of the Illinois and Missouri Geological Surveys, began in the 1950's with reports on the type Chesterian strata, by Rexroad (1957, 1958) and Rexroad and Collinson (1961). Mehl (1960, 1961) and Scott and Collinson (1961) developed the currently accepted definition of the Devonian-Mississippian boundary, including the clarification of several Late Devonian and Early Mississippian units that had previously been classified only as "Devonian-Mississippian."

Preliminary system-wide faunal studies having been completed for the type Mississippian, Collinson et al. (1962) published the first conodont zonal scheme for the system. Detailed Meramecian faunas were published by Rexroad and Collinson (1963, 1965). Thompson (1967) and Thompson and Fellows (1970) published a detailed conodont zonation for the Kinderhookian and Osagean Series, based on faunas collected in southwestern Missouri. This was followed by publication of a detailed Mississippian conodont zonation for North America, by Collinson et al. (1971), supplemented by further data on the Chesterian and Osagean Series, by Thompson (1972, 1975). Thus, a comprehensive sequence of conodont faunas has been defined, allowing precise correlation of Mississippian strata in the North American Midcontinent region with those of the type region of the system (table 2).

Acknowledgments

During compilation, and particularly during the review phase, of this report several geologists versed in Mississippian stratigraphy of the Midcontinent region gave their time and efforts to help me. Foremost among these are A.C. Spreng, Department of Geology and Geophysics, University of Missouri-Rolla, and C.E. Robertson and David Work, Missouri Department of Natural Resources, Division of Geology and Land Survey, Rolla, who reviewed the entire manuscript and offered suggestions for the final format and contents. I particularly thank J.D. Vineyard, Assistant State Geologist, Division of Geology and Land Survey, for support and encouragement during initiation and major compilation of the manuscript, and Betty Harris and Susan C. Dunn for the many hours they spent in final preparation of this report.

East-central	Southeastern	Northeastern	Southwestern	West-central	Central
	Vienna Limestone Tar Springs Sandstone Glen Dean Formation Hardinsburg Formation Golconda Formation Haney Limestone Mbr. Fraileys Shale Member Beech Creek Ls. Mbr. Cypress Formation Paint Creek Formation Ridenhower Ls. Mbr. Bethel Member Downeys Bluff Ls. Mbr. Yankeetown Sandstone Renault Formation		Fayetteville Formation (Wedington Ss. Mbr.) Batesville Formation Hindsville Limestone (Carterville Formation)		
Ste. Genevieve Ls. St. Louis Limestone Salem Formation Warsaw Formation	Aux Vases Sandstone Ste. Genevieve Ls. St. Louis Limestone Salem Formation Warsaw Formation	Ste. Genevieve Ls. St. Louis Limestone Salem Formation Warsaw Formation	Warsaw Formation	St. Louis Limestone Salem Formation Warsaw Formation	Salem Formation Warsaw Formation
Keokuk Limestone Burlington Limestone "lower Burlington Ls." Fern Glen Formation Meppen Ls. Member	Keokuk Limestone Burlington Limestone "lower Burlington" Fern Glen Formation Meppen Ls. Member	Keokuk Limestone Burlington Limestone	Keokuk Limestone Short Creek Oolite Mbr. Burlington Limestone Elsey Formation Reeds Spring Formation Pierson Limestone	Keokuk Limestone Short Creek Oolite Mbr. Burlington Limestone Elsey Formation Pierson Limestone	Keokuk Limestone Burlington Limestone "Pierson Limestone"
Bachelor Formation Bushberg Sandstone	Chouteau Group undiff. Bachelor Formation Bushberg Sandstone	Chouteau Group "McCraney Limestone" "Chouteau Limestone" Hannibal Shale Horton Creek Limestone	Chouteau Group Northview Formation Baird Mtn. Ls. Mbr. Compton Limestone Bachelor Formation	Chouteau Group Northview Formation Sedalia Formation Compton Limestone Bachelor Formation	Chouteau Group Northview Formation Sedalia Formation "Unnamed Limestone" Compton Limestone Bachelor Formation

Table 1. *List of formally recognized stratigraphic units of Mississippian age in Missouri, by geographic region. Adapted from table 2 of Spreng (1961).*

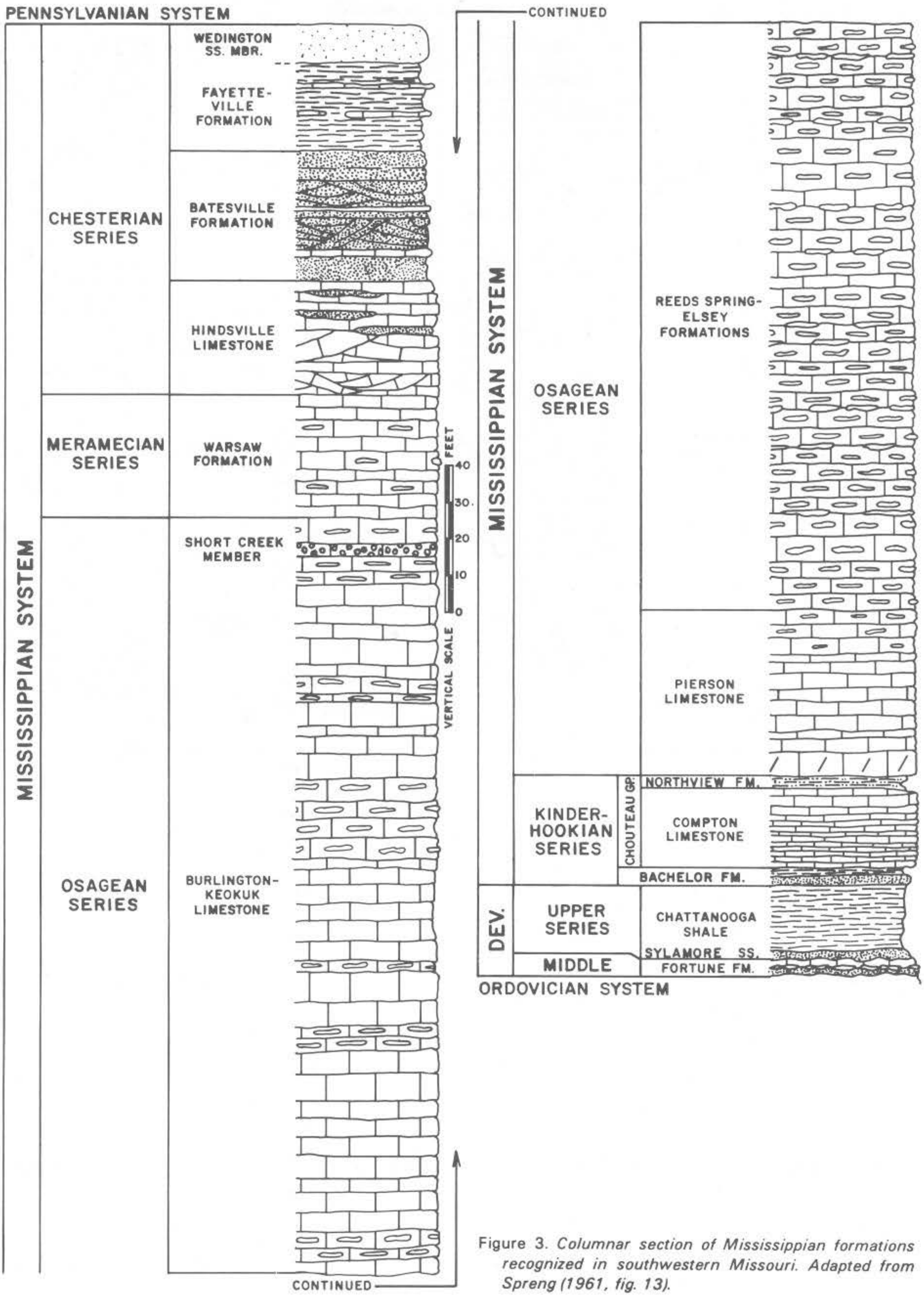


Figure 3. *Columnar section of Mississippian formations recognized in southwestern Missouri. Adapted from Spreng (1961, fig. 13).*

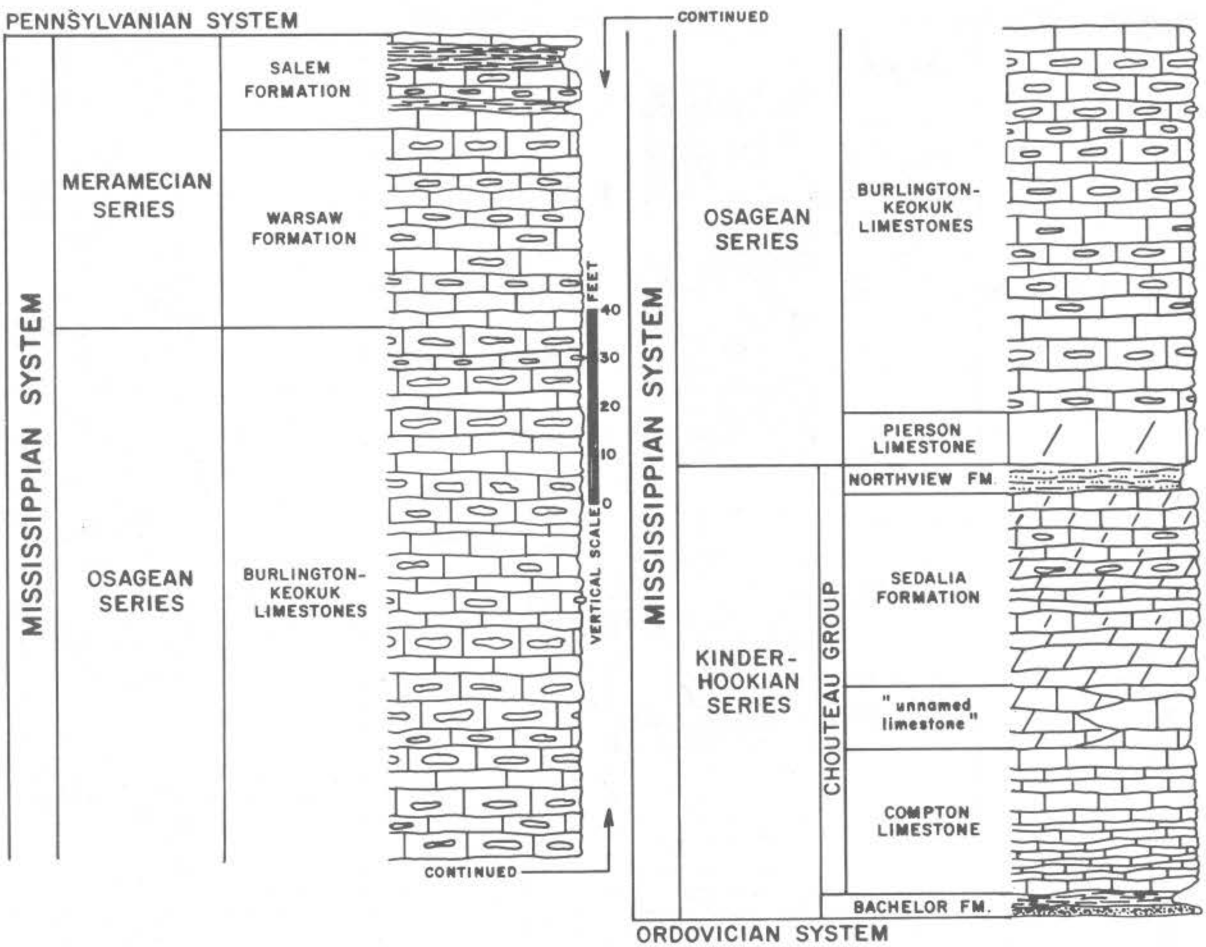


Figure 4. *Columnar section of Mississippian formations recognized in central Missouri. Adapted from Spreng (1961, fig. 11).*

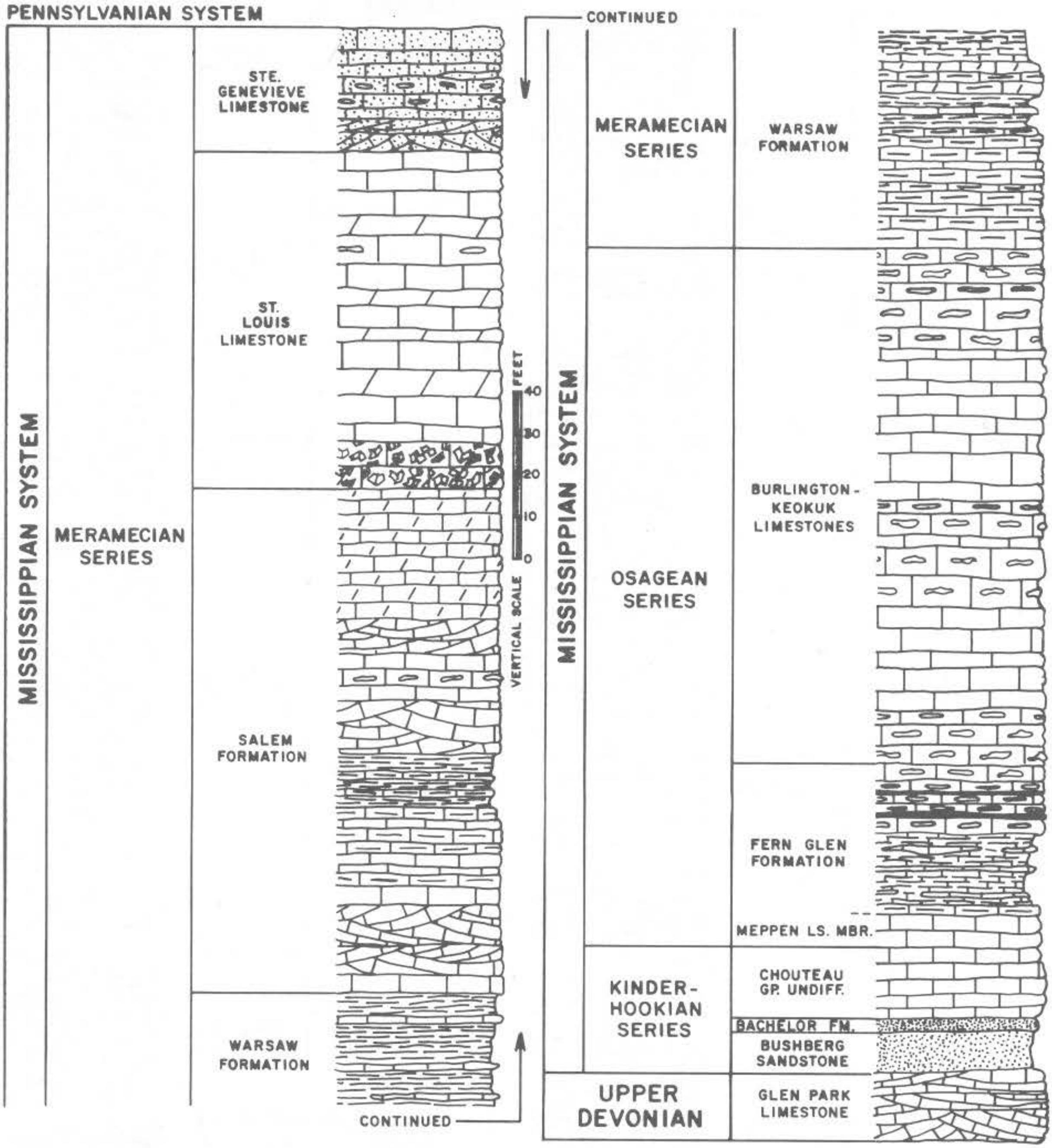


Figure 5. *Columnar section of Mississippian formations recognized in east-central Missouri. Adapted from Spreng (1961, fig. 12).*

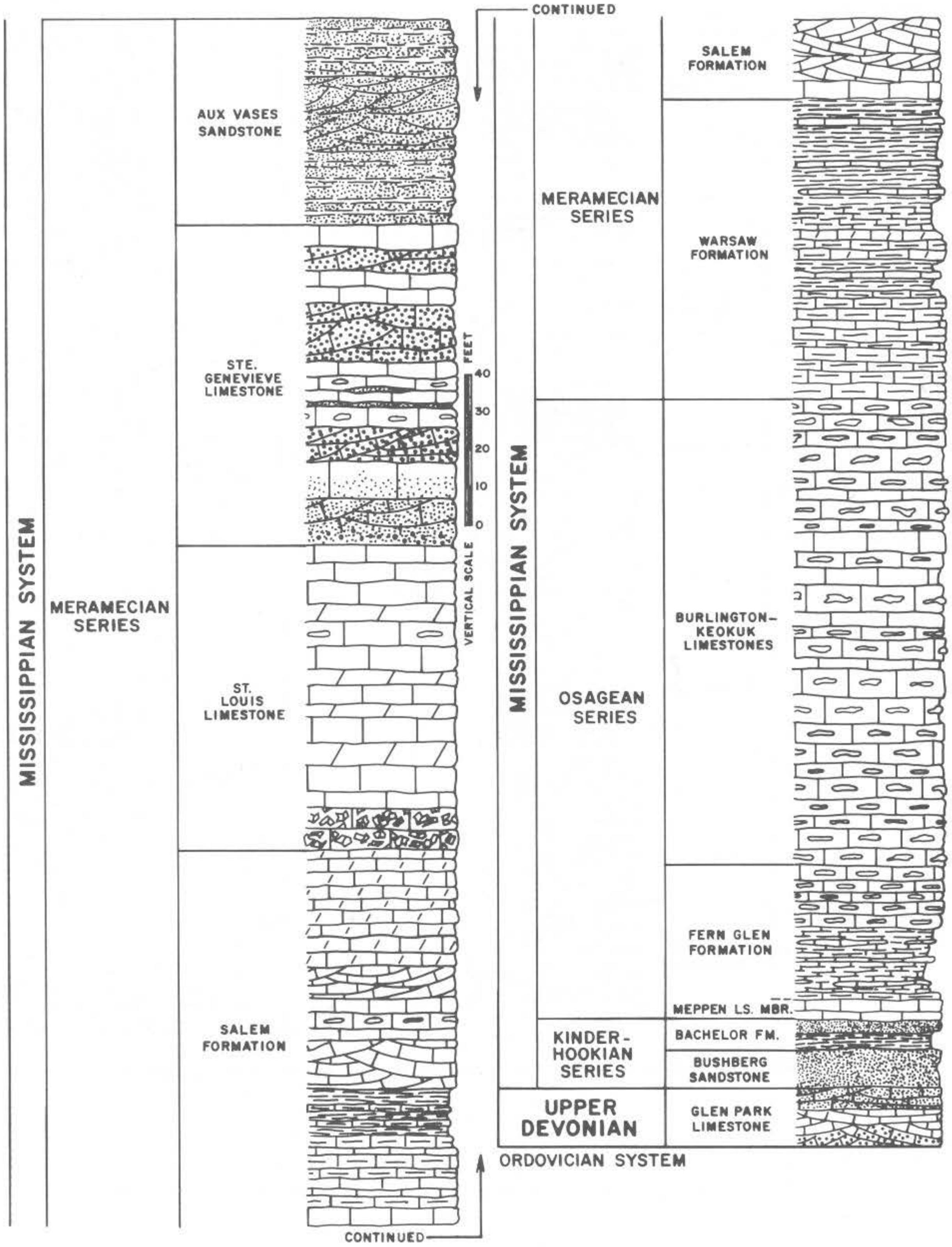


Figure 6. *Columnar section of Kinderhookian, Osagean, and Meramecian formations recognized in southeastern Missouri. Adapted from Spreng (1961, figs. 12 and 14).*

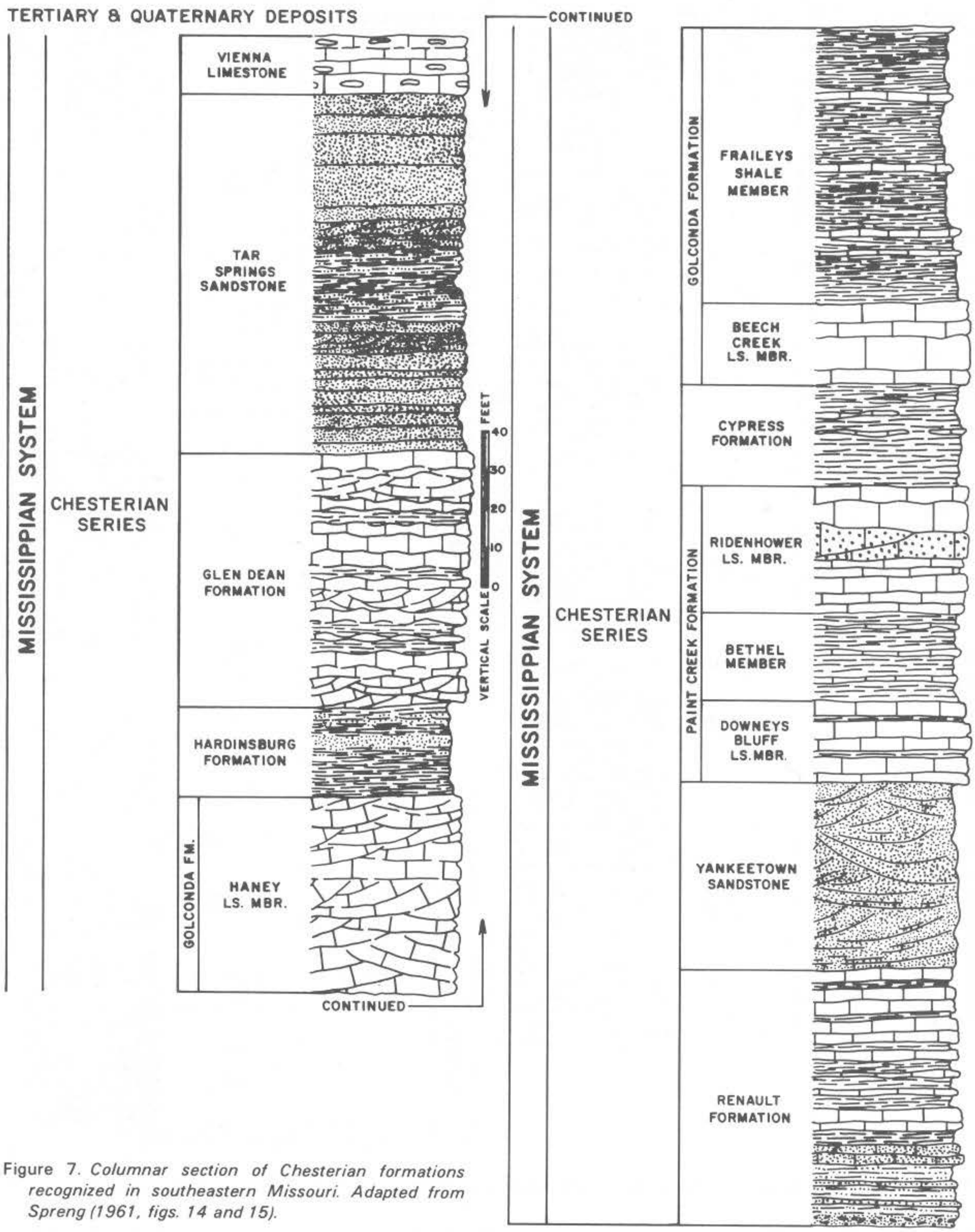


Figure 7. *Columnar section of Chesterian formations recognized in southeastern Missouri. Adapted from Spreng (1961, figs. 14 and 15).*

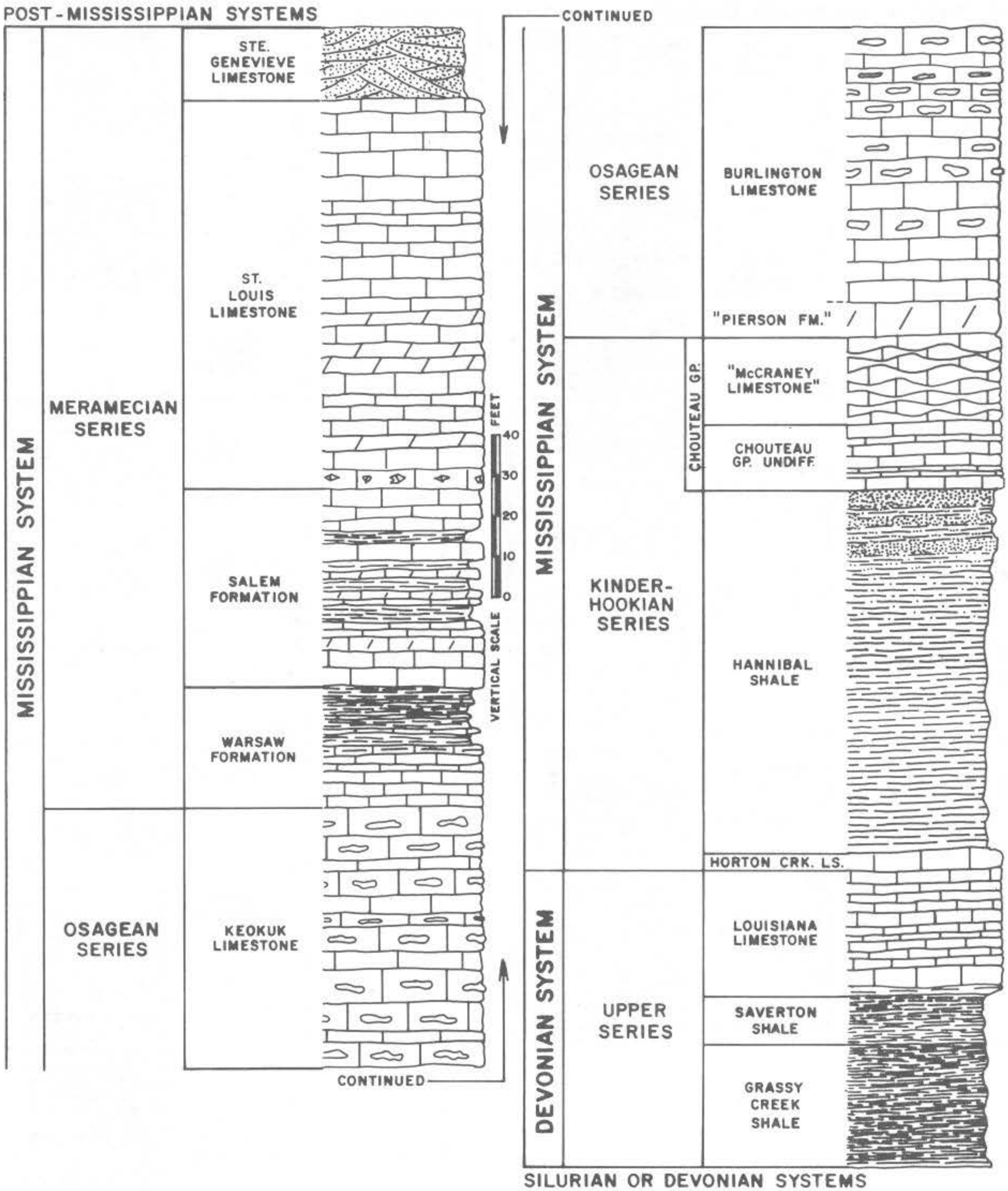


Figure 8. *Columnar section of Mississippian formations recognized in northeastern Missouri. Adapted from Spreng (1961, fig. 10).*

Conodont Zone	Formations included (*)	Series
Streptognathodus unicornis Zone (Collinson et al., 1962)	Grove Church	CHESTERIAN
Kladognathus-Cavusgnathus naviculus Zone (Collinson et al., 1962)	Kincaid	
	Degonia	
	Clore	
	Palestine	
	Menard	
Kladognathus primus Zone (Collinson et al., 1962)	Waltersburg	
	Vienna Limestone	
	Tar Springs Formation (Fayetteville Formation)	
Gnathodus bilineatus-Kladognathus mehli Zone (Collinson et al., 1962	Glen Dean Formation (Fayetteville Formation)	
Gnathodus bilineatus-Cavusgnathus altus Zone (Collinson et al., 1962)	Hardinsburg (Batesville)	
	Golconda (Hindsville) (Carterville)	
Gnathodus bilineatus-Cavusgnathus charactus Zone (Collinson et al., 1962)	Cypress (Hindsville)	
	Paint Creek Formation	
	Yankeetown Sandstone	
	Renault Formation	
	Aux Vases Sandstone	MERAMECIAN
	Ste. Genevieve Limestone	
Apatognathus scalenus-Cavusgnathus Zone (Collinson et al., 1962	St. Louis Limestone	
Taphrognathus varians-Apatognathus Zone (Collinson et al., 1962)	Salem Formation	
	Warsaw Formation	
Gnathodus texanus-Taphrognathus Zone (Collinson et al., 1962)	Keokuk Limestone	OSAGEAN
Gnathodus bulbosus Zone (Thompson, 1967)	(Reeds Spring Formation)	
	(Pierson Limestone)	
Bactrognathus distortus-Gnathodus cuneiformis Zone (Thompson, 1967)	Burlington (Burlington)	
	(Elsey Formation)	
	Fern Glen (Reeds Spring)	
Bactrognathus-Polygnathus communis Zone (Collinson et al., 1962)	Burlington (Burlington)	
	(Elsey Formation)	
	Fern Glen (Reeds Spring)	
	Meppen Limestone Member (Pierson)	
Gnathodus semiglaber-Pseudopolygnathus multistriatus Zone (Thompson, 1967)	(Reeds Spring)	
	Fern Glen (Elsey)	
	Meppen Limestone Member (Pierson)	
Gnathodus semiglaber-Polygnathus communis carinus Zone (Thompson, 1967)	Meppen Limestone Member of Fern Glen Formation (Pierson Limestone)	
Siphonodella cooperi hassi-Gnathodus punctatus Zone (Thompson and Fellows, 1970	(Baird Mountain Limestone Member Northview Formation)	KINDERHOOKIAN
Siphonodella isosticha-S. cooperi Zone (Collinson et al., 1962)	"Chouteau Limestone" (Northview Formation)	
Siphonodella quadruplicata-S. crenulata Zone (Collinson et al., 1962)	"Chouteau" (Compton Limestone)	
	Hannibal Shale	
Siphonodella lobata-S. crenulata Zone (Thompson and Fellows, 1970)	"Chouteau" (Compton Limestone) Hannibal Shale (Bachelor)	
Siphonodella sandbergi-S. duplicata Zone (Sandberg and Klapper, 1967)	Hannibal Shale (Bachelor)	
Siphonodella sulcata Zone (Collinson et al., 1962)	Hannibal Shale	
Ptotognathodus kuehni-P. kockeli Zone (Collinson et al., 1962)	basal Hannibal Shale Horton Creek Limestone	

(*) Units in ( ) from central, western, and/or southwestern Missouri.

Table 2. *Conodont zonation of Mississippian strata in the Stratotype region and adjacent Midcontinent area (*). Adapted from Collinson et al. (1971), with additions from Thompson (1972, 1975).*

MISSISSIPPIAN SYSTEM
Winchell, 1869

Original description — (Winchell, 1869, p. 79) ". . . it appears from observations made by others and by myself, that the Knobstone formation of Indiana and Kentucky, with the associated shales and limestones, is substantially restricted to the horizon of the Keokuk division of the Mississippi Limestone series, or 'Mississippi group.'"

Williams (1891, p. 136) quoted Winchell as originating the proposal for ". . . the use of the name Mississippi limestone series or Mississippi group as a geographical designation for the carboniferous limestones of the United States which are so largely developed in the valley of the Mississippi River."

Type locality — Named for exposures along the Mississippi River Valley from Iowa to southern Missouri.

History of nomenclature —

	European	
	Early geologists	Lower Carboniferous
		Mountain limestone
		Subcarboniferous
		Lower Carboniferous
1838	Owen	Subcarboniferous group (included Chattanooga Shale)
1847	Englemann	Carboniferous or "Mountain limestone on the Mississippi"
1869	**Winchell**	**Mississippi Limestone series, or "Mississippi group"**
1891	**Williams**	**Mississippian series**
1897	Schuchert	Waverly
1903	Buckley	Lower Carboniferous system
1904	Buckley & Buehler	Mississippian (Sub-Carboniferous) system
1910	Schuchert	Mississippic Period
		Tennesseeic Period
1961	Spreng	Mississippian system

Remarks — Although the name "Mississippi" as a stratigraphic term was originally proposed by Winchell, it was Williams (1891) who formally proposed its usage as a major time-stratigraphic unit. Williams (1891, p. 135) stated,

> "The formations resting upon the Devonian where these occur and in other places upon the Silurian, are under the names 'Mountain limestone,' 'Carboniferous limestone,' 'Subcarboniferous,' and 'Lower Carboniferous.' No one of these names is satistifactory, and as these formations are bound together by a common general fauna and constitute a conspicuous feature in the geology of this region, it is proposed to call them the *Mississippian series.* This series is defined stratigraphically as that series of rocks, prevailingly calcareous, which occupies the interval between the Devonian system and the Coal Measures, and is typically developed in the States forming the upper part of the Mississippi River, viz, Missouri, Illinois, and Iowa. The name is a slight modification in form and usage of a name proposed by Alexander Winchell in 1870."

Keyes (1892) accepted William's concept of the "Mississippian series" until 1914 (table 1), when he determined that Winchell's original description applied only to those strata of the present Chouteau-Salem sequence. Thus, he restricted "Mississippian series" so that it was synonymous with "Osagean Series," and a little of the uppermost Kinderhookian and lowermost Meramecian Series of the present classification. This concept apparently was not accepted by any others.

Mississippian strata were initially recognized as constituting four depositional sequences or "series": the **Kinderhookian, Osagean, Meramecian,** and **Chesterian.** As knowledge multiplied, the boundaries between these series were redefined (fig. 9), usually many times. Today, the prevailing tendency is to recognize three series for the Mississippian System, the two original middle series (Osagean and Meramecian) have been combined into the **Valmeyeran Series.** Other classifications identify two series, **Lower** and **Upper,** instead of three or four. The four-part classification of Mississippian strata, which is compatible with the three-part classification used elsewhere, is still used in Missouri.

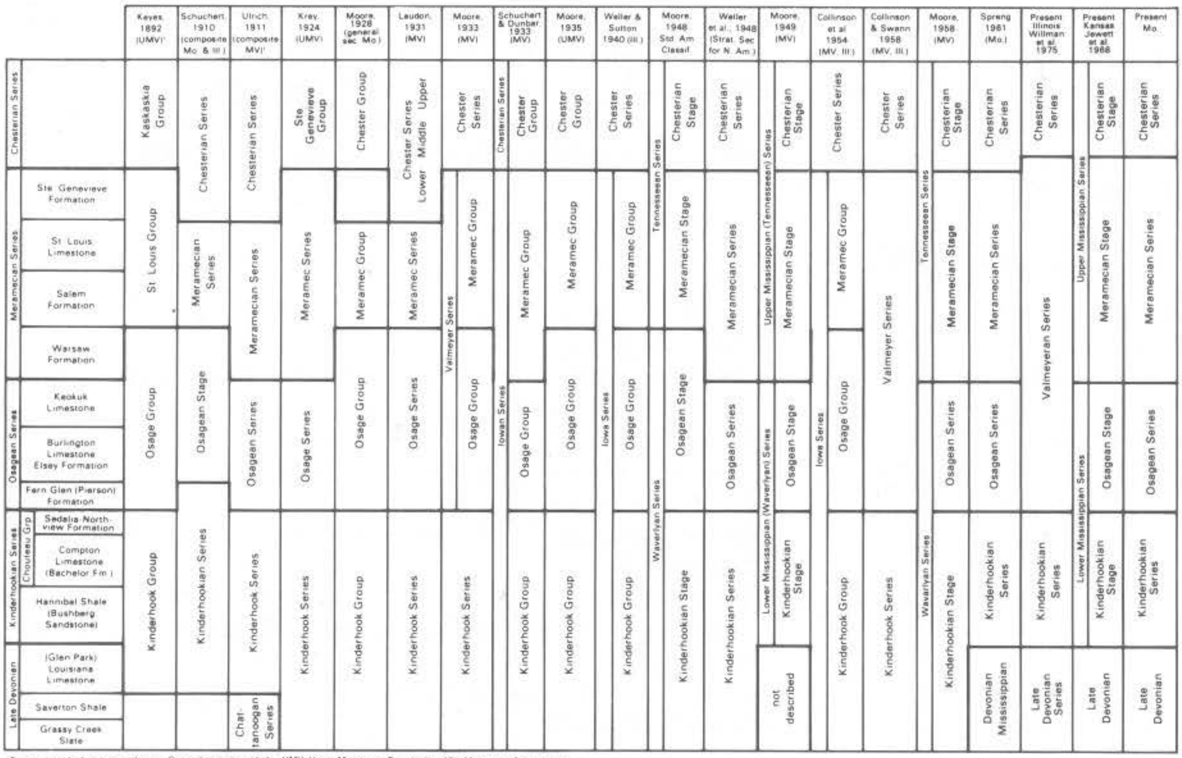


Figure 9. *Development of nomenclature of Mississippian series in Missouri and surrounding Midcontinent region, from the 1890's to present. Adapted from Thompson (1979a, fig. 3).*

KINDERHOOKIAN SERIES
Meek and Worthen, 1861b

Original description — (Meek and Worthen, 1861b, p. 288) "The name 'Kinderhook Group' is now proposed by these authors to include the beds lying between the Black Slate and the Burlington Limestone, which have heretofore been considered the equivalents of the Chemung Group of New New York."

Type locality — Exposures in the east bluffs of the Mississippi River Valley immediately north of the town of Kinderhook (from the SE¼ sec. 14 to the center of sec. 24, T. 45 S., R. 7 W.), Pike County, Illinois constitute the type locality for the Kinderhookian Series, Hull 7½' Quadrangle (fig. 10). Keyes (1941) proposed a new type section at Burlington, Iowa, but it was not accepted by later stratigraphers.

History of nomenclature —

1852	Owen	Argillo-calcareous group
1855	Swallow	Chemung group
1861	**Meek & Worthen (b)**	**Kinderhook Group** (upper part; included from Grassy Creek to base of Burlington)
1869	Winchell	Chemung group
1874	Broadhead	Chouteau Group (to replace Chemung group)
1891	Williams	Chouteau group
		Kinderhook stage ("= Chouteau age"; part, included Louisiana Limestone)
1904	Buckley & Buehler	Tullahoma formation (up to Ste. Genevieve County, Missouri; lower part; named by Stafford and Killebrew (1900), from Tennessee)
1911	Ulrich	Waverlyan series (upper part)
1914	Weller	Kinderhook group
1944	Branson (a)	Kinderhook group (lower part of "Lower Mississippian series")
1948	Weller et al.	Easley group of Kinderhookian series ("Fabius group of Kinderhookian series" now considered Upper Devonian in age
1961	Scott & Collinson	Kinderhookian series (**as presently defined**)

Remarks — The Kinderhookian Series was originally proposed by Meek and Worthen (1861b) to include all strata from the base of what is now the Grassy Creek Shale to the base of the Burlington Limestone. Thus, initially the Upper Devonian Grassy Creek and Saverton Shales and Louisiana Limestone, as well as the lower Osagean Fern Glen Formation, were included within the Kinderhookian Series. The base was not firmly established until Scott and Collinson (1961) defined the Devonian-Mississippian boundary as being between the Louisiana Limestone and the Hannibal Shale, whereas Moore (1928) showed Fern Glen strata to be lower Osagean, through correlation with the Reeds Spring Formation of southwestern Missouri.

In older reports, Kinderhookian rocks in southwestern Missouri and northwestern Arkansas were believed to be missing. They constituted the lower part of the St. Joe Limestone, or "St. Joe Limestone member of the Boone Formation," and the Kinderhookian age of the lower part of the St. Joe was not clearly defined until the study, by Thompson and Fellows (1970), of Lower Mississippian strata in southwestern Missouri. Prior to this, the St. Joe had generally been considered entirely Osagean (Girty, 1915b; Spreng, 1961; Gordon, 1964). Today, Kinderhookian rocks appear to be

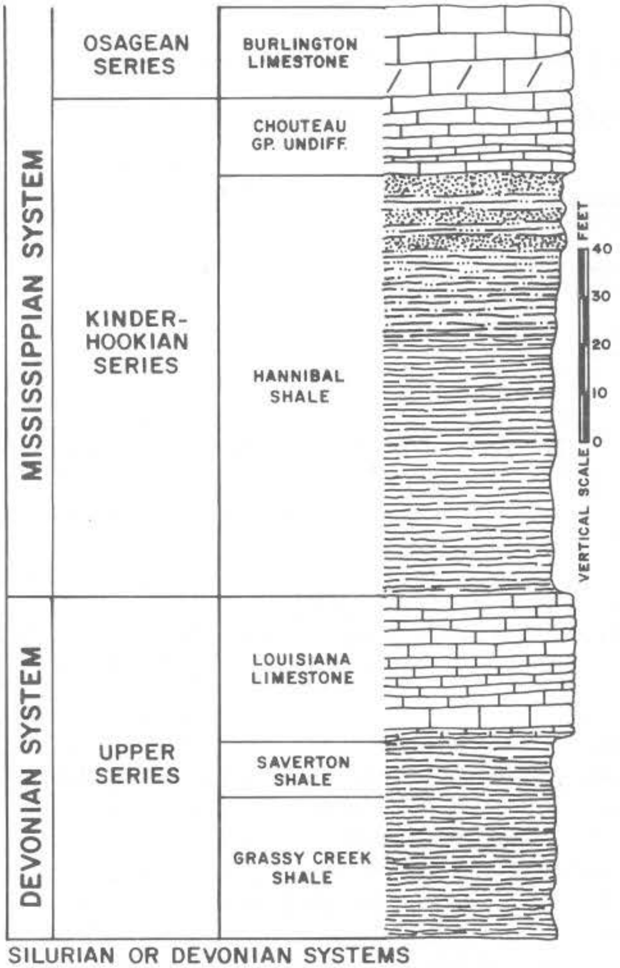


Figure 10. *Generalized columnar section of Kinderhookian strata as found within the type area of the Kinderhookian Series. Adapted from Spreng (1961, fig. 3).*

present in outcrops beneath the Osagean limestones wherever the latter are exposed (fig. 11), although the Kinderhookian may only be represented by the thin Bachelor Formation in some parts of the Ozarks.

In northeastern Missouri the Kinderhookian Series is represented by two formations, the Hannibal Shale, a thick shale and siltstone, overlain by a thin limestone, the latter commonly referred to in older reports as the "Chouteau limestone." Thus, in eastern Missouri Kinderhookian rocks are limestone (Chouteau) and/or shale (Hannibal), except for a region south of St. Louis, where only sandstone (Bachelor and Bushberg) lies beneath the Osagean Fern Glen Formation.

South and west of its type area, the Hannibal Shale thins to less than 5 ft in the subsurface and is absent in the outcrop area, but the carbonate sequence (Chouteau) thickens. The latter becomes a prominent limestone unit in western northeastern Missouri and the central Mississippian outcrop region of the state, where it includes four Kinderhookian formations, the Compton Limestone, an "unnamed limestone," and the Sedalia and Northview Formations. In central Missouri these four units constitute the **Chouteau Group**, the lower part of which (the "lower Chouteau of Swallow" or "Chouteau (restricted) of Moore") is equivalent to the Compton Formation of southwestern Missouri. The Sedalia Formation, a dolomitic limestone, and the overlying Northview, a silty shale to shaly limestone, are characteristic only of west-central and southwestern Missouri.

Southwestward from the central region, the Northview thickens and in places laterally interfingers with the upper part of Sedalia Formation, which thins southward and gradually loses its identity as a formation. With the loss of the Sedalia, the Chouteau Group comprises only the

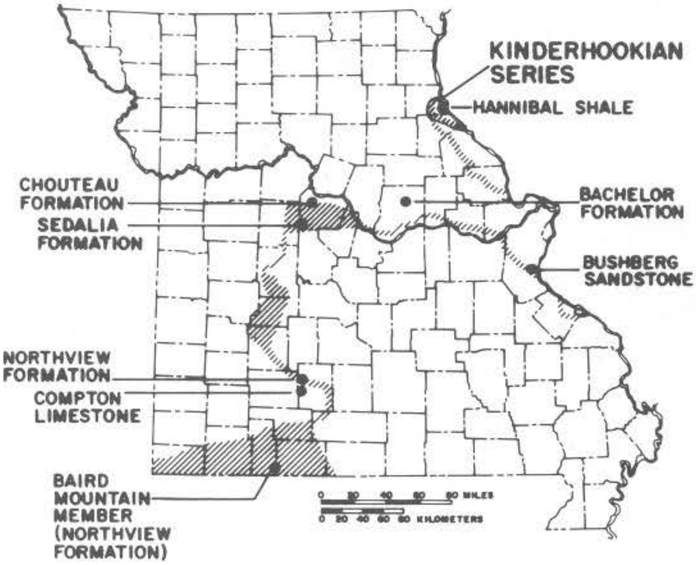


Figure 11. *Base map of Missouri showing general regions of exposure of rocks of the Kinderhookian Series, and locations of type sections for Kinderhookian formations named from Missouri sections.*

Compton Limestone and Northview Formation (fig. 3). Southwestward from Springfield the Northview thins rapidly to a shaly limestone 1 to 3 ft thick. From extreme southwestern Missouri the Compton and Northview continue into northwestern Arkansas (Thompson and Fellows, 1970) as the lower part of the St. Joe Limestone.

Beneath the Chouteau group throughout its extent in the east-central and southwestern parts of the state, a thin, widespread sandstone occurs which has been variously referred to as "Bushberg" or "Sylamore" by different authors. Before 1970 this unit was assigned to the Upper Devonian Series by most authors and correlated with either the Bushberg or Sylamore Sandstones. Thompson and Fellows (1970) defined this sandstone as approximately middle Kinderhookian. The Sylamore Sandstone in its type region of northwestern Arkansas is a facies of the Late Devonian Chattanooga Shale. The Bushberg Sandstone, which is confined to southeastern Missouri, is very early Kinderhookian, and does not correlate with either the Sylamore of Arkansas, or with the thin sandstone beneath the basal Mississippian carbonate section over most of the Missouri outcrop region. This widespread "blanket" sandstone under the Chouteau Group is not a correlative of either the Sylamore or Bushberg, and is now identified as the **Bachelor Formation** (Mehl, 1960, 1961; Thompson and Fellows, 1970).

Conodont zones applicable to the Kinderhookian Series of Missouri, and the Standard Mississippian Section of the Upper Mississippi River Valley, as described by Collinson et al. (1971) are listed in table 2.

The following are the formations of the Kinderhookian Series in Missouri:

Southwestern Missouri	**Central Missouri**	**Eastern Missouri**
Chouteau Group	Chouteau Group (undiff.)	Chouteau Group
Baird Mountain Limestone Member		
Northview Formation	Northview Formation	
	Sedalia Formation	"McCraney Limestone"
	"unnamed formation"	
Compton Limestone	Compton Limestone	"Chouteau limestone"
		Hannibal Shale
Bachelor Formation	Bachelor Formation	*Bachelor Formation
		Horton Creek Limestone
		*Bushberg Sandstone

*Not present in region of Hannibal Shale or Horton Creek Limestone

Horton Creek Limestone

Conkin and Conkin, 1973

Original description — (Conkin and Conkin, 1973, p. 14-15) "The Horton Creek consists of a basal, thin, quartz sandy siltstone (or in places, only a few quartz grains), succeeded by silty shale, and in some places, dolomitic limestone and limestone (some parts of which are oolitic, and occasionally conglomeratic at its base); it thus includes all the units of the old "Glen Park" Member of the Hannibal as well as the thin detrital quartz sandy siltstone (or few sand grains) at its base which was previously considered to belong to the uppermost Saverton by Collinson (in Koenig, *et al.,* 1961, pp. 65-76) and by Sandberg, *et al.,* (1972, p. 188), but which was allocated to the base of the Mississippian (Kinderhookian) by Conkin and Conkin (1967b, pp. 38,39). The lower limit of the Horton Creek Member is its contact with the underlying Louisiana Limestone or Saverton Formation (as at its type locality) and the upper limit is its contact with the shale and siltstone of the Hannibal Formation proper. At its type locality, the Horton Creek Member is approximately 16 feet thick, but at other places it varies in thickness from several feet to a few feet to only a few inches or less."

Type section — Conkin and Conkin (1973, p. 14) stated, "The type locality of the Horton Creek Member is the hillside on the south bank of Horton Creek (loc. 6; fig. 8), Pike County, Illinois, where exposures of the member are better than those at Hamburg, Calhoun County." This section is in the NW¼ NW¼ NW¼ (NW corner) sec. 6, T. 6 S., R. 5 W., Rockport 7½' Quadrangle.

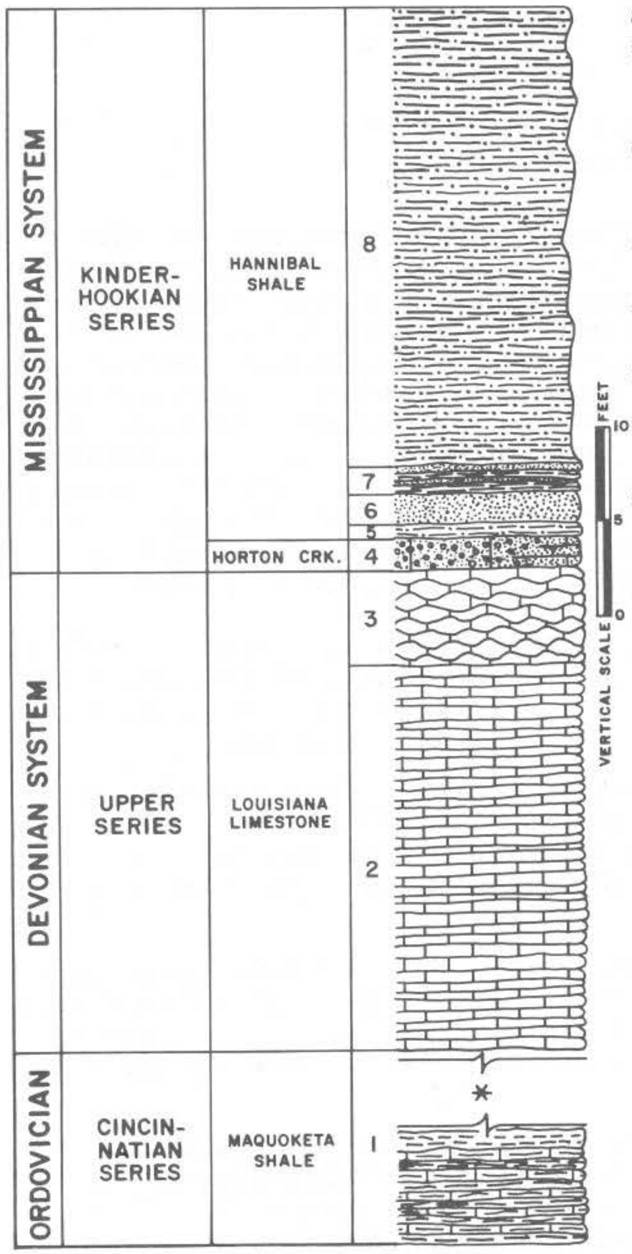
The type section originally assigned for the "Hamburg oolite" ("Glen Park") is a section along the creek bank in the south part of the small town of Hamburg, SW¼ NE¼ sec. 35, T. 9 S., R. 3 W., Calhoun County, Illinois. Here the "Glen Park" immediately overlies the Louisiana Limestone. This section was described by Collinson (1961a, p. 55-59), but was not used by Conkin and Conkin (1973) as the type for the Horton Creek.

Reference section — In Missouri, the Horton Creek Limestone is well exposed in a roadcut on the south side of Pike County Road NN, about 0.5 mi south of Stark Nursery, SE¼ NE¼ SW¼ (mislocated by Conkin and Conkin, 1973, p. 6, as "SE SE SW") sec. 25, T. 54 N., R. 2 W., Louisiana 7½' Quadrangle. This section was also described by Koenig and Martin (1961, p. 30), the Horton Creek (fig. 12) being identified as "Hamburg oolite."

According to Conkin and Conkin (1973, p. 20), Horton Creek is also exposed as a 0.01-ft-thick siltstone and 0.25-ft-thick silty shale between the eroded top of the Louisiana Limestone and the basal Hannibal Shale beds at the type section of the Hannibal Shale, Lover's Leap (SE¼ SE¼ sec. 28, T. 57 N., R. 4 W., Hannibal East 7½' Quadrangle), Marion County, Missouri.

History of nomenclature —

1906	**Weller**	**Hamburg oolite**
1943	Williams	"thin wavy beds of dolomite" in Hannibal Formation ("= Glen Park of Illinois")
1959	Collinson et al.	Glen Park
1961	**Collinson (a)**	**"Glen Park" formation** (includes Hamburg oolite)
	Koenig (a)	"Hamburg oolite" ("= "Glen Park" of Illinois")
1962	Collinson et al.	"Glen Park"
1968	Conkin & Conkin	Glen Park Limestone Member of Hannibal Group
1971	Collinson et al.	"Glen Park Limestone"
1973	**Conkin & Conkin**	**Horton Creek Limestone Member of Hannibal Shale**
1979	Collinson et al.	Horton Creek Formation



8. Shale, dark-gray, silty, fissile. (25′+)

7. Shale, medium-yellowish-green, silty; alternating with siltstone, medium-gray, blocky; beds 4 to 3 in. thick respectively. (1 ft 2 in.)

6. Siltstone, medium-gray, very slightly calcareous; contains pea-sized nodules of noncrystalline pyrite. (1 ft 10 in.)

5. Siltstone, medium-greenish-buff, blocky; overlies 1 in. olive green, fissile shale. (0 ft 11 in.)

4. Limestone, medium-yellowish-buff to speckled dark-brown, oolitic, fossiliferous; nonpersistent. (1 ft 10 in.)

3. Limestone, medium-buffish-gray, irregularly wavy bedded; intercalated with yellowish-buff, dolomitic siltstone which is laminated; contains many egg-sized to billiard ball-sized calcite nodules. (5 ft 1 in.)

2. Limestone, medium-buffish-gray, sublithographic, medium-bedded (2-5 in.); contains egg-sized to head-sized calcite nodules; weathers yellowish buff and breaks down readily into small blocks. (23 ft 3 in.)

*Covered interval. (65 ft+)

1. Shale, medium-gray to dark-green, fissile; alternating with dark-gray very argillaceous limestone. Limestone beds are 1 to 3 in. thick and are separated by 6 to 8 in. of shale. (60 ft+)

Figure 12. *Columnar section of exposure of* **Horton Creek Limestone,** *near the Stark Nursery, SE¼ NE¼ SW¼ sec. 25, T. 54 N., R. 2 W., Louisiana 7½′ Quadrangle, Pike County, Missouri. This is one of the few known exposures of this formation in Missouri. Adapted from Koenig and Martin (1961, p. 30).*

Remarks — Originally named the **Hamburg oolite** by Weller (1906), this limestone was later referred to as the **Glen Park limestone** (Hamburg being preempted), because it was at first considered to be equivalent to the Glen Park Limestone of the Sulphur Springs Group of southeastern Missouri (Collinson et al., 1959). However, Collinson et al. (1962) realized that the "Hamburg" in Illinois was not equivalent to the Late Devonian Glen Park of Missouri, but was Early Mississippian; therefore, the limestone was informally referred to as the **"Glen Park"** (Collinson et al., 1971). Later, Conkin and Conkin (1973) named it the **Horton Creek Limestone Member of the Hannibal Shale,** thus removing the confusion of correlation with the Glen Park in Missouri.

The Horton Creek is not well known from exposures in Missouri, but limestone lenses and beds in the lower part of the Hannibal Shale in Missouri may be equivalent to the Horton Creek of west-central Illinois. In Illinois, the Horton Creek Limestone is now regarded as a separate formation, beneath the Hannibal Shale (Collinson et al., 1979), and the base of the Horton Creek, when present, is regarded as the base of the Mississippian System. In Illinois the Horton Creek Limestone usually rests on Grassy Creek-Saverton or older formations; the Louisiana Limestone is generally not present.

Hannibal Shale
Keyes, 1892

Original description — (Keyes, 1892, p. 289) "The Hannibal shales (Vermicular shales of Swallow) have a maximum thickness of about 75 feet at the typical locality. In Missouri the upper portion is sandy in places and forms often a rather compact, shaly sandstone, becoming harder northward, where it assumes the character of a substantial sandrock. The latter is apparently entirely absent in the southwestern part of the state. Downward, the shaly sandstone rapidly loses its arenaceous character and passes quickly into bluish or greenish clay-shale which appear remarkably uniform over broad areas."

Type section — Exposures in the lower part of Lover's Leap, in the western bluffs of the Mississippi River Valley above the railroad yard at the southern edge of Hannibal, Marion County, Missouri, are generally regarded as the type section for the Hannibal Shale, NW¼ SE¼ sec. 28, T. 57 N., R. 4 W., Hannibal East 7½' Quadrangle (fig. 13). This section (figs. 14 and 15) has been described by Koenig and Martin (1961, p. 45), Collinson et al. (1979, p. 31), and Thompson (1984).

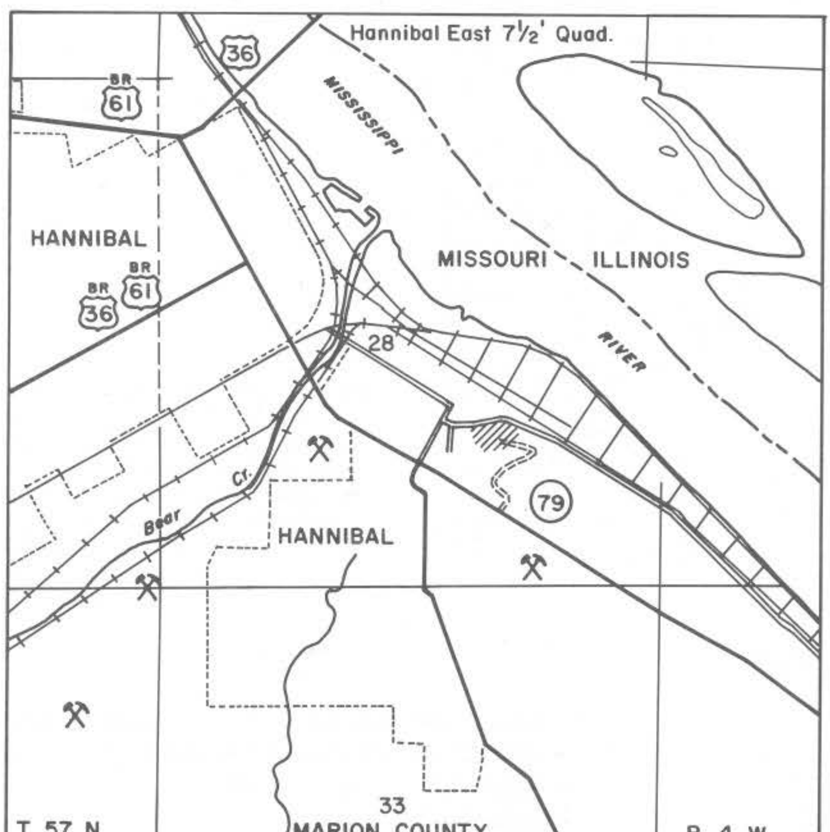
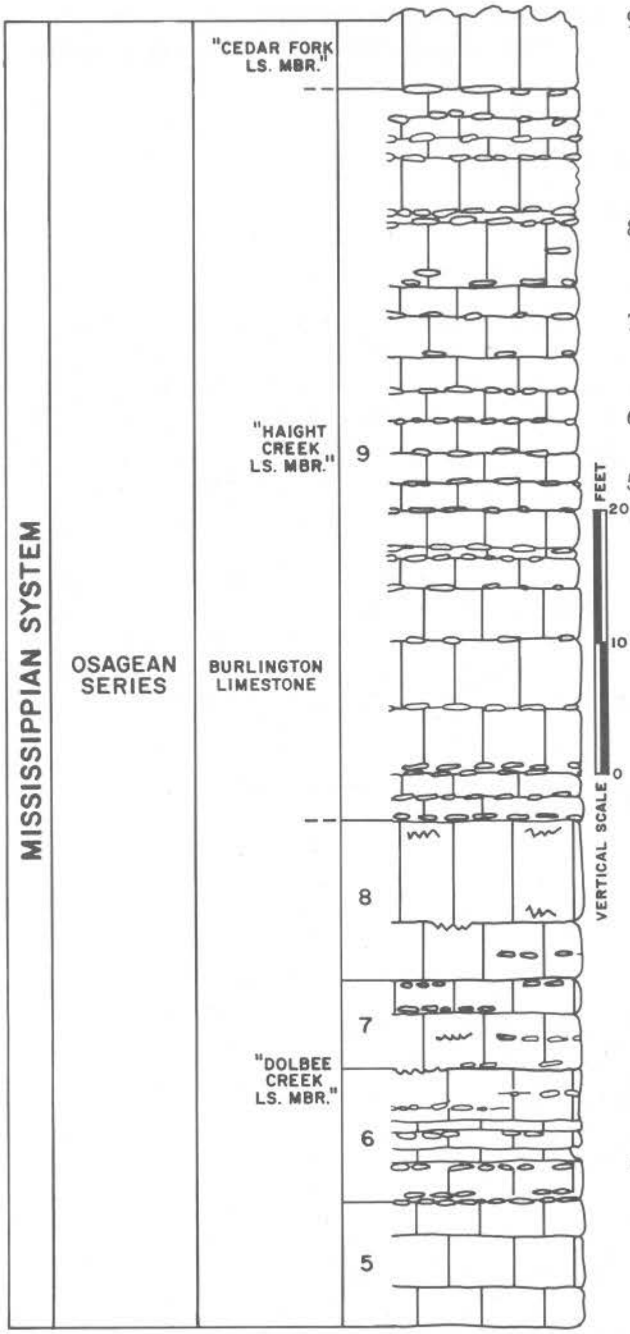


Figure 13. *Copy of part of the Hannibal East 7½' Quadrangle, Marion County, Missouri showing location of the type section of the* **Hannibal Shale**.

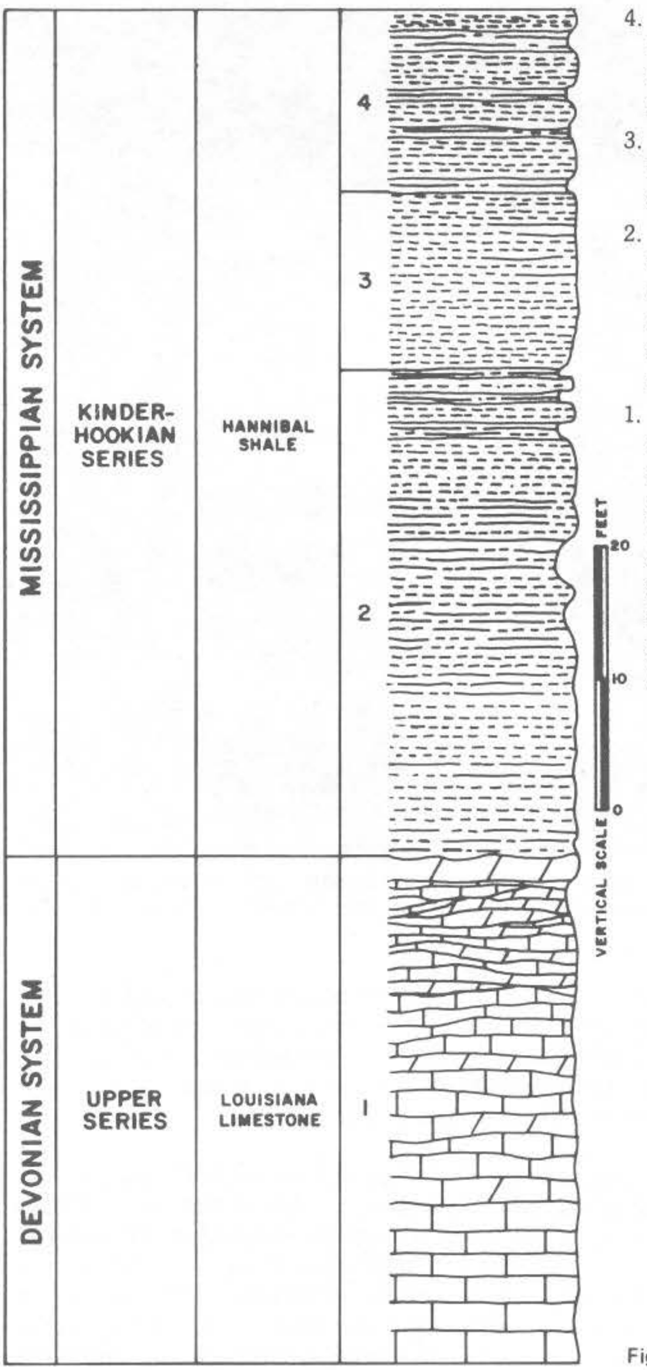


9. Limestone, very light-buff to brown, crinoidal; medium- to thin-bedded; dolomite, brown, siliceous, interbedded with limestone; chert, buff to white, in numerous layers of nodules; *Physetocrinus ventricosus* Zone covers lowermost 45 ft (13.7 m); *Pentremites elongatus* Zone covers the uppermost 25 ft (7.6 m). (70 ft)
8. Limestone, very light-gray, crinoidal, pure, massive; "white ledge" of quarrymen; *Cactocrinus proboscidalis* Zone. (12 ft)
7. Limestone, light-buff to light-brown, crinoidal, dolomitic; *Cryptoblastus melo* common: *Cryptoblastus melo* Zone. (7 ft)
6. Limestone, buff to brown, crinoidal, with white chert; *Uperocrinus longirostris* Zone. (10 ft)
5. Limestone, light-buff to brown, crinoidal, weathers brown; dolomitic in places; *"Batocrinus" calvania* Zone. (10 ft)

Figure 14. *Columnar section of the type section of the Hannibal Shale. Ralls County, Missouri (NW ¼ SE ¼ sec. 28, T. 57 N., R. 4 W., Hannibal East 7½' Quadrangle). Located above the railroad yard in the southern part of Hannibal, this section has been described in detail by Koenig and Martin (1961, p. 45) and Collinson et al. (1979, p. 31). Adapted from Collinson et al. (1979, p. 31).*

History of nomenclature —

(not) 1852	Owen	Encrinital Group of Hannibal (= Burlington Limestone)
1855	Swallow	Vermicular sandstones and shales
1891	Williams	Vermicular shale and sandstone
1892	**Keyes**	**Hannibal shales**
1897	Keyes	Hannibal shale ("Devonian in age")
1900	Keyes	Hannibal shales of Kinderhook formation
1946	Reed	Hannibal shale ("= Boice shale of Nebraska")



4. Siltstone, gray, very argillaceous, massive, slightly calcareous, vermicular in upper part; shale, gray, very silty, calcareous, pyritic, interbedded with siltstone; all unfossiliferous. (14 ft)
3. Siltstone, gray, argillaceous, slightly calcareous, massive, vermicular, discontinuous shaly streaks; shale, gray, very silty in lower part. (13 ft)
2. Shale, gray, very silty, vermicular in lower part; siltstone, very argillaceous, interbedded with shale; accumulations of eroded material on lower slopes give appearance of more shale than is present. Some gradation at contact with underlying carbonates with some brown coloration of lowermost beds. (36 ft)
1. Limestone, light gray to gray, lithographic, pure; irregularly interbedded with dolomitic clay partings and buff to brown sucrosic dolomite. Beds thin in uppermost 10 ft, increasing in thickness downward. Beds of dolomite most numerous in upper part, decreasing downward. Limestone weathers very light gray and breaks with conchoidal fracture. Formation capped by thick dolomite bed whose uneven upper surface apparently represents an eroded surface. (38 ft)

Figure 14. *continued*

1948	Weller et al.	Maple Mill shale (Hannibal shale)
1960	Mehl	Cuivre shale (= basal part of Hannibal)
1961	Spreng	Hannibal formation
1963	Carlson	Boice Shale (Forest City basin of northwestern Missouri and subsurface of Nebraska)
1973	Conkin and Conkin	Hannibal Formation Cuivre Member of Hannibal Formation
1984	Thompson	Hannibal Shale

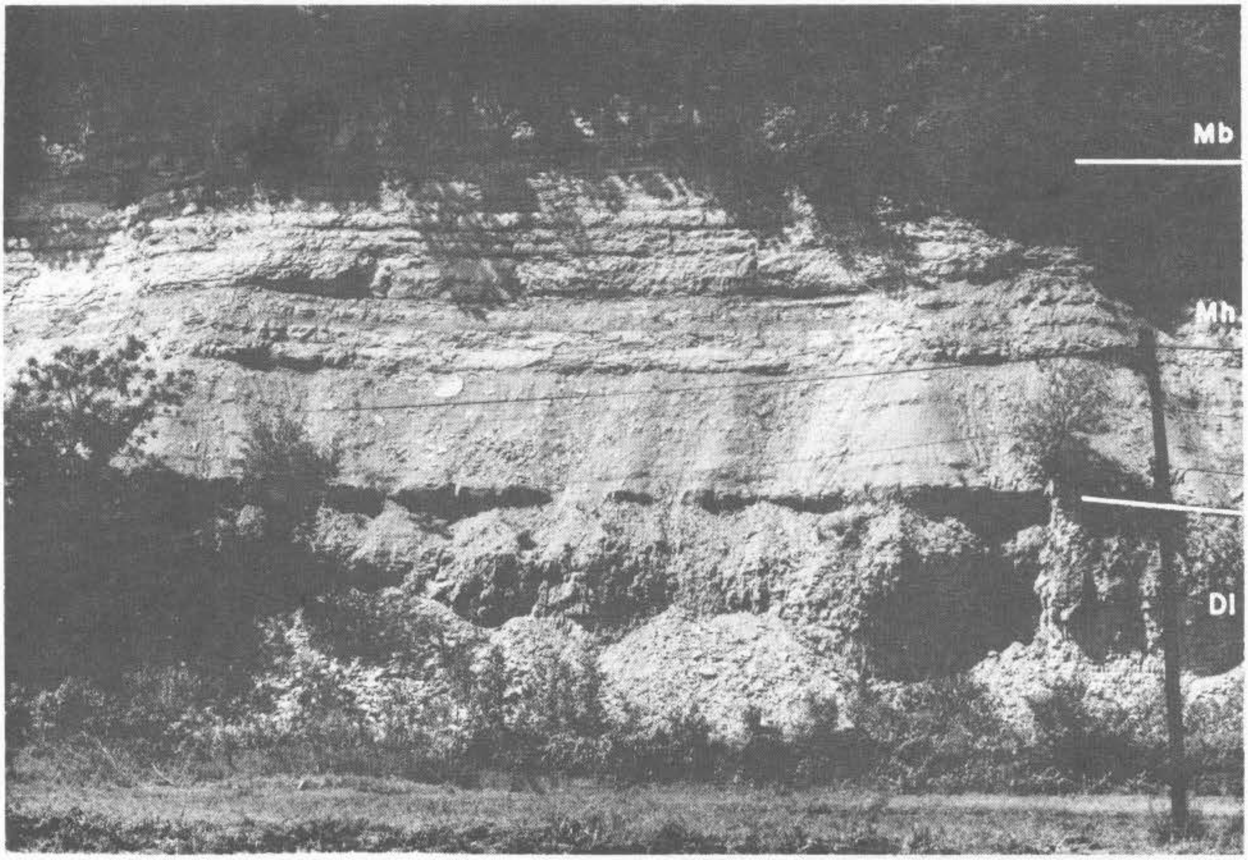


Figure 15. *Type section of the* **Hannibal Shale** *at Lover's Leap, southeastern edge of Hannibal, Marion County, northeastern Missouri (see fig. 14). Dl = Louisiana Limestone; Mh = Hannibal Shale; Mb = Burlington Limestone. Photograph by T.L. Thompson.*

Remarks — In northeastern Missouri, particularly in the vicinity of the type section at Hannibal, Kinderhookian strata are often represented solely by the Hannibal Shale, a sequence of up to 100 ft of gray to bluish-green shale, siltstone, and argillaceous sandstone. It weathers to pale bluish-green or light brown, and forms gentle slopes. Wherever it is composed of alternating layers of coarse- and fine-grained siltstone it has a characteristic banded appearance.

The base of the Hannibal Shale is early Kinderhookian; it is regarded as transitional with the underlying Late Devonian Louisiana Limestone (Scott and Collinson, 1961). In the region of the type section, the Hannibal is directly overlain by the early Osagean Burlington Limestone. Westward and southwestward, however, upper Hannibal strata are replaced by limestone of the Chouteau Group. Farther southward and westward, the Chouteau continues to thicken at the expense of the Hannibal, but the oldest Chouteau is probably never much older than middle Hannibal (middle Kinderhookian). The Hannibal, Horton Creek Limestone, and Bushberg Sandstone represent the only lower Kinderhookian Mississippian rocks identified in the state (table 1).

Present throughout the Mississippian outcrop region of northeastern Missouri, Hannibal shales and siltstones thin westward and southward, but can be traced westward in the subsurface until they become difficult to distinguish from shales of the "Kinderhook shale." Composed in places of both Hannibal and Chattanooga (or Grassy Creek) shales, the "Kinderhook shale" can be traced eastward in the subsurface of northwestern Missouri. Where the intervening Louisiana Limestone is absent, the greenish-gray Hannibal shales can be difficult to distinguish from the Upper Devonian Saverton and/or Grassy Creek shales. Where Hannibal Shale rests directly on the Upper Ordovician Maquoketa Shale, recognition of definite boundaries can also be difficult.

Where present, the Horton Creek Limestone intervenes between the Louisiana Limestone (or the uppermost Devonian unit present) and the Hannibal Shale. In some regions of northeastern Missouri, Mehl (1960) identifies a dark-gray to blue-black fissile shale in the lower part of the Hannibal as the **Cuivre Shale** (pronounced "quiver"), and he recovered a large conodont fauna from it. Future work may determine that the Cuivre shale should be recognized as a formal member of the Hannibal Shale. Mehl (1960, p. 98) identified the type locality for the Cuivre shale as

> "the SE NE SE sec. 35, T. 54 N., R. 4 W., Pike County, Missouri, about 4.5 miles north of Bowling Green, exposed in one of the head branches of Grassy Creek."

In Illinois, immediately across the Mississippi River Valley from northeastern Missouri, at least two other units have been identified in the Hannibal (Collinson et al., 1979): the **Nutwood Member,** and a "Brown silt facies" (fig. 16). One or both may be equivalent to the Cuivre Shale of northeastern Missouri.

In the Hannibal Shale, fossils are generally sparse and pyritized. Brachiopods and pelecypods are major constituents of the fauna; conodonts and foraminifers are abundant in some beds. Common features of the formation are *"Taonurus caudagalli"* ("rooster-tail" markings) and *Scalarituba missouriensis* (irregular tubular structures or worm borings), the latter having led to the Hannibal Shale originally being named the "Vermicular shale and sandstone," and to initial correlation of the Hannibal with the "Vermicular Sandstone and Shales" (now identified as the Northview Formation of southwestern Missouri (Swallow, 1855).

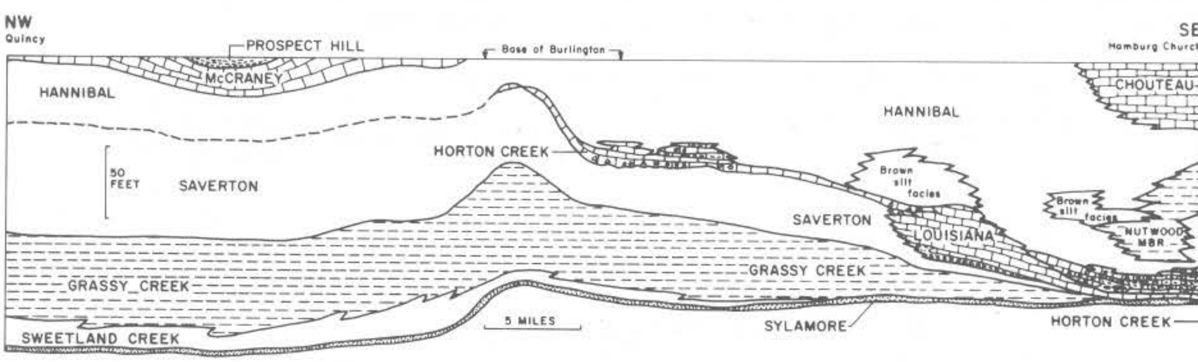


Figure 16. *Cross section along east bluff of Mississippi River Valley between Quincy and Hamburg, Illinois, showing relationship of Late Devonian and Early Mississippian formations and members (from Collinson et al., 1979, p. 29-30).*

"Kinderhook Shale"

Remarks — "Kinderhook Shale" is a term long used in studies of the subsurface of western and northwestern Missouri for a sequence of black to gray and green shales between Devonian and Mississippian carbonates. Carlson (1963) recognized two shales: a lower, Upper Devonian black shale (Chattanooga) and an upper, Lower Mississippian gray to green shale (Boice). He considered the latter to be equivalent of the Hannibal Shale of northeastern Missouri.

Koenig (1961b, p. 48-49) stated,

> "As pointed out by Wallace Lee (1956), the name 'Kinderhook shale,' however inappropriate, has been widely accepted and commonly used by most petroleum geologists. The subsurface division of the Missouri Geological Survey also recognizes the limitations of the term but applies it consistently in the designation of this particular shale unit on its well records and regards such application as the only practical expedient until such time as the unit can be studied in detail.

"In Missouri, the upper part of the 'Kinderhook shale,' which has been referred by Reed and Lee to the Boice in Nebraska and Kansas, consists of a grayish-green shale which is in part carbonaceous and interbedded with dolomitic shale. The basal part contains beds of oolitic limonite and hematite or of dark red shale. This interval may also include irregularly shaped hematite oolites in the upper part. The thickness of the unit varies between 25 and 50 feet. Below the lower hematitic oolite zone, there is a black, fissile, carbonaceous shale which is micaceous. Spores are present throughout. In Missouri, the thickness of the shale increases from a feather edge around the periphery of the [Forest City] basin in Clay, Caldwell, Daviess, and Harrison Counties to a thickness of 150 to 200 feet in Holt and Atchison Counties."

Bushberg Sandstone

Ulrich, 1904

Original description — (Ulrich, 1904, p. 110) "In the area about Glen Park and Sulphur Springs I have further distinguished, at the base of the Kinderhook and perhaps top of the Devonian, the Sulphur Springs formation. This formation is divisible into three members, a thin sandstone (about 10 feet) at the top to which the name Bushberg sandstone may be applied; beneath this a 1- to 5-foot bed of oolitic limestone, probably early Kinderhook in age, which may be called Glen Park (oolitic) limestone; and finally, at the base a shale, 0-15 feet thick, either earliest Kinderhook or late Devonian in age, for which no subordinate designation is proposed."

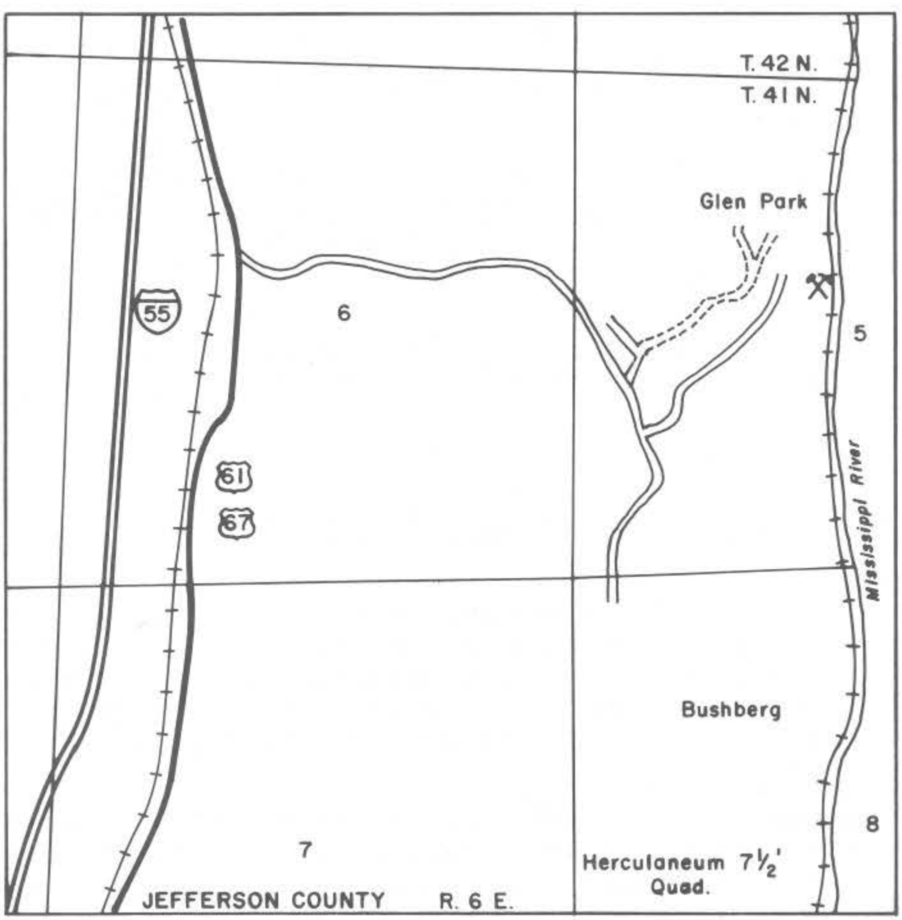


Figure 17. *Part of the Herculaneum 7½' Quadrangle, Jefferson County, Missouri, showing location of the type section of the* **Bushberg Sandstone.**

Type section — Mehl (1960, p. 69) designated the type section for the Bushberg Sandstone as "...at the head of a ravine into the Mississippi River at Bushberg, a one time station on the St. Louis Iron Mountain and Southern Railroad. This is in the NW NE NW sec. 8, T. 41 N., R. 6 W., Jefferson County, Missouri." (Herculaneum 7½' Quadrangle; figs. 17 and 18.)

Reference sections — An excellent exposure of the Bushberg Sandstone is in a roadcut on I-55, just north of the intersection of Jefferson County road M (figs. 19 and 20), at the Barnhart exit, Jefferson County, Missouri (SW¼ NW¼ SE¼ sec. 19, T. 42 N. R. 6 E., Herculaneum 7½' Quadrangle). Another similar section is a roadcut on Missouri Highway 30 north of House Springs (fig. 65), in northern Jefferson County (SE¼ Se¼ NE¼ sec. 33, T. 43 N., R. 4 E., House Springs 7½' Quadrangle).

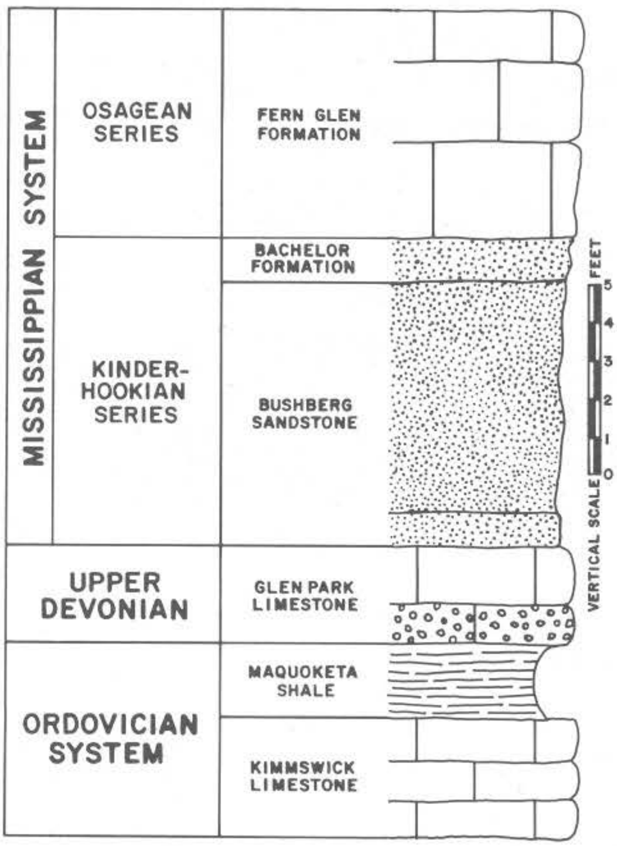


Figure 18. *Columnar section of exposure of* **Bushberg Sandstone** *at the type section of the Glen Park Limestone, 1 mi north of the type section of the Bushberg Sandstone, center sec. 5, T. 41 N., R. 6 E., Herculaneum 7½' Quadrangle, Jefferson County, Missouri.*

History of nomenclature —

1904	**Ulrich**	**Bushberg sandstone member of Sulphur Springs formation**
1910	Schuchert	Bushberg formation
1911	Fenneman	Bushberg sandstone member of Kinderhook formation
1928	Moore	Bushberg sandstone
1935	Morey (a)	Bushberg sandstone
(not) 1935	Morey (b)	Bushberg sandstone (= Bachelor Formation)
1938	Keyes (a)	Hannibal shales (part; rejected the name "Bushberg")
1940	Weller & Sutton	Sulphur Springs formation (upper part) Bushberg sandstone
(not) 1956	Echols & Gouty	Bushberg (= Bachelor Formation)
1960	Sohn	Bushberg sandstone (part; = Bachelor Formation at some sections)
1961	Koenig (b)	Bushberg formation

Figure 19. ***Maquoketa Shale (Om), Bushberg Sandstone (Mbb), and Fern Glen Formation (Mf) in a roadcut on I-55, Jefferson County, eastern Missouri (fig. 20). Photograph by T.L. Thompson.***

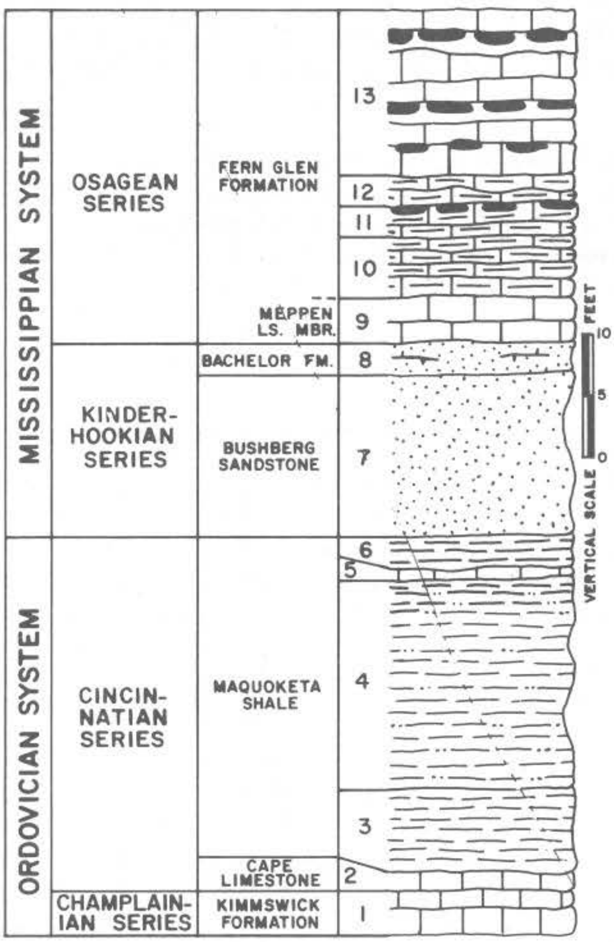
1979	Thompson (a)	Bushberg Sandstone
	Sable	Bushberg Sandstone Member of Sulphur Springs Formation
1984	Thompson	Bushberg Sandstone

Remarks — The Bushberg Sandstone comprises 10 to 15 ft of yellow to yellowish-brown, fine- to coarse-grained, friable, porous, quartz sandstone, similar in texture to the St. Peter Sandstone. The unit, generally comprising a single massive bed, can be traced in eastern Missouri from northern St. Louis County to east-central Jefferson County. In the southern area of exposure, Jefferson County, Missouri, in the region of its type section (fig. 18), the early Kinderhookian Bushberg Sandstone (the uppermost member of the Sulphur Springs Group of Ulrich, 1904), is underlain by the Late Devonian Glen Park Limestone and/or an "unnamed shale of the Sulphur Springs Group. North of the type section, in St. Louis County, Missouri, the Bushberg is often found lying on the Late Ordovician Maquoketa Shale. At an exposure in northern Jefferson County, the Bushberg lies on the Early Silurian Sexton Creek Limestone. The Bushberg is overlain by the middle Kinderhookian sandstone of the Bachelor Formation, the greenish-brown sandstone of the Bachelor readily distinguishable from the yellowish sandstone of the Bushberg. The Bachelor is in turn overlain by the early Osagean Fern Glen Formation, no late Kinderhookian strata being present in this region, from south of the Meramec River, in St. Louis County, to northern St. Genevieve County.

In the past, several sandstones in approximately the same stratigraphic position have been incorrectly identified as Bushberg, particularly the thin, widespread sandstone member of the middle Kinderhookian Bachelor Formation. Also, several sandstones of limited aerial extent in Warren, Montgomery, and Callaway counties, Missouri, have at various times been labeled as possibly equivalent to the Bushberg (such as the Massy Creek Sandstone of Mehl, 1960). Their

relationship to the Bushberg Sandstone of the type area is not clearly known; some appear to be channel fillings in Ordovician and Middle Devonian limestones.

The Bushberg Sandstone has been variously identified as Late Devonian and as Early Mississippian. Current data, however, indicate a very early Kinderhookian age that predates early Hannibal and/or Horton Creek deposition.



13. Limestone, light-brown to light-gray — weathers buff-gray, fine to coarsely crystalline; thin to massively bedded; very fossiliferous; alternating beds of limestone and chert. (12 ft)
12. Limestone, reddish-brown, very shaly; like #10. (2 ft)
11. Limestone, light-gray, finely crystalline, argillaceous; very fossiliferous; 4-6 in. chert bed in upper part. (2 ft)
10. Limestone, red, finely crystalline, very shaly; thin, highly irregular beds; fossiliferous. (5 ft)
9. Limestone, light-brown-tan — weathers greenish-gray, finely crystalline, massive; abundant fossils. (3 ft)
8. Sandstone, greenish-gray, slightly calcareous, nodular; sand grains rounded and frosted. (2-3 in.)
7. Sandstone, yellow-brown, medium grained, well-sorted, very friable; grains rounded and frosted. (13 ft 6 in.)
6. Shale, medium-gray, very fissile; abundant graptolites: *Climacograptus mississippiensis.* (3 ft 3 in.)
5. Limestone, dark-gray, finely crystalline, very sandy; contains phosphatic material. (3 in.)
4. Shale, gray to greenish-gray, appears silty, fissile; abundant graptolites: *Orthograptus truncatus socialis*; phosphatic debris. (17 ft 4 in.)
3. Shale, gray; thin-bedded; appears to be mudstone. (7 ft 6 in.)
2. Limestone, medium-gray, coarse grained calcarenite; brachiopods and other fossils abundant. (6-10 in.)
1. Limestone, pinkish-tan, coarse grained calcarenite, massive 1-1.5 ft beds; fossiliferous; base at I-55 level. (3 ft 6 in.)

Figure 20. *Columnar section of exposure of* **Bushberg Sandstone** *and Fern Glen Formation in a roadcut on the west side of I-55, north of the junction with Jefferson County Road M, near Barnhart, Herculaneum 7½' Quadrangle. Adapted from Thacker and Satterfield (1977, p. 81).*

Bachelor Formation

Mehl, 1960

Original description — (Mehl, 1960, p. 95) "The lithology of the Bachelor, . . . is markedly varied although it consists dominantly of pale buff quartz sandstone of medium grain size, moderately well to poorly sorted.

"In most places the basal part of the Bachelor . . . is marked by an abundance of phosphatic nodules that are more or less spherical or flattened, irregular and elongate, and which measure up to several inches in diameter."

Thompson and Fellows (1970) emended this description to include, in southwestern Missouri, a two-part Bachelor, comprising a lower sandstone and an upper thin shale that grade southward and southwestward, through the loss of the sandstone, into a single shale bed.

Thompson (1975) described the Bachelor of southeastern Missouri as comprising only the sandstone, with limestone of the Fern Glen Formation lying on it.

Type section — The type section of the Bachelor Formation was defined by Mehl (1960, p. 94) as an exposure in a streambed in the SE¼ NW¼ SW¼ sec. 9, T. 48 N., R. 8 W., Callaway County, Missouri, Calwood 7½' Quadrangle (fig. 21).

Reference sections — Due to the poor nature of the type section, three reference sections are located that illustrate the nature of the Bachelor Formation over the state of Missouri. The Bachelor comprises a lower sandstone and an upper shale in all but the extreme southwestern, east-central, and southeastern parts of Missouri. An excellent exposure of the two-part Bachelor (fig. 22) is in the quarry at Baird Mountain, Taney County, Missouri (SW¼ NW¼ sec. 26, T. 22 N., R. 22 W., Table Rock Dam 7½' Quadrangle).

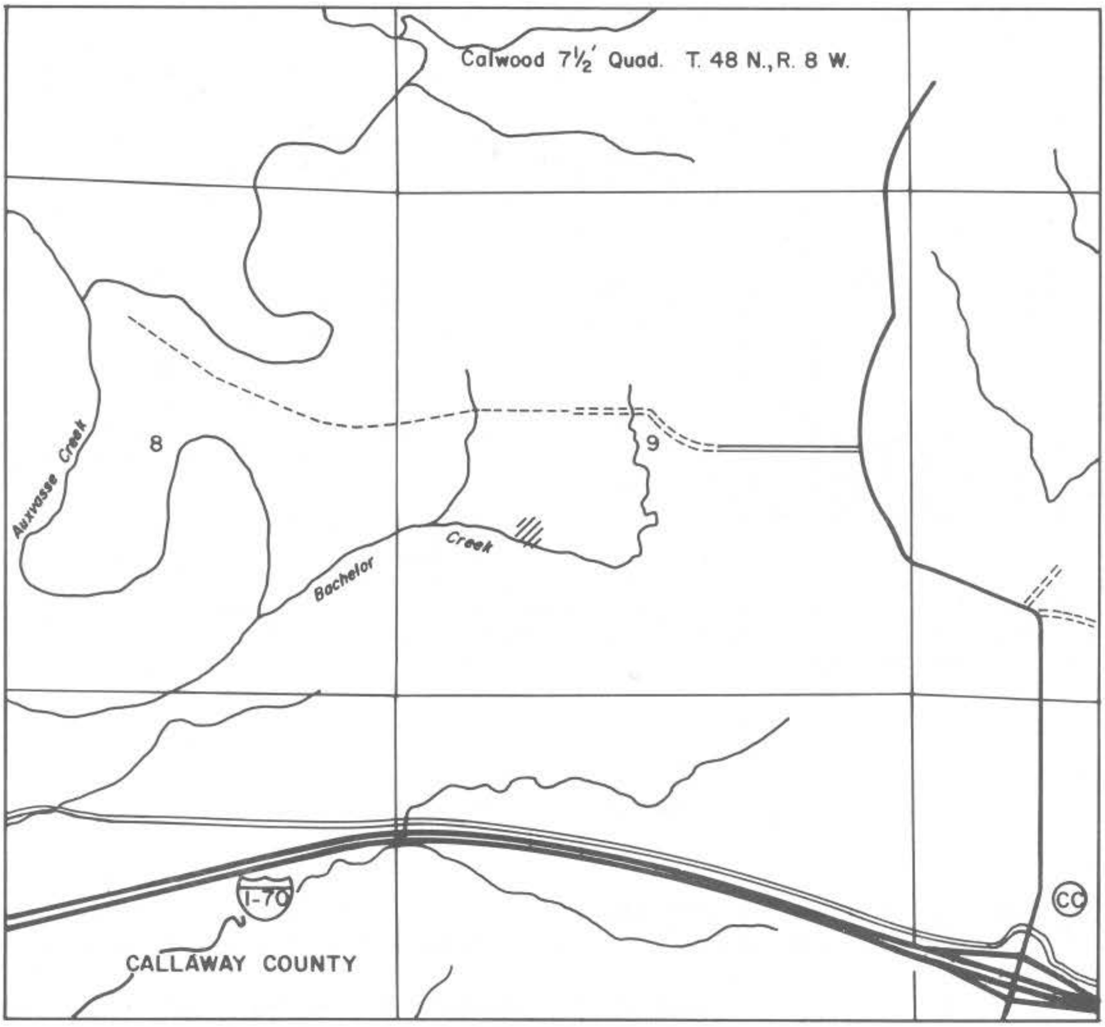
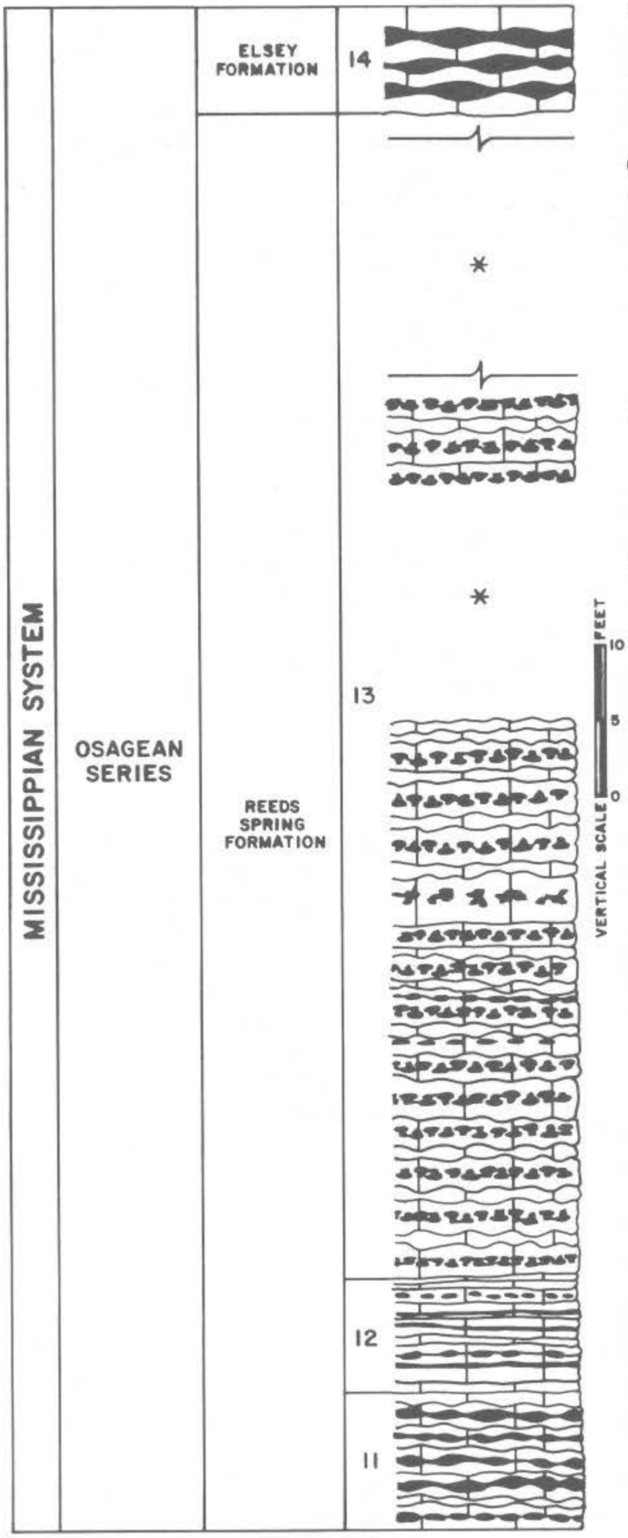


Figure 21. *Part of the Calwood 7½' Quadrangle, Callaway County, Missouri, showing the location of the type section of the* **Bachelor Formation.**



14. Chert (75%), white with gray to brown mottles, as large nodules. Limestone, dark-gray to gray-brown, finely crystalline, cross-laminated, in thin nodular beds between chert nodules. Large float block at top of quarry. (5 ft 6 in.)

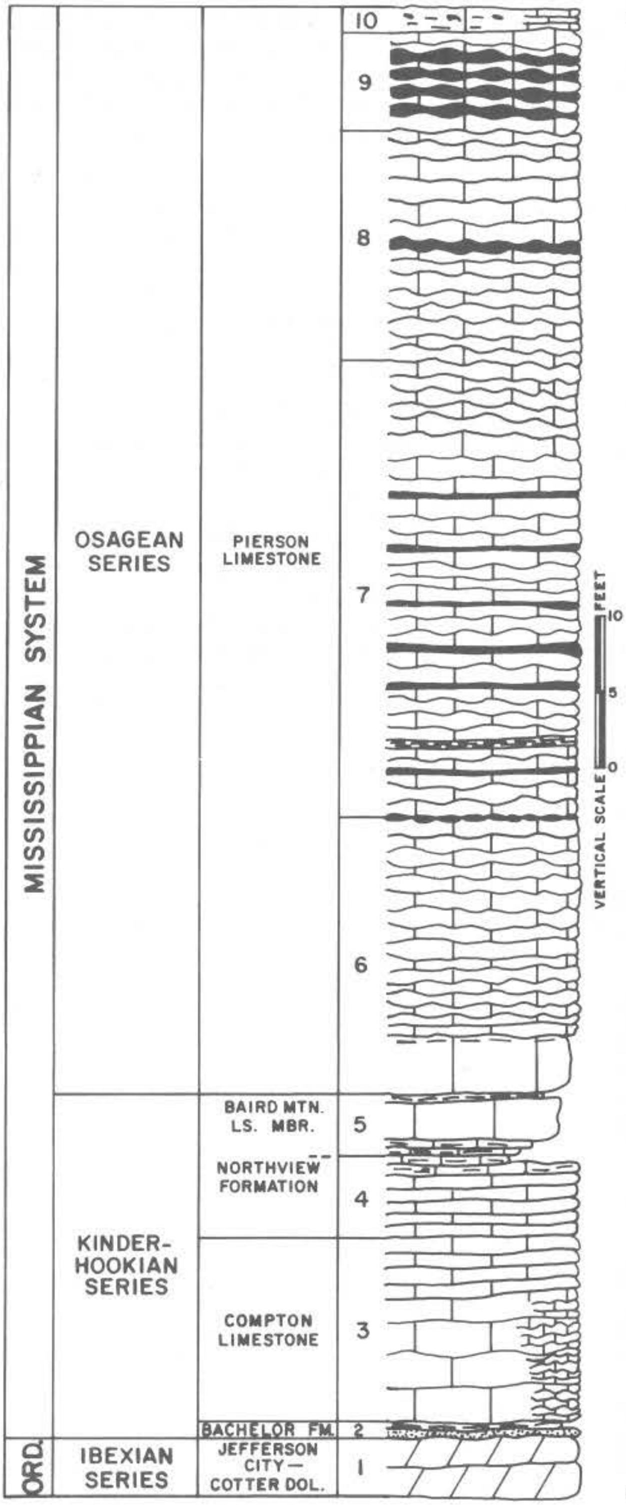
Covered interval. (33 ft)

13. Limestone (50-75%), dark-gray, brown, to gray-green, medium-crystalline, semicrinoidal to crinoidal, thin to medium nodular bedding, numerous thin shale partings. Chert, brown in lower part, gray to blue-black upper part, fossiliferous, as large nodules and thin nodular beds. Includes 16-ft covered interval. (70 ft)

12. Limestone (60%), gray-tan to gray-green, with streaks of red, finely to medium-crystalline, argillaceous, in thin, slabby beds. Chert, dark-blue to blue-black, as thin beds and nodules, green opaque and blue translucent nodules toward base. (6 ft 10 in.)

11. Limestone (60%), gray to gray-green, finely crystalline, thinly bedded, nodular, with scattered crinoid debris. Chert, blue-gray, tan, and green, with brown rinds, as scattered nodules and beds. (9 ft 8 in.)

Figure 22. *Columnar section of exposure in Baird Mountain quarry, SW¼ NW¼ sec. 26, T. 22 N., R. 22 W., Table Rock Dam 7½' Quadrangle, Taney County, southwestern Missouri, illustrating the* **Bachelor Formation** *as it appears in most of Missouri. Adapted from Thompson and Fellows (1970, sec. B, p. 149-155).*



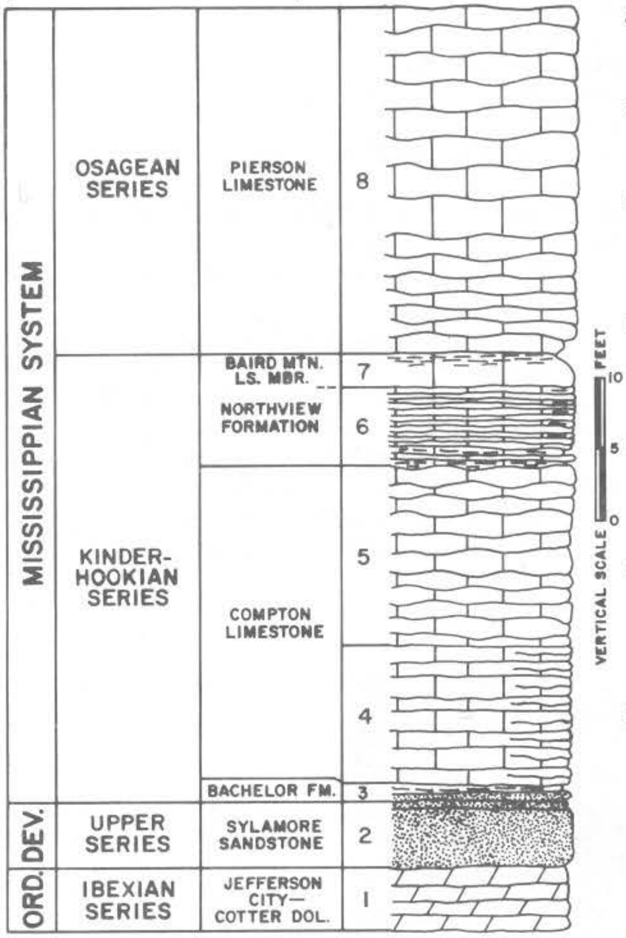
10. Shale, green and gray-green, calcareous, fossiliferous; contains dark-gray chert nodules (**Wolfpen Gap shale**). (1 ft 6 in.)
9. Chert (60%), brown and blue-gray, as smooth irregular nodules and beds, with brown rinds. Limestone, gray-green to brown, finely crystalline, thin- to medium-bedded, nodular. (6 ft 10 in.)
8. Limestone, green-gray, fine- to medium-crystalline, medium-bedded; nodular bedding with green shale partings in lower part. Chert, dark-gray, brown, and blue-black, with green to white rinds, as nodules and nodular beds; contains inclusions of limestone. (15 ft)
7. Limestone, red to brick-red, some green shale partings, crinoidal, argillaceous, thin- to medium-bedded; a few nodular beds of dark-red to black fossiliferous chert with greenish-white rinds. (28 ft 7 in.)
6. Limestone, gray-green and red, fine- to medium-crystalline, argillaceous, medium-bedded; scattered crinoid debris to semicrinoidal; red and green shale partings. Floor of main quarry in middle of unit. (20 ft)
5. Limestone, brick-red to red and green mottled, medium-crystalline, crinoidal, shaly; 6-in. shale at top and bottom; limestone in middle. (3 ft 5 in.)
4. Limestone, green, argillaceous, crinoidal; dense at base, shaly toward top, medium- to even-bedded. (5 ft 4 in.)
3. Limestone, gray-tan to gray-green, fine- to medium-crystalline, medium- to wavy bedded; green wavy shale partings form incipient thin bedding on thicker even beds; massive on fresh surface. (12 ft 3 in.)
2. Shale and sandstone. Upper part shale, green, sandy, and clayey, blocky to platy. Lower unit sandstone, green, quartzose, well-cemented with "glint" calcite; contains phosphatic nodules and abraded chert pebbles. (0 ft 6-9 in.)
1. Dolomite, thick-bedded. (4 ft+)

Figure 22. *continued*

At a section on the Missouri-Arkansas border in northern Boone County, northwestern Arkansas (NW¼ NE¼ sec. 9, T. 21 N., R. 21 W., Omaha 7½′ Quadrangle), Thompson and Fellows (1970, p. 188-189) described the Bachelor Formation lying on the Late Devonian Sylamore Sandstone (fig. 23).

A roadcut on Missouri Highway 86 in southern Stone County, Missouri (center S½ NW¼ NW¼ sec. 24, T. 21 N., R. 24 W., Lampe 7½' Quadrangle), exposes only the shale between Lower Ordovician dolomite and the overlying Compton Limestone.

In eastern and southeastern Missouri, only the Bachelor Sandstone is present, exemplified in an exposure in a roadcut on Missouri Highway 30 (fig. 65), near House Springs, Missouri (SE¼ SE¼ NE¼ sec. 33, T. 43 N., R. 4 E., House Springs 7½' Quadrangle, Jefferson County, Missouri) (Collinson et al., 1979, p. 99; Thompson, in press).



8. Limestone, gray to brick-red, medium-crystalline; nodular thin, argillaceous beds at base, becoming thicker upward. (22 ft 6 in.)
7. Limestone, red, finely crystalline with scattered crinoid debris, in thick even beds; upper 6 in. argillaceous. (2 ft 2 in.)
6. Limestone, red with green mottling in upper part, gray-green to gray in lower part, finely crystalline, with scattered crinoid debris; basal 1 ft 2 in. more shaly. (5 ft)
5. Limestone, light-gray, medium- to coarsely crystalline with abundant crinoid debris, argillaceous; in nodular 2- to 4-in. beds. Base appears disconformable on unit 4. (12 ft)
4. Limestone, gray-green and brown, fine- to medium-crystalline matrix with scattered crinoid debris; in even 3- to 8-in. beds with wavy 0.5- to 1-in. partings. (10 ft)
3. Shale and sandstone. Shale, gray-green, calcareous; fossiliferous limestone lens near center. Underlying sandstone, gray-green, quartzose, "glint" calcareous cement; thin zone of phosphatic pebbles at base. Thins toward south. (0 ft 8-11 in.)
2. Two sandstones. Upper sandstone gray, soft. Lower sandstone brown, soft, friable, laminated. Upper unit better cemented. Disconformable on unit 1. (4 ft 6 in.)
1. Dolomite, brown, argillaceous, in thin beds, truncated by unit 2. (10 ft+)

Figure 23. *Columnar section of railroad cut at the Missouri-Arkansas border, NW¼ NE¼ sec. 9, T. 21 N., R. 21 W., Omaha 7½' Quadrangle, northern Boone County, northwestern Arkansas. The* **Bachelor Formation** *lies on the Late Devonian Sylamore Sandstone. Adapted from Thompson and Fellows (1970, sec. N, p. 185-188).*

History of nomenclature —

1898	Shepard	Phelps Sandstone (Hamilton Stage)
1901	Weller	Phelps Sandstone ("resembles Sylamore of Arkansas")
1907	Purdue	Sylamore sandstone
1934	Branson & Mehl	Bushberg sandstone (upper part)
	Branson	Sylamore sandstone
1935	Morey (b)	Bushberg sandstone
1937	Keyes	"so-called Sylamore sandstone"
1939	Kindle & Miller	Phelps sandstone
1944	Branson (a)	Bushberg formation (upper part)
	Branson (b)	Sylamore sandstone

1956	Echols & Gouty	Bushberg
1960	Mehl	Bachelor Formation
	Sohn	Bushberg sandstone (part)
		Sylamore sandstone
1961	**Mehl**	**Bachelor Formation**
	Koenig (b)	Sylamore sandstone
	Spreng	Sylamore sandstone
	Sohn	Sylamore sandstone
		"basal Mississippian sandstone"
1964	Gordon	Gaylor Sandstone (in Arkansas)
1969	Freeman & Schumacher	Sylamore Sandstone (some Sections)
1970	Thompson & Fellows	Bachelor formation
1974	Pierce & Langenhaim	Bushberg Sandstone (from Branson & Mehl, 1934)
1979	Sable	Bachelor Formation
		Sylamore Sandstone Member of Chattanooga Shale
1984	Thompson	Bachelor Formation (southwestern Missouri)
		Bachelor Sandstone (east-central and southeastern Missouri)

Remarks — A thin (1-in to 1-ft), widespread sandstone at the base of the Mississippian carbonate section has been variously correlated (depending on the backgrounds of the individuals involved, and the areas studied) with the Sylamore Sandstone of Arkansas (a facies of the Upper Devonian Chattanooga Shale) and with the Lower Mississippian Bushberg Sandstone of eastern Missouri. Mehl (1960, 1961) reported that the sandstones called Sylamore in Missouri are late Devonian in some cases and Early Mississippian (middle Kinderhookian) in others. The age difference was too great to attribute to transgression (Late Devonian to middle Kinderhookian); therefore, Mehl proposed the name **Bachelor** to replace "Sylamore" for the basal Mississippian sandstone beneath the Kinderhookian limestones in Missouri.

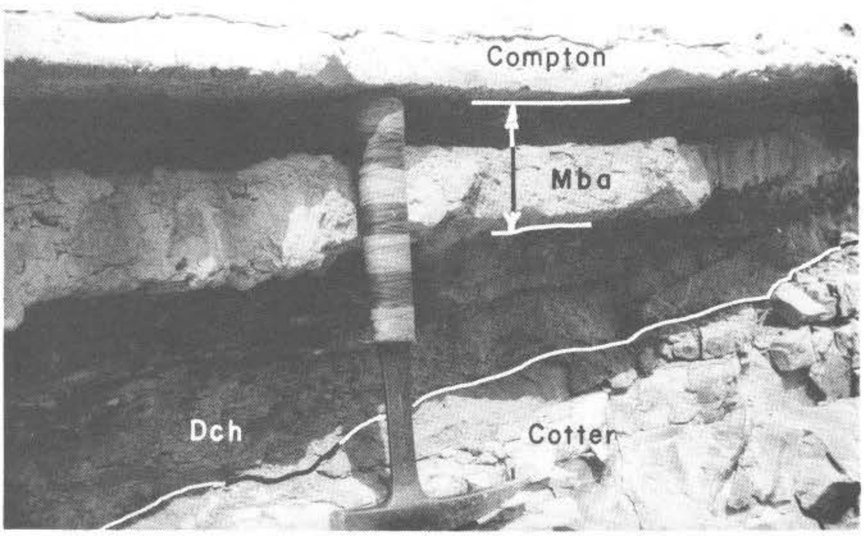


Figure 24. *The two members of the* **Bachelor Formation** *(Mba), between a thin Chattanooga Shale (Dch) and overlying Compton Limestone, in a roadcut on U.S. Highway 65 (Woods Fork exposure), SE¼ SE¼ SW¼ sec. 33, T. 26 N., R. 21 W., Selmore 7½' Quadrangle, Christian County, southwestern Missouri. Photograph by T.L. Thompson.*

The composition of this formation varies; in all but extreme southwestern Missouri it comprises a characteristic thin (3-in. to 1-ft), light-green to tan quartzose sandstone, with a calcareous "glint" ("poikilitic") cement (calcium carbonate in optical continuity). It usually contains phosphatic debris and nodules, and often contains chert fragments from underlying strata and occasional teeth of bradyodont ("pavement-toothed") sharks. In central, western, and southwestern Missouri, a thin (1- to 3-in.), sandy, gray to green calcareous shale overlying this sandstone and underlying the Compton Limestone was designated the upper member of the Bachelor (fig. 24) by Thompson and Fellows (1970). In extreme southwestern Missouri and northeastern Oklahoma the shale persists, but the sandstone member disappears.

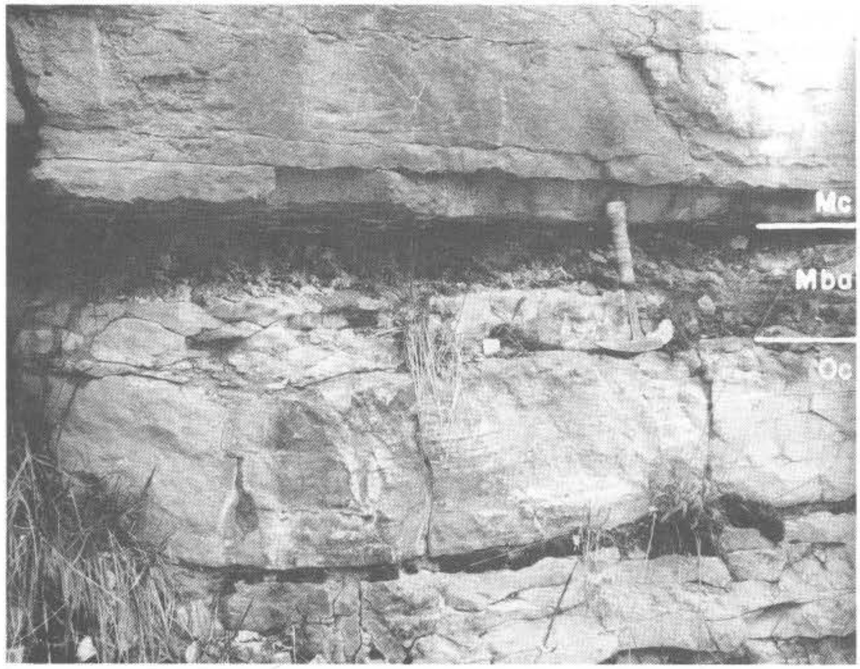


Figure 25. *"Welded" basal contact of the* **Bachelor Formation** *(Mba) with the underlying Lower Ordovician Cotter Dolomite (Oc), Baird Mountain quarry, Taney County, southwestern Missouri. (Mc) = Compton Limestone. Photograph by T.L. Thompson.*

In outcrop the sandstone member of the Bachelor has been identified at almost all exposures of basal Mississippian strata. The only place it has not been positively identified is exteme southwestern Missouri and the region of the Hannibal Formation in northeastern Missouri, but even in the Hannibal a thin sandstone bed contains the typical Bachelor conodont fauna. Beneath the upper Kinderhookian Chouteau (or Compton) limestones, the greenish sandstone is almost always present lying on strata ranging from Lower Ordovician (Ibexian) (fig. 22) to Late Devonian (fig. 23). In many places, the lower contact appears transitional but is actually a "welded" contact (fig. 25). This thin (often 3- to 6-in) sandstone represents a rapid transgression of lower-middle Kinderhookian seas over essentially the entire Missouri region, and it lies in many places with marked unconformity, on Early Ordovician to Late Devonian rocks (fig. 26). Only in extreme southwestern Missouri (west-central Barry and McDonald Counties) is the lower sandstone member absent, but the upper shale member is continuous throughout the region, even identifiable between the Late Devonian

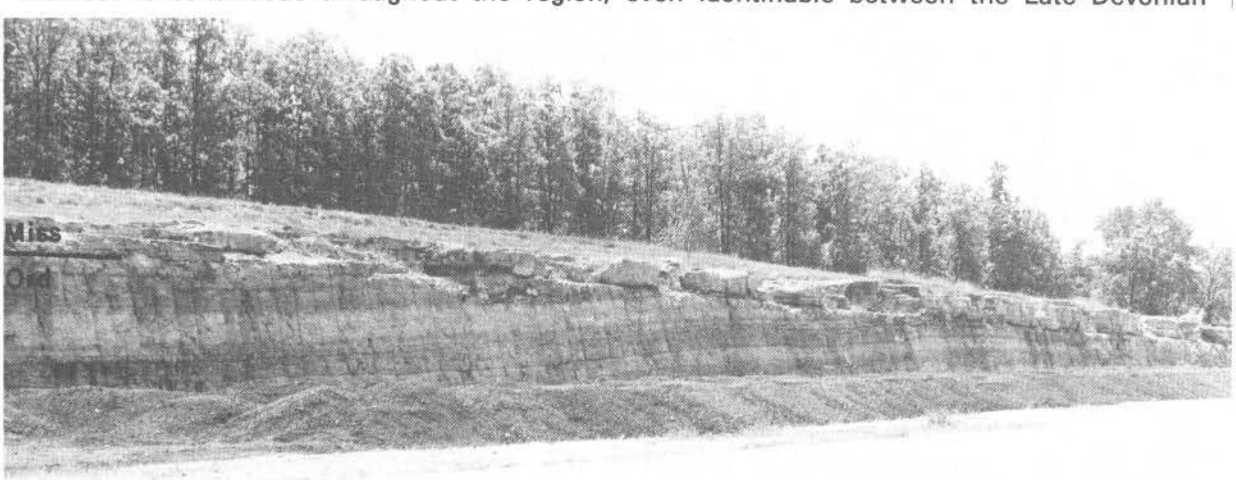


Figure 26. *Angular unconformity at contact of Lower Mississippian* **Bachelor Formation** *and Compton Limestone (Miss) with underlying Lower Ordovician formation (Ord), a roadcut on Missouri Highway 13, about 10 mi north of Springfield, northern Greene County, southwestern Missouri. Photograph by T.L. Thompson.*

Chattanooga Shale and the base of the middle Kinderhookian Compton Formation. Because both members of the Bachelor occur as remnants in isolated sections on the Ozark Uplift region (Embry locality, Thompson and Fellows, 1970; sec. EE, p. 252), they indicate that the formation once covered most of the Ozark region.

In eastern Missouri, south of St. Louis, the Bachelor sandstone lies on the early Kinderhookian Bushberg Sandstone, the former a distinct greenish color, the latter brown. The two sandstones yield distinctly different conodont faunas. In most places, the Bachelor is overlain by middle and upper Kinderhookian carbonates, but in the region south of St. Louis it is overlain by the Fern Glen-Meppen limestones of early Osagean age, no upper Kinderhookian strata being present until northern Ste. Genevieve County. In this region of eastern Missouri, the upper shale member is not present in most places but is replaced by a thin, sandy, siliceous, 1- to 3-in thick limestone bed (Thompson, 1975). In northern Ste. Genevieve County, the Bachelor overlies a thin (1- to 2-ft) Kinderhookian shale bed that overlies the Late Devonian Glen Park Limestone.

Conodonts (Thompson and Fellows, 1970) date the sandstone member of the Bachelor as just older than middle Kinderhookian, an age that seems consistent throughout the outcrop region. The shale member, where present in central and southwestern Missouri, contains its own distinct conodont fauna (*Siphonodella lobata-S. crenulata* Zone), distinct from either the fauna of the sandstone member beneath (*Siphonodella sandbergi-S. duplicata* Zone) or the overlying Compton Limestone (*Gnathodus delicatus-Siphonodella cooperi cooperi* Zone).

Although not referring to the Bachelor Formation in Missouri, Conkin and Conkin (1973, p. 29) stated,

> ". . . the basal part of the Maury Formation (in Alabama) is a thin sandstone unit bearing phosphatic nodules, glauconite grains, and fish teeth (and is thus a bone bed); the contact at Cypsy is one of paraconformity with the Lower Mississippian Maury Formation overlying Ordovician intercalated limestones and shales.
>
> "The evidence is thus overwhelming for the widespread presence of a basal Lower Mississippian detrital unit containing Kinderhookian fossils, which immediately overlies a paraconformity (physical surface of discontinuity, coincident with a faunal break) which marks the contact between the Devonian and Mississippian in several areas of North America. . ."

Chouteau Group

Swallow, 1855

Original description — (Swallow, 1855, p. 101-102) "This formation, when fully developed, is made up of two quite distinct divisions.

"1st. At the top, immediately under the Encrinital Limestone, we find some forty or fifty feet of brownish gray, earthy, silico-magnesian limestone in thick beds, which contain disseminated masses of white or limped calcareous spar. This rock is very uniform in character, and contains but few fossils. Reticulate corals, and fucoidal markings like the Caudigalli, are most abundant.

"2nd. The upper division passes down into a fine compact blue, or drab thin-bedded limestone, whose strata are quite irregular and broken. Its fracture is conchoidal, and its structure somewhat concretionary.

"In the northeastern part of the State the Chouteau Limestone is represented by a few feet of coarse, earthy, crystalline rock, like the lower division of the Encrinital Limestone."

Type section — Swallow described the Chouteau Limestone from exposures near Chouteau Springs, Cooper County, Missouri, Pilot Grove North 7½' Quadrangle (fig. 27). The specific section is in a short valley about 0.25 mi north of Chouteau Springs, in the center of sec. 16, T. 48 N., R. 17 W.

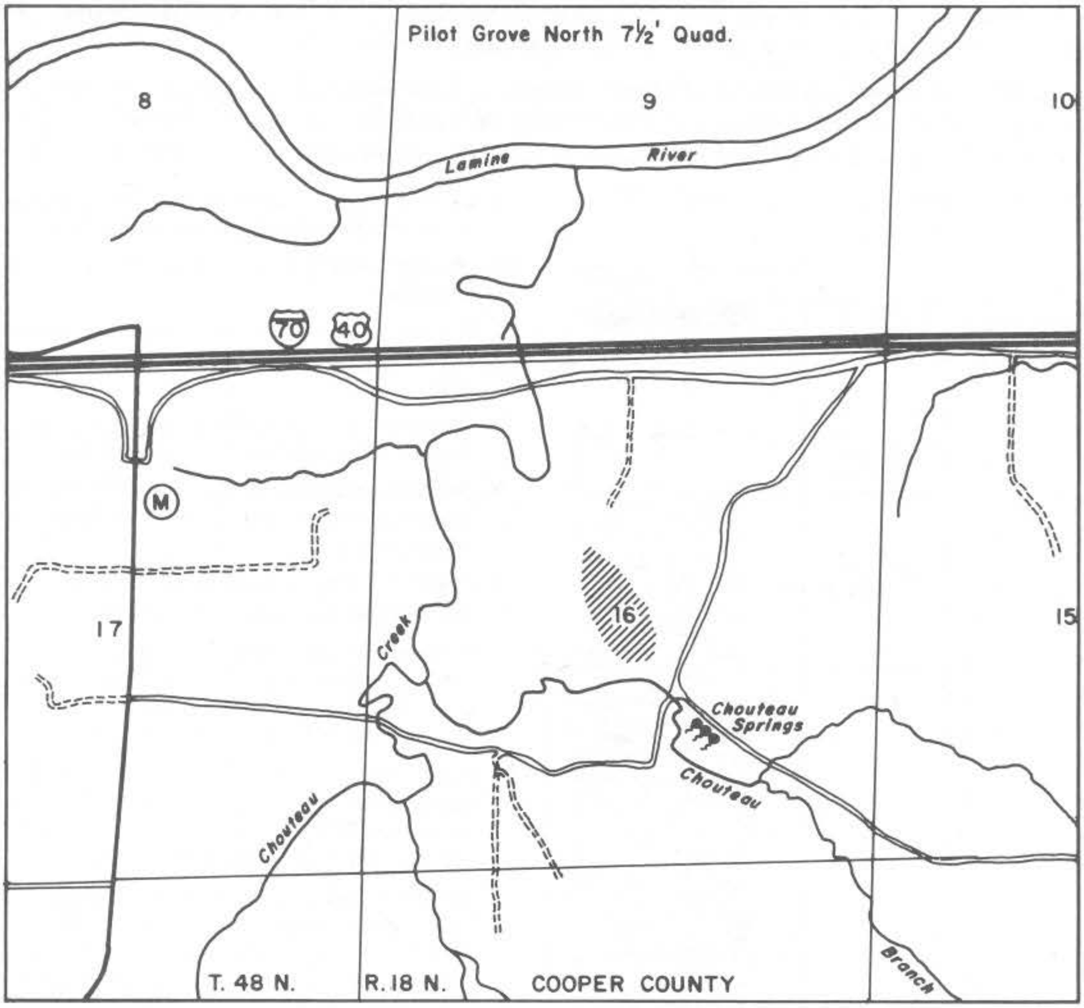


Figure 27. *Part of the Pilot Grove North 7½' Quadrangle showing location of the type section of the* **Chouteau Group**, *Cooper County, central Missouri.*

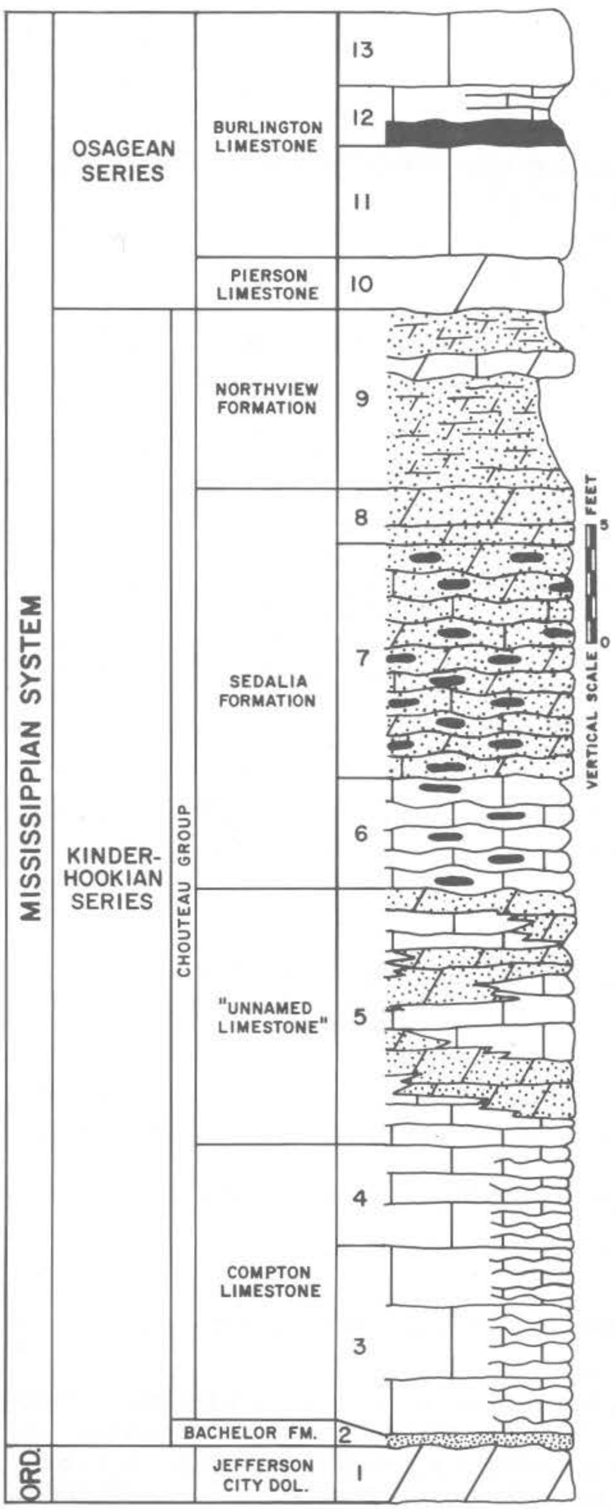
Moore (1928, p. 84) described the type section of the Chouteau (incorrectly located by him in T. 38 N.) and noted that approximately 50 ft of Kinderhookian carbonates were present:

	Thickness feet
"(Mississippian)	
(Osage group)	
Encrinital (Burlington) limestone	
3. Limestone, coarse, crystalline, brown, white or gray, crinoidal	105
Upper Chouteau (Sedalia) limestone	
2. Limestone, brownish-gray, earthy, silico-magnesian, in heavy beds which contain masses of calcite	30
(Kinderhook group)	
Lower Chouteau (Chouteau) limestone	
1. Limestone, blue or gray, compact, irregularly stratified in thin beds with characteristic fossils	20"

Moore went on to state," Exposures are now too poor to permit advantageous study of the formation at Swallow's locality, but at other places not far distant the Chouteau is admirably exposed." The section Moore selected was in the Missouri, Kansas, and Texas Railway Sweeney Quarry, in sec. 4, T. 46 N., R. 19 W., 2.5 mi northeast of Clifton City, Cooper County, Missouri. In this quarry, 43 ft of

"Upper Chouteau (Sedalia)" and 25 ft of "Lower Chouteau (Chouteau)" were described. Moore designated the quarry the type section for his "Sedalia Formation."

Figure 28, which represents the Chouteau Group as it appears in the type area, is derived from exposures on Highway 65 about 6 mi north of Sedalia, Pettis County, central Missouri, NE¼ SE¼ sec. 33 and SE¼ SE¼ sec. 28, T. 47 N., R. 21 W., and is also representative of the exposure in the



13. Limestone, gray, coarsely crystalline, crinoidal; with zones of interbedded chert nodules. (3 ft)
12. "Rubble zone"; chert and weathered limestone. (2 ft 6 in.)
11. Limestone, dark-blue-gray, medium- to coarsely crystalline, very fossiliferous, crinoidal; single bed. (5 ft)
10. Dolomite, gray, coarsely to very finely crystalline, very dense, fossiliferous; single bed. (2 ft 6 in.)
9. Siltstone, dolomitic, dark-blue-gray to green, blocky; single uneven continuous bed of silty dolomite in upper part. (8 ft)
8. Dolomite, silty, dark-blue-gray, single bed, laminated; phosphatic zones. (2 ft 6 in.)
7. Dolomite and dolomitic limestone, silty, dark-gray-brown; scattered fossils. Chert (25%) as nodules and beds, dark-gray-black; scattered calcite-filled vugs (Sedalia and "Chouteau chert"). (9 ft)
6. Limestone ("Chouteau"), light-gray, lithographic, fossiliferous; irregular beds with silty dolomitic partings. Chert (5-10%), as irregular masses and nodules within limestone beds. (5 ft)
5. Dolomite and limestone, as alternating zones or beds; lateral facies. Dolomite ("Sedalia"), buff, silty, calcitic, very finely crystalline. Limestone ("Chouteau"), dark-blue-gray, lithographic; beds 1-2 ft thick. (10 ft)
4. Limestone, dark-gray to buff, finely crystalline, very fossiliferous; incipient nodular bedding very prominent in lower part; very even major beds. (3 ft)
3. Limestone, light-gray to green-gray; even, medium beds with incipient nodular bedding when weathered; very finely crystalline matrix, scattered fossils. (7 ft)
2. Sandstone, light-gray-green; calcite cement, very irregular base, even top. (0 ft 3-6 in.)
1. Dolomite, buff, dense.

Figure 28. *Columnar section of* **Chouteau Group** *as exposed in the vicinity of Sedalia, Pettis County, central Missouri. Adapted from Thompson (1979, fig. 6).*

T. and O. Railway quarry, in the NE¼ SW¼ sec. 34, T. 47 N., R. 21 W., described by Clark and Beveridge (1952, p. 18).

History of nomenclature —

1855	**Swallow**	**Chouteau limestone** (Chemung Group; part)
1861	Meek & Worthen (a)	Chouteau limestone
1874	Broadhead	Chouteau group (to replace "Chemung Group" of Swallow)
1895	Gordon	"Argillaceous-calcareous group of Evans Falls"
1898	Weller (a)	Kinderhook formation Chouteau limestone Kinderhook limestone (group)
1900	Keyes	Chouteau limestone member of Kinderhook formation (part)
1928	Moore	Chouteau limestone (restricted; did not include Sedalia)
1950	Bassler	Chouteau limestone Providence limestone ("= upper Chouteau limestone")
1952	**Beveridge and Clark**	**Chouteau group** (composed of Compton, Sedalia, and Northview formations; west-central and central Missouri St. Joe group (lower part; Compton and Northview formations; southwestern Missouri
1958	Koenig	Chouteau group (undifferentiated; rejected "Compton," "Sedalia," and "Chouteau" limestones, restricted, of Moore, 1928)
1961	Spreng	"Chouteau group undifferentiated"
	Collinson	Chouteau formation
1963	Carlson	Hampton (Chouteau) Group (northeastern Missouri)
1965	Brill	Chouteau Formation ("= McCraney of Illinois")
1979	**Thompson (a)**	**Chouteau group** (four formations; central and southwestern Missouri) **Chouteau Limestone** (restricted; northeastern Missouri)

Remarks — Swallow (1855) desginated the entire Mississippian carbonate sequence below the Burlington Limestone ("Encrinital limestone") the **Chouteau limestone.** He recognized two distinct carbonate units within his Chouteau, but did not name them (fig. 29). Moore (1928) further refined Swallow's concept of a two-fold carbonate sequence. He designated the lower unit of Swallow ("2nd") "Chouteau formation restricted" and the upper ("1st") the "Sedalia Formation." Moore regarded only the Chouteau "restricted" as Kinderhookian; the entire Sedalia he identified as Osagean, placing the upper boundary of his Sedalia at the position now considered the top of the Pierson Formation. The upper beds of Moore's Sedalia correlate with the lower part of the Fern Glen Formation in eastern Missouri, the Pierson Limestone of southwestern Missouri, and with the lower part of the Burlington Limestone, where the former two formations are not identified. The Illinois Geological Survey identified an Osagean unit in west-central Illinois, below the Burlington Limestone, the "Sedalia," an Osagean formation based on Moore's concept of the Sedalia. The "Sedalia" of Illinois is now identified as the Meppen Formation (see "Fern Glen Formation").

Beveridge and Clark (1952) redefined "Chouteau" as entirely Kinderhookian (fig. 29), in the sense originally proposed by Swallow, but retained Moore's name Sedalia for the lower part of Moore's original Sedalia (the upper part of Swallow's Chouteau). In addition, Beveridge and Clark correlated the lower strata in the type region of the Chouteau with the Compton Formation, a unit Moore (1928) had named from exposures in southwestern Missouri, and proposed to retain "Chouteau" as **Chouteau Group,** for the name for the entire Kinderhookian Series, comprising, in sequence upward, the Compton Limestone; a Compton-Sedalia transitional sequence of interfingering lithographic limestone and silty, dolomitic limestone; the Sedalia Formation, a dolomitic and siliceous limestone; and the Northview Formation, a thin (1- to 2-ft) shale in the type area of the Chouteau.

Series	Swallow (1855)		Moore (1928)	Beveridge & Clark (1952)		Spreng (1961)		Present report		Series
OSAGEAN	Encrinital Limestone		Burlington limestone	Burlington limestone		Burlington limestone		Burlington limestone		OSAGEAN
			Sedalia limestone	Pierson formation		"Lower Burlington"		"Lower Burlington-Pierson"		
KINDERHOOKIAN	CHOUTEAU	"1st"		CHOUTEAU GROUP	Northview formation	CHOUTEAU GROUP	Northview formation	CHOUTEAU GROUP	Northview formation	KINDERHOOKIAN
					Sedalia formation		Sedalia formation		Sedalia formation	
		"2nd"	"Chouteau restricted"		Compton-Sedalia transition		Compton formation		"Unnamed limestone"	
					Compton formation				Compton limestone	

Figure 29. *Chart showing development of unit nomenclature in the* **Chouteau Group,** *from the original proposal of Swallow (1855) to that used in this report.*

The upper Sedalia of Moore (the "Sedalia" of Illinois), a dense, brown limestone above the Northview shale bed (described, but not identified as Northview by Moore), was called the Pierson Formation by Beveridge and Clark, but has also been called the "Lower brown beds of the Burlington," or simply "Lower Burlington," in central Missouri.

Beveridge and Clark's "Chouteau Group" has continued to be used for Kinderhookian carbonate rocks in west-central and central Missouri, where it comprises four formations: Compton, an "unnamed limestone," Sedalia, and Northview. Spreng (1961) regarded the "Compton-Sedalia transitional beds" of Beveridge and Clark as part of the Compton, but this interval is very different lithologically from either Compton or Sedalia; it comprises interfingering beds of lithographic and silty dolomitic limestones. This interval is now regarded as an "unnamed limestone" between the Compton Limestone and the Sedalia Formation. The true nature of this unit, i.e., whether it consists of different interbedded carbonates or represents facies of two laterally distinct carbonate units in the region of the type Chouteau-Sedalia exposures is still unclear. Whether this interval will remain as a separate formation is also unclear; nevertheless, it differs from the units immediately below and above.

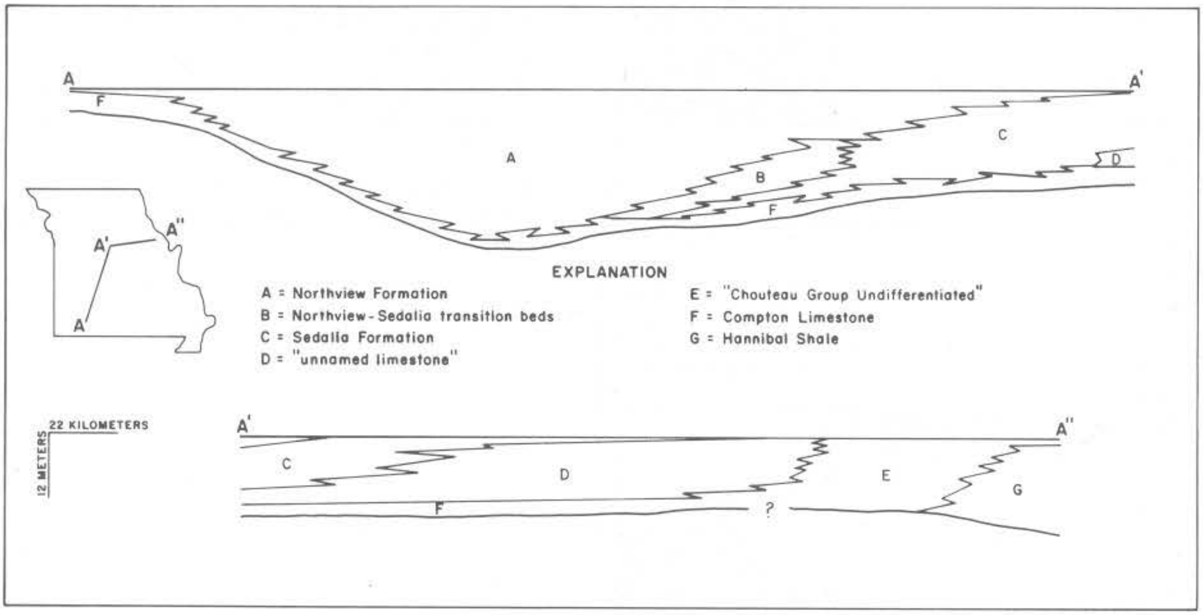
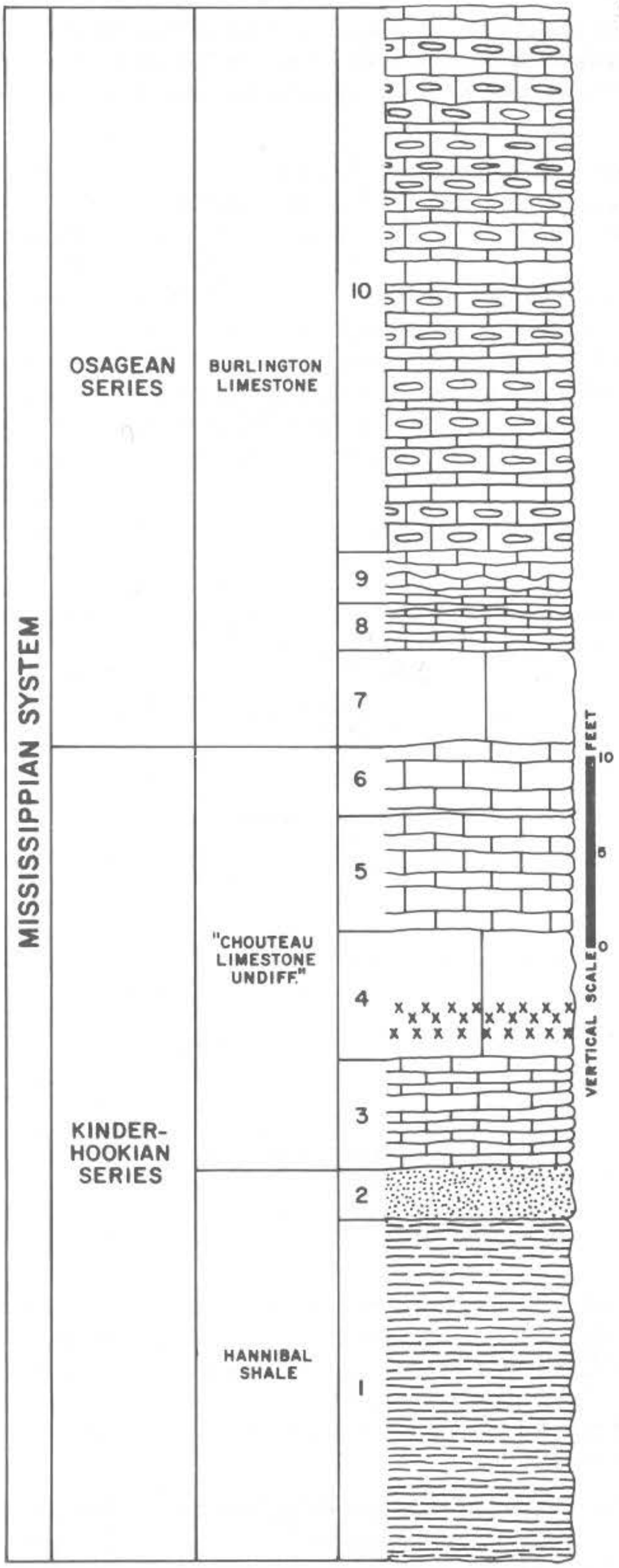


Figure 30. *Cross section of* **Chouteau Group**, *from the southern border of Missouri (A) to the region of the type section, in Cooper County (A'), to the Missouri-Illinois border, in Pike-Ralls Counties (A"), northeastern Missouri. Adapted from Frey (1967, fig. 5) and Thompson (1979a, fig. 8).*

In southwestern Missouri, the Chouteau Group includes only the Compton Limestone and the Northview Formation. The Sedalia thins southward from its type area to a featheredge in southern Cedar County (fig. 30). As currently understood, the type section of the Chouteau, compared to Swallow's description, comprises the Compton Limestone, an "unnamed limestone" ("2nd part"), and the Sedalia Formation ("1st part"), with the thin Northview Formation separating the top of the Sedalia from the basal Burlington (or Pierson) beds.

In parts of northeastern Missouri, as noted by Swallow (1855), a medium-crystalline limestone represents the post-Hannibal Kinderhookian interval. Lithologically unlike other Chouteau carbonates, this unit has been identified as "Chouteau Group undifferentiated," or simply the "Chouteau Limestone" (fig. 31).

In addition, sections exposed in a few quarries in northeastern Missouri contain a limestone unit, above the "Chouteau undifferentiated," that is lithologically similar to the McCraney Limestone in



10. Limestone, light-gray, finely crystalline, medium-bedded (2-6 in.); contains nodules of white chert. (30 ft)
9. Limestone, white, coarsely crinoidal, medium crystalline, thin (2-4 in.) flaggy beds. (3 ft)
8. Limestone, light-brown or cream to white, coarsely crinoidal thin (1-2 in.) flaggy beds. (2 ft 6 in.)
7. Limestone, slightly dolomitic, medium-yellowish-brown to gray to white, coarsely crinoidal, massive. (5 ft 5 in.)
6. Limestone, yellowish-buff, finely crinoidal, medium- to finely crystalline, medium (3-6 in.) beds. (4 ft)
5. Limestone, light-pinkish-gray, finely crinoidal, medium-crystalline, medium (3-6 in.) beds. (6 ft 8 in.)
4. Limestone, greenish-gray, dense to finely crystalline; contains a zone of pea-size pyrite nodules 18 in. thick 20 in. above base; basal 2 in. of bed contains fossil debris; bed is massive with paper thin incipient bedding. (7 ft 7 in.)
3. Limestone, dark-yellowish-brown, crinoidal, medium-crystalline, thinly bedded, fossiliferous. (5 ft 9 in.)
2. Siltstone, yellowish-brown, massive. (3 ft 2 in.)
1. Shale, dark-greenish-gray, fissile; largely covered. (19 ft+)

Figure 31. *Columnar section of* **"Chouteau Limestone undifferentiated,"** *exposed in NE¼ SW¼ NW¼ sec. 5, T. 53 N., R. 4 W., Vandalia 7½' Quadrangle, Pike County, Missouri. Adapted from Koenig and Martin (1961, fig. 11).*

its type region in west-central Illinois immediately across the Mississippi River from Hannibal, Missouri.

Within the type area (Pettis, Saline, Howard, and Cooper Counties), the Chouteau Group attains a maximum thickness of more than 100 ft. Exposures 50 to 75 ft thick may be seen in quarries and in bluffs along the Missouri River, in Howard and Saline Counties.

As currently understood, the Chouteau Group in Missouri includes the following formations:

Southwestern Missouri	**Central Missouri**	**Eastern Missouri**
Northview Formation	Northview Formation	"McCraney Limestone"
Baird Mountain Limestone Member		
	Sedalia Formation	
	"Unnamed limestone"	"Chouteau Limestone"
Compton Limestone	Compton Limestone	

Compton Limestone
Moore, 1928

Original description — (Moore, 1928, p. 120) "The Compton limestone is a light bluish drab, or grayish blue, compact limestone, very fine-grained and breaking with a conchoidal fracture. . . . The beds are generally of moderate thickness, averaging 6 to 8 inches, but in places they are of as much

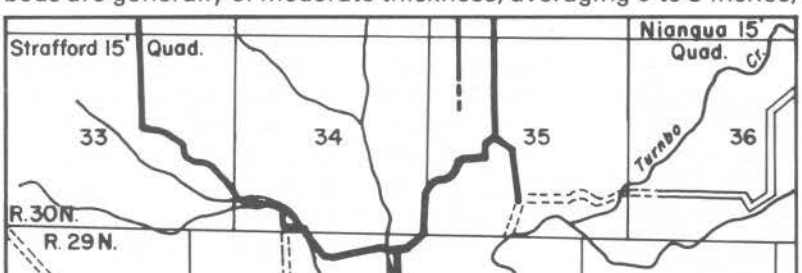


Figure 32. *Parts of the Fordland, Niangua, Strafford, and Ozark 15' Quadrangles, showing location of the type section of the* **Compton Limestone.** *This exposure has been almost completely buried by new road construction.*

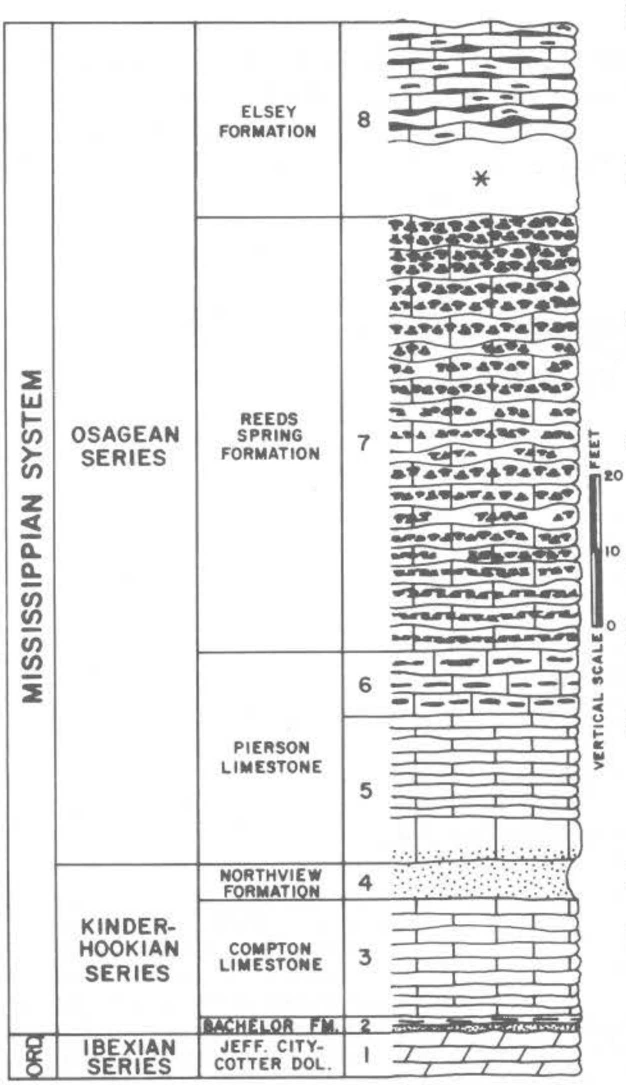
as 2 feet thick. The upper beds merge into the soft bluish shale of the Northview formation. As observed on Finley Creek, the rock is very compact, hard, fine-grained, breaking with a splintery, conchoidal fracture."

Type section — To represent the Compton Formation, Moore (1928, p. 118) originally described "A section measured by Weller at Bridwell's Hill (sec. 3, T. 29 N., R. 19 W.), on James river near Compton. . . ," the name derived from that of a former post office, in Webster County.

Beveridge and Clark (1952, p. 73) stated, "The original type area is along the James River in the vicinity of the now non-existent Compton post office which stood in the NW/4 NW/4 SE/4 sec. 8, T. 29 N., R. 19 W., Webster County.

"The Compton is not exposed in the immediate vicinity of the namesake post office site, and the type section is hereby designated as being in the center SE/4 NE/4 SE/2 sec. 3, T. 29 N., R. 19 W., on the northwest side of a gravel road, Webster County. This section is two miles northeast of the Compton post office site, and shows the Compton in its entirety."

Because section 3 is almost 2 miles long north-south, Thompson and Fellows (1970, p. 14) indicated the site as "SE¼ E½ E½ Lot 2 of the NE¼ sec. 3 . . ." Fordland 7½' Quadrangle (fig. 32). This exposure has been almost completely buried by relocation of the gravel road to above the outcrop; therefore, no type section currently exists for the Compton Limestone.



8. Limestone (50-60%), gray-brown, finely crystalline with semicrinoidal lenses, some medium-crystalline. Chert, white to blue, some brown, mottled, fossiliferous; in large irregular nodules between and within limestone beds. (26 ft; 10 ft covered)
7. Chert (50-70%), brown to white, with gray-brown centers, opaque to translucent; in anastomosing masses and nodules within limestone beds. Limestone, gray to dark-gray, very finely crystalline; as 4- to 6-in. beds with chert within limestone. (57 ft)
6. Limestone (75%), light-gray-brown, very finely crystalline, nodular, with shale partings. Chert, bluish-gray with white rinds, as irregular nodules within limestone beds. (9 ft)
5. Limestone, gray-green to tan, very finely crystalline, in beds 6 in. to 1 ft thick with some thin shale partings. Lower 3 ft dolomitic, greenish-brown to blue-gray; reworked material from unit 4. (19 ft 6 in.)
4. Siltstone, blue to gray-green, dolomitic, dense, massive, weathers shaly to blocky. (5 ft 3 in.)
3. Limestone, gray-brown, very finely crystalline with scattered crinoid ossicles, in 6-in. to 1-ft beds with 0.5- to 1-in. incipient shale partings. (15 ft)
2. Shale and sandstone. Upper shale (0 ft 3 in.), green and brown, clayey. Lower sandstone (0 ft 4 in.), greenish-brown, quartzose, well-sorted, cemented with "glint" calcareous cement; contains abraded chert pebbles and phosphatic nodules. (0 ft 7 in.)
1. Dolomite, light-brown, finely crystalline, thin- to medium-bedded. (5 ft+)

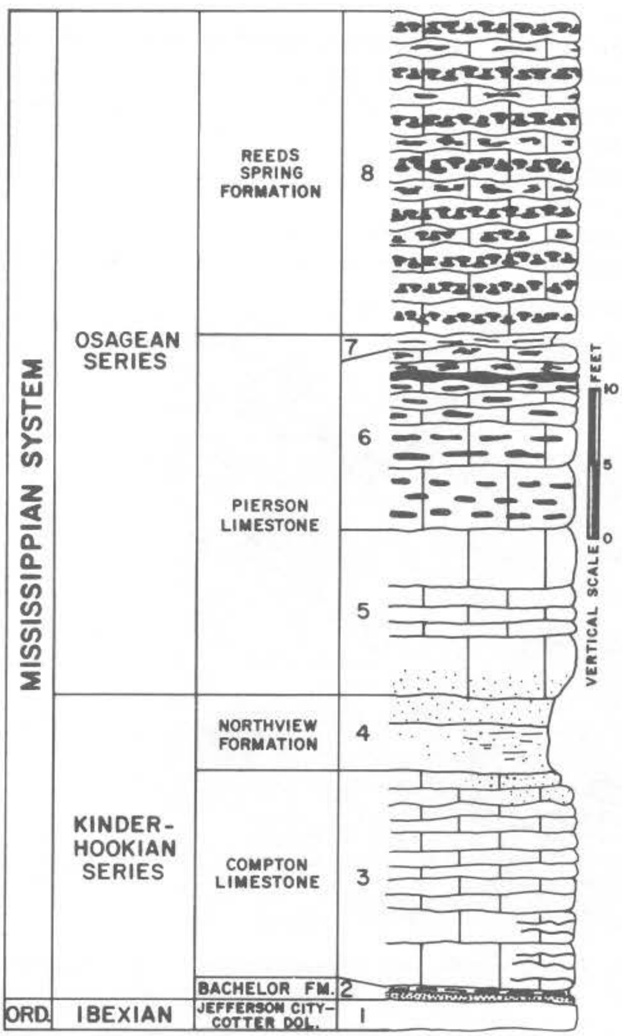
Figure 33. *Columnar section of reference section for the* **Compton Limestone,** *in a roadcut on U.S. Highway 65 south of Springfield, SW¼ SW¼ NE¼ sec. 22, T. 25 N., R. 21 W., Day 7½' Quadrangle, Christian County, Missouri. Adapted from Thompson and Fellows (1970, sec. M, p. 180-184).*

Reference sections — Inasmuch as the type section no longer exists, two existing roadcuts can be used to determine the characteristics of the Compton Limestone. One is on U.S. Highway 65 south of Springfield, in Christian County, Missouri (SW¼ SW¼ NE¼ sec. 22, T. 25 N., R. 21 W., Day 7½′ Quadrangle) (Thompson and Fellows, 1970, section M, p. 180; fig. 33).

The other referenced section (fig. 34) is a roadcut on I-44, just east of Mt. Vernon, Lawrence County, Missouri (NW¼ NE¼ SE¼ sec. 7, T. 28 N., R. 25 W., Halltown 7½′ Quadrangle) (Thompson and Fellows, 1970, section J, p. 170-172).

History of nomenclature —

1855	Swallow	Lithographic limestone
1892	Vodges	Sedalia limestones
1894	Keyes	Louisiana limestone (in southwestern Missouri)
1897	Schuchert	Chouteau
1898	Shepard	Sac formation
		Louisiana limestone (southwestern Missouri)
		King formation (part)
1900	Keyes	Lithographic limestone ("not equivalent to the Louisiana limestone of northeastern Missouri")



8. Limestone (70-85%), light- to dark-gray, very finely to medium-crystalline. Chert, blue with bluish-black centers, as irregular nodules within limestone beds. (24 ft 6 in. exposed)
7. Shale, bluish-gray, calcareous, fossiliferous. (0 ft 7 in.)
6. Limestone (60-90%), dark-gray to brownish-gray, very finely crystalline. Chert, blue to light-bluish-gray with blue centers and white rinds, as irregular nodules, beds and discontinuous beds of nodules within limestone beds. (13 ft)
5. Limestone, dark-gray to blue-gray, finely to medium-crystalline, silty, dense, massive; beds 6 in. to over 3 ft thick. Basal 4 ft yellowish-brown, dolomitic, medium crystalline; increasingly silty toward base. Contains reworked dolomitic silt from unit 4. (11 ft)
4. Siltstone, blue to blue-gray, dolomitic, blocky massive beds. (5 ft)
3. Limestone, dark-gray, finely crystalline matrix with scattered crinoid debris, upper 2 ft silty; upper 9 ft as even 3- to 6-in beds; lower 5 ft as two massive beds broken by 0.5- to 1-in. incipient shale partings. (14 ft)
2. Shale and sandstone. Upper shale (0 ft 3 in.), gray, silty. Lower sandstone (0 ft 3 in.), green, quartzose, "glint" calcareous cement; contains abundant phosphatic nodules and fish teeth. (0 ft 6 in.)
1. Dolomite, yellow-brown, very finely crystalline. (0 ft 6 in.)

Figure 34. *Columnar section of reference section for the* **Compton Limestone**, *in a roadcut on the west-bound lane of I-44 east of Mt. Vernon, NW¼ NE¼ SE¼ sec. 7, T. 28 N., R. 25 W., Halltown 7½′ Quadrangle, Lawrence County, Missouri. Adapted from Thompson and Fellows (1970, sec. J, p. 170-172).*

1901	Weller	Sac limestone
1902	Keyes	Louisiana limestone (southwestern Missouri)
		Sac limestone
	Weeks	Sedalia limestone (Vodges, 1892)
1904	Shepard	Kings limestone
1905	Weller	Hannibal limestone (regarded it as part of what is now the Northview Formation)
		Chouteau limestone (in southwestern Missouri)
	Shepard	Kings Branch limestone
1906	Weller	Chouteau limestone (lower part)
1907	Purdue	St. Joe limestone (upper part)
1915	Girty (b)	St. Joe limestone member of Boone formation (lower part)
		Fern Glen (St. Joe) (lower part)
1918	Branson	Chouteau limestone
1928	**Moore**	**Compton limestone**
		St. Joe limestone member of Boone formation (lower part)
1933	Moore	Saint Joe member of Boone formation
1944	Branson (a)	Compton member of Chouteau formation
1949	Laudon & Bowsher	St. Joe formation (lower part)
		Chouteau ("= Compton")
1952	Beveridge & Clark	Compton formation of Chouteau group (central and west-central Missouri)
		Compton formation of St. Joe group (southwestern Missouri)
1954	Searight	Compton formation of Chouteau group
1961	Spreng	Compton formation of Chouteau group
1967	Yochelson & Saunders	Chouteau Limestone
1969	Freeman & Schumacher	St. Joe Limestone (lower part)
1970	Thompson & Fellows	Compton Formation
1979	Thompson (a)	Compton Formation (of Chouteau Group)
	Dutro et al.	**St. Joe Limestone Member of Boone Formation (lower part)**

Figure 35. *Roadcut exposure of the* **Compton Limestone** *on U.S. Highway 65 south of Springfield, SW¼ SW¼ NE¼ sec. 22, T. 25 N., R. 21 W., Day 7½' Quadrangle, Christian County, Missouri (fig. 33), illustrating characteristics of bedding. Photograph by T.L. Thompson.*

Remarks — The Compton Limestone, ranging from 6 to 12 ft thick in southwestern Missouri, is characteristically finely to medium crystalline to sublithographic, with scattered fossil debris throughout. Crinoid remains, although common, are small and scattered, giving a "peppery" appearance to the limestone. The Compton is characteristically very even bedded (fig. 35). The lower half is thick bedded, the beds varying from 2 to 4 ft thick, and weathering to incipient, thin, wavy beds 0.5 to 1 in. thick; the upper half typically shows thinner but more uniform bedding, individual beds varying from 4 to 6 in. thick.

Exposures of the Compton Limestone are widespread, extending from northwestern Arkansas and northeastern Oklahoma, northward to central and east-central Missouri (fig. 30). In the vicinity of Stockton, Cedar County, Missouri, two other carbonate units occur between the Compton and the overlying Northview Formation and thicken northward into the Sedalia Formation and an "unnamed limestone" between the Compton and Sedalia ("Compton-Sedalia transitional beds" of Spreng, 1961). The Compton, however, can be recognized as a distinct lithologic unit in the base of the Kinderhookian carbonate sequence (Chouteau Group), eastward and northeastward to at least east of Montgomery County, in east-central Missouri.

In northern Greene County, Missouri, the Compton Limestone is locally dolomitic, brown, and massive; it can be distinguished from the underlying Lower Ordovician Jefferson City-Cotter Dolomites by reddish calcite "blebs" of scattered crinoid ossicles. Chert occurs only locally in the Compton and, when encountered, is usually associated with small Waulsortian-type bioherms that developed in the Compton in southwestern Missouri and northwestern Arkansas (Troell, 1962; Manger and Thompson, 1982; fig. 36). The chert is bluish gray, pink, to bluish black, with a white rind, and is similar to that in the Sedalia Formation in central Missouri. Northview and sometimes upper Compton strata are truncated as they rise over the sides of these bioherms (figs. 37 and 38).

As stated by Spreng (1961, p. 56)

"The Compton formation is not abundantly fossiliferous at any one locality. Its chief faunal constituents are echinoderms and brachiopods. Common brachiopods are: *Schumardella missouriensis, S. obsolens, Pustula concentrica, Chonetes logani,* and *Leptaena analoga.*

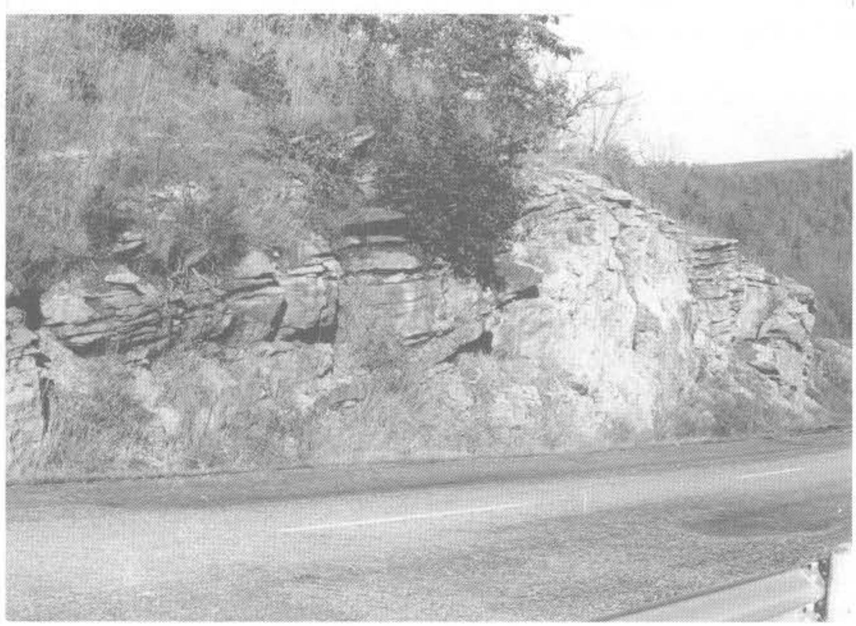


Figure 36. *Waulsortian-like bioherm in* **Compton Limestone** *exposed in a roadcut on Missouri Highway 86, at Indian Creek, southern Stone County, southwestern Missouri. Photograph by T.L. Thompson.*

Figure 37. *Exposure of Compton (Mc), Northview (Mnv), and Pierson (Mp) strata in a roadcut on U.S. Highway 71 in southern McDonald County, showing truncation of Kinderhookian formations by Pierson Limestone, the result of bioherm development in the Compton Limestone (see fig. 38). Photograph by T.L. Thompson.*

These also occur in the 'undifferentiated Chouteau' of northeastern Missouri. Among the echinoderms, the blastoids *Schizoblastus roemeri* and *S. sampsoni* are the most common, as well as species of the crinoid *Playtcrinites.* Weathered exposures exhibit an abundance of small crinoid columnals which stand out in relief on the surface of the rock."

Microfossils are abundant in the Compton. Conodonts have been useful for biostratigraphic zonation of Compton and Northview strata in western and southwestern Missouri, where Thompson and Fellows (1970) identified conodonts representative of the *Gnathodus delicatus-Siphonodella cooperi cooperi* Zone in the Compton Limestone. Arenaceous foraminifers are also abundant in Compton beds (Conkin et al., 1968).

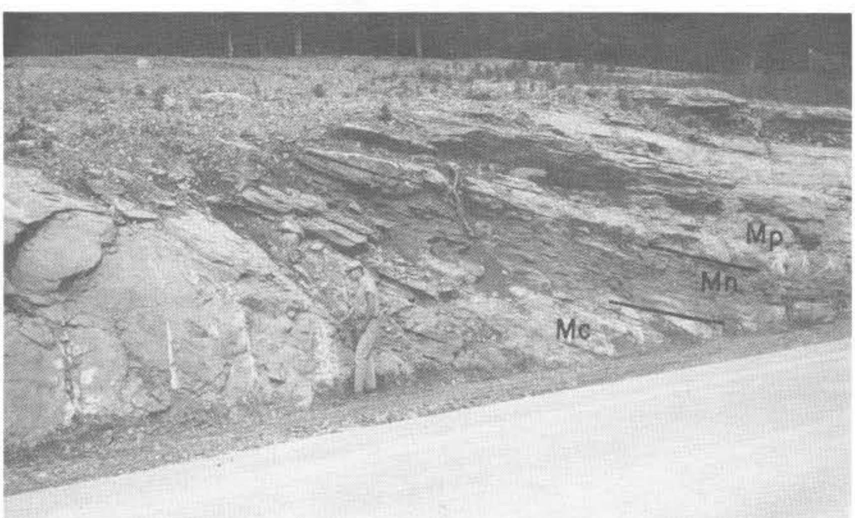


Figure 38. *Effect of bioherm development in the* Compton Limestone, *on overlying and adjacent Compton (Mc), Northview (Mn), and Pierson (Mp) strata exposed in a roadcut on U.S. Highway 71, on Tanner Branch, southern McDonald County, southwestern Missouri (Thompson and Fellows, 1970, sec. X). Photograph by T.L. Thompson.*

The Compton can be differentiated from the Sedalia in the latter's type area and to the southwest, by thinner bedding, lack of chert, and greater calcium carbonate content, i.e., it is less dolomitic and siliceous. In this area, the Compton averages less than 15 ft thick, whereas the Sedalia is often over 50 ft thick.

Eastward from Pettis County the Compton Limestone gradually thins as the transitional, or "unnamed limestone," between it and the Sedalia Formation appears to thicken. North and east of Montgomery County (fig. 30), identification of the Compton becomes difficult, and the Chouteau Group is represented by a medium- to coarsely crystalline limestone that is coarser and more fossiliferous than the Compton facies: the "Chouteau Group undifferentiated."

Throughout most of its extent in central, east-central, and southwestern Missouri the Compton lies on a thin sandstone and shale unit, the Bachelor Formation. In southwestern Missouri, northward to about Cedar County, the Compton is overlain by the Northview Formation; it is overlain by the "unnamed limestone" eastward to where the Compton is lithologically lost within the "Chouteau Group undifferentiated."

"Unnamed limestone"

History of nomenclature —

1952	Clark and Beveridge	Sedalia-Compton transition beds
1979	Thompson	"alternating beds of Sedalia Formation and Chouteau Limestone"

Remarks — The sequence Swallow (1855) designated "Chouteau" is divisible into three separate lithologic units. He originally combined the lower two into his "2nd" unit. Moore (1928) placed the entire "2nd" unit into his "Chouteau (restricted)." Beveridge and Clark (1952) divided the "2nd" unit into two lithologic entities: the lower, the Compton Limestone, and the upper, the "Compton-Sedalia transitional beds." Although Spreng (1961) believed both constituted the Compton Formation, it

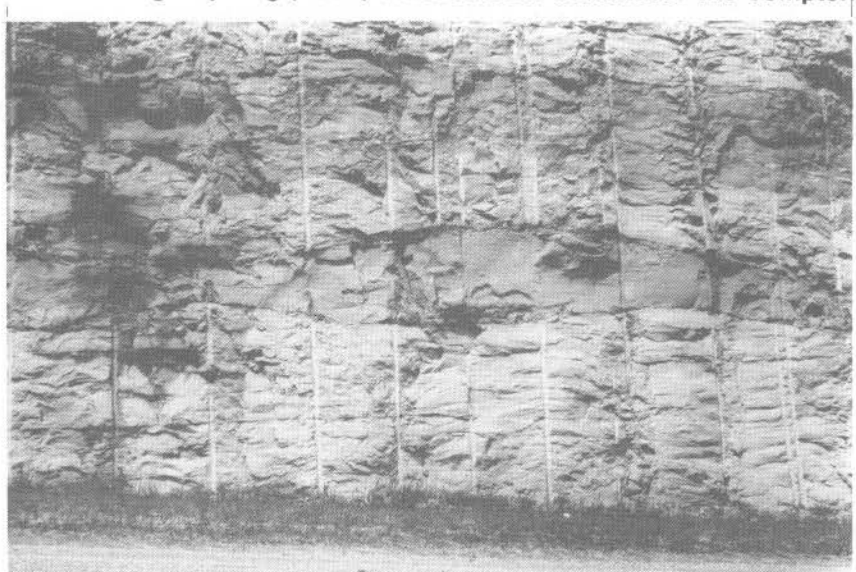


Figure 39. **Chouteau Group** *showing "boudinage" structures in the* **"Unnamed limestone"** *between the underlying Compton Limestone and overlying Sedalia Formation, in a roadcut on Missouri Highway 83, southern Benton County, Missouri. Photograph by T.L. Thompson.*

appears more reasonable to recognize the lithologic differences between the Compton and the "transitional beds" and to consider the latter, which is not present in the Compton type area, to be a distinct, albeit unnamed, formation.

The "unnamed limestone" comprises alternating and visibly interfingering beds of light-bluish-gray, finely crystalline to lithographic limestone and buff or tan, silty to dolomitic limestone (fig. 28). The lithographic limestone resembles that of the underlying Compton but is more uniformly finer grained than "typical" Compton limestone. The dolomitic or silty limestone is like that of the overlying Sedalia but appears more silty and finer grained than the "typical" siliceous dolomitic limestone of the Sedalia. This silty dolomitic limestone is similar to a unit above the Compton and below the Sedalia, which crops out in Cedar and Benton Counties, but does not interfinger with limestone. In places, this silty dolomite exhibits well-developed "boudinage" structure (fig. 39).

The "unnamed limestone" is present from the region of Sedalia, Missouri, eastward to Montgomery County. If the silty dolomite in Cedar and Benton Counties, discussed above, is a facies of this unit, its range can be extended. In the Sedalia and type Chouteau regions, the "unnamed limestone" averages 6 to 8 ft thick.

Sedalia Formation

Moore, 1928

Original description — (Moore, 1928, p. 149) "The name Sedalia limestone is here proposed for the gray to light buff 'silico-magnesian' limestone which was termed the Upper Chouteau by Swallow and other geologists. In the words of Swallow who first distinguished the horizon, the 'Upper Chouteau' (Sedalia) limestone is a 'brownish-gray, earthy, silico-magnesian limestone in thick beds, which contain disseminated masses of white or limped calcareous spar.' The formation is really a siliceous dolomite throughout the region of its typical development.

"The Sedalia is massively bedded, individual layers being in many places 10 to 20 feet in thickness. These massive beds weather in rather smooth, characteristically rounded surfaces unlike either the Chouteau or the Burlington. The rock is somewhat soft on fresh exposure and breaks with an even or subconchoidal fracture. On exposed surfaces it appears locally to be much harder, though this is not a universal peculiarity. At different horizons in the formation layers of grayish or bluish black, very dense, hard chert nodules are commonly found which range in size from 2 to 12 inches in length, 1 to 6 inches in width and 1 to 3 inches in thickness. Locally there are nearly continuous thin chert bands. The dark, flinty chert nodules typically possess an outer rim of white cherty material."

Type section — The type section for the Sedalia Formation was designated by Moore (1928) as the Missouri, Kansas, and Topeka Railroad Sweeney Quarry, SW¼ SW¼ SE¼ sec. 4, T. 46 N., R. 19 W., Cooper County, Missouri, Clifton City 7½' Quadrangle (fig. 40). Moore (1928, p. 151-152) described the type section of the Sedalia as follows:

Section at Sweeney, Cooper County [Missouri]. Sec. 4, T. 46 N., R. 19 W.

	Thickness Feet	Inches
Osage group		
Burlington Limestone (Lower)		
19. Limestone, bluish gray, coarse crystalline, crinoidal, very massively bedded	35	
Sedalia limestone		
18. Limestone, light bluish to bluish gray, fine-grained, uniform, lower part thin bedded, upper part massive, upper surface very even. Contains fossils. [Pierson Limestone]	3	1

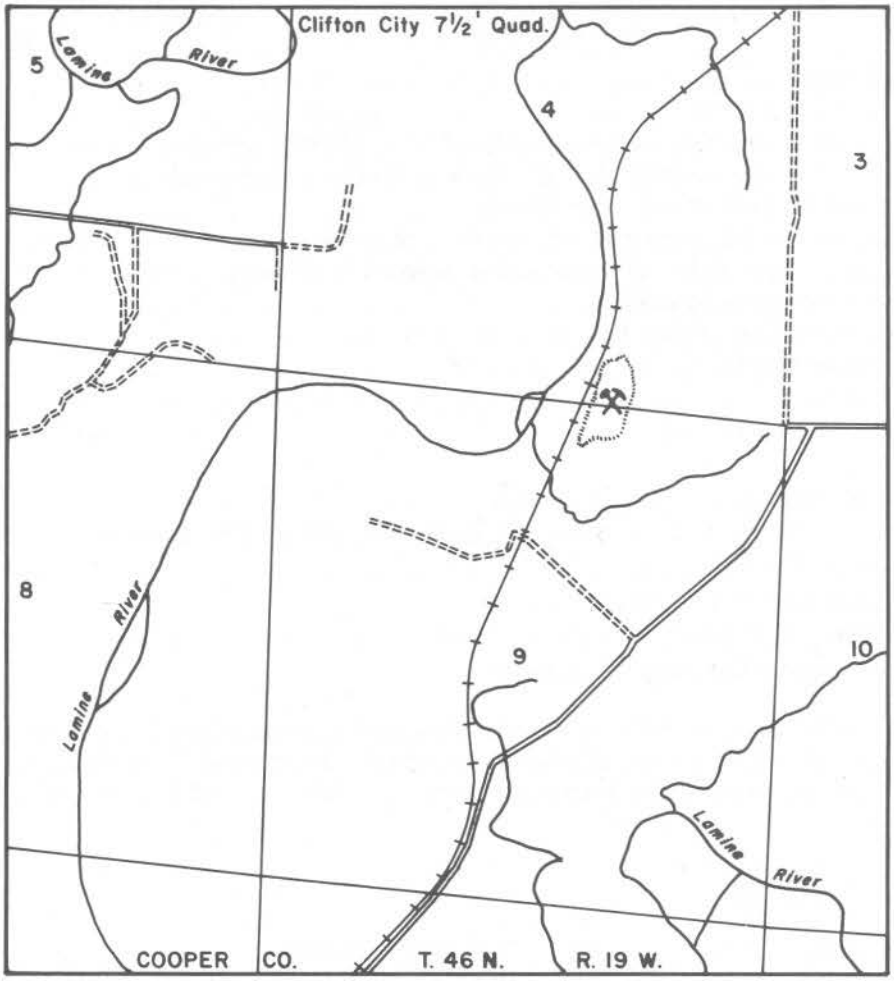


Figure 40. *Part of the Clifton City 7½' Quadrangle, showing location of the type section of the* **Sedalia Formation,** *in the Sweeney Quarry, Cooper County, Missouri.*

		Thickness Feet	Thickness Inches
17.	Shale, light bluish to yellowish, calcareous, sandy, especially toward bottom. [Northview Formation]		11
16.	Limestone, light blue, lighter and more greenish than beds below, arenaceous. Appears to rest with slight disconformity upon the eroded surface of the subjacent limestone. Greatest thickness	1	6
15.	Limestone, light blue when fresh weathering to brown, dolomitic, and siliceous, very massive, uniform texture, fracture subconchoidal. Marked by fine stylolites at intervals. The upper surface apparently eroded and markedly uneven to the extent of 9 inches	2	3
14.	Shale parting, dark bluish		0.5
13.	Limestone like 15 with large chert bluish black flinty nodules with thin white rims, larger in size in the lower part of the bed	6	8
12.	Shale, calcareous, a prominent parting on weathered surface		1
11.	Limestone and chert like 13. The chert occurs in nodules and irregular, discontinuous bands throughout the zone. It is very fossiliferous, especially in the upper part, being crowded with the remains of bryozoans and other fossils	9	3

		Thickness	
		Feet	Inches
10.	Shale parting		0.5
9.	Limestone like 15		8
8.	Chert, white, in thin, continuous band. The chert resembles a very siliceous limestone rather than the dark flint, and contains many poorly preserved bryozoans and other fossils		0.75
7.	Limestone, like 15. Very massively bedded. Marked by innumerable fine, horizontal lines which on weathering stand out in relief because of greater resistance to erosion	15	
6.	Chert, dark bluish, flinty, in thin persistent band		3
5.	Limestone, like 15	1	10
4.	Shale parting		2
3.	Limestone like 15	1	9
Kinderhook group			
Chouteau limestone [Compton Limestone]			
2.	Limestone, bluish drab, very compact, dense, fine-grained, breaking with conchoidal fracture	25	8
Sylamore sandstone [Bachelor Formation]			
1.	Sandstone, light green, calcareous, shaly		2-5
Devonian limestone [Callaway Limestone]			

A nearly identical section in Pettis County, Missouri, approximately 6 mi north of the town of Sedalia, is illustrated in figure 28, which was based on roadcuts on U.S. Highway 65 (Sedalia East 7½′ Quadrangle), just west of the section described by Beveridge and Clark (1952, p. 18) in the old T. & O. Quarry.

History of nomenclature —

1855	Swallow	Upper Chouteau Limestone
(not) 1892	Vogdes	Sedalia limestones (= Compton Limestone)
(not) 1902	Weeks	Sedalia limestone (Vogdes, 1892; = Compton Limestone)
	various authors	Chouteau limestone (or formation; part)
1928	**Moore**	**Sedalia limestone** ("Osagean in age"; part)
1933	Moore	Sedalia formation
(not) 1937	Laudon	Sedalia limestone (= Fern Glen or Meppen Formation)
1938	McQueen & Greene	Sedalia formation ("Osagean in age")
1944	Branson (a)	Sedalia member of Chouteau formation
1950	Kaiser	Sedalia dolomite
1952	Beveridge & Clark	Sedalia formation of Chouteau group
1961	Spreng	Sedalia formation
(not) 1962	Collinson et al.	"Sedalia" formation (in Illinois; Osagean in age; = Meppen Limestone Member of Fern Glen Formation)
1979	Thompson (a)	Sedalia Formation (of Chouteau Group)

Remarks — The best discussion of the present state of understanding of the Sedalia Formation was by Koenig (1961a, p. 79), who stated,

"Another formation in the Illinois-Missouri area of the Lincoln fold which has given rise to a good bit of lively discussion in years past is the Sedalia formation. In central Missouri where the formation was originally defined, the formation is a brown to buff dolomitic limestone and it underlies the Northview formation which is a silty shale. The age of the Sedalia, as well as that of the Northview, is now considered by Missouri geologists to be Kinderhookian, but when it was defined by Moore in 1928 (p. 149) the Sedalia was thought to be Osagean in age.

Overlying the Northview in central Missouri, there is a thin unit of yellowish-buff dolomitic limestone which can be traced into southwestern Missouri where it thickens and is named the Pierson formation which faunally has proven to be Osagean in age. It is believed that this same unit of central Missouri extends eastward and northward into the Lincoln fold area where it is tentatively recognized as the brown dolomitic limestone bed at the base of the Burlington formation. It is possible, therefore, that the unit, which is designated as "Sedalia" in Illinois, may be the equivalent of what is thought to be an extension of the Pierson into northeastern Missouri."

Moore's original description of the Sedalia included all strata in the type Chouteau region between his "Chouteau (restricted)" (Swallow's "2nd" unit: the Compton Limestone and "unnamed limestone") and the Burlington Limestone ("Encrinital limestone" of Swallow) (fig. 29). This included the upper half to two-thirds of Swallow's Chouteau, the thin Northview shale, and the lower dense, brown limestone beds of the Osagean Series; the latter are now called the "brown beds of the Burlington," or Pierson Limestone. Beveridge and Clark (1952) redefined the Sedalia to include only the "1st" unit of Swallow's Chouteau, above the "Sedalia-Compton transition beds" ("unnamed limestone") and below the Northview shale (fig. 28). Moore's upper Sedalia was identified as Pierson.

As stated by Spreng (1961, p. 57),

"The Sedalia is typically a medium to thickly bedded, finely crystalline, dolomitic and siliceous limestone. It is less crinoidal than the Compton. When fresh, the limestone is gray to bluish

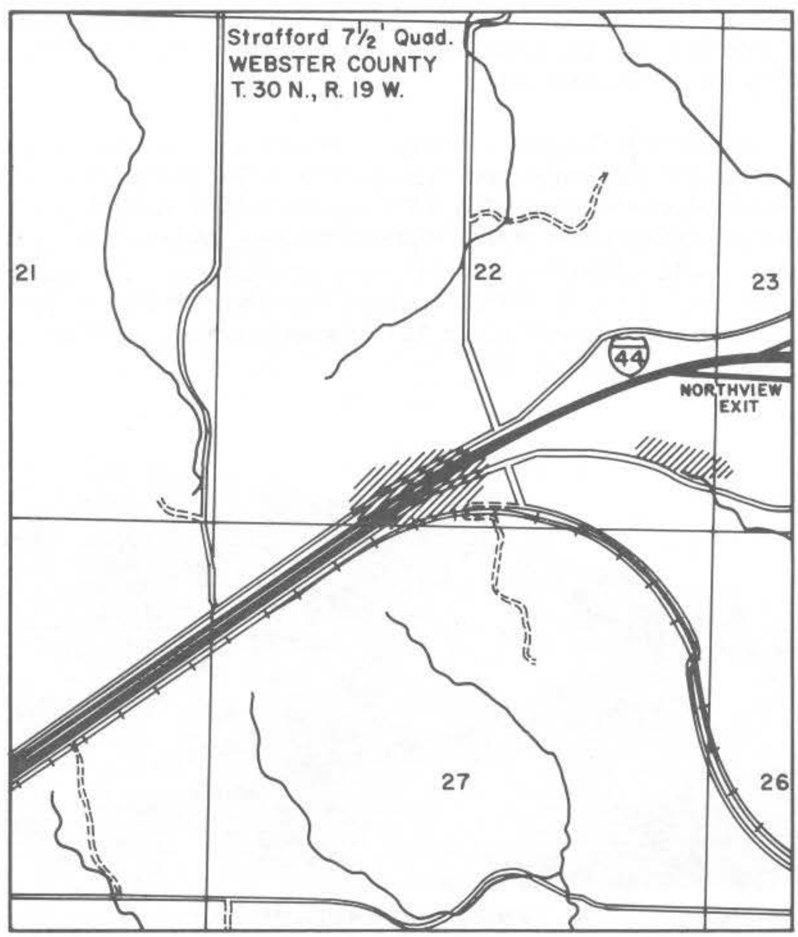


Figure 41. *Part of the Strafford 7½' Quadrangle, showing the locations of the two parts of the type section of the* **Northview Formation**, *as proposed by Beveridge and Clark (1952), Webster County, southwestern Missouri.*

gray, but it weathers to shades of brown and buff, and its exposed surfaces become smooth and rounded. Calcite-filled vugs occur in the upper part. Bluish-gray to bluish-black, white-rimmed chert is diagnostic of the Sedalia.

"The maximum thickness of the Sedalia formation in west-central Missouri is about 50 feet. Southward from Pettis County, it thins and gradually interfingers with the overlying Northview shales and siltstones. Sedalia type lithology can be identified as far south as Cedar County; beyond, it is absent or unrecognizable. East of Pettis County, the Compton and Sedalia formations are not readily distinguished because of their interfingering relations."

Northview Formation

Weller, 1901

Original description — (Weller, 1901, p. 140) "In the older geological reports these beds have been known as the Vermicular sandstone and shales from the abundance of worm burrows which occur in the sandstones.

"The sandstones of the formation are abundantly fossiliferous near Northview, in the western edge of Webster County, and therefore this name is suggested for the formation.

"Shephard's investigations have shown that the formation has a thickness ranging from ten to ninety feet. It is typically made up of two members, a lower bluish shale and an upper fine-grained yellowish sandstone. The two members of the formation grade from one into the other with no sharp line of separation, and one member is frequently thickened at the expense of the other, the lower shale member being the most persistent."

Type section — Weller (1901) originally named the Northview from exposures near Northview, Webster County, Missouri. Beveridge and Clark (1952, p. 74) designated as type section the composite of two sections, one in SW¼ SW¼ SW¼ sec. 23, T. 30 N., R. 19 W., on what they thought would be the south (eastbound) lane of U.S. Highway 66 (now Webster County road B); the other exposure, the upper part of the Northview, was exposed on what is now the eastbound lane of I-44, in NE¼ SE¼ SE¼ sec. 22, T. 30 N., R. 19 W., Strafford 7½' and Marshfield 7½' Quadrangles (fig. 41). As reported by Thompson and Fellows (1970, p. 17), new construction on I-44 completely obliterated the upper part of the type section (fig. 42).

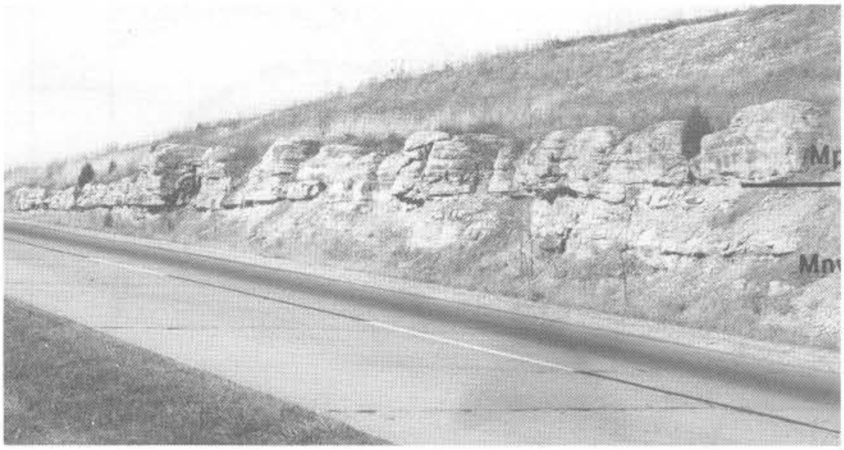


Figure 42. *Upper portion of the type section of the* **Northview Formation** *(Mnv), before destruction by highway construction in 1969, beneath the Pierson Limestone (Mp) in roadcut on I-44, near the town of Northview, Webster County, Missouri. Photograph by T.L. Thompson.*

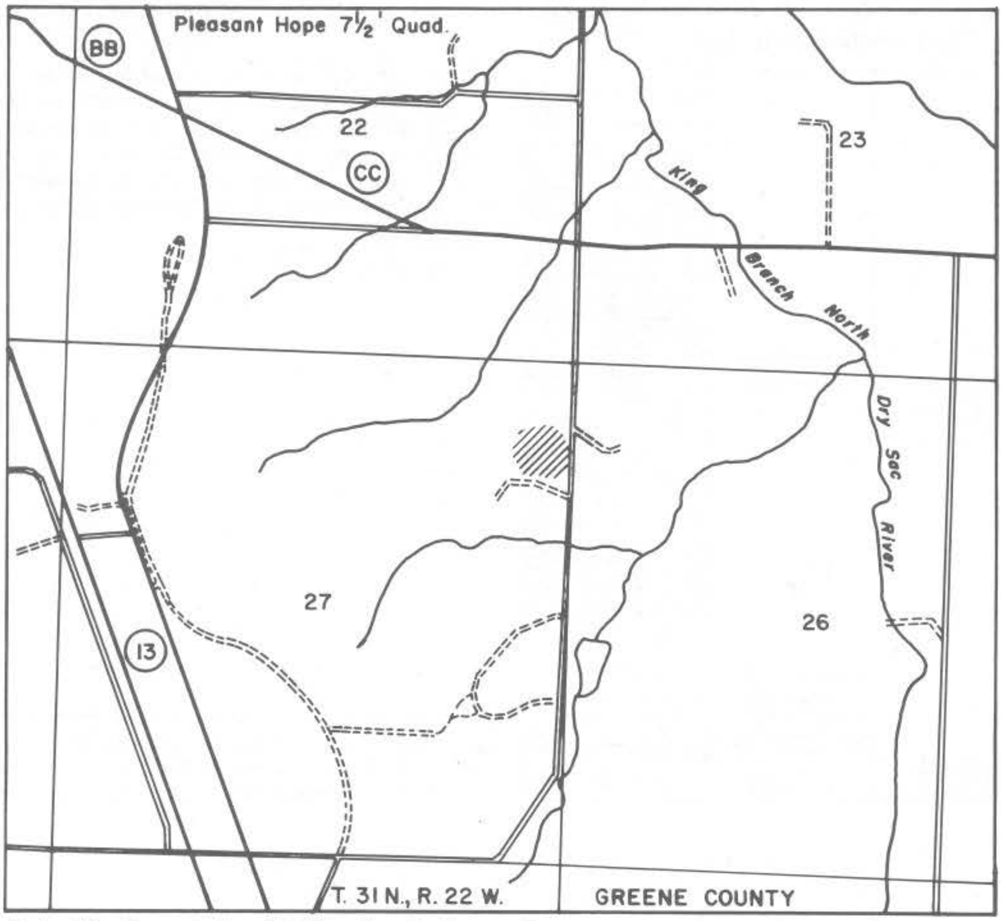


Figure 43. *Part of the Pleasant Hope 7½' Quadrangle, Greene County, southwestern Missouri, showing location of King Butte (see figs. 44 and 45).*

Reference sections — Because of the destruction of the type section, the exposure at King Butte, Greene County, Missouri is designated a principal reference section for the Northview Formation (fig. 43). Here, nearly 60 ft of Northview are exposed (figs. 44 and 45). This section, approximately 15 mi northwest of the original type section, is located in the SE¼ NE¼ NE¼ sec. 27, T. 31 N., R. 22 W., Pleasant Hope 7½' Quadrangle, and was described by Clark and Beveridge (1952, p. 39).

Another excellent complete exposure of the Northview Formation in the "Northview basin" is in a roadcut on Missouri Highway 123, southwest of the town of Aldrich, Polk County, Missouri, NE¼ SE¼ NE¼ sec. 4, T. 32 N., R. 24 W., Aldrich 7½' Quadrangle (figs. 46 and 47).

Two other sections illustrate the Northview as a dolomitic silstone or silty dolomite. One is a roadcut on U.S. Highway 65 in Christian County, Missouri (fig. 33); SW¼ SW¼ NE¼ and NW¼ NW¼ SE¼ sec. 22, T. 25 N., R. 21 W., Day 7½' Quadrangle (Thompson and Fellows, 1970, section M, p. 180). The other, with approximately 6 ft of silty dolomite, is a roadcut on I-44, near Mt. Vernon, Lawrence County, Missouri (figs. 34 and 48), NW¼ NE¼ SE¼ sec. 7, T. 28 N., R. 25 W., Halltown 7½' Quadrangle (Thompson and Fellows, 1970, section J, p. 170). The Northview at these two sections is described under "Compton Limestone."

A section illustrating the Northview as an argillaceous limestone is in the quarry at Lanagan, McDonald County, Missouri, on the east side of County Road EE (figs. 49 and 50), NW¼ SE¼ NE¼ sec. 36, T. 22 N., R. 33 W., Noel 7½' Quadrangle (Thompson and Fellows, 1970, section K, p. 173-176). A similar section is in Baird Mountain Quarry, near Table Rock Dam (fig. 22), Taney County, Missouri, SW¼ NW¼ sec. 26, T. 22 N., R. 22 W., Table Rock Dam 7½' Quadrangle (Thompson and Fellows, 1970, section B, p. 153).

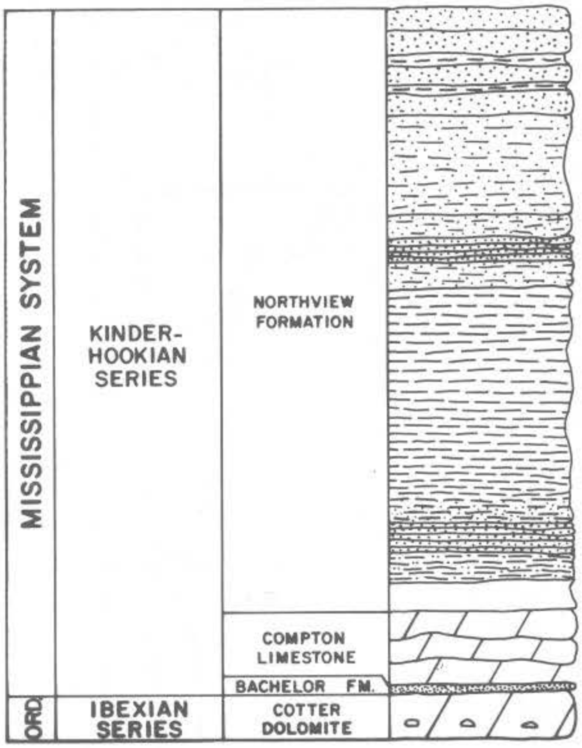


Figure 44. *Columnar section of* **Northview Formation** *exposed at King Butte, SE¼ NE¼ NE¼ sec. 27, T. 31 N., R. 22 W., Pleasant Hope 7½' Quadrangle, Greene County, Missouri. This is designated a Principal Reference Section for the Northview Formation. Adapted from Clark and Beveridge (1952, fig. 13).*

Figure 45. *Exposure of* **Northview Formation** *at topographic feature known as King Butte (fig. 44), a reference section for the Northview, in Greene County, Missouri. Photograph by T.L. Thompson.*

Figure 46. *Part of the Aldrich 7½' Quadrangle, showing location of a thick section of* **Northview Formation** *in a roadcut on Missouri Highway 123, Polk County, Missouri.*

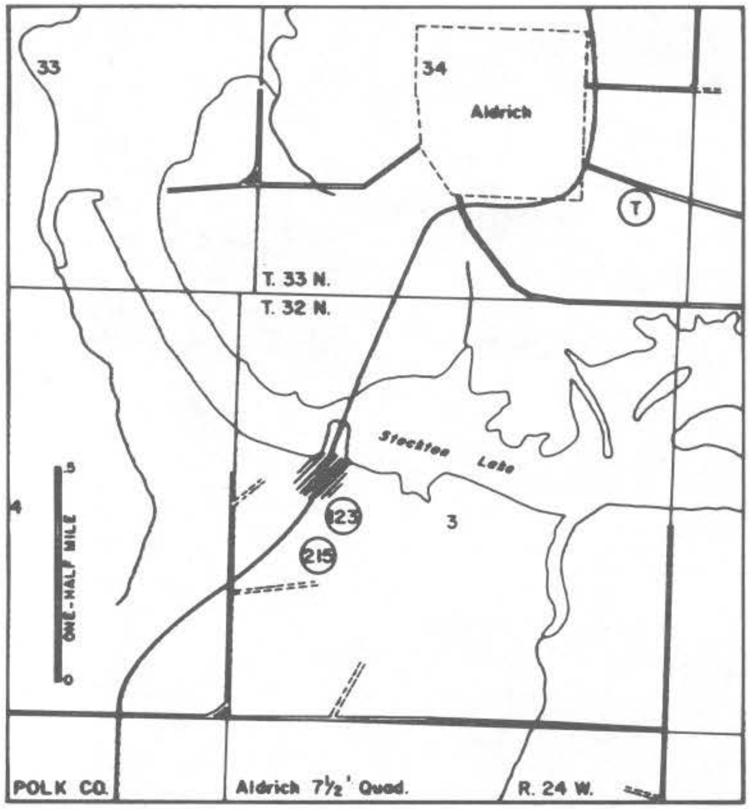
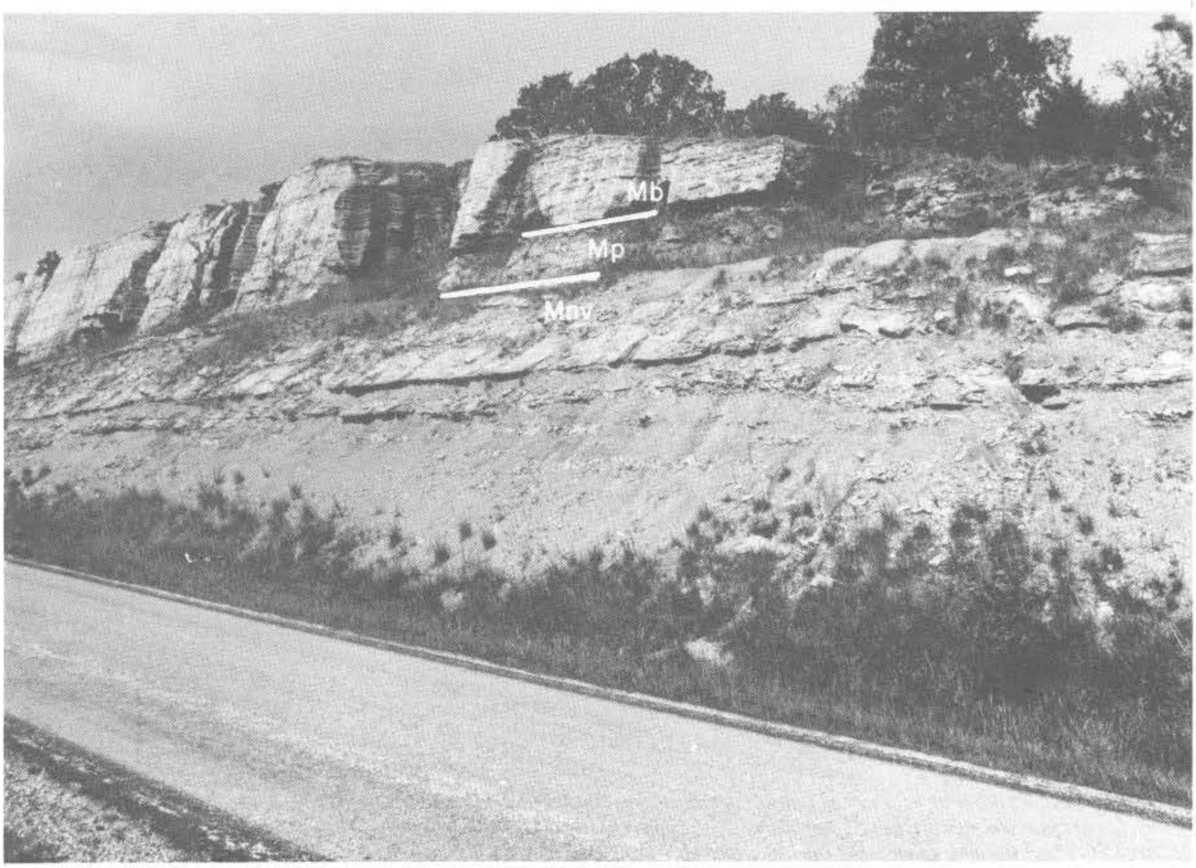


Figure 47. *Nearly complete exposure of the* **Northview Formation** *(Mnv), a reference section for the Northview, in a roadcut on Missouri Highway 123, 1 mi south of Aldrich, Polk County, Missouri (fig. 46). (Mp) = Pierson Limestone; (Mb) = Burlington Limestone. Photograph by T.L. Thompson.*



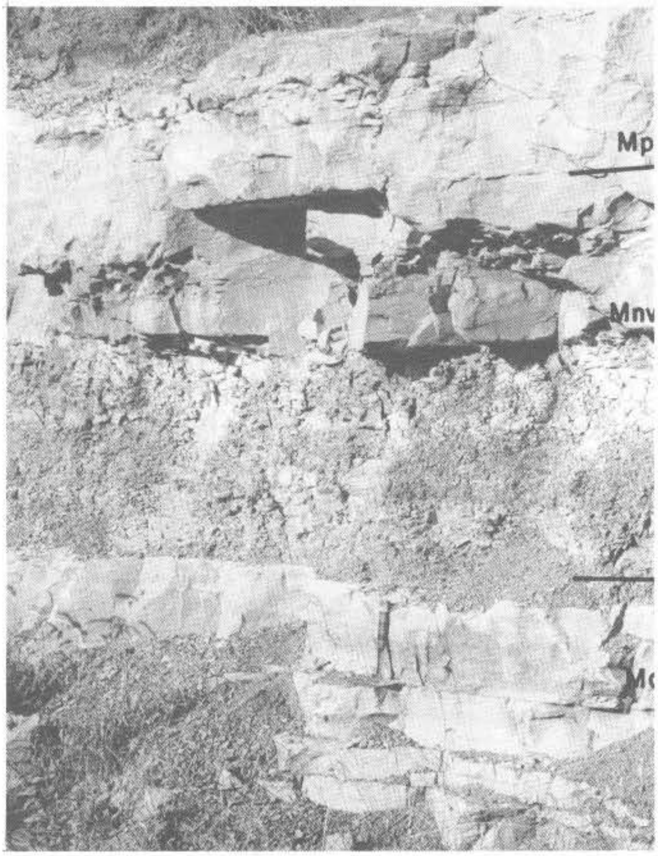


Figure 48. *The Compton Limestone (Mc),* **Northview Formation** *(Mnv), and Pierson Limestone (Mp) in a roadcut on the west-bound lane of I-44 (fig. 34), 7 mi east of Mt. Vernon, NW¼ NE¼ SE¼ sec. 7, T. 28 N., R. 25 W., Halltown 7½' Quadrangle, Lawrence County, Missouri. Photograph by T.L. Thompson.*

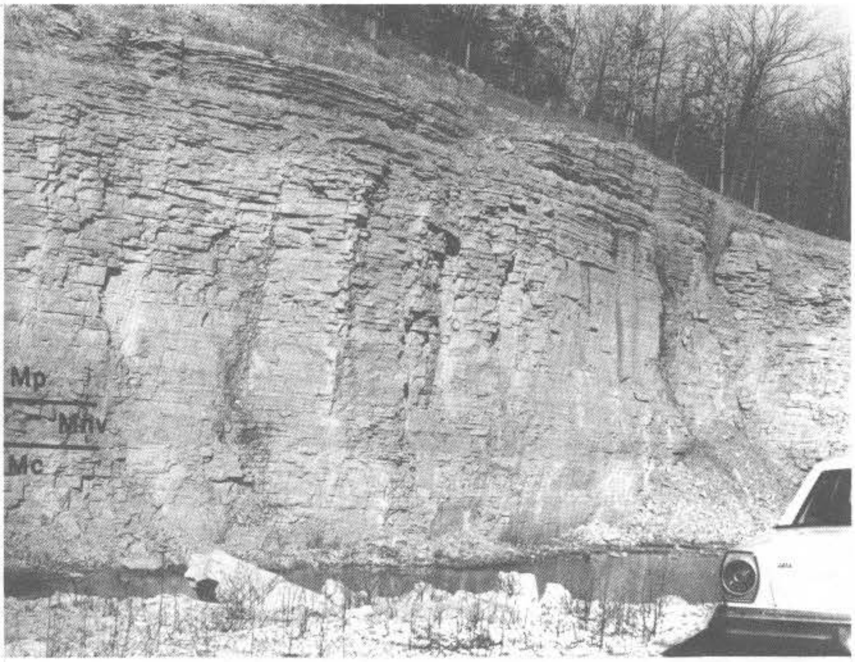
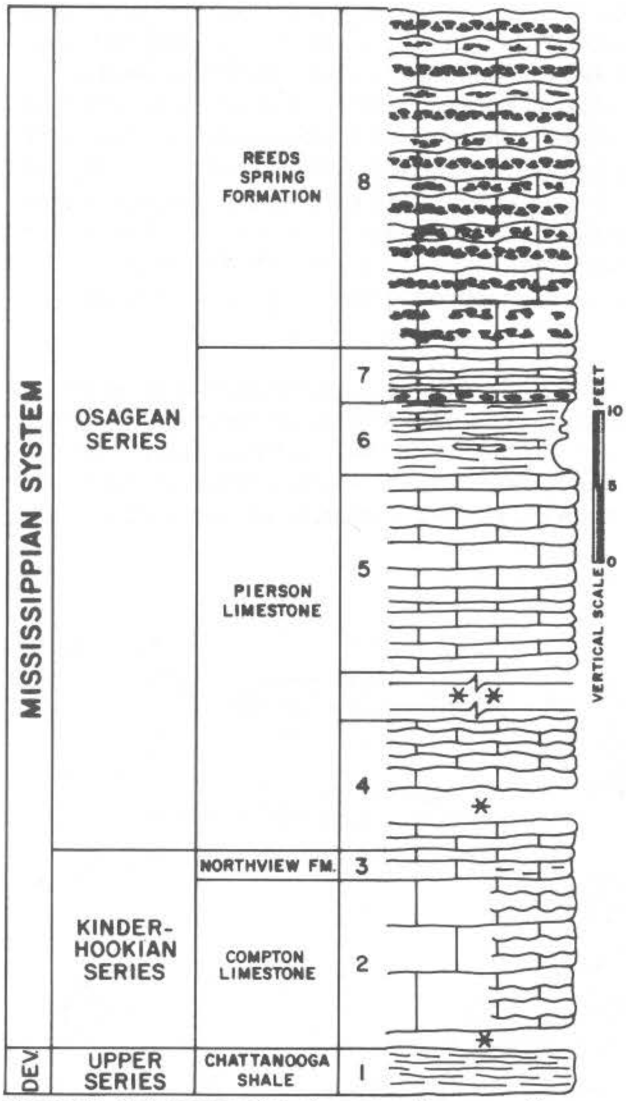


Figure 49. *Lower face of the quarry at Lanagan, containing the argillaceous limestone facies of the* **Northview Formation** *(Mnv) between the underlying Compton (Mc) and overlying Pierson (Mp) Limestones, NE¼ NE¼ sec. 36, T. 22 N., R. 33 W., Noel 7½' Quadrangle, McDonald County, Missouri. Photograph by T.L. Thompson.*



8. Limestone (50-70%), gray to dark-gray in upper part, brownish-gray in lower part, finely crystalline, brittle, in nodules and nodular beds 6 in. to 1 ft thick. Chert, blue-black, in beds and nodules within limestone beds, weathers brown to white. (22 ft)

7. Limestone, brown to brownish-black, very finely to medium-crystalline to crinoidal; lenses of crinoid columnals; middle 1 ft 9 in. argillaceous; some lenses of sublithographic limestone. Chert, blue-black, as discontinuous nodular 1-in. band near base. (3 ft 10 in.)

6. Shale, yellow-brown, calcareous, semicrinoidal, very fossiliferous; contains soft brownish-black limestone nodules and stringers; top of unit at lowest chert. (5 ft)

5. Limestone, gray to greenish-gray, medium-crystalline to semicrinoidal, in even 1-ft beds; nodular toward top. (13 ft)

Covered interval. (7 ft)

4. Limestone, gray-brown, very finely crystalline at top, grading to medium-crystalline at base; 2- to 3-in. nodular beds upper 3 ft, 4- to 6-in. beds lower 2 ft. (8 ft 10 in.)

3. Limestone, green to green-gray to dark-gray-green to brown, finely to medium-crystalline, argillaceous, numerous green shale partings; upper 1 ft in 4- to 6-in. beds with pyrite inclusions; single bed lower 1 ft 3 in. (2 ft 1 in.)

2. Limestone, gray-green to gray, medium- to coarsely crystalline, massive when fresh, weathers to uneven 0.5-in. incipient beds; lower 4 ft finely crystalline; base not exposed. (10 ft)

1. Shale, black, fissile, forms floor of quarry.

Figure 50. *Columnar section of exposure in quarry at Lanagan, 0.75 mi south-southeast of Lanagan on east side of County Road EE, SW¼ NE¼ NE¼ sec. 36, T. 22 N., R. 33 W., Noel 7½' Quadrangle, McDonald County, southwestern Missouri. Included are the Compton, Northview, Pierson, and Reeds Spring formations. Adapted from Thompson and Fellows (1970, sec. K, p. 173-176).*

History of nomenclature —

1855	Swallow	Vermicular Sandstone and Shales
1898	Shephard	Hannibal shale
1899	Weller	"Vermicular sandstone at Northview"
1901	**Weller**	**Northview sandstone and shale**
1902	Keyes	Hannibal shale (southwestern Missouri)
		St. Joe marble (middle part)
1905	Weller	Northview sandstone
1944	Branson (a)	Northview member of Chouteau formation
1952	Beveridge and Clark	Northview formation of Chouteau group (central and west-central Missouri)
		Northview formation of St. Joe group (southwestern Missouri)
1961	Spreng	Northview formation of Chouteau group
1967	Yochelson & Saunders	Northview Shale ("Vermicular Sandstone at Northview")
1970	Thompson & Fellows	Northview Formation (1 member)

Remarks — In its type area in Greene and Webster Counties, southwestern Missouri, the Northview Formation is about 80 ft thick and divisible into two parts: a lower predominantly blue to bluish-green shale and an upper predominantly blue to brown siltstone with subordinate shale. The formation is locally fossiliferous. In the type region fossils are mostly internal molds of brachiopods, composed of pyrite and limonite. Earlier reports called this formation the "Vermicular sandstone and shale," from the presence of tubular perforations (worm burrows) and abundant "rooster tail" markings (*"Taonurus caudagalli,"* or *Zoophycus*). These features are similar to those in the Hannibal Shale of northeastern Missouri. Fossils in the Northview of central Missouri are restricted to worm burrows in the siltstones and to solitary corals, but a more varied fauna is in the Northview at King Butte (see **Reference sections**) and in the argillaceous limestone facies of the Northview, near the Arkansas-Missouri boundary.

The Northview extends from the Missouri River in central Missouri southward into Arkansas. Its maximum thickness of 80 to 90 ft is along the "Northview basin," which trends northwestward from Greene to Barton County (fig. 51). North of Cedar County, the Northview thins rapidly and interfingers with the uppermost beds of the underlying Sedalia Formation. In the Missouri River area, only 6 to 8 in. of Northview separate the Sedalia from the overlying Osagean limestone (Burlington

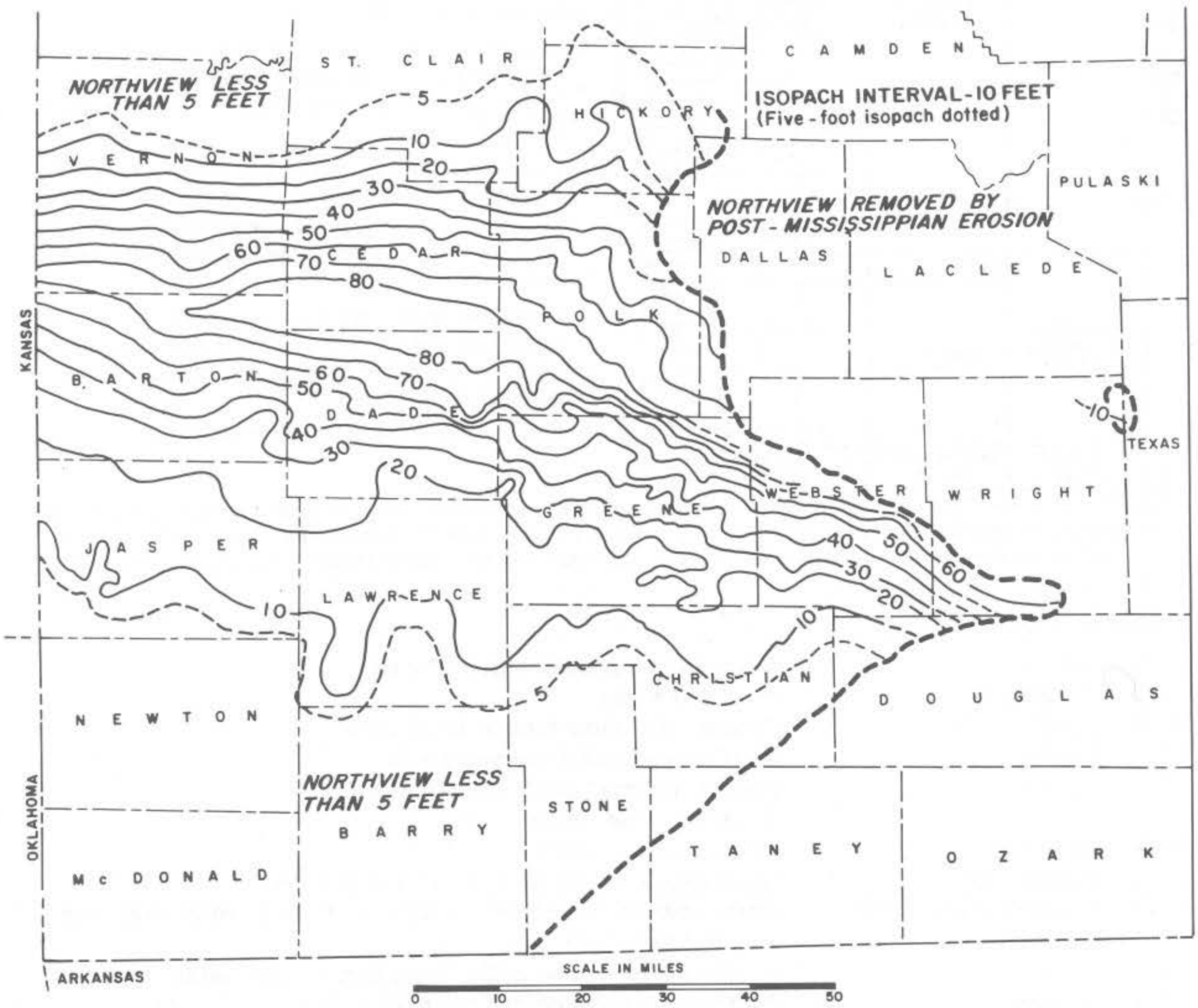


Figure 51. *Isopach map of the* **Northview Formation** *in southwestern Missouri, showing position of the "Northview basin." Adapted from Beveridge and Clark (1952, fig. 3).*

and/or Pierson). South of the "Northview basin" the Northview thins rapidly to 4 to 6 ft of bluish dolomitic siltstone and silty dolomite.

Thompson and Fellows (1970) noted that the Northview becomes more calcareous southward from the type section. South of an east-west line of Waulsortian mounds in the underlying Compton Limesotne, near the Missouri-Arkansas border (Manger and Thompson, 1982), the Northview becomes a 1- to 5-ft thick greenish-gray argillaceous limestone, a limestone facies of the Northview which decreases in thickness southward in Arkansas and Oklahoma to around 3 in. in the extreme southern part of its extent. In the region of the argillaceous limestone facies, the Northview can be distinguished from the Compton by the higher clay content of the former, and by the rapid breakdown of the Northview upon weathering, leaving a reentrant between the Compton and Pierson limestones (fig. 52).

Near the Missouri-Arkansas border, the grayish-green Northview calcareous shale (or argillaceous limestone) is capped by a dark-red fossiliferous argillaceous limestone 1 to 3 ft thick. Conodonts (*Siphonodella cooperi hassi-Gnathodus punctatus* Zone; Thompson and Fellows, 1970) indicate it is latest Kinderhookian and younger than the uppermost Northview to the north (table 2). Because this thin unit is transitional with the Northview beneath it and distinctly older than the immediately overlying Osagean Pierson Limestone (containing *Polygnathus communis carinus*), it was designated the **Baird Mountain Limestone Member of the Northview Formation** by Thompson and Fellows.

In northern Arkansas, the Compton, Northview, and Pierson sequence is defined as the **St. Joe Limestone Member of the Boone Formation.** In Arkansas and Oklahoma, the thin argillaceous zone identifying the Northview can be recognized nearly as far south as the extent of the St. Joe Limestone. At the extreme southern limits of St. Joe deposition, the entire St. Joe may be only 6 to 8 in. thick, and the Northview horizon is not identified, probably due to lack of terrigeneous sediment.

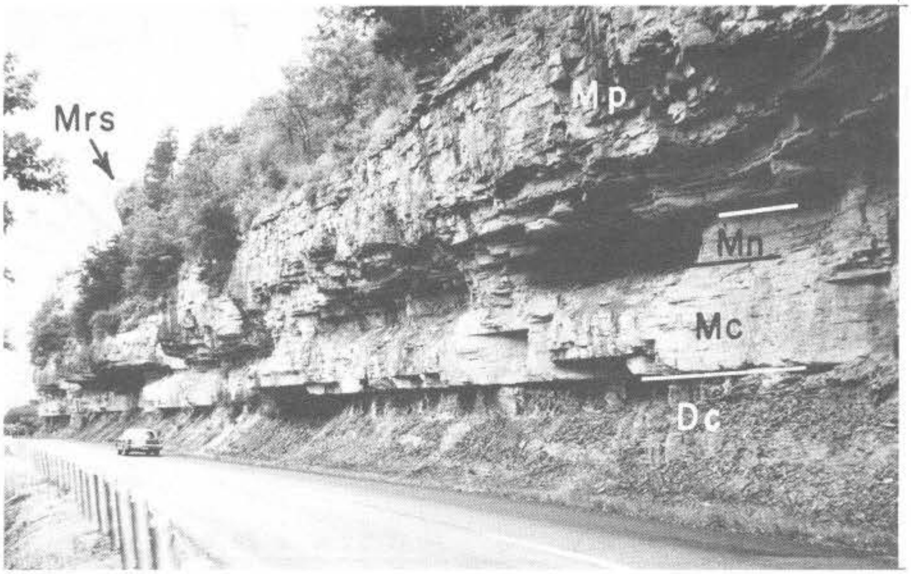


Figure 52. ***Roadcut on Missouri Highway 59 about 1 mi north of Noel, McDonald County, southwestern Missouri, of Chattanooga Shale (Dc) beneath the lower Mississippian Compton (Mc), Northview (Mn), and Pierson (Mp) carbonates, capped by the Reeds Spring Formation (Mrs). Northview is identified as 2-3 ft reentrant in overhanging bluff. Photograph by T.L. Thompson.***

Baird Mountain Limestone Member of Northview Formation

Thompson and Fellows, 1970

Original description — (Thompson and Fellows, 1970, p. 21) "The Baird Mountain can usually be subdivided into two portions, a lower thin-bedded 1-inch to 1-foot limestone with finely crystalline matrix and abundant small crinoid ossicles, and an upper foot or so of slabby-bedded argillaceous limestone. Both units are brick red."

Type section — The Baird Mountain Limestone Member was named from a large quarry on Baird Mountain (fig. 22), immediately south of Table Rock Lake dam, SW¼ NW¼ sec. 26, T. 22 N., R. 22 W., Taney County, Missouri, Table Rock Dam 7½' Quadrangle (figs. 53 and 54). The type section of the Baird Mountain Limestone Member of the Northview Formation (fig. 22) was described by Thompson and Fellows (1970, p. 153-156).

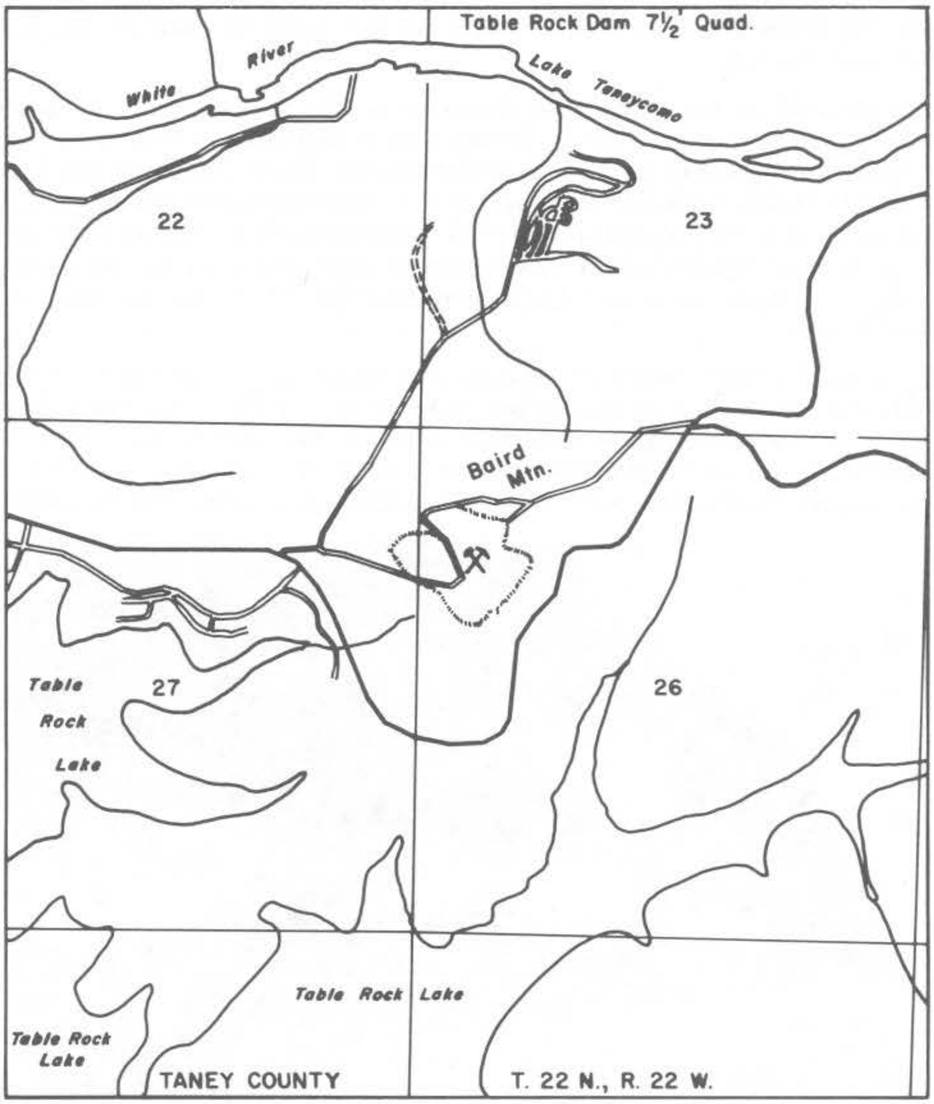


Figure 53. *Part of the Table Rock Dam 7½' Quadrangle, showing location of the type section of the* **Baird Mountain Limestone Member of the Northview Formation,** *in Taney County, southwestern Missouri.*

Remarks — The Baird Mountain Limestone Member of the Northview Formation has been recognized only in the southern part of southwestern Missouri, and northwestern Arkansas. Characteristically a red argillaceous, fossiliferous limestone, usually 1 to 2 ft thick, it is quite distinct from the greenish-gray argillaceous limestone below and the red and gray mottled limestone of the Pierson above (fig. 22). Branson (1944a) had previously noted thin, red Fern Glen-like Northview members in Stone and Barry Counties.

The unit is recognized as neither Northview, as usually defined, nor Pierson, but as a wedge of upper Kinderhookian sediment truncated to the north by erosion before deposition of basal Osagean Pierson strata. Conodont studies (Thompson and Fellows, 1970) determined that in its normal occurrence, the Baird Mountain Limestone is everywhere younger than the Northview Formation, but older than the basal Osagean Pierson Limestone. In Missouri the Baird Mountain is the only rock unit known to be in the uppermost Kinderhookian *Siphonodella cooperi hassi-Gnathodus punctatus* Zone (table 2). The top of the Baird Mountain marks the top of the Kinderhookian Series.

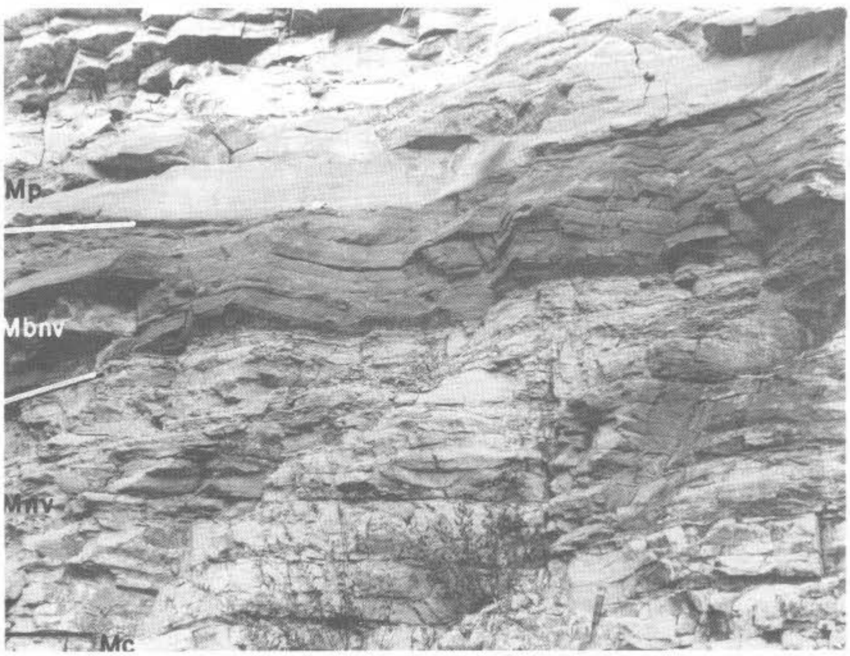


Figure 54. *Lower part of the Baird Mountain quarry, Taney County, southwestern Missouri, showing* **Compton Limestone** *(Mc), Northview Formation (Mnv),* **Baird Mountain Limestone Member of the Northview Formation** *(Mbnv, at its type section), and basal Pierson Limestone (Mp). Photograph by T.L. Thompson.*

Chouteau Limestone undifferentiated

Reference section — An excellent exposure of the "Chouteau Limestone undifferentiated," a crystalline, crinoidal phase of the usually finer crystalline Chouteau, is just below the Clarence Cannon Dam, on either side of the valley of the Salt River, SE¼ sec. 22 and NE¼ sec. 27, T. 55 N., R. 7 W., Ralls County, northeastern Missouri, Joanna 7½' Quadrangle.

Another section of this unit is at Buzzard Cave (Koenig and Martin, 1961, p. 22-24) in the NE¼ SW¼ NW¼ sec. 5, T. 53 N., R. 4 W., Pike County, northeastern Missouri (fig. 31).

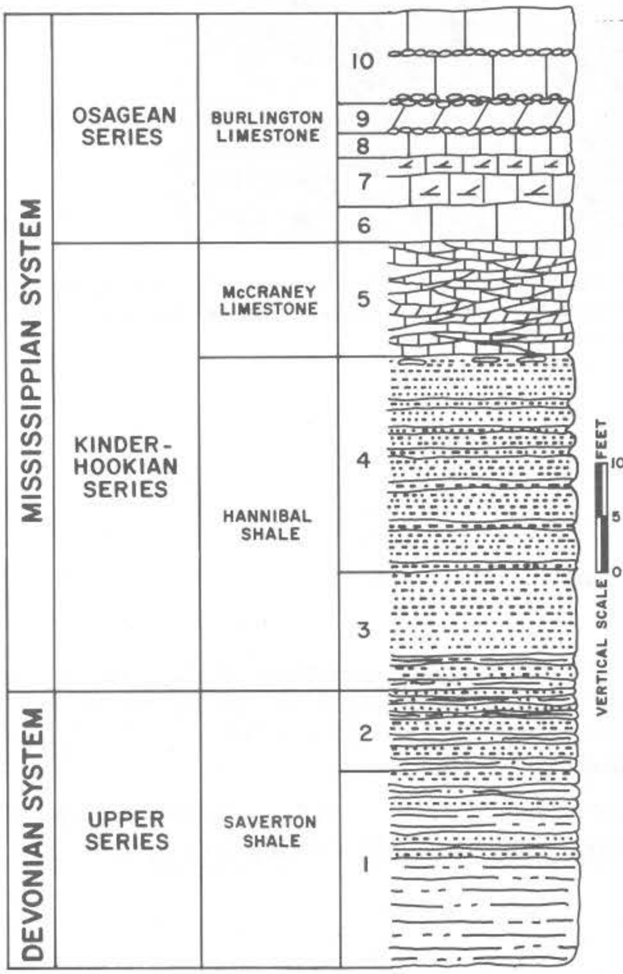
History of nomenclature —

1961	Koenig et al.	Chouteau group undifferentiated ("Chouteau limestone")
1967	Frey	Buzzard's Cave facies of Chouteau Limestone

Remarks — In portions of northeastern Missouri, there are strata of the Chouteau Group identified only as "Chouteau Group undifferentiated" or "Chouteau Limestone." These rocks are not lithologically part of the Compton, Sedalia, or "unnamed limestone," but constitute two distinct, separate limestone formations within the Chouteau Group. One of them closely resembles the McCraney Limestone of western Illinois, and is discussed under "McCraney Limestone."

Lithologically the other Chouteau limestone is mostly finely to medium crystalline, even bedded, and very fossiliferous, often crinoidal (fig. 31). In sharp contrast, the "McCraney Limestone" is a very irregularly to wavy bedded, fine-grained mudstone, with scattered pockets of fossils. At some sections in the vicinity of the Lincoln arch, in Pike and Ralls Counties, the Chouteau is represented only by the crystalline limestone; at other sections, the crystalline limestone is overlain by the "McCraney Limestone."

The finely to medium-crystalline limestone is massively bedded and very fossiliferous, containing most or all of the taxa "representative" of the Chouteau. In some places this lithology is the only representative of the Chouteau Group; in others it is overlain by the "McCraney Limestone." This crystalline facies, which is from 10 to 40 ft thick, appears to be restricted to the region of the Lincoln fold, from Knox to Ralls and Pike Counties, in northeastern Missouri. It is a distinct, identifiable facies of the complex carbonate sequence called "Chouteau," and will soon become a named formation of the Chouteau Group.



10. Limestone, light-buff, massive, coarsely crinoidal. Chert, light-buff to white. (8 ft)
9. Dolomite, buff, fine-grained to crinoidal. (2 ft)
8. Limestone, very light-gray, coarsely crinoidal. (1 ft)
7. Limestone, light-buff, dolomitic, crinoidal. (3 ft)
6. Limestone, very light-gray to light-buff, crinoidal. (4 ft)
5. Limestone, gray to brownish-gray, lithographic to sublithographic, weathers very light-gray; irregularly interbedded with buff, silty dolomite; numerous calcite vugs. (10 ft)
4. Siltstone, buff, massive, calcareous and slightly vermicular in uppermost few feet. Intergrades with overlying limestone. Shaly beds form reentrants in outcrop that may in some places contain silty shale. (20 ft)
3. Siltstone, blue-gray to buff, very massive; upper 3 in. marked by blue-gray zone. Lowermost 3 ft especially vermicular, pyritic and fossiliferous. Casts of brachiopods and pelecypods. (10 ft)
2. Siltstone, blue-gray to buff, argillaceous; indistinctly alternating with silty shale beds. (8 ft)
1. Shale, greenish-gray, very silty, pyritic. Poorly exposed on slope below main outcrop. (20 ft)

Figure 55. *Columnar section of the type section of the* **McCraney Limestone**, *SE¼ SE¼ sec. 14, T. 4 S., R. 7 W., Pike County, west-central Illinois. Adapted from Collinson et al. (1979, p. 26).*

"McCraney Limestone"
Moore, 1928

Original description — (Moore, 1928, p. 51) "For reasons presented in the discussion of correlation the compact, bluish drab limestone . . . which occurs at the top of the Kinderhook section at Kinderhook, Illinois, is regarded as a member (McKerney) of the Hannibal formation. This limestone which is fine-grained and breaks with a sharp conchoidal fracture, is not known in Missouri."

Type section — Moore named the McCraney ("McKerney") Limestone from exposures in bluffs on the east side of the Mississippi River Valley, immediately north of the town of Kinderhook, on the north and south sides of the mouth of McCraney Creek (fig. 55), SW¼ NW¼ and SE¼ SE¼ sec. 14, T. 4 S., R. 7 W., Pike County, Illinois, Hull 7½' Quadrangle.

Reference section — The quarry southwest of the town of Newark, Knox County, northeastern Missouri, center S½ SW¼ sec. 23, T. 60 N., R. 10 W., Newark 7½' Quadrangle, is a good section of the "Chouteau Limestone undifferentiated" overlain by the "McCraney Limestone."

History of nomenclature —

1928	**Moore**	**McKerney [sic] member (or beds) of the Hannibal formation (in western Illinois)**
1935	Moore	McKerney [sic] limestone of the North Hill Member of the Hampton formation (in Iowa)
1940	Keyes	McKerney [sic] limestone ("= Earthy ledge of the Burlington limestone")
1949	Thomas	McCraney limestone (in Iowa; Kinderhookian in age)
1961	Scott & Collinson	McCraney formation (in northeastern Missouri)

Remarks — A limestone of peculiar blocky bedding and very dense, compact ("sublithographic") lithology, the McCraney Limestone of western Illinois, was originally considered equivalent to the Louisiana Limestone of northeastern Missouri. Moore (1928), however, recognized that the Louisiana Limestone is beneath the Hannibal Shale and that the then-unnamed McCraney is above the Hannibal and directly beneath the Burlington Limestone (fig. 16). For this reason, he designated the unnamed limestone the "McKerney" limestone, as a separate formation (Moore apparently misunderstood "McCraney Creek," from which the name was derived, as "McKerney Creek"). The McCraney of western Illinois was regarded as equivalent to the Chouteau of eastern Missouri. Straka (1968) concluded that the McCraney of Iowa was equivalent to the Hannibal Shale of northeastern Missouri and was below the Chouteau, but no significant conodont or other invertebrate fauna has been recovered from the McCraney to substantiate this. The peculiar lithology suggests that the McCraney may have been associated with evaporite deposition or with other unusual depositional conditions; therefore, a normal marine fauna should not be expected from it.

In Missouri, rocks of McCraney-like lithology, herein called "McCraney Limestone," are known from quarries in northeastern Missouri, where they overlie a crystalline limestone of the "Chouteau Group undifferentiated." These McCraney-like rocks may be related to, or a western continuation of, the restricted McCraney Limestone of western Illinois. The Missouri "McCraney" is more fossiliferous than the latter, but it generally shows the same irregular wavy bedding and is as fine grained as the true McCraney. In Knox County, it lies on the previously described crystalline facies of the Chouteau Group, whereas in Montgomery County it appears to represent the entire Chouteau Group, with a thin Compton Limestone at the base.

Gilmore City Formation
Van Tuyl, 1922

Original description — (Van Tuyl, 1922, p. 113) "Section in Gilmore Portland Cement Company's quarry.

		Feet
5.	Limestone, light gray, fine-grained, thin-bedded, rather soft. Exposed at south end of quarry	4.5
4.	Limestone, compact, gray, dense, fine-grained, brittle, very faintly oolitic, massive	10.5
3.	Limestone as in bed 2 but filled with cylindrical corals	2.5
2.	Limestone, gray, oolitic, compact, brittle	4
1.	Limestone, gray, massive, slightly crinoidal, oolitic, exposed	6"

Type section — The Gilmore City Formation was named from the Gilmore Portland Cement Company quarry, 1.5 mi northwest of Gilmore City (now Midwest Limestone Company quarry) in the SW¼ sec. 36, T. 92 N., R. 31 W., Pocahontas County, Iowa.

Remarks — In the subsurface of northwestern Missouri two oolitic horizons occur in the carbonate section above the basal Mississippian Boice Shale (Hannibal Shale) of Carlson (1963). The lower oolite is in the Compton (Chapin); the upper, above the "Chouteau Group" (Carlson, 1963, p. 6), has been identified as the Gilmore City. The Gilmore City facies is part of the overall Kinderhookian sequence of the "Chouteau Group," but as it is only locally identified in the subsurface of northwestern Missouri, it has not been formally identified in that sequence in Missouri.

OSAGEAN SERIES
Williams, 1891

Original description — (Williams, 1891, p. 169) Williams did not describe this unit, but included it in a list of names.

Type locality — Williams (1891) did not designate a type area for the Osagean Series, although he indicated it was named for the area of the Osage River in west-central Missouri in St. Clair and adjacent counties (fig. 2). Keyes (1892) regarded the vicinity of Osceola, St. Clair County, Missouri as the most typical region for the Osagean.

Kaiser (1950, p. 2157) stated, "The lower two-thirds of the Burlington limestone is the only part of the Osagian [as spelled in some states] represented in the Osceola area. The most complete section is at the Hunt-Ballard quarry about 1 mile west of town in the NE. ¼, NW. ¼, SE. ¼ of Sec. 18, T. 38 N., R. 25 W., (locality 56, Fig. l). The lowest beds are best exposed in a railroad cut in the town of Osceola 2 blocks east of the dam across Osage River. No rocks of Keokuk age are present in the Osceola area. Thus, as Keyes (1892, p. 60) pointed out, the type section of the Osage is not well chosen and contains only a part of the Burlington formation. Nevertheless, the term Osagian has gained wide acceptance and should continue to be used."

History of nomenclature —

1874	Broadhead	Keokuk group
1891	**Williams**	**Osage group**
		Osage age
1893	Keyes	Augusta limestone (part; included all limestone between the top of the Kinderhook group and the base of the St. Louis [now Salem] Formation)
1895	Keyes	Augusta group
	Gordon	Lower series (upper part)
1898	Weller (a, b)	Osage group (excluded Warsaw)
1904	Buckley & Buehler	Tullahoma formation (upper part; recognized up to Ste. Genevieve County, Missouri)
1911	Ulrich	Waverlyan series (upper part)
1915	Girty (b)	Boone limestone
1920	Weller	Iowa series (middle part)
1940	Weller & Sutton	Iowa Series (middle part)
		Osage group (part; included Warsaw)
1944	Branson (a)	Middle Mississippian series
1961	Spreng	Osagean series
1964	Swann	Valmeyeran Series (lower part)
1979	Thompson (a, b)	Osagean Series
	Collinson et al.	Valmeyeran Series (lower part)
	Dutro et al.	Boone Formation

Remarks — The Osagean Series is composed primarily of medium- to coarsely crystalline, crinoidal limestone and cherty, finely to medium-crystalline limestone. The limestones are often very crinoidal, and chert content varies from 0 to over 50 percent. Osagean limestones were deposited on a broad, relatively shallow prograding shelf (Manger and Thompson, 1982) that

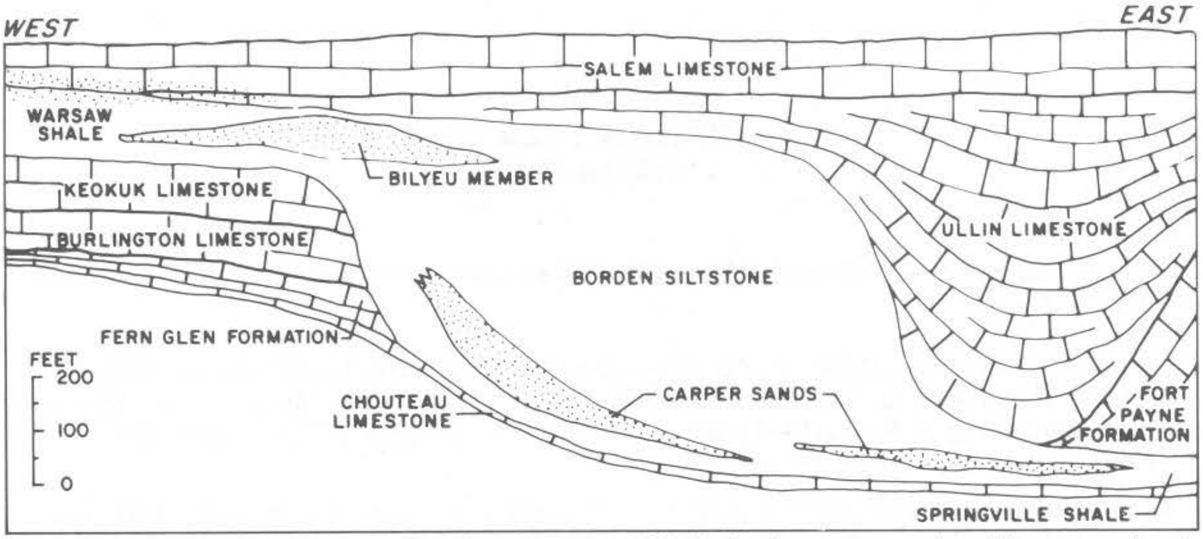


Figure 56. *Diagrammatic east-west cross section across central Illinois showing eastern terminus of* **Osagean carbonate shelf** *against clastics of the Borden Siltstone. Adapted from Lineback (1968, fig. 3).*

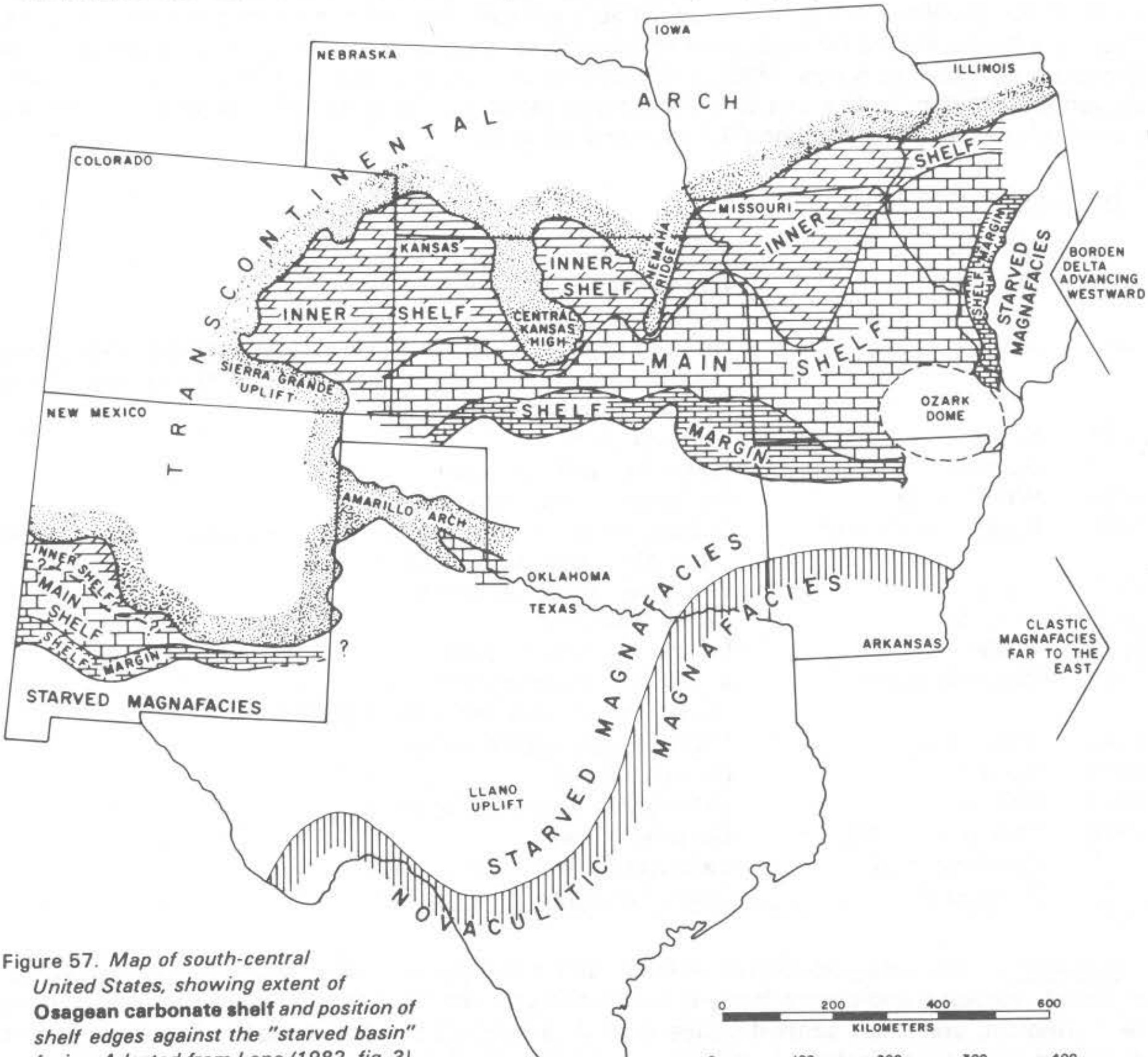


Figure 57. *Map of south-central United States, showing extent of* **Osagean carbonate shelf** *and position of shelf edges against the "starved basin" facies. Adapted from Lane (1982, fig. 3).*

abruptly terminated eastward in the Illinois Basin, just east of the Missouri-Illinois boundary (fig. 56), southwestward in northwestern Arkansas and northeastern Oklahoma, and westward against the Transcontinental Arch in central Colorado (fig. 57). The shelf extended northward into Iowa and westward across Kansas.

Basal Osagean strata are mostly chert-free to sparsely cherty limestones: the Pierson Limestone of southwestern and western Missouri, the "lower brown beds of the Burlington" in central Missouri, the lower part of the Fern Glen Formation (Meppen Limestone Member) in eastern Missouri, and the lower part of the Burlington Limestone in northeastern Missouri. Above the basal limestone, along the shelf margins in southwestern and eastern Missouri, a sequence of very cherty, finely to medium-crystalline limestones (Reeds Spring and Elsey Formations in southwestern Missouri and upper Fern Glen and "lower Burlington" strata in eastern Missouri) were deposited. Shoreward from the shelf margins these units grade laterally into the Burlington Limestone (fig. 58) through the loss of chert.

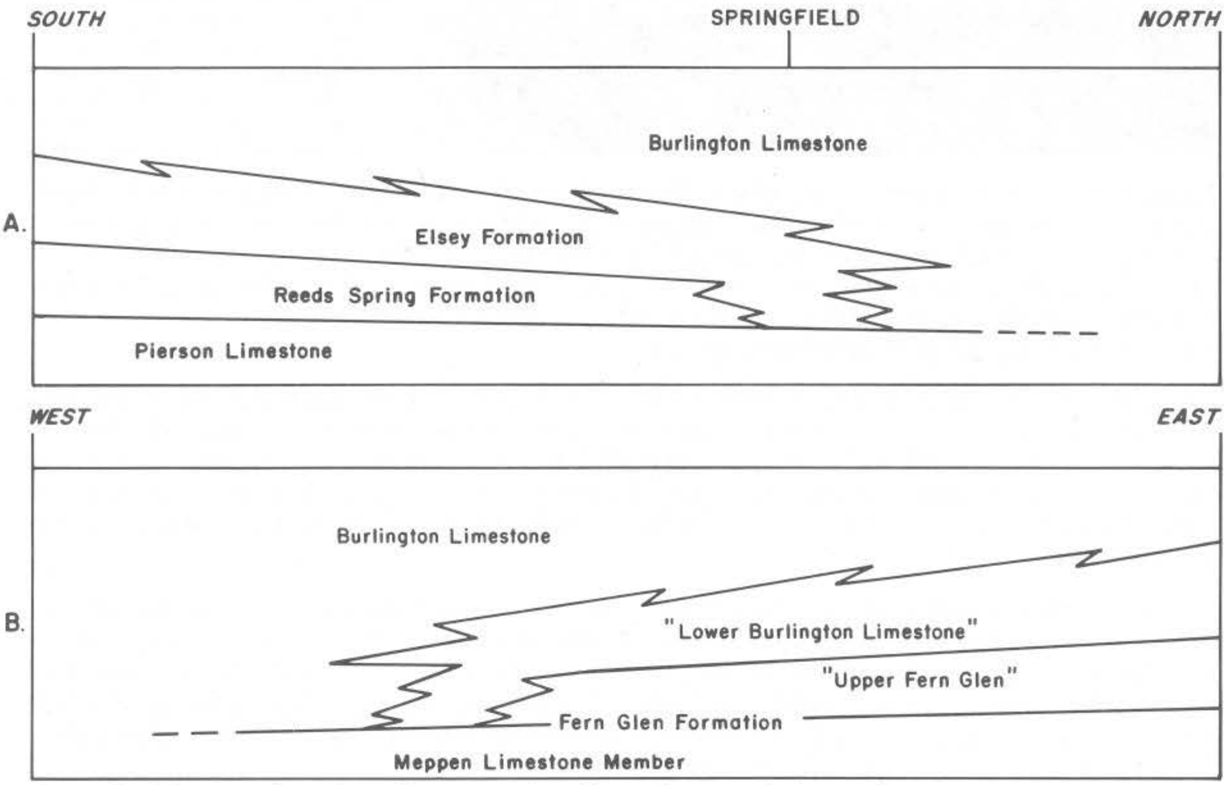


Figure 58. *Diagrammatic north-south cross section of formations constituting the Osagean carbonate shelf in southwestern Missouri (section A), and east-west cross section of similar rocks in east-central Missouri (section B), illustrating facies relationships of lower Osagean formations to the Burlington Limestone.*

Osagean carbonates are extensively silicified in two areas of Missouri. In the region of Joplin, Missouri, silicification resulted in a dense chert unit (Grand Falls Chert) that is associated with the lead and zinc deposits of the region. South of Joplin, in McDonald County, Missouri, the process was more extensive, and resulted in near-total silicification of upper Pierson, Reeds Spring, and Elsey strata, and in the preservation of original carbonate textures and fossils (fig. 59). The latter area of silicification is associated with the tripoli deposits in extreme western McDonald County and adjacent Oklahoma and possibly also with a broad anticlinal structure extending into Missouri from northeastern Oklahoma.

Because the Burlington and Keokuk Limestones can be difficult to distinguish from each other, they are often identified collectively as the "Burlington-Keokuk Limestone." These strata are very

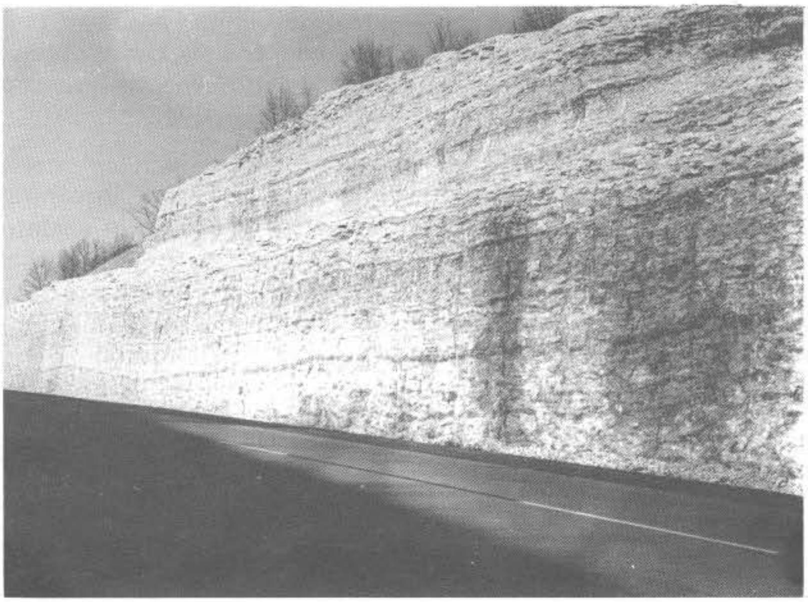


Figure 59. *Silicified zone in lower Osagean formations, in roadcut on U.S. Highway 71, at Anderson, McDonald County, southwestern Missouri. Dark nodules and beds are limestone; white is chert. Photograph by T.L. Thompson.*

widespread, extending across most of the Mississippian outcrop area and throughout the subsurface of northern and western Missouri. They are recognized in the subsurface as far west as eastern Colorado, and extend northward into central Iowa. The top of the Keokuk is marked by the Short Creek Oolite Member in western and southwestern Missouri, and by the base of the shaly limestone or shale of the Warsaw Formation in eastern and northeastern Missouri; the latter contact is more difficult to distinguish than in western Missouri.

Osagean rocks outcrop in a fairly continuous band around the Ozarks (fig. 60), extending from northeastern Missouri (Knox and Pike Counties), southeastward to Perry County, and west and southwestward across the state into Arkansas and Oklahoma. In the northeastern, east-central, and southwestern parts of the state, they are about 180 ft thick, 200 ft thick, and 250 ft thick, respectively. However, in some areas of the Tri-State district (Missouri-Kansas-Oklahoma), their thickness may exceed 400 ft.

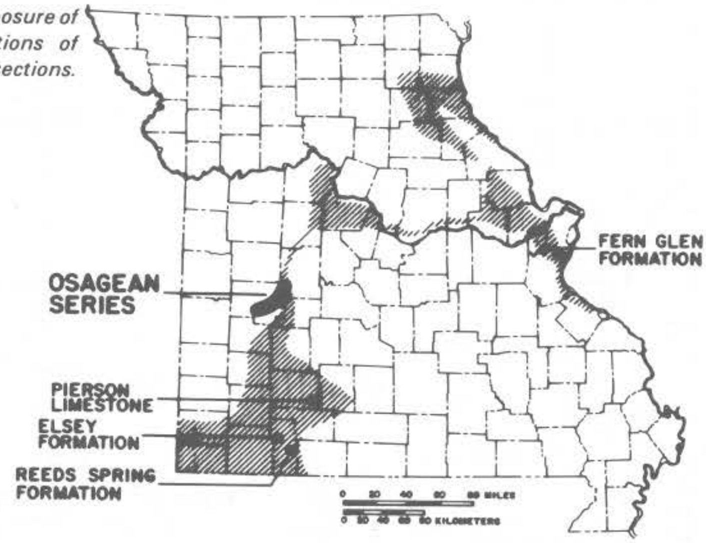
Osagean rocks in northwestern Arkansas constitute the **Boone Formation.** The very cherty Reeds Spring and Elsey Formations are often called the "Boone chert." A basal limestone of the Boone Formation, the **St. Joe Limestone Member**, was once considered equivalent to the Pierson of southwestern Missouri, but Thompson and Fellows (1970) determined that the basal St. Joe was Kinderhookian and equivalent to the Compton Limestone and Northview Formation of southwestern Missouri; therefore, only upper St. Joe strata are Osagean.

Conodont zones defined for the Osagean Series in Missouri (Thompson, 1967; Thompson and Fellows, 1970; Collinson et al., 1971) are defined in table 2.

Osagean formations formally recognized in Missouri include the following:

Southwestern Missouri	Central Missouri	Eastern Missouri
Keokuk Limestone	Keokuk Limestone	Keokuk Limestone
Short Creek Oolite Member		
Burlington Limestone	Burlington Limestone	Burlington Limestone
Elsey Formation		"lower Burlington"
Reeds Spring Formation		Fern Glen Formation
Pierson Limestone	Pierson Limestone ("lower brown beds of the Burlington Limestone")	Meppen Limestone Member

Figure 60. *Map of Missouri, showing regions of exposure of* **Osagean** *rocks, and locations of type sections of Osagean formations named from Missouri sections.*



Fern Glen Formation

Weller, 1906

Original description — (Weller, 1906, p. 438) "Red limestone with greenish blotches, the green color becoming somewhat more marked towards the top, capped by a conspicuous chert band six to eight inches in thickness. In the midst of this bed, besides some scattered chert masses, are two conspicuous, continuous chert bands, each four inches in thickness, one three feet and the other six feet from the base of the bed. . . . This red, more or less argillaceous limestone formation has a rather wide geographic distribution, and always contains its own characteristic fauna. . . . It is again exposed near Fern Glen station on the Missouri Pacific Railroad, on the Meramec River, twenty miles west of St. Louis. . . . Because of its good exposure at Fern Glen, the formation may be called the Fern Glen Formation."

Type section — As stated above, the Fern Glen Formation was named from Fern Glen, southwestern St. Louis County, Missouri. The type section was stated only to be near the Fern Glen station, at Fern Glen. As Fern Glen station no longer exists, Thompson (1975, p. 164) redescribed and amended the type section to be a composite of two railroad cuts on either side of Fern Glen, on the north bank of the Meramec River, center SE¼ sec. 14, and NW¼ SW¼ SW¼ sec. 13, T. 44 N., R. 4 E., Manchester 7½' Quadrangle, St. Louis County, Missouri (figs. 61 and 62).

History of nomenclature —

1873	Shumard	Chouteau limestone of Chemung group (upper part)
1906	Weller	Fern Glen formation
1907	Weller	Kinderhook beds (upper part)
1909	**Weller**	**Fern Glen formation** (Kinderhookian in age)
1911	Fenneman	Fern Glen limestone member of Kinderhook formation
1928	Moore	Fern Glen formation
1934	Keyes	Burlington limestone (lower part; rejected name "Fern Glen")
1937	Laudon	Fern Glen formation
		Sedalia formation ("Sedalia" of Illinois; = Meppen Formation)

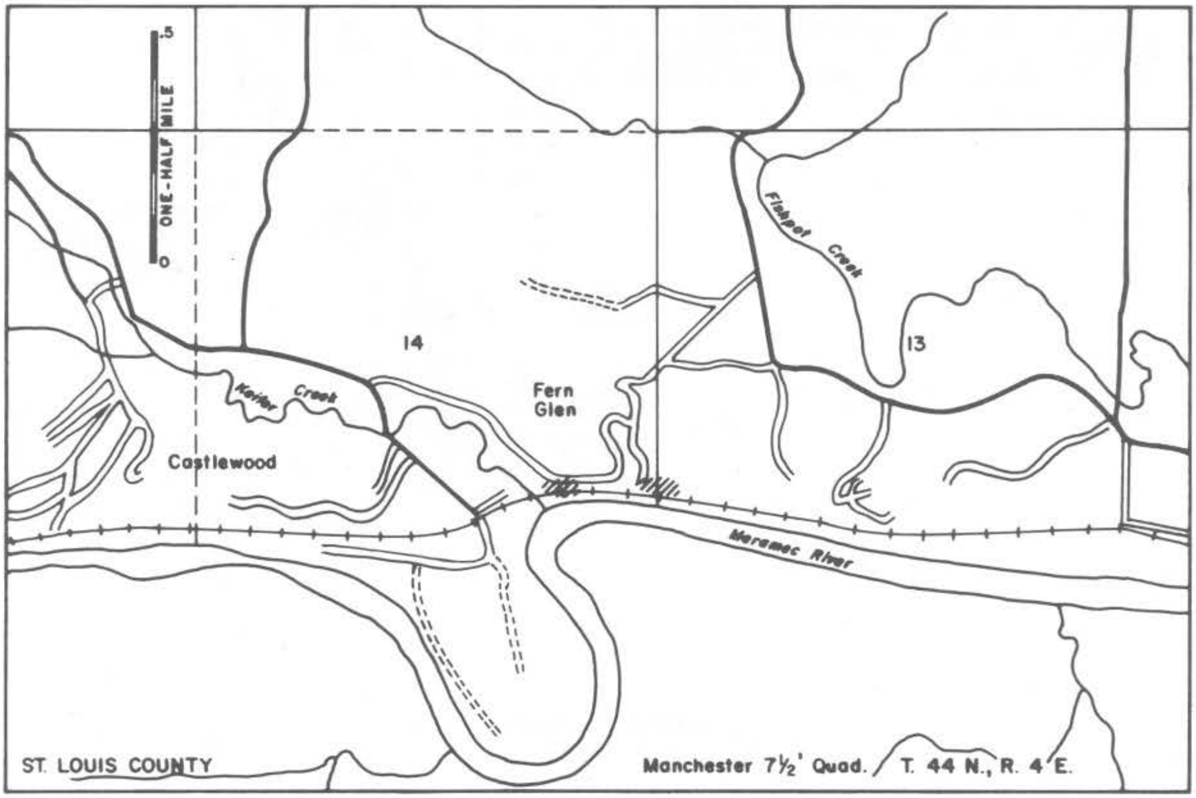
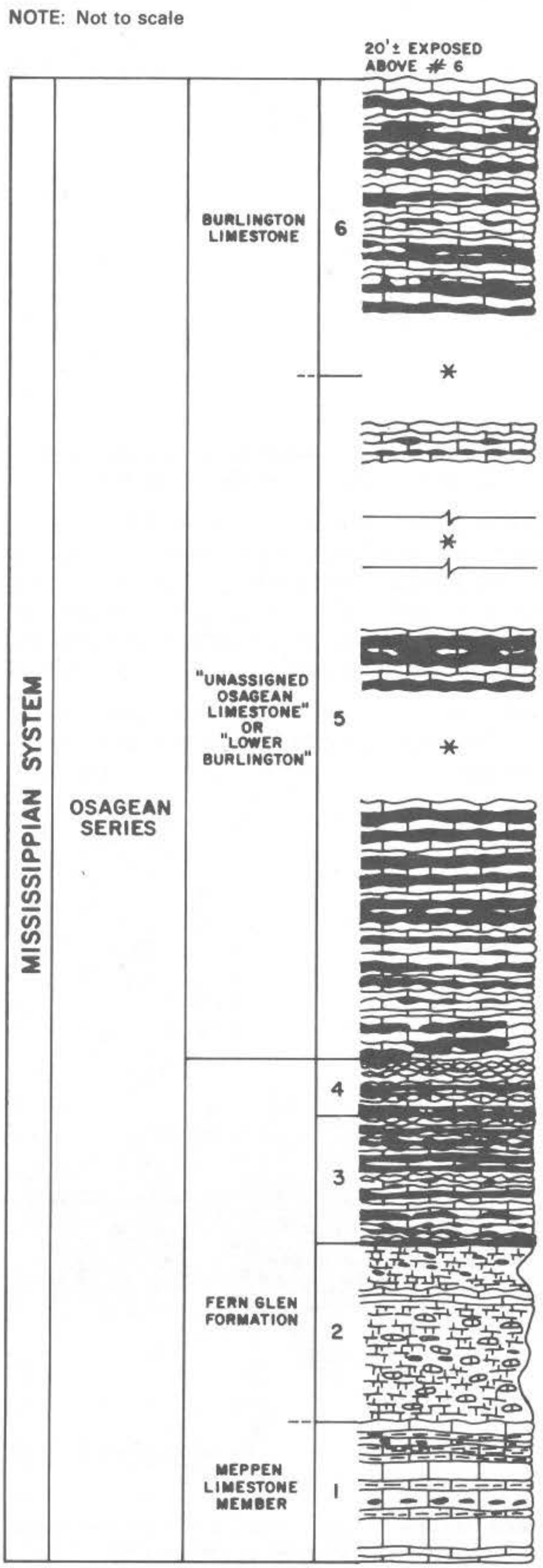


Figure 61. *Part of the Manchester 7½' Quadrangle, St. Louis County, east-central Missouri, showing location of the type section of the* **Fern Glen Formation.**

1939	McQueen	Fern Glen
		Lower Fern Glen or Sedalia
		Northview
		Chouteau
1944	Branson (a)	Fern Glen member of Chouteau formation
1948	Weller et al.	Fern Glen formation (Osagean in age)
1961	Spreng	Fern Glen formation
1962	Collinson et al.	"Sedalia" Formation (in Illinois; basal beds of Fern Glen)
1971	Collinson et al.	Meppen Formation (= basal part of Fern Glen; replaced "Sedalia" in Illinois)
1975	Thompson	Fern Glen Formation
	Atherton et al.	Fern Glen Formation
		Meppen Limestone
1984	Thompson	Fern Glen Formation
		Meppen Limestone Member

Remarks — In Missouri the Fern Glen Formation is recognized only in the east-central and southeastern regions, from eastern Franklin County, east through St. Charles and St. Louis Counties, and south through Jefferson and Ste. Genevieve Counties to northern Perry County (fig. 63). Bridge (1917) identified a "Fern Glen fauna" from residual boulders in the Phelps County region, south-central Missouri, but this fauna is also characteristic of the Pierson Limestone of southwestern Missouri; therefore, the Fern Glen strata in south-central Missouri cannot be definitively identified, only their equivalent. Over much of its extent Fern Glen can be divided into three lithologic types: a



6. Limestone, gray, coarsely crinoidal, thick-bedded; scattered chert. (20 ft)
5. Limestone, gray to grayish-green, finely crystalline, crinoidal to sparsely fossiliferous, stylolitic, in beds 6- to 8-in. thick; nodular toward base. Chert (40-50%), mottled gray and white when fresh, some bluish-gray with cream colored rims; waxy, spicular; as large irregular nodules, discontinuous bands of nodules, and occasional continuous beds; calcite geodes associated with chert. (23 ft)
4. Limestone, grayish-green, finely crystalline, thinly bedded, nodular; abundant crinoid ossicles; scattered pyrite upper 1 ft. Chert, bluish-gray with cream rims, waxy, spicular, stained rusty on exposed surfaces; as anastomosing beds with irregular limestone inclusions; numerous continuous heavy chert beds. (16 ft)
3. Limestone, grayish-green, finely crystalline, abundantly fossiliferous, argillaceous, thin-bedded, nodular. Chert, olive, as poorly developed nodules; some white siliceous nodules up to 1 in. in diameter. (4 ft)
2. Limestone, red, to mottled green and red, finely crystalline, fossiliferous, argillaceous, thin-bedded, nodular; weathers shaly in lower 10 ft; prominent 5-in. siliceous bed 1 ft below top; siliceous nodules and chert nodules in middle. (11 ft 5 in.)
1. Limestone, gray to mottled gray and pink, finely crystalline to moderately crinoidal, thin- to medium-bedded. Chert, mottled green and pink to pink, abundantly fossiliferous; one continuous band of smooth nodules in unit. (11 ft)

Base not exposed.

Figure 62. *Columnar section of* **Fern Glen Formation** *type section, which is a composite of sections on either side of Fern Glen, the first two Missouri-Pacific Railroad cuts east of the Keifer Creek railroad bridge, on the north bank of the Meramec River, center SE¼ sec. 14 and NW¼ SW¼ SW¼ sec. 13, T. 44 N., R. 4 E., Manchester 7½' Quadrangle, St. Louis County, Missouri. Adapted from Thompson (1975, p. 164-166).*

Figure 63. *Base map of eastern Missouri, showing distribution of outcrops of the* **Fern Glen Formation.**

basal, non-cherty, red or brown, thick-bedded, dense to crinoidal limestone, 4 to 15 ft thick, containing a few quartz geodes and calcite-lined vugs in places (**Meppen Limestone Member**); a middle, red and/or green, fossiliferous, calcareous, and siliceous shale 5 to 20 ft thick, which is cherty toward the top; and an upper sequence of alternating beds of finely crystalline limestone and chert grading upward to finely crystalline limestone, bedded to nodular crinoidal limestone, and gray, waxy chert, 12 to 30 ft thick, containing quartz geodes. The formation is 20 to 45 ft thick.

The Fern Glen usually crops out at the base of bluffs in the overlying Burlington-Keokuk Limestones. Where the upper part of the formation is very cherty, it is ledge forming; whereas the middle shale forms a reentrant in many places. Southward from the type area in St. Louis County,

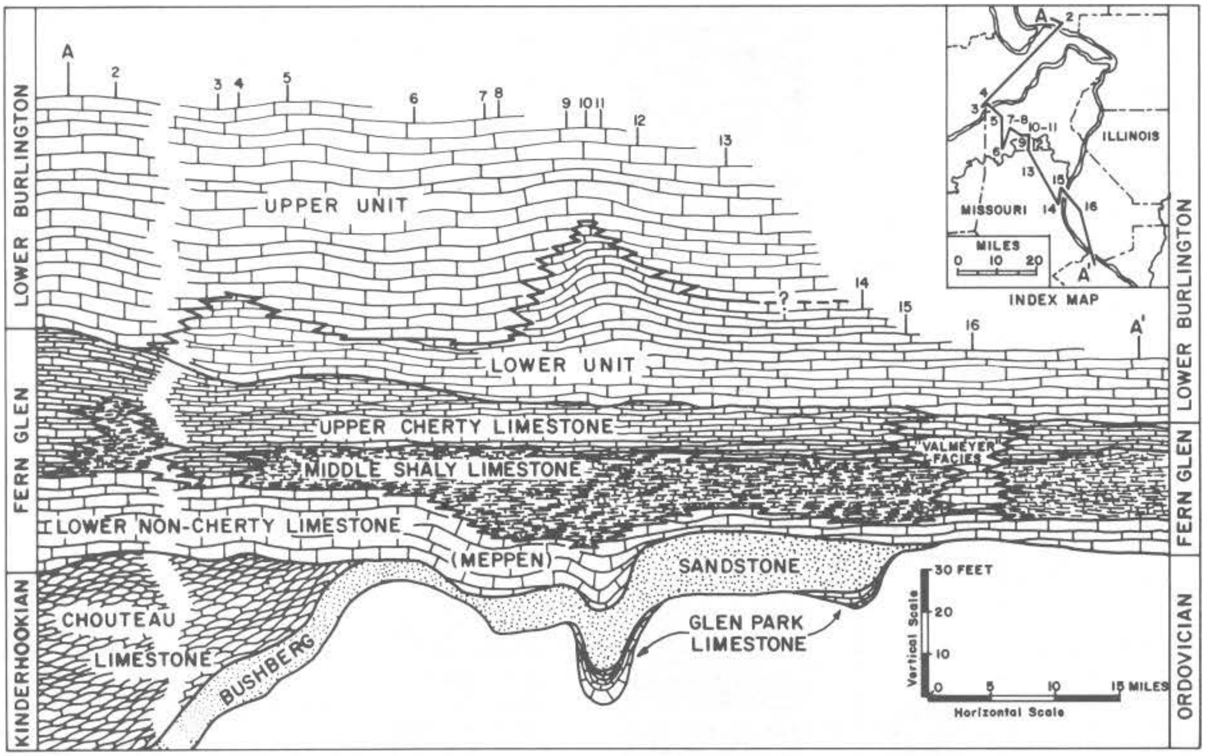
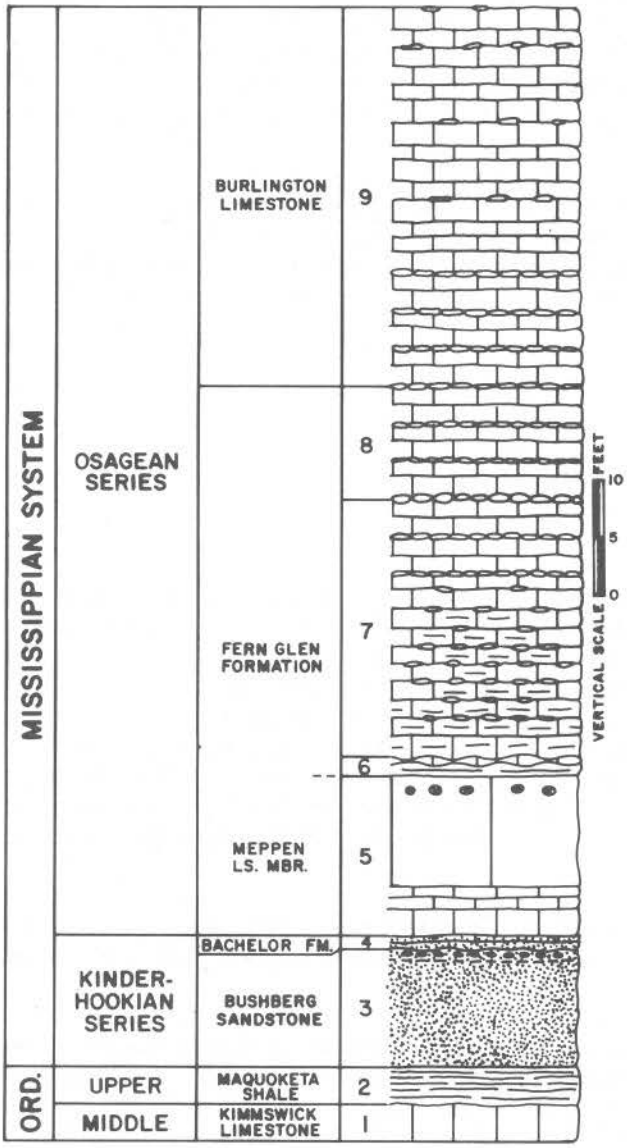


Figure 64. *Diagrammatic cross section of Lower Osagean formations in eastern Missouri, showing thickness and distribution of the several facies of the* **Fern Glen Formation.** *Cross section adapted from Kissling (1961, p. 146).*

toward Jefferson County, the upper cherty limestone thickens (fig. 64). The lithology of this part resembles that of the Reeds Spring Formation of southwestern Missouri; because of this, faunal similarities, and regional considerations, the two are considered correlative.

Although the "typical" lower chert-free Fern Glen limestone is medium to coarsely crystalline, red, and very fossiliferous, in some places it is a dense, brown, finely crystalline, massive limestone, a lithology similar to that of the **Meppen Limestone** of western Illinois. "Meppen" was introduced by Atherton et al. (1975) to replace **"Sedalia,"** a name used by Moore (1928) in redefining the Chouteau of central Missouri. In Missouri, characteristic "Meppen" limestones are not continuous; the red "Fern Glen" limestone may crop out between "Meppen" exposures. The lower Fern Glen at the type section is the red bioclastic "Fern Glen" facies, the Castlewood exposure, approximately 1 mi to the west, is representative of the "Meppen" facies. Because of the discontinuous nature of the "Meppen" lithology, these strata are regarded as part of the Fern Glen Formation and are identified as the **Meppen Limestone Member of the Fern Glen Formation.**



9. Limestone, light-gray, medium-crystalline to crinoidal. Chert, white, 50% in lower 10 ft, 20% in upper 25 ft. (35 ft)
8. Limestone, grayish-brown, finely crystalline; fossiliferous zones. Chert (40-50%), bluish-gray to white. (9 ft)
7. Limestone, grayish-green, changing to gray-brown 10 ft above base; lower part very argillaceous; lower 3 ft chert-free; upper part with bluish-gray and pink nodules; upper part very fossiliferous. (20 ft)
6. Limestone, brown, finely crystalline to sublithographic. Shale, green; siliceous nodules. (2 ft)
5. Limestone, brownish-gray to brown, very fine at bottom becoming coarser toward top; scattered fossil debris; large calcite-filled vugs in upper part; lowermost bed arenaceous with elongate calcite vugs. (12 ft)
4. Sandstone, light-green, calcareous; phosphate nodules in lower ft. (2 ft)
3. Sandstone, yellowish-brown, calcareous, fine to coarse, massive, porous. (8 ft)
2. Shale, blue-gray to dark-gray, silty, hard, fossiliferous. (3 ft)
1. Limestone, dark-gray, finely crystalline. (3 ft)

Figure 65. *Columnar section of roadcut on Missouri Highway 30, near House Springs, SE¼ SE¼ NE¼ sec. 33, T. 43 N., R. 4 E., House Springs 7½' Quadrangle, Jefferson County, Missouri, exposing the* **Meppen Limestone Member of Fern Glen Formation.** *Adapted from Collinson et al. (1979).*

North of the type area, in a region of southern St. Charles County and Franklin County, the middle shale disappears, and the cherty limestone of the upper Fern Glen lies directly on the lower (Meppen) member of the Fern Glen (fig. 64).

The base of the Fern Glen Formation rests on limestone of the "Chouteau Group undifferentiated," of late Kinderhookian age, in the northern limits of its occurrence, but throughout most of its extent from St. Louis County, south to northern Ste. Genevieve County, basal Fern Glen strata lie directly on the thin middle Kinderhookian Bachelor Sandstone; no late Kinderhookian strata are present (figs. 19, 20, and 65). A thin "Chouteau limestone" is present in northern Ste. Genevieve County between the Bachelor and Fern Glen.

Throughout its extent the Fern Glen is overlain by the Burlington Limestone. The upper contact between the cherty upper Fern Glen beds and the cherty basal Burlington strata is gradational, very similar to that between the Reeds Spring and Elsey Formations in southwestern Missouri.

The Fern Glen Formation contains abundant brachiopods, corals, and crinoids. As reported by Spreng (1961), the bryozoan *Evactinopora sexradiata*; the brachiopods *Spirifer vernonensis, S. rowleyi, Athyris lamellosa*, and representatives of the genus *Cleiothyridina*; and the coral *Cyathaxonia arcuatas* are common. Many species are restricted to this formation and to its correlatives in northwestern Arkansas (upper St. Joe Limestone) and southwestern Missouri (Pierson Limestone). Conodonts are abundant in the limestones of the Fern Glen, and have proved useful in regional correlations. The Fern Glen conodont fauna has been subdivided into two zones (Thompson, 1975), the *Gnathodus semiglaber—Polygnathus communis carinus and Bactrognathus-Pseudopolygnathus multistriatus* Zones.

Faunally and lithologically, the Pierson Limestone of southwestern Missouri is correlative with the lower limestone of the Fern Glen in eastern Missouri. Many well logs from southwestern Missouri have cited red Pierson limestone samples as "Fern Glen." Thompson (1975) also noted the similarity of the conodont faunas of the Pierson of southwestern Missouri and the Fern Glen of eastern Missouri.

Meppen Limestone Member of Fern Glen Formation
Atherton, et al., 1975

Original description — Collinson (1969) first placed the name Meppen in print in a guidebook for the North American Paleontological Convention; the name was taken from an M.S. dissertation. Atherton et al. (1975, p. 135) first described the Meppen in a formal publication, in which they stated that at the type section "the formation is 7 feet thick, consists of buff, massive dolomite containing numerous small calcite geodes, and stands out as a distinct buff band in the quarry face... The Meppen is a tan or buff, very fine-grained, slightly crinoidal, dolomitic limestone or calcareous dolomite that commonly contains many calcite geodes 0.5-2 inches in diameter. The Meppen rests unconformably on the Chouteau Limestone... The Meppen is overlain conformably by the Fern Glen Formation, but north of the Lincoln Anticline the Fern Glen grades into the Burlington, and the Burlington overlaps the Meppen."

Type section — Atherton et al. (1975, p. 135) stated, "The Meppen Limestone is named for the village of Meppen, Calhoun County (Illinois), and the type section is in a quarry 0.6 mile north of Meppen (SW NE 23, 12S-2W)..."

Reference section — An excellent example of the Meppen Limestone Member of the Fern Glen Formation in Missouri is in a roadcut on Missouri Highway 30, near House Springs, northern Jefferson County, Missouri (figs. 65 and 66), SE¼ SE¼ NE¼ Sec. 33, T. 43 N., R. 4 E., House Springs 7½' Quadrangle (Collinson et al., 1979).

Another exposure of the Meppen Limestone Member is in the Hamburg Quarry, on the north bank of the Missouri River, SE¼ NE¼ Sec. 7, T. 45 N., R. 3 E., St. Charles County, Missouri.

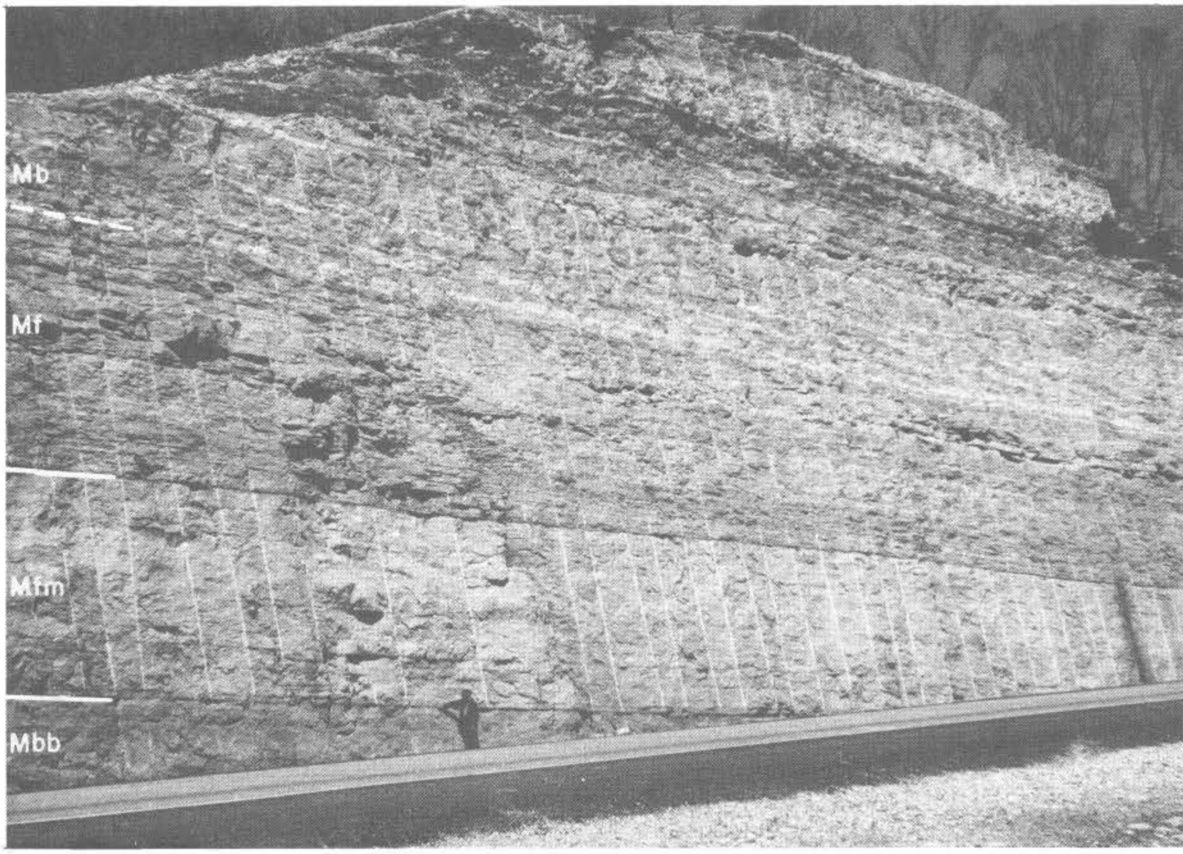


Figure 66. **Fern Glen Formation** *(Mf) in a roadcut on Missouri Highway 30, near House Springs (fig. 65), Jefferson County, Missouri, with well-developed* **Meppen Limestone Member** *(Mfm). Also exposed are the underlying Bushberg Sandstone (Mbb) and overlying Burlington Limestone (Mb). Photograph by T.L. Thompson.*

History of nomenclature —

1971	**Collinson et al.**	**Meppen Formation** (= basal part of Fern Glen; replaced "Sedalia" in Illinois)
1975	Atherton et al.	Meppen Limestone
1979	Collinson et al.	Meppen Limestone

Remarks — Named to replace the "Sedalia" in Illinois, the Meppen Limestone is equivalent to the lower Fern Glen limestone in Missouri, and also to the "lower brown beds of the Burlington" in central Missouri. As Fern Glen is a well-established name in Missouri, the Meppen is recognized as the lower limestone member of the Fern Glen, and as such is useful in stratigraphic understanding of the Fern Glen. The Meppen Limestone in many places is a brick-red, very fossiliferous limestone that breaks down readily on weathering. Examples are the type section and a section in a roadcut on I-55, immediately north of mile post 146, NW¼ sec. 20, T. 37 N., R. 9 E., Ste. Genevieve County, Missouri, Ste. Genevieve 7½' Quadrangle (Thompson, 1975, p. 170). Typically it is a dense, hard, buff limestone that forms resistant ledges.

Pierson Limestone
Weller, 1901

Original description — (Weller, 1901, p. 144) "*Pierson limestone* —This is a fine-grained buff colored, gritty limestone having a maximum thickness, according to Shepard, of thirty feet, being the formation designated by him as the Chouteau limestone."

Type section — Weller (1901) described the Pierson as "...well exposed along Pierson Creek [actually spelled Pearson Creek] near the zinc mines."

Beveridge and Clark (1952, p. 76) designated the type section as the " cut on the north side of County Road D in the NE¼ SW¼ SW¼ sec. 29, T. 29 N., R. 20 W., near Turner Station, in Greene County..." This section is just east of the bridge over the James River, Galloway 7½; Quadrangle (figs. 68 and 68), and has been described by Robertson (1967, p. 54-57) and Thompson and Fellows (1970, p. 147). Road D has recently been reconstructed to expose more of the upper Pierson and overlying Elsey than previously described. The original type section is now on the blacktop road paralleling Road D, as the new road was moved slightly north of the old road.

Reference Sections — Because the Pierson at its type section is atypical of the Pierson for the region, being more dolomitic than normal, it is suggested that other sections of Pierson strata be

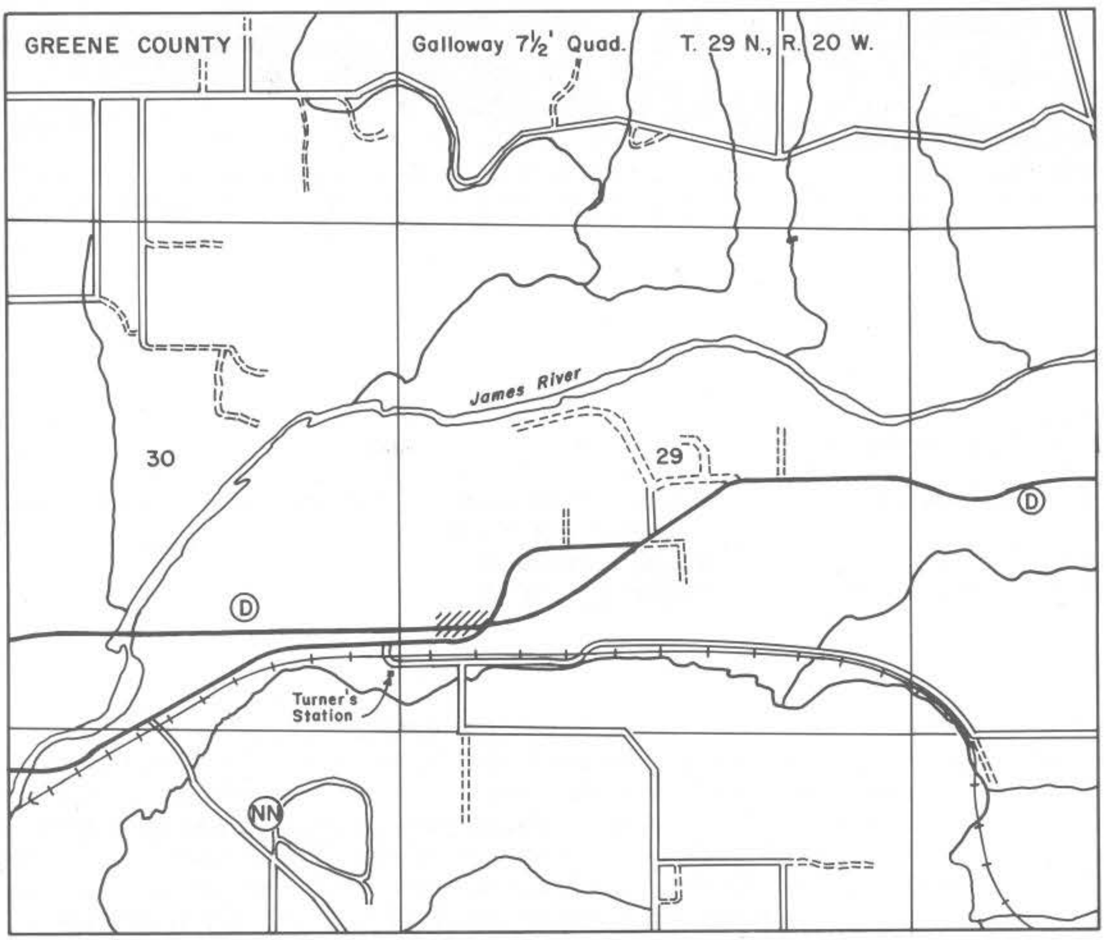
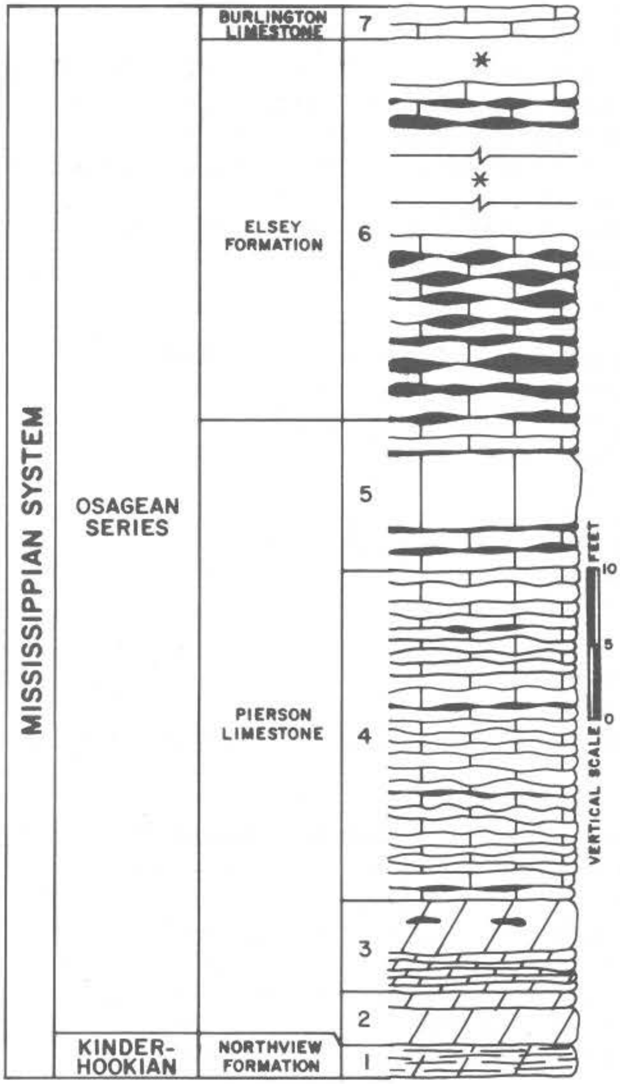


Figure 67. *Part of Galloway 7½' Quadrangle, Greene County, southwestern Missouri, showing location of the type section of the* **Pierson Limestone.**



7. Limestone, light-tan, dolomitic, coarse-grained, thin-bedded. (0 ft 6 in.)
6. Limestone (50%), light-gray, finely to very finely crystalline with scattered crinoidal debris, thick-bedded. Chert, white with gray mottles, crinoidal, as large nodules between nodular limestone beds. (27 ft exposed)
5. Limestone, dark-brown to brown, dolomitic, finely crystalline, scattered crinoid debris, medium- to thick-bedded; scattered white and brown mottled chert nodules. (10 ft 2 in.)
4. Limestone, light-brown, dolomitic, finely crystalline, thin to medium nodular beds; some scattered nodules of white and brown chert. (20 ft 4 in.)
3. Dolomite, calcareous, brown to tan, finely to medium-crystalline, single bed at top, thin, slabby beds at base; scattered gray to tan chert nodules in upper bed. (5 ft 10 in.)
2. Siltstone, dolomitic, yellow-brown to greenish-gray, laminated. (3 ft 6 in.)
1. Siltstone, yellow-brown, shaly. (2 ft+)

Figure 68. *Columnar section of the type section of the* **Pierson Limestone**, *at Turner Station, in a roadcut on old Highway D, 0.1 mi northeast of Turner store, NW¼ SW¼ SW¼ sec. 29, T. 29 N., R. 20 W., Galloway 7½′ Quadrangle, Greene County, southwestern Missouri. Adapted from Thompson and Fellows (1970, sec. A, p. 146-148).*

studied to determine its characteristics. A roadcut on I-44, near Mt. Vernon, NW¼ NE¼ SE¼ sec. 7, T. 28 N., R. 25 W., Halltown 7½′ Quadrangle, Lawrence County, Missouri (fig. 34), is a good example of Pierson Limestone (Thompson and Fellows, 1970, section J, p. 170-172).

Another representative section for the Pierson Limestone is a roadcut on U.S. Highway 65, NW¼ NW¼ SE¼ sec. 22, T. 25 N., R. 21 W., Day 7½′ Quadrangle, Christian County, Missouri (fig. 33) (Thompson and Fellows, 1970, section M, p. 181-184).

History of nomenclature —

1883	Swallow	Chouteau limestone
1898	Shepard	Chouteau limestone
1901	**Weller**	**Pierson [sic] limestone** (named for Pearson Creek, Greene County, Missouri
1902	Keyes	St. Joe marble (upper part)
(not) 1902	Weeks	St. Joe limestone ("= Pennslyvanian limestone of Gallaher, 1898")

1905	Weller	Pierson limestone
1915	Girty (b)	Fern Glen (St. Joe) (upper part)
		St. Joe limestone member of Boone ("= Fern Glen limestone member of Kinderhook formation"; upper part)
	Ulrich	Fern Glen formation ("of Missouri and Arkansas")
1928	Moore	Pierson formation (restricted to area of type section in Greene County, Missouri)
		St. Joe limestone member of Boone formation (upper part; elsewhere in southwestern Missouri)
1931	Fowler and Lyden	Fern Glen (Pierson)
1935	Giles	Boone limestone
		Fern Glen limestone member of Boone limestone
		St. Joe limestone member of Boone limestone (upper part)
1944	Branson (a)	Pierson member of Chouteau formation
1948	Weller et al.	St. Joe limestone (part)
1950	Bassler	St. Joe limestone
		"Fern Glen zone"
1952	Beveridge & Clark	Pierson formation of St. Joe group
1961	Spreng	Pierson formation
1970	Thompson & Fellows	Pierson Formation
1979	Thompson (a, b)	Pierson Formation
	Sable	Pierson Limestone
		St. Joe Group (upper part)
	Dutro et al.	St. Joe Limestone Member of Boone Formation (upper part)

Remarks — Over most of its distribution in southwestern and west-central Missouri, the Pierson Limestone is a greenish-gray, fine to coarsely crystalline, relatively chert-free limestone, with prominent green shale partings. At the type section, east of Springfield, Greene County, Missouri, the Pierson locally is a brown dolomitic limestone that resulted from alteration by processes responsible for the Pearson Creek mining district in the same area (Weller, 1901). Chert normally occurs in the upper quarter of the formation, increasing in amount upward, from zones of discontinuous nodules, to continuous beds near the top. Some discontinuous nodular beds of chert, often red or black, occur in lower Pierson beds, but not at all sections; normally they occur farther south in southwestern Missouri.

Approximately 40 ft thick at the type section, the Pierson Limestone gradually thins northward to about 3 ft near Sedalia, and merges with the "lower brown beds of the Burlington" in central Missouri. Southward from the type area, it gradually thickens to as much as 75 ft in the Branson region, but normally it varies from 30 to 50 ft.

The Pierson lies everywhere on the upper Kinderhookian Northview Formation; their contact is usually easily identified. In southern Taney, Stone, and Barry Counties, Missouri, and in western Arkansas, uppermost Northview strata are a red argillaceous limestone (Baird Mountain Limestone Member); the Northview-Pierson contact is between this red limestone and the green-gray to reddish-gray limestone of the Pierson (figs. 22 and 54). Conodont faunal studies have shown that the Kinderhookian-Osagean boundary is at the top of the red limestone (Thompson and Fellows, 1970).

In southwestern Missouri, due to facies changes to the north, the Pierson Limestone is overlain, south to north, by the Reeds Spring Formation and the Elsey Formation (fig. 58). The contact with the Elsey Formation, which overlies the Pierson from just south of Springfield northward until Pierson and Burlington become the same, is transitional within a short distance, but can be located relatively easily (figs. 69 and 70). Southward and westward from the type area, the contact with the overlying Reeds Spring Formation is locally gradational, often becoming a matter of choice. Thompson and

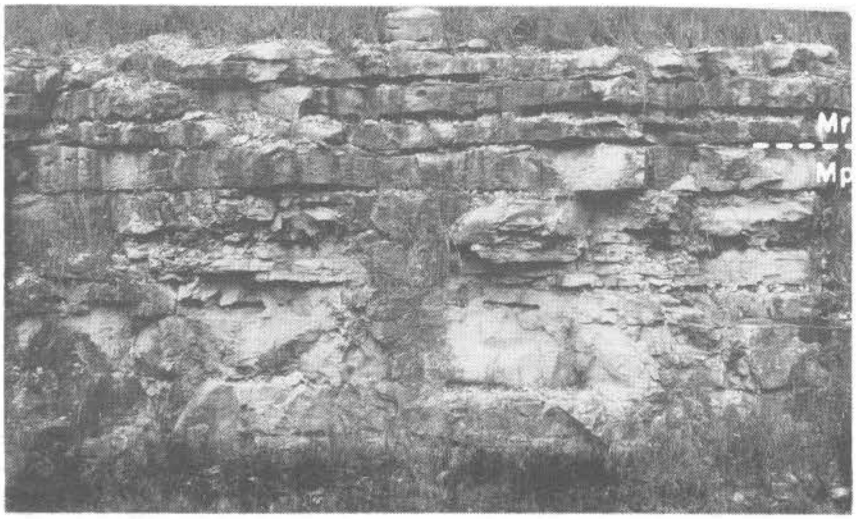


Figure 69. *The* **Pierson Limestone** *(Mp) and* **Elsey Formation** *(Me) at the* ***type*** *section of the Pierson Limestone (fig. 68). Photograph by T.L. Thompson.*

Fellows (1970) noted that the limestone of the Reeds Spring is normally very fine grained, finer grained than that of the Pierson. In addition, in most sections, not too far above the lowest chert beds, the identified a thin shale bed, usually only 2 to 4 in. thick, but in a few places up to 6 ft thick, the top of which was used to designate the Pierson-Reeds spring contact where the limestone change was not apparent (fig. 71). This shale zone has informally been named the "**Wolfpen Gap shale**" (C.E. Robertson, personal communication), named from exposures at Wolfpen Gap, on Missouri Highway 86 (center S½, NW¼ sec. 33, T. 22 N., R. 26 W., Eagle Rock 7½' Quadrangle), Barry County, southwestern Missouri. This shale is also present in western McDonald County (fig. 50). In southern McDonald and Barry counties, the Pierson is very crinoidal (fig. 72), and at some sections the lithology changes abruptly from Pierson to Reeds spring, from coarse to very fine, **across a bedding plane. Occasionally, the top of the Pierson is cross-stratified** (figs. 73 and 74).

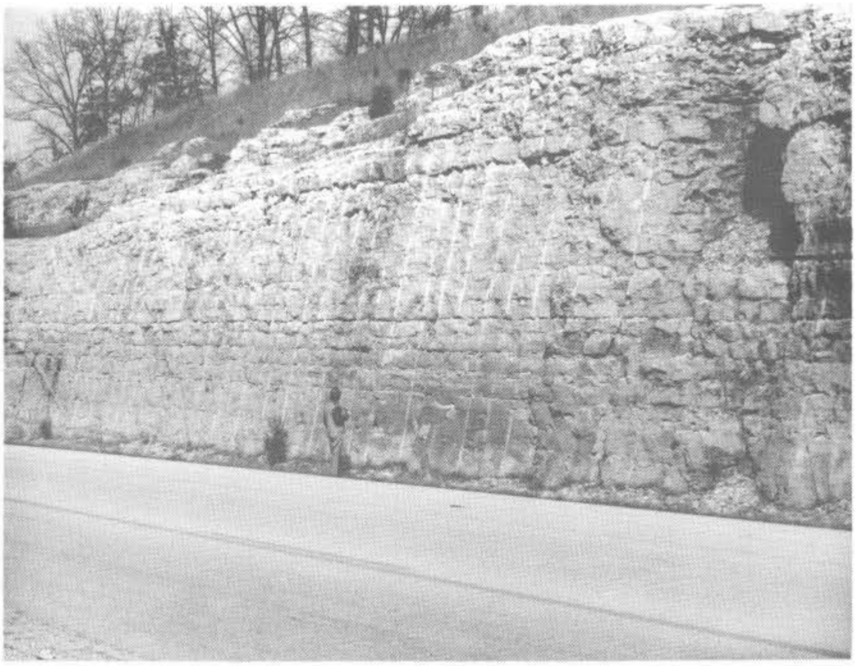


Figure 70. *Upper* **Pierson Limestone** *(Mp) and Lower* **Elsey Formation** *(Me) in roadcut on Greene County Highway D, adjacent to type section of Pierson Limestone (figs. 67-69), showing nature of Pierson-Elsey contact. Photograph by T.L. Thompson.*

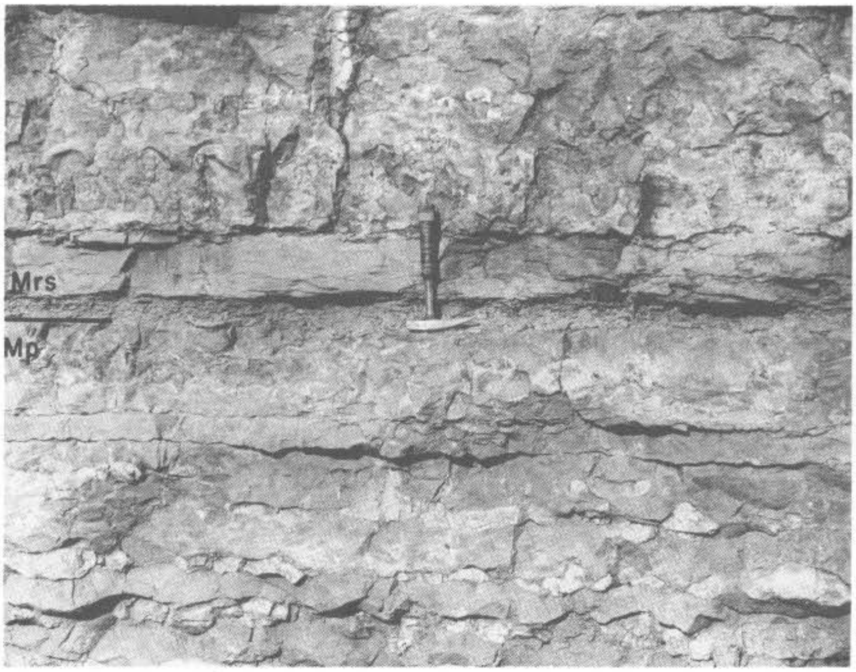


Figure 71. *"Wolfpen Gap shale" (at base of Hammer) at the top of the Pierson Limestone (Mp), in a roadcut on I-44, Lawrence County, Missouri (fig 34). The shale has been used to identify the Pierson-Reeds Spring (Mrs) contact in sections where it is transitional in nature. Photograph by T.L. Thompson.*

North of Springfield, the identities of the Reeds Spring and Elsey Formations are lost through northward reduction in the amount of chert (fig. 58). The limestone becomes similar to that of the Pierson, and in the vicinity of Polk County, the Burlington Limestone lies directly on the Pierson Limestone.

Figure 72. *Upper part of the* **Pierson Limestone**, *just beneath the "Wolfpen Gap shale," in the Lanagan Quarry (fig. 50), McDonald County, Missouri. The section shows the crinoidal nature of upper Pierson beds in the southern part of southwestern Missouri. Photograph by T.L. Thompson.*

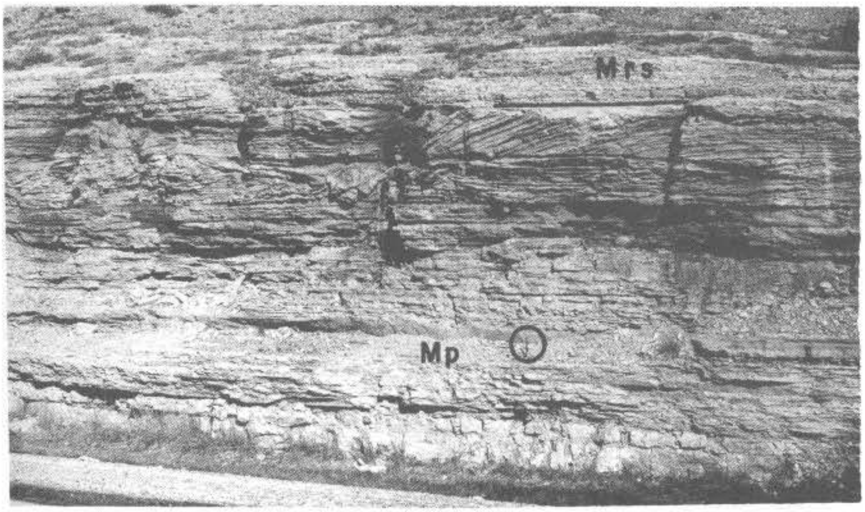
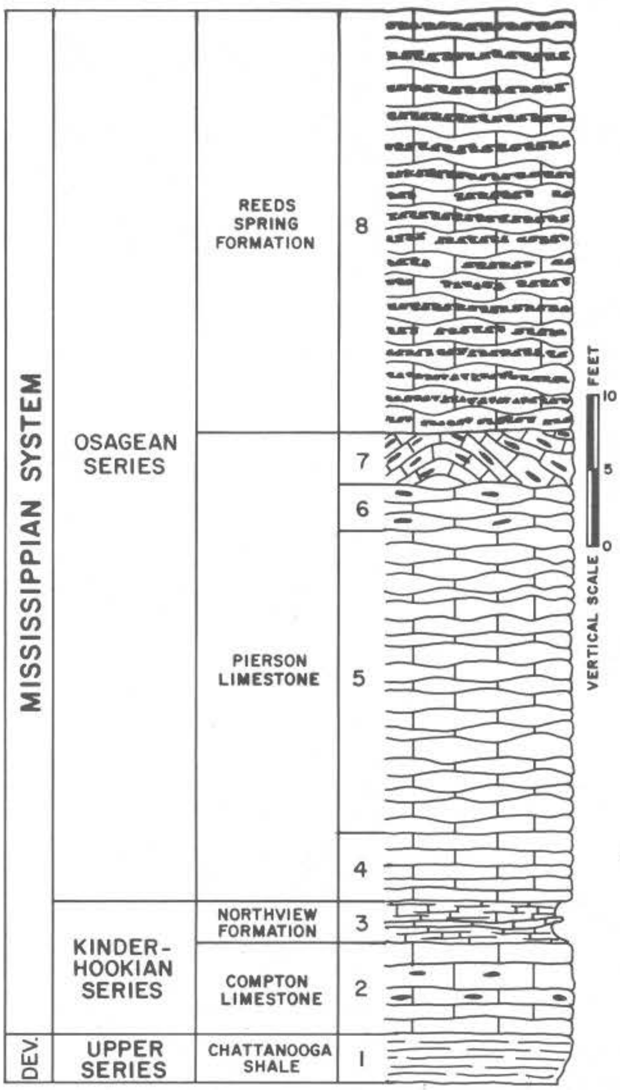


Figure 73. *Upper part of the* **Pierson Limestone** *(Mp) exposed in a roadcut on U.S. Highway 71 (fig. 74), center sec. 18, T. 21 N., R. 31 W., Jane 7½' Quadrangle, southern McDonald County. This section shows the abrupt contact between the Pierson and overlying Reeds Spring Formation (Mrs). Uppermost Pierson beds are prominently cross-stratified. Photograph by L.D. Fellows.*

(Note: Circled hammer for scale)



8. **Limestone (50%), light-gray, finely crystalline to sublithographic, nodular. Chert, dark-blue, in anasto-**mosing masses within limestone beds. Boundary with unit 6 very abrupt. (30 ft)
7. Limestone (70%), gray, crinoidal, in 3-in. beds; wavy or coarsely cross-bedded. Chert, black to dark-blue, in nodules and discontinuous beds. (3 ft 6 in.)
6. Limestone, gray, very argillaceous, crinoidal, nodular; a few poorly developed chert nodules in two zones. (4 ft 0 in.)
5. Limestone, gray to light-brownish-gray, finely to medium-crystalline, several 6-in. argillaceous zones throughout; fossiliferous; in uneven nodular beds. (19 ft)

(Wedge of limestone intervening between units 4 and 5, thickening toward northwest over core of bioherm, is not present in southwestern part of roadcut where photograph (fig. 73) was taken.)

4. Limestone, dark-brownish-gray, medium-crystalline, in two 8-in. beds; thins over bioherm; basal 2 to 3 in. transitional with unit 3. (4 ft 6 in.)
3. Limestone, blue-green upper and lower 1 ft, dark-reddish-gray middle 2-4 in.; very argillaceous, semi-crinoidal; weathers olive-drab to dark-gray, shaly, and blocky; middle unit thin even beds of more pure limestone with abundant crinoid remains. Entire unit thins and wedges out over large bioherm core. (2 ft 8 in.)
2. Limestone, gray-green, finely crystalline, fossiliferous, scattered, irregular light-blue to pink chert nodules; bedding uneven, reflecting numerous bioherm cores in exposure; thickness very irregular. (6-30 ft)
1. Shale, black, fissile; contact with unit 2 not exposed. (25 ft)

Figure 74. *Columnar section of roadcut on U.S. Highway 71, SE¼ sec. 12, T. 21 N., R. 32 W., SW¼ sec. 7 and NW¼ sec. 18, T. 21 N., R. 31 W., Jane 7½' Quadrangle, southern McDonald County, Missouri (fig. 73), relationship of the* **Pierson Limestone** *to the overlying Reeds Spring Formation. Adapted from Thompson and Fellows (1970, sec. X, p. 207-209).*

Reeds Spring Formation
Moore, 1928

Original description — (Moore, 1928, p. 163) "... interstratified dense, dark blue limestone and dark chert ... is characteristic of the Reeds Spring limestone member of the Boone in southwestern Missouri."

Type section — Named by Moore (1928) from exposures in the vicinity of Reeds Spring, Stone County, Missouri, the type section is along the Missouri-Pacific Railroad south of the tunnel south of the town, N½ NW¼ SW¼ sec. 31, T. 24 N., R. 22 W., Garber 7½' Quadrangle (figs. 75 and 76). It was described by Thompson and Fellows (1970, section D, p. 161-163).

Reference section — An excellent exposure of the Reeds Spring, more accessible than the type section, is in a roadcut on U.S. Highway 65, 0.5 mi north of the junction with Christian County Road

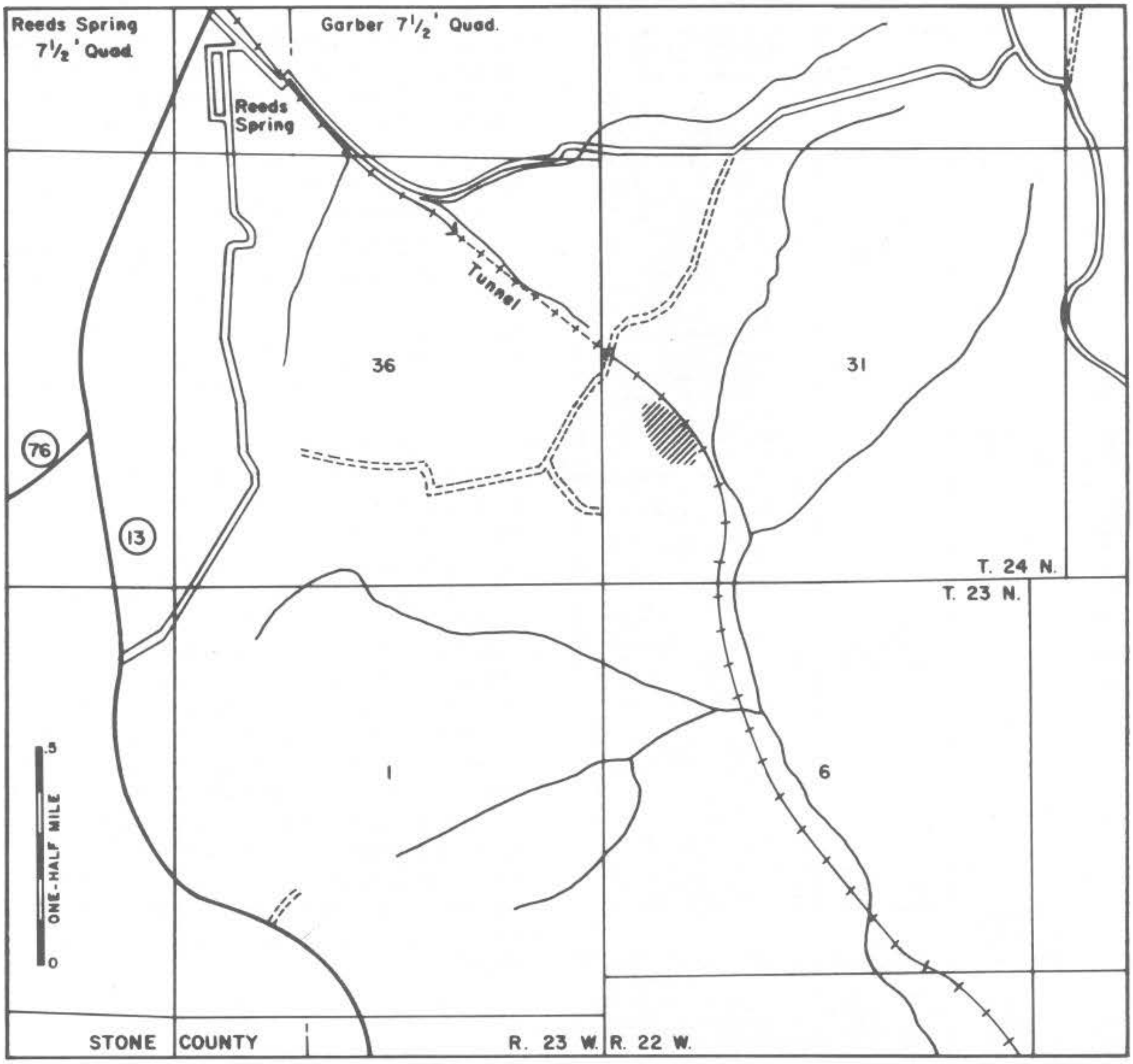
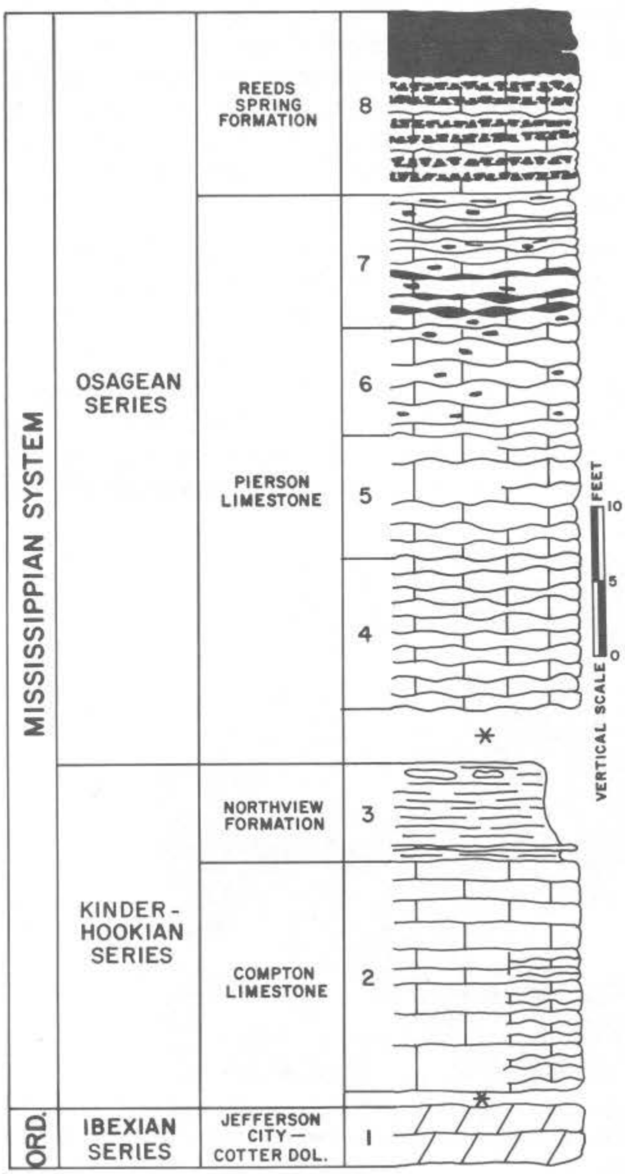


Figure 75. *Part of the Garber 7½' Quadrangle, Stone County, southwestern Missouri, showing location of the type section of the* **Reeds Spring Formation**.

BB (fig. 33), SW¼ SW¼ NE¼ and NW¼ NW¼ SE¼ sec. 22, T. 25 N., R. 21 W., Day 7½' Quadrangle. The section was described by Thompson and Fellows (1970, section M, p. 180).

History of nomenclature —

	early geologists	"Boone chert"
1910	Schuchert	Boone formation (part)
1918	Barton	Boone chert (lower part)
1928	**Moore**	**Reeds Spring limestone member of Boone formation**
1931	Fowler and Lyden	Reeds Spring (R Bed)
1934	Cline	Reeds Spring formation (suppressed "Boone" as a synonym of "Osage")
1944	Branson (a)	Reeds Spring member of Chouteau formation
1948	Weller et al.	Reeds Spring limestone



8. Chert (60-75%), light- to medium-gray and brown. Opaque to translucent, in irregular nodules and discontinuous beds. Limestone, dark-gray, very finely crystalline. (17 ft exposed)
7. Limestone, brown to dull-green to gray, finely to very finely crystalline; some argillaceous, nodular bedded; beds in upper 4 ft alternate with thin beds of brown to dull-green shale and calcareous shale. Chert, up to 50% in middle 3 ft, blue-black, weathers red-brown, in beds and scattered nodules. (9 ft 5 in.)
6. Limestone, gray-green, finely crystalline, argillaceous; beds nodular, weathering thin and slabby. Chert (10%), blue-black, smooth, translucent, as small nodules and thin discontinuous beds. (6 ft 7 in.)
5. Limestone, gray-green to brown, dense to finely crystalline, argillaceous at top, semicrinoidal; massive when fresh, nodular on weathered surface; scattered nodules of red-brown limestone. (9 ft)
4. Limestone, brown to gray-brown to brick-red, finely to medium-crystalline, massive; in nodular beds with reddish shale partings; brick-red lower 7 ft. (10 ft 10 in.)

Covered interval. (10 ft)

3. Shale, light-green to gray, crinoidal at base, calcareous; limestone nodules in upper part; 8-in. very finely crystalline limestone bed near base. (7 ft)
2. Limestone, light-brown, finely to medium-crystalline matrix, semicrinoidal; in medium beds; weathers to thin, slabby beds lower 10 ft. (16 ft)
1. Dolomite, brown, finely crystalline.

Figure 76. *Columnar section of the type section of the* **Reeds Spring Formation,** *in a railroad cut immediately south of the tunnel at Reeds Spring, N½ NW¼ SW¼ sec. 31, T. 24 N., R. 22 W., Stone County, southwestern Missouri. Adapted from Thompson and Fellows (1970, sec. D, p. 161-163).*

1950	Kaiser	Reeds Spring formation (lower part; some sections include Elsey strata)
1959	Barney	Reeds Spring Formation of Boone Group (lower part)
1961	Spreng	Reeds Spring formation
1965	Hessler	Reeds Spring Limestone Member of Boone Formation
1970	Thompson & Fellows	Reeds Spring Formation

Remarks — The Reeds Spring Formation consists of alternating beds of dense, very fine-grained, gray or bluish-gray, slightly argillaceous limestone, and bluish-black to grayish-white, nodular and irregularly bedded chert. The chert has a distinctive light-gray border. The chert beds often appear to be within the limestone beds (fig. 77), not just between them. On weathered surfaces from which the limestone has been removed, a box-work, or lattice structure, in the chert is exposed as horizontally and vertically anastomosing beds. Chert constitutes over 50 percent of the formation.

The northern limit of Reeds Spring distribution appears to be in a region that extends from just south of Springfield, in Greene County, Missouri, to northwest of Springfield. North of this line, the lithologic characteristics of the Reeds Spring become indistinguishable from those of the overlying Elsey, a similar limestone and chert formation. These characteristics include grain size of the limestone and the type of chert, whether as beds of nodules (Elsey) or as interconnected beds and bands of chert (Reeds Spring). Southwestward, the Reeds Spring extends in Arkansas and Oklahoma where it is called the **"Boone chert."** In its type area the formation averages less than 100 ft thick, but it thickens southward and westward. It is 100 to 150 ft thick in the Joplin area, and has been reported up to 225 ft thick in the extreme southern part of the state.

Throughout the area, the Reeds Spring apparently lies conformably on the Pierson Limestone. It is also conformable with the overlying Elsey Formation. It is distinguished from both by its dark-gray, extremely finely crystalline limestone that contrasts with the lighter gray, finely to medium-crystalline limestone of the Pierson and Elsey.

At the northern limit of its extent, the Reeds Spring is indistinguishable from the Elsey, and farther north, where the chert content decreases and limestone is dominant, the Reeds Spring-Elsey interval becomes part of the Burlington Limestone (fig. 58). Similar changes occur in the cherty upper portion of the Fern Glen Formation in eastern Missouri, a unit correlative with the Reeds Spring.

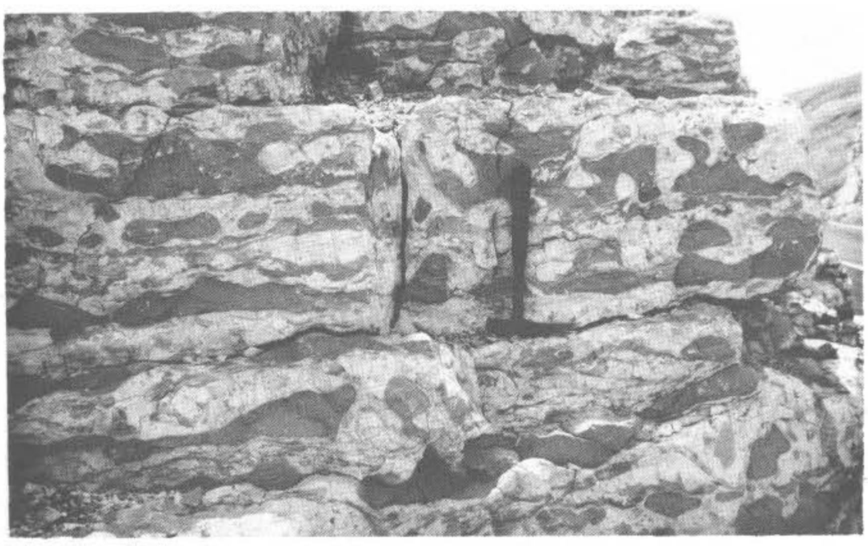


Figure 77. *The* ***Reeds Spring Formation*** *in a roadcut on U.S. Highway 65, SW¼ SW¼ NE¼ sec. 22, T. 25 N., R. 21 W., Day 7½' Quadrangle, Christian County, Missouri (see fig. 33), depicting the relationship of limestone to chert. The chert is light; the limestone, dark. Photograph by T.L. Thompson.*

Elsey Formation
Robertson, 1967

Original description — (Robertson, 1967, p. 14-15) "The Elsey consists of alternating beds of chert and limestone that are 6 to 18 inches thick. The limestone beds are fine-grained to dense, brown to gray and contain very little argillaceous material. The chert is very distinctive. Always present is a white to grayish-white chert which has prominent, very irregular brown mottled areas and contains comparatively large circular spots one sixteenth to one quarter of an inch in diameter. Darker brown or gray cherts similar to those of the Reeds Spring, and lighter porous cherts characteristic of the cherts of the overlying Burlington-Keokuk Limestones may also occur within the Elsey Formation. Locally, lenses of white crinoidal limestone . . . strongly resemble the limestones of the Burlington-Keokuk."

Type section — Robertson (1967) located the type section of the Elsey Formation in a roadcut on the north side of Missouri Highway 248, a half mile south of a bridge over Dry Creek, 1.5 mi west of the junction with Highway 173, and 2.5 mi south of the town of Elsey, NW¼ NW¼ SE¼ and NE¼ NE¼ SW¼ sec. 5, T. 24 N., R. 24 W., Stone County, Missouri, Elsey 7½' Quadrangle (fig 78). The section was measured by Robertson (1967, p. 49-51) and Thompson and Fellows (1970, p. 232-234).

The following description of the type section of the Elsey Formation is adapted from Robertson (1967, p. 49-51):

	Thickness Feet	Inches
Mississippian System Osagean Series Burlington-Keokuk Limestone		
11. Limestone, gray to white, coarsely crinoidal, calcarenitic; occurs in thick massive beds; contains large nodules of smooth to rough white chert in lower part, less chert in upper part, some "cotton rock," chert contains crinoid casts.	25+-	

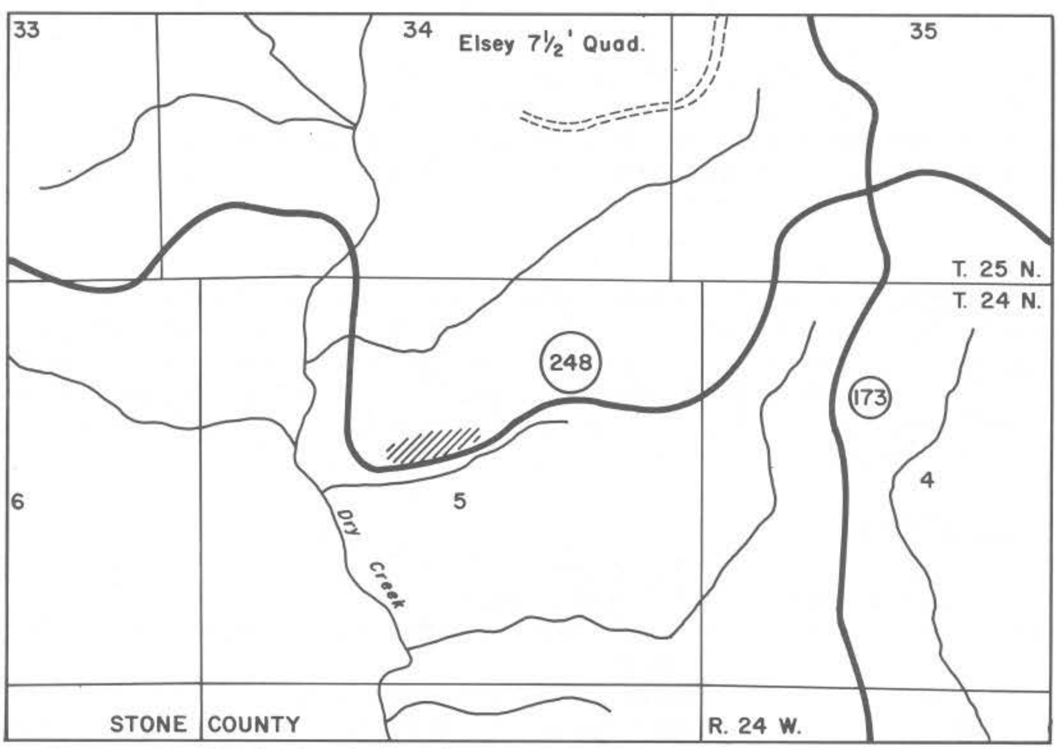


Figure 78. *Part of the Elsey 7½' Quadrangle, Stone County, southwestern Missouri, showing location of the type section of the* **Elsey Formation.**

		Thickness	
	Elsey Formation	Feet	Inches
10.	Interbedded limestone and chert; limestone is gray, dense to coarsely crinoidal, contains more crinoid columnals than occurs in Elsey at most localities but has a dense matrix; chert is light-gray to white to blue-white with brown to gray very irregular mottled areas and circular spots.	5	0
9.	Interbedded limestone and chert; limestone is coarsely crinoidal and thick bedded, gray; chert is white to very light-gray with irregular brown mottled areas and circular spots, occurs in smooth undulating beds and large masses from 8 in. to 1 ft thick.	2	0
8.	Interbedded limestone and chert; occurs in thick (12 to 18 in.) even beds, smooth wavy contacts between limestone and chert; limestone is fine-grained to dense with crinoid columnals throughout, somewhat laminated; chert is light-brown to white and contains dark-brown, very irregular mottled areas, most of the chert is smooth and compact; some chert beds and nodules contain crinoid casts, rare in the Elsey Formation.	20	8
	Reeds Spring Formation		
7.	Interbedded limestone and chert; limestone is fine-grained, gray to brown; thin (2 to 6 in.) irregular beds, argillaceous; chert is smooth, translucent, gray with brownish mottled areas, spicular, nodules enclosed in rinds of porous gray chert one-fourth inch thick.	3	0
6.	Covered interval.	40+-	
5.	Interbedded limestone and chert in beds 6 to 8 in. thick (30-40 percent chert); limestone is gray, fine-grained, laminated, shaly; chert is bluish-gray, translucent, spicular, serrated.	10	0
4.	Limestone, gray, fine-grained, very shaly.	3	0
3.	Limestone, gray, fine-grained, very shaly, thin slabby bedding; contains much chert; chert is blue, translucent and occurs in thin serrated beds and nodules.	17	0
	Pierson Formation		
2.	Limestone, brown, fine-grained, medium-bedded (6 to 10 in.); contains much chert; chert brown with blue centers, translucent.	8	0
1.	Interbedded limestone and chert; limestone brown, dense to fine-grained, thin-bedded; chert is gray to brown, mottled, translucent.	7	0

Reference section — Excellent exposures of Elsey are in roadcuts on Greene County Road D, on the east side of Springfield, NW¼ SW¼ SW¼ sec. 29, T. 29 N., R. 20 W., Galloway 7½' Quadrangle. They extend from the type section of the Pierson limestone (fig. 68) westward to the bridge over Pearson Creek (fig. 79). Although described by Beveridge and Clark (1952, p. 76) and Thompson and Fellows (1970, section A, p. 146), construction on highway D has produced better exposures of Pierson and Elsey strata than previously described (fig. 70).

History of nomenclature —

1918	Barton	Boone chert (upper part)
1931	Fowler & Lyden	O, P, and Q beds
(not) 1934	Cline	Grand Falls formation ("local variant of Reeds Spring formation")
1935	Giles	Grand Falls chert member of Boone limestone
1941	Clark	Grand Falls member of Reeds Spring formation (unpublished manuscript)
1944	Branson (a)	Grand Falls (quoted Clark, 1941)

1948	Weller et al.	Grand Falls Chert
1950	Kaiser	Reeds Spring formation (part; some sections)
	Bretz	Grand Falls member of Boone Formation
1952	**Clark & Beveridge**	**Grand Falls formation** (stratigraphic unit above Reeds Spring)
	Robertson, F.	Grand Falls chert
1961	Spreng	Grand Falls formation
1967	**Robertson, C.**	**Elsey Formation** (restricted "Grand Falls" to local chert developed in Joplin area)
1970	Thompson & Fellows	Elsey Formation
1979	Thompson (a, b)	**Elsey Formation**

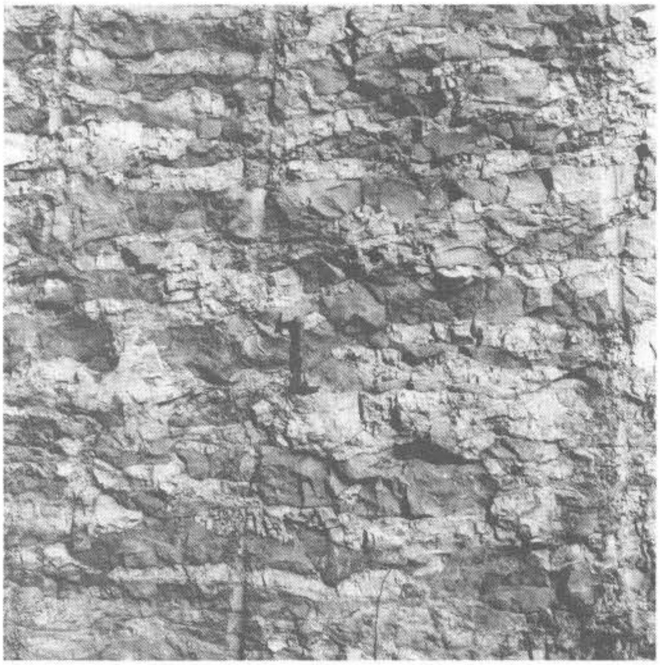


Figure 79. **Elsey Formation** *in a roadcut on Greene County Highway D, just east of the Pearson Creek bridge, east of Springfield, showing the typical relationship of limestone and chert in the formation. Compare this with the Reeds Spring Formation in figure 77. Photograph by T.L. Thompson.*

Remarks — The name "Grand Falls" was first assigned to 24 to 40 ft of chert exposed at Grand Falls, on Shoal Creek, near Joplin, Newton County, Missouri, by Winslow (1894, p. 411-419), who believed that its occurrence was local. Smith and Siebenthal (1907) and Cline (1941) also shared this opinion. Clark (1941) mapped the "Grand Falls member of the Reeds Spring formation" in the Cassville Quadrangle, and Clark and Beveridge (1952, p. 13-15) extended the name "Grand Falls" to include a limestone and chert unit, between the Reeds Spring and Burlington formations, that crops out over much of southwestern Missouri.

Robertson (1967, p. 46) proposed the name "Elsey" for the cherty limestone unit, above the Reeds Spring Formation in southwestern Missouri, that Clark and Beveridge (1952) had referred to as "Grand Falls." He recommended (p. 38) that the name "Grand Falls" be restricted to the chert body that crops out along Shoal Creek, near Joplin, Missouri, because he had determined that the chert at Grand Falls (Winslow's Grand Falls), resulted from silicification of more than one stratigraphic formation (Reeds Spring, Elsey, and possibly lower Burlington); therefore, the name "Grand Falls" was not well chosen for the stratigraphic unit it was to represent elsewhere.

The Elsey Formation is present only in southwestern Missouri and in adjacent parts of Arkansas, Oklahoma, and Kansas. It consists of finely to medium-crystalline gray limestone and white chert, which occur as ellipsoidal nodules, discontinuous beds, and nodular massive beds. Crinoidal lenses, usually finely crystalline, are common in the limestone. The chert is usually mottled white and gray and contains abundant fossil fragments, including spicules. A type of chert that is brecciated, with a gnarly structure, is widespread but does not appear to be confined to any particular stratigraphic horizon. When weathered, much of the chert breaks into sharp slivers; in this form, it is commonly called "butcher-knife flint."

The Elsey, which is approximately 30 ft thick, conformably overlies the Reeds Spring Formation or Pierson Limestone, and is immediately below the Burlington-Keokuk Limestone. In southern Greene County, Missouri, the Reeds Spring and Elsey appear to merge, the Reeds Spring characteristics being lost, into a single formation between the underlying Pierson and overlying Burlington. The Reeds Spring appears to be a southern facies of the lower Elsey. Where the Elsey lies on Pierson, the contact is sharp. North of Springfield, field relations indicate that the Elsey is a facies of the lower Burlington. Further northward the Elsey merges into lower Burlington, through loss of diagnostic chert and coarsening of the limestone.

Grand Falls Chert

Winslow, 1894

Original description — (Winslow, 1894, p. 417) "At Grand Falls, the chert is exposed on both sides of the creek, about 30 feet high, and over a bluff of this rock the creek falls. It is very dense, hard chert, in massive layers 6 or more feet thick; it has a gnarled and knotted structure, producing an uneven surface; the fracture is distinctly conchoidal."

Type section — The type section is at the Grand Falls of Shoal Creek, center N½ S½ sec. 28, T. 27 N., R. 33 W., just west of Joplin, Newton County, Missouri, Joplin West 7½' Quadrangle (fig. 80).

The following description of the type section of the Grand Falls Chert is adapted from Robertson (1967, p. 30-31):

	Thickness	
Mississippian System	Feet	Inches
Osagean Series		
Grand Falls Chert		
(relict Burlington-Keokuk Limestones) (N-bed)		
4. Chert, massive ledge, thick (12 to 18 inches) relict beds visible; chert is white to light-gray with brown mottled areas; fossiliferous; contains *Orthotetes keokuk, Tetracamera subtrigona, Delthyris similis.*	3	0
3. Chert ledge; 4- to 8-in. relict beds visible; chert is translucent gray to bluish-gray; contains small fossils; *Spiriferina* sp., *Delthyris similis.*	6	0
(relict Elsey Formation)		
2. Chert, smooth, brown to tan with gray to brown irregularly mottled areas.	6	0
(relict Reeds Spring Formation)		
1. Badly weathered ledge of chert, thin (1 to 3 in.) relict beds and nodules visible; contains large quantities of very dark bluish-black chert.	5	0
Low water level of Shoal Creek below falls.		

History of nomenclature —

1894	Jenney	Seneca chert (as cited by Smith and Siebenthal, 1907)
	Winslow	**Grand Falls chert**
1907	Smith & Siebenthal	Grand Falls chert member of Boone formation
1931	Fowler & Lyden	N, O, P, and Q Beds
1944	Branson (a)	Grand Falls chert (part; some sections)

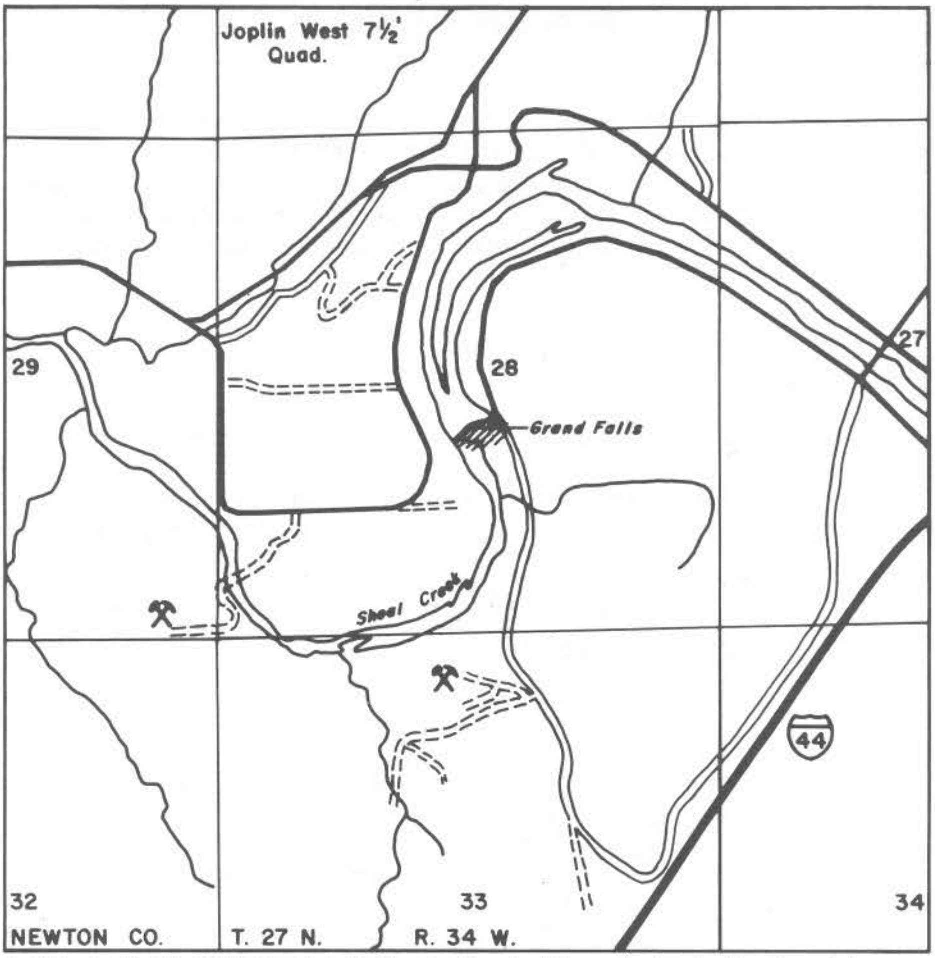


Figure 80. *Part of the Joplin West 7½' Quadrangle, Newton County, Missouri, showing location of the type section of the* **Grand Falls Chert.**

1950	Kaiser	Grand Falls chert member of Reeds Spring formation (local facies)
1959	Barney	Grand Falls chert member of Reeds Spring formation
1967	**Robertson**	**Grand Falls chert** (designated as local facies of Reeds Spring and Elsey Formations)
1979	Sable	Grand Falls Chert of Boone Formation

Remarks — Robertson (1967) described the Grand Falls at its type section as a silicified sequence of strata that were formerly part of the Reeds Spring and Elsey Formation, and the lower Keokuk Limestone; he could recognize chert types of all three formations in the Grand Falls. "Grand Falls" is restricted to this local chert unit along Shoal Creek and in the general vicinity of Joplin, Missouri. The formation is 24 to 40 ft thick in its type area, in western Jasper and Newton Counties, where exposures are numerous.

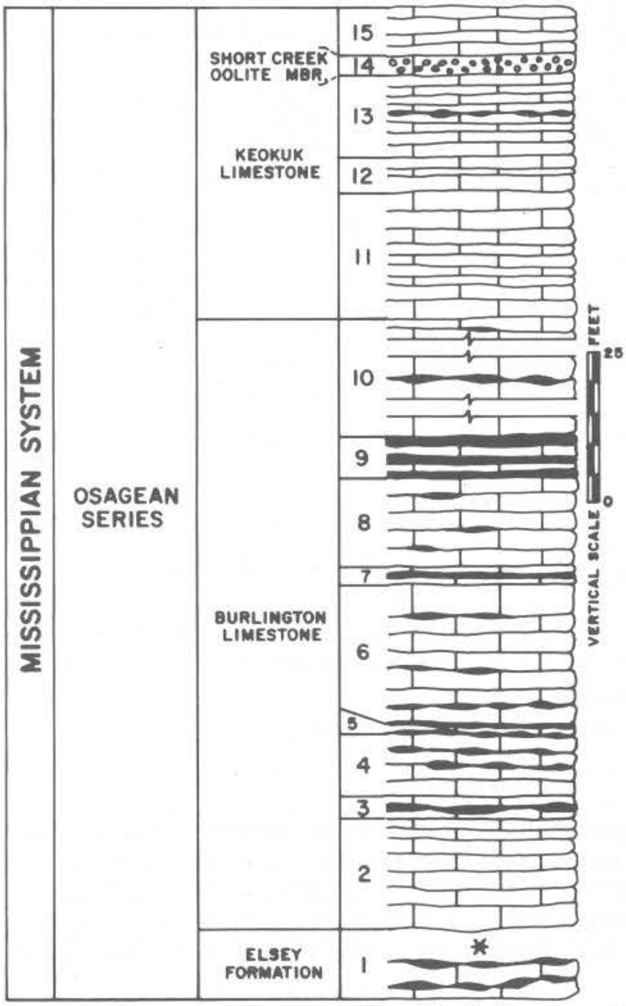
Distribution of the Grand Falls Chert is discontinuous. It may be well developed close to outcrops of the Reeds Spring, Elsey, and Keokuk, the units that make up the Grand Falls Chert; thus, transition from normal limestone formations to chert may occur in very short distances.

Burlington Limestone
Hall, 1857

Original description — (Hall, 1857, p. 190) "The encrinital limestone of Burlington, or, as we shall hereafter term it, the *Burlington limestone,* is characterized by its great numbers of crinoids, of which Drs. D.D. Owen and B.F. Shumard have described numerous species. The rock is in a great measure composed of the broken and comminuted remains of this family of fossils: large masses of the rock consist almost entirely of the separated but unbroken joints of the columns of various species."

Type section — The Burlington Limestone was named from exposures in the bluffs of the Mississippi River Valley at Burlington, Des Moines County, Iowa.

Reference section — In southwestern Missouri, the entire Burlington Limestone is exposed in a roadcut on U.S. Highway 65 immediately south of Springfield, Greene County, (fig. 81), beginning at the south edge of the bridge over Lake Springfield and continuing approximately 0.5 mi to the south, W½ E½ sec. 21, T. 28 N., R. 21 W., Ozark 7½' Quadrangle (Thompson and Fellows, 1970, section Y, p. 210-212).



15. Limestone, light-gray, medium- to coarsely crystalline, pelletal, glauconitic, well-sorted; in 1-ft beds. (8 ft)
14. Limestone, light-gray, oolitic; some oolites contain doubly terminated quartz crystals as nuclei; welded contact with unit 13. (3 ft)
13. Limestone, light-gray, medium-crinoidal, well-sorted, very finely crystalline adjacent to chert nodules. Chert, gray, very fossiliferous, in discontinuous bands of nodules in middle 3 ft of unit. (16 ft)
12. Limestone, gray, medium- to coarsely crinoidal, glauconitic; brachiopods abundant. (6 ft)
11. Limestone, light-gray, finely to coarsely crinoidal; in beds 1- to 2-ft thick. (21 ft)
10. Limestone, light-gray, crinoidal with some finely crystalline beds, in beds 0.5- to 3-ft thick. Chert, gray, as scattered ellipsoidal nodules. (60 ft 6 in.)
9. Limestone (50%), as in unit 10; chert in three 1-ft beds. (6 ft)
8. Limestone, as in unit 10. (14 ft 6 in.)
7. Limestone (50%), and chert, as in unit 9. (2 ft 6 in.)
6. Limestone, as in unit 10. (24 ft)
5. Limestone (50%), and chert, as in unit 9. (1 ft 6 in.)
4. Limestone, as in unit 10. (10 ft 6 in.)
3. Limestone (50%), light- to medium-gray, locally brown, dolomitic, crinoidal; in 1- to 14-in. beds. Chert, gray, weathers white, fossiliferous; as elongate nodules and discontinuous beds. (3 ft 4 in.)
2. Limestone, medium- to dark-gray, slightly dolomitic, finely to coarsely crinoidal, stylolitic; major bedding plane with solution features 15 ft above base (small cave). (18 ft 9 in.)
1. Limestone (50%), light-gray, finely crystalline with abundant crinoid ossicles; beds 4- to 8-in. thick. Chert, white to cream, in discontinuous beds and elongate nodules up to 4 in. thick. (6 ft)

Figure 81. *Composite columnar section of the* **Burlington and Keokuk Limestones** *exposed at Springfield, Greene County, southwestern Missouri. Compiled from (1) a roadcut on U.S. Highway 65 south of Springfield, E½ sec. 21, T. 28 N., R. 21 W., Ozark 7½' Quadrangle, and (2) a quarry (Brown Quarry) in western Springfield, E½ NW¼ SE¼ sec. 28, T. 29 N., R. 22 W., Springfield 7½' Quadrangle. Adapted from Thompson and Fellows (1970, sec. Y, p. 210-212; sec. Z, p. 213-214).*

History of nomenclature —

1852	Owen	Encrinital group of Burlington (part) "reddish brown encrinital group of Hannibal"
1855	Swallow	Encrinital limestone (part)
1857	**Hall**	**Burlington limestone**
1863	Englemann	Encrinital or Burlington limestone
1891	Williams	Burlington stage of Osage age
1895	Gordon	Encrinital group of Burlington Encrinital group of Hannibal
	Weller	Burlington limestone
1902	Weeks	Augusta limestone (lower part) Burlington limestone
1904	Ulrich	Boone limestone (lower part)
1905	Ulrich	Tullahoma limestone (lower part)
1917	Bridge	Burlington limestone ("Burlington white chert"; lower part of Burlington Limestone at Louisiana, Missouri)
1928	Weller & St. Clair	Burlington formation
1935	Giles	Burlington limestone member of Boone limestone
1960	Kissling	"unassigned Osagean limestone" (lower cherty part of Burlington Limestone)
1961	Spreng	Burlington formation
	Kissling	Burlington limestone "lower Burlington limestone" ("unassigned Osagean limestone" of Kissling, 1960)
1968	Carter	Burlington Limestone ("White Ledge")
1974	Carter	Lower Burlington Limestone (= Dolbee Creek Limestone Member, the "White Ledge" of Rowley; lowermost Burlington)
1975	Thompson	Burlington Limestone (included "lower Burlington Limestone" of Kissling, 1961)
1979	Collinson et al.	Burlington Limestone Cedar Fork Member Haight Creek Member Dolbee Creek Member

Remarks — Present in nearly all major Mississippian outcrop regions in Missouri, the Burlington Limestone is widespread throughout the Midcontinent region. It is known from Iowa to northwestern Arkansas and from western Illinois to western Kansas. It is present throughout the subsurface of Missouri, from the northeastern to the northwestern, western, and southwestern borders, except in the Ozark uplift, where it has been removed by erosion. It represents an extensive region of very uniform, shallow, prograding carbonate shelf deposition.

The Burlington Limestone is characteristically a white to gray, medium- to coarsely crystalline, medium- to coarsely crinoidal, medium- to thick-bedded, often cross-stratified (fig. 82), chert-free to sparsely cherty limestone. Chert occurs in zones 1 to 10 ft thick, separated by chert-free zones 30 to 50 ft thick. It is concentrated in the upper 50 to 70 ft in northeastern Missouri. The lower 20 to 30 ft in the St. Louis area contains 50 percent chert and has been called the "lower Burlington Limestone" by Kissling (1961) and Thompson (1975). The "lower Burlington Limestone" is considered equivalent to the Elsey Formation of southwestern Missouri, which is recognized as a facies of the lower part of the Burlington Limestone to the north of Springfield. The chert-free zones are extensively quarried for agricultural lime, road metal, and lime manufacture.

Toward the shelf edges, a sequence within the lower portion of the Osagean carbonate shelf becomes increasingly cherty, and separation into several formations is possible (fig. 58). Inland from

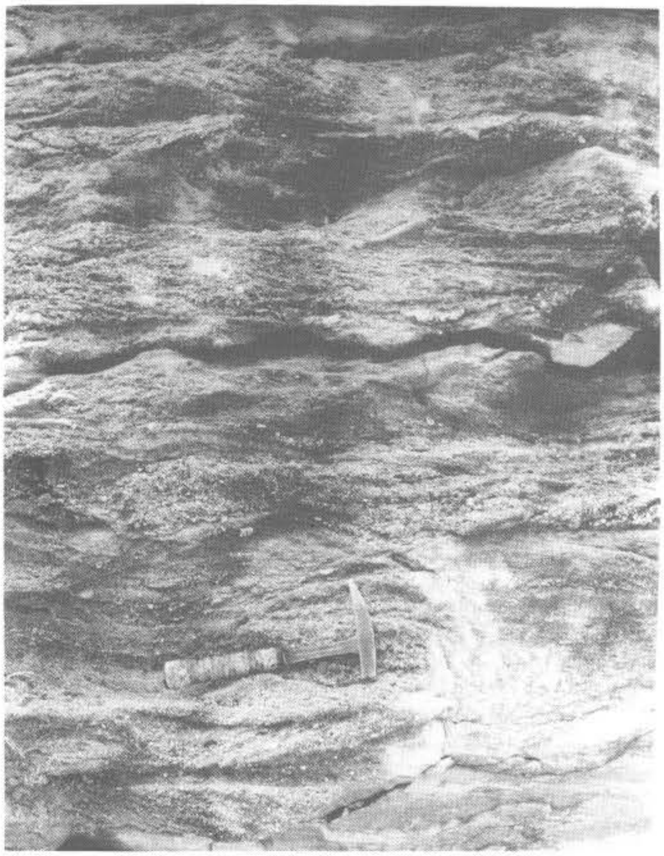


Figure 82. *Characteristic bedding of the* **Burlington Limestone**, *in a roadcut on Highway 65 south of Springfield*, Greene County, *Missouri. Photograph by T.L. Thompson.*

the shelf margins, little chert is present, and the Burlington Limestone is the basal unit of the Osagean Series. On the margins, both in east-central Missouri and southwestern Missouri, the lower Osagean strata are divisible into several formations, including the Fern Glen, in east-central Missouri, and the Pierson, Reeds spring, and Elsey, in southwestern Missouri. These units are lateral facies of lower Burlington limestones inward from the shelf. The Burlington Limestone lies on several formations; it is conformable on those of Osagean age: the Elsey Formation, or Pierson Limestone, in southwestern and west-central Missouri, and the Fern Glen Formation, in east-central Missouri (fig. 58). Where the other lower Osagean formations are absent, Burlington limestone lies disconformably on late Kinderhookian strata (fig. 14): the Hannibal Shale or "Chouteau Group undifferentiated," in northeastern Missouri, and the Northview Formation, in central, western and southwestern Missouri.

The contact with the overlying, lithologically similar Keokuk Limestone is transitional and often difficult or impossible to identify; hence, the sequence of Osagean limestones is sometimes identified as the "Burlington-Keokuk Limestone." The thickness of the Burlington Limestone, however, is believed to be fairly uniform throughout the state, seldom exceeding 100 ft. the formation is absent in the immediate Joplin area and has not been identified south of southern Barry County, in southwestern Missouri.

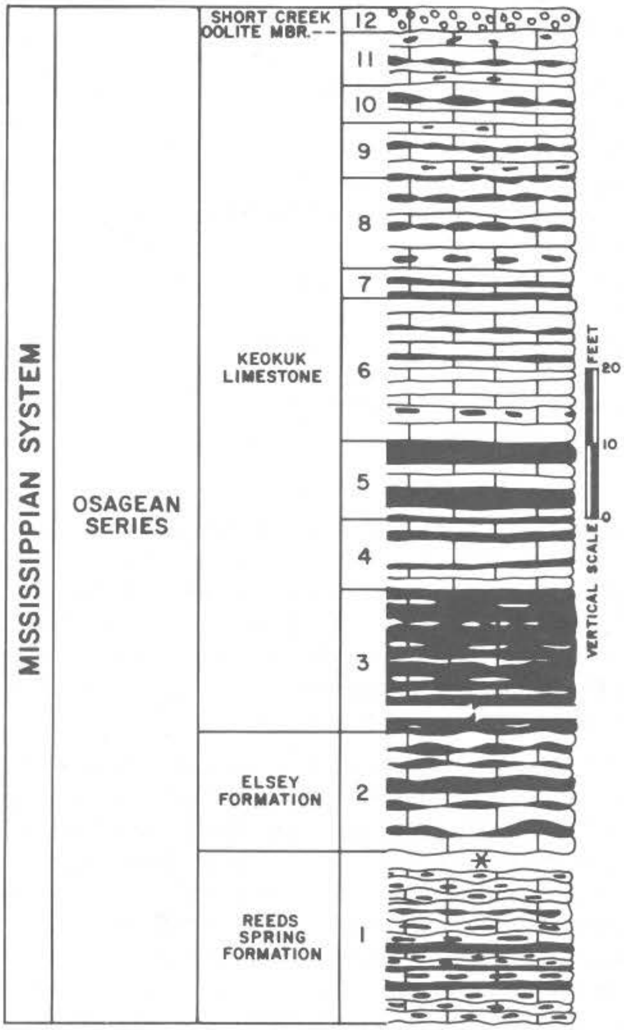
Keokuk Limestone

Owen, 1852

Original description — (Owen, 1852, p. 91) "4. The latter division passes upwards into the gray, cherty limestones, which form the wall washed by the Mississippi, below the Keokuck [sic] Landing."

Type section — The Keokuk Limestone was named from exposures along the western bluffs of the Mississippi River Valley in the vicinity of Keokuk, Iowa. Willman et al. (1975, p. 138) state that the type locality is along and at the mouth of Soap Creek, in Lee County, Iowa.

Reference sections — An excellent exposure of Keokuk Limestone is in Brown Quarry, on the south bank of Wilson Creek, 0.5 mi northwest of the intersection of Sunshine Street and Scenic Drive, in western Springfield, Greene County, southwestern Missouri (fig. 81), E½ NW¼ SE¼ sec. 28, T. 29 N., R. 22 W., Springfield 7½' Quadrangle (Thompson and Fellows, 1970, section Z, p. 213). The Short Creek Oolite Member is well exposed in this section.



12. Limestone, light-gray, oolitic; single bed. (3 ft)
11. Limestone (70%), gray, semicrinoidal, in 4-in. to 1-ft beds. Chert, white, opaque, fossiliferous, as nodules and beds. (7 ft 6 in.)
10. Limestone (50%), gray, semicrinoidal with some finely crystalline lenses, in 4-in. to 1-ft beds. Chert, white, opaque, fossiliferous, as nodules and beds. (5 ft)
9. Limestone and chert, same as unit 11. (7 ft)
8. Limestone, gray, medium-crystalline to semicrinoidal, massive, thick-bedded. Chert, white, mottled, contains spherical limestone inclusions; thick (1-ft), nodular bed near middle of unit, and scattered dull-white opaque chert nodules. (12 ft)
7. Limestone (50%), gray, medium-crystalline to semicrinoidal, alternating with beds of white, opaque, fossiliferous chert. (4 ft)
6. Limestone, gray, semicrinoidal; contains scattered chert nodules and prominent chert bed near middle of unit. (19 ft)
5. Chert (75%), dull-white, opaque, in thin beds. Limestone, gray, medium-crystalline to semicrinoidal with scattered finely crystalline lenses, in thick irregular beds. Upper fourth of unit 100% chert. (10 ft)
4. Limestone (80%), gray, medium-crystalline to semicrinoidal with some finely crystalline lenses, in 1- to 2-ft beds. Chert, white, opaque, tripolitic, fossiliferous, in discontinuous nodular 2- to 6-in. beds between limestone beds. (10 ft)
3. Chert (90%), white, opaque, in thick uneven beds. Limestone, dark-gray, very finely crystalline, as nodules and thin beds. (29 ft)
2. Limestone (60%), gray, finely crystalline with scattered crinoidal lenses, in medium to thick irregular beds. Chert, light-gray to white with brown mottles, as 6-in. to 1-ft thick nodules. Part of unit better exposed 0.4 mi east of quarry. (15 ft)
1. Chert (60%), gray to tan, mottled, as smooth nodules and anastomosing beds within limestone. Limestone, dark-gray, finely crystalline with some crinoidal lenses, as thin nodular beds. (16 ft)

Figure 83. *Columnar section of* **Keokuk Limestone** *exposed in the Kirshmann-Jeffries Quarry, on the south bank of Shoal Creek, 0.7 mi southwest of Grand Falls, S½ SE¼ SE¼ sec. 29, T. 27 N., R. 3 W., Joplin West 7½' Quadrangle, Newton County, southwestern Missouri. Adapted from Thompson and Fellows (1970, sec. G, p. 165-169).*

The Keokuk Limestone and Short Creek Oolite Member is well exposed in the Kirshmann-Jeffries quarry in the southwestern edge of Joplin, Newton County, Missouri (fig. 83), S½ SE¼ SE¼ sec. 29, T. 27 W., R. 33 W., Joplin West 7½' Quadrangle (Thompson and Fellows, 1970, section G, p. 166).

History of nomenclature —

	Early geologists	Encrinital limestone (upper part)
1852	**Owen**	**Keokuck [sic] cherty limestone**
		Lower Archimedes limestone
1855	Shumard	Archimedes limestone (part)
	Swallow	Archimedes limestone (part)
1857	Hall	Lower Archimedes limestone or Keokuk limestone
1861	Meek & Worthen (a)	Keokuk limestone
1866	Worthen	Keokuk group (part)
1874	Broadhead	Keokuk limestone **(first use of this name in Missouri)**
1891	Williams	Keokuk stage of Osage age
1895	Keyes	Keokuk limestone
		Montrose chert
1898	Marbut	Archimedes limestone (part)
	Gallaher	Carthage limestone (lower part)
	Weller (a)	Keokuk formation
1902	Weeks	Augusta limestone (middle part)
1928	Moore	Keokuk limestone member of Boone formation
1944	Branson (a)	Keokuk limestone
	Gordon	Boone formation (upper part; Joplin district)
1961	Spreng	Keokuk limestone
1959	Barney	Keokuk limestone of Boone group
1970	McKnight & Fischer	Joplin Member of Boone Formation
	Thompson & Fellows	Keokuk Limestone (1 member)
1979	Thompson (a, b)	Keokuk Limestone

Remarks — Similar in distribution to the Burlington Limestone, the Keokuk Limestone is present at all major Mississippian outcrop areas in Missouri, except the southeastern, and occurs throughout the subsurface, from the northeastern to the northwestern, western, and southwestern borders. The Keokuk Limestone is mostly a medium-crystalline limestone, with some finely to coarsely crystalline, and/or crinoidal zones; it is generally more finely crystalline than the underlying Burlington. Chert, which is common throughout the formation, is more abundant in the lower and upper parts. The chert is light gray and nodular, often with tripolitic borders.

Except for the region of Joplin, and extreme southwestern Missouri, the Keokuk Limestone is everywhere transitional with the underlying Burlington Limestone; hence, this contact is not really possible to place, a circumstance that results in the Osagean sequence being called the "Burlington-Keokuk Limestones." In the region of Joplin, where the Keokuk lies on a thick chert sequence and the Burlington Limestone is locally absent, the Keokuk is about 60 to 75 ft thick and, as in most of southwestern Missouri, is capped by a very diagnostic oolitic limestone, the **Short Creek Oolite Member.** North of Joplin, in the subsurface of western Missouri, the Burlington-Keokuk Limestone is present throughout the region and continues northward unbroken, into the subsurface of northwestern Missouri. In some areas of western Missouri, because of pre-Pennsylvanian erosion, Burlington-Keokuk strata are the uppermost Mississippian strata preserved. Throughout most of its extent, the Keokuk appears to be overlain conformably by the Warsaw Formation, but in southwestern Barry County, near the Arkansas border, the Keokuk is disconformably overlain by the Middle Chesterian Hindsville Limestone.

As noted by Spreng (1961, p. 65),

"Fossils are common in the formation but are not readily removed from the limestone. The productid brachiopods *Buxtonia, Dictyoclostus, Linoproductus,* and *Marginirugus* are common, as well as the following species of brachiopods: *Orthotetes keokuk, Cleiothyridina obmaxima, Echinoconchus alternatus, Spirifer logani,* and *Tetracamera* spp. Horn corals and bryozoans, especially the distinctive bryozoan genus *Archimedes,* are relatively abundant in the formation.

". . . thickness determinations for either the Burlington or Keokuk are difficult to make because of the obscure boundary between them. This is especially true in east-central and southeastern Missouri where the two formations together have a thickness of about 125 feet. Of this amount, about 50 feet belongs to the Keokuk. In northeastern Missouri, the thickness of the formation ranges from 60 to 70 feet. In central and southwestern Missouri, it may range up to 100 feet thick.

"The Keokuk is used for road metal and occasionally for building stone. Agstone quarry operators utilize the less cherty parts of the formation which includes the Short Creek Member. Tripoli is mined from weathered Keokuk chert in western Newton County."

In eastern and southwestern Missouri, the Keokuk is represented by a conodont fauna of the *Gnathodus texanus-Taphrognathus* Zone (Rexroad and Collinson, 1965; Thompson and Fellows, 1970), a fauna nearly indistinguishable from that of the overlying Warsaw Formation; indeed, the contact between the Keokuk and Warsaw is conformable.

Short Creek Oolite Member of Keokuk Limestone
Smith and Siebenthal, 1907

Original description — (Smith and Siebenthal, 1907) "The Short Creek member is a thin but very persistent bed of oolitic limestone. Generally it forms a single, massive, homogeneous bed which in the Joplin area ranges from 18 inches to 8 feet in thickness. . . . The spherules are round, never flattened, though some are concave where they touch. . . . One of the most constant characteristics of the Short Creek oolite is the regularity in size of the spherules in a hand specimen, though they vary somewhat in size from place to place. . . . The individual spherules in the Short Creek are solid, and though apparently formed by concentric growth, rarely show the center darker than the shell. . . . The Short Creek spherules are embedded in a calcareous matrix which in places is coarsely crystalline . . . In most cases the rock has a slightly splintery fracture, and this character is more pronounced the more complete the cementation."

Type section — According to Smith and Siebenthal (1907, p. 5), "The member is named from Short Creek, a stream flowing westward between the cities of Galena and Empire, Kansas, and the type locality is the north bluff of the creek half a mile south of west of the Empire depot and a hundred yards north of the crossing of the Missouri, Kansas, and Texas and Frisco railways." This is just north of the center of the line separating secs. 14 and 15, T. 34 S., R. 25 E., Cherokee County, Kansas, Baxter Springs 7½′ Quadrangle.

Reference sections — There are several excellent exposures of Short Creek in southwestern Missouri: in the Brown Quarry at Springfield (fig. 81), Greene County, and in the Kirshmann-Jeffries Quarry near Joplin (fig. 83), Newton County. Both are located under "Reference sections" for the Keokuk Limestone. The Short Creek is also exposed in several roadcuts on I-44, in the south edge of Joplin: a roadcut on the north side (west-bound lane) in the SE¼ SE¼ SW¼ sec. 23, T. 27 N., R. 33 W., and approximately 0.25 mi west of the first, on the northwest side of the intersection of I-44 with Missouri Highway 86, NE¼ SE¼ NE¼ sec. 27, T. 27 N., R. 33 W., Newton County, Missouri, Joplin West 7½′ Quadrangle.

History of nomenclature —

1907	**Smith & Siebenthal**	**Short Creek oolite member of Boone formation**
1917	Bridge	Short Creek oolite
1941	Clark	Short Creek oolite of Keokuk formation
1944	Branson (a)	Short Creek oolite (either top of Keokuk or base of Warsaw)
1961	Spreng	Short Creek member of Keokuk formation
1966	Gordon	Short Creek Oolite Member of Boone Formation
1970	Thompson & Fellows	Short Creek Oolite Member of Keokuk Limestone

Remarks — According to Spreng (1961, p. 65-66),

"Throughout southwestern Missouri and adjacent areas of Kansas and Oklahoma, a thin, persistent bed of oolitic limestone, 2 to 8 feet thick is present at the top of the Keokuk. This unit is the Short Creek member of the formation. It is generally a single, massive bed and is commonly used as a datum in field mapping. However, because of the difficulty of determining the Keokuk-Warsaw boundary in drill cuttings, the base of the Short Creek member is arbitrarily designated as the base of the Warsaw in subsurface studies. The ooliths are usually less than one millimeter in diameter, round in cross section, and often have as a nucleus a doubly terminated quartz crystal. The matrix in which the ooliths are embedded is a white limestone which contains scattered glauconite grains. An insoluble residue of the member usually contains doubly terminated quartz crystals, glauconite, and some chert. Fossils consist mostly of brachiopods such as *Orthotetes keokuk, Rhipidomella* spp. and *Chonetes illinoisensis*."

Because there is no faunal evidence for a Meramecian-Osagean boundary in western and southwestern Missouri, the Short Creek Oolite designates the top of the Osagean Series in that region. It also defines the Keokuk-Warsaw contact for regional mapping purposes, because the lower Warsaw strata are lithologically similar to upper Keokuk limestones. Regionally, the Short Creek is a member of the Keokuk limestone, and the top is the marker for the base of the Warsaw Formation.

The type section of the Short Creek Oolite Member is in southeastern Kansas, a few miles west of the Missouri-Kansas border. In Missouri it is best exposed in the southwest. The Short Creek has been identified near Joplin, in Newton and Jasper Counties; in Lawrence, Dade, and Cedar Counties; and in isolated outcrops in southern Barry County. It is also known from outcrops in the area of Springfield, Greene County, Missouri, and from a few wells in Vernon and Bates Counties, north of Joplin, in western Missouri. Occasional reports allude to the presence of more than one oolitic limestone zone in upper Keokuk strata of southwestern Missouri, but no such zone has yet been reported. No specific zone correlative with the Short Creek has been confidently identified in eastern Missouri.

MERAMECIAN SERIES
Ulrich, 1904

Original description — (Ulrich, 1904, p. 110) "(7) The Warsaw limestone (and shales) occur at the base of the group at Meramec Highlands and extend northward from that point. This, together with the overlying Spergen Hill and St. Louis limestones are embraced in a group for which I propose the name Meramec group."

Type area — Ulrich (1904) named the "group" from the "Meramec Highlands," a region in eastern St. Louis County, Missouri, immediately west of I-270, and extending westward to the bluffs of the Meramec River Valley. The best exposures today are the roadcuts along I-270 immediately north of the junction of this highway with I-44. These, combined with an old quarry immediately east of I-270 and exposures along I-44 immediately east of the junction, include Warsaw, Salem, and St. Louis strata. These exposures are located in the NE¼ sec. 25, T. 44 N., R. 5 E., and the NW¼ sec. 30, T. 44 N., R. 6 E., in St. Louis County, Kirkwood 7½' Quadrangle (fig. 84).

History of nomenclature —

1847	Englemann	St. Louis limestone
1855	Shumard	Archimedes group (lower part; included Meramecian and Chesterian strata)

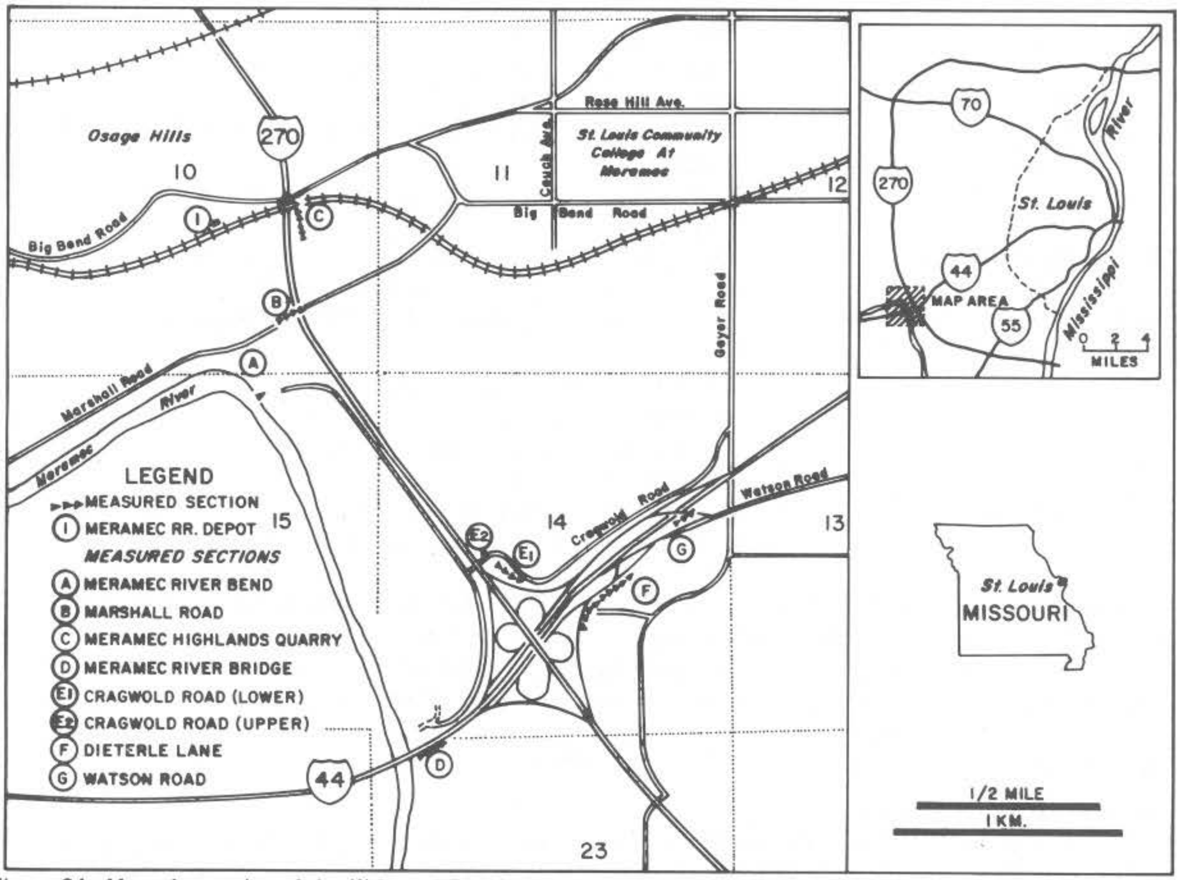


Figure 84. *Map of a portion of the Kirkwood 7½' Quadrangle, St. Louis County, eastern Missouri, showing locations of reference sections in the type area of the* **Meramecian Series.** *Adapted from Lane and Brenckle (1977, fig. 1).*

1866	Worthen	St. Louis group
1891	Williams	Genevieve group (lower part; included Warsaw)
1892	Keyes	St. Louis group (excluded Warsaw)
1895	Gordon	Upper series (lower part)
1898	Weller (a, b)	Ste. Genevieve epoch (lower part)
		Osage epoch (upper part; included Warsaw)
1902	Weeks	Mountain limestone (Warsaw-Aux Vases)
1904	**Ulrich**	**Meramec group**
1905	Ulrich	Tennessean series (lower part)
1910	Schuchert	Meramecian series of Tennesseic Period (excluded Ste. Genevieve)
1911	Girty	Mountain limestone (Richmond, Missouri)
	Ulrich	Meramecian series of Tennessean Period (excluded Ste. Genevieve)
1914	Weller	Meramec group (excluded Warsaw and Ste. Genevieve)
	Keyes	Tennessean series (lower part)
		Mississippian series (upper part)
1915	Girty (b)	St. Louis group
1919	Keyes	Louisian series (upper part)
1920	Weller	Iowan series (upper part; included all strata from base of Kinderhookian to top of Meramecian)
1922	Williams	Ste. Genevieve group (lower part)
	Keyes	Mississippian series (upper part; rejected "Tennessean series")
1924	Krey	Meramecian series of Lower Mississippian subsystem
1928	Weller & St. Clair	Meramec group
1933	Keyes	Chartresan series (lower part)
		Mississippian series (upper part)
	Weller & Sutton	Valmeyer series (upper part)
1937	Laudon	Meramec subseries (rejected "Valmeyer" of Weller and Sutton, 1933)
1938	Keyes (c)	Chartresan series (emended; = Meramecian, but excluded Warsaw)
1940	Weller & Sutton	Meramec group (excluded Warsaw; upper part of Iowa series)
1944	Branson (a)	Middle Mississippian series (upper part)
1945	Cheney et al.	Meramec series (upper part of "Middle Mississippian")
1961	Spreng	Meramecian series
1963	Swann	Valmeyeran Series (upper part; in Illinois)
		Genevievian Stage of Valmeyeran Series (= Ste. Genevieve Limestone and Aux Vases Sandstone)
1979	Thompson (a)	Meramecian Series
	Collinson et al.	Valmeyeran Series (upper part)
	Sable	Meramec Series (includes Aux Vases Sandstone)

Remarks — The lower boundary of the Meramecian Series is between the Keokuk Limestone and Warsaw Formation, marked by the top of the Short Creek Oolite Member of the Keokuk Limestone in western and southwestern Missouri, and the contact of the Keokuk Limestone and limestone and shaly limestone of the overlying Warsaw Formation in eastern Missouri. In eastern Missouri, where basal Warsaw strata are limestone, the Keokuk-Warsaw boundary, and thus, the Osagean-Meramecian boundary, can be very difficult to identify.

Spreng (1961, p. 66) stated,

"The position of the boundary between the Meramecian and Osagean Series has long been disputed. The problem involves the assignment of the Warsaw formation. Some geologists regard the Warsaw as the lowest formation of the Meramecian Series because its predominantly clastic lithology differs from the calcareous composition of the Keokuk, and its fauna contains many new species which are not present in the Keokuk. Other geologists have placed the Warsaw at the top of the Osagean Series because the Warsaw fauna resembles the Keokuk fauna in many respects, and the boundary between the two formations is obscure in many areas."

Obviously, those who regarded the faunas as distinctly different worked with fossils collected in eastern Missouri, where the clastic limestone of the Warsaw overlies the relatively pure limestone of the Keokuk, whereas those who described the similarity of faunas, and of lithologies, of the Keokuk and Warsaw, drew their conclusions from studies in central, western, and/or southwestern Missouri.

Thus, the Warsaw and Keokuk were treated as separate faunal units by some and as a single faunal unit by others, using the same faunal evidence. In Missouri, the Warsaw has long been defined as the basal formation of the Meramecian Series, which, as thus defined, is conformable with the underlying Osagean Series.

Because a clearly defined faunal break between the Osagean and Meramecian Series is lacking, the Illinois and Indiana Geological Surveys, among others, have adopted a three-part subdivision of the Mississippian System in place of the traditional four-part subdivision; the **Valmeyeran Series** is their Middle Mississippian unit. They regard the Osagean and Meramecian as a single series. The type locality for the Valmeyeran Series is in west-central Illinois, south of St. Louis, around the town of Valmeyer, Monroe County, Illinois, in secs. 3 and 10, T. 3 S., R. 11 W., Valmeyer 7½' Quadrangle. Several other Midcontinent states no longer recognize an Osagean or Meramecian Series and use a three-part division of the Mississippian System, instead of a four-part division. Kansas recognizes an Upper and a Lower Mississippian Series, which are separated by the Osagean-Meramecian boundary; the four named units constitute *stages* of the two series (e.g., Meramecian Stage of Upper Mississippian Series).

The upper boundary of the Osagean (and Valmeyeran) Series was originally defined as the top of the Ste. Genevieve Formation. As defined by Spreng (1961), the upper boundary of the Meramecian (or Valmeyeran) Series is at the top of the Ste. Genevieve Limestone, where Chesterian strata occur, at the base of the Aux Vases Sandstone (fig. 9). Recently, in the southern part of the Illinois basin this boundary was moved upward (fig. 86) into the middle of the Renault Formation (Swann, 1963; Atherton et al., 1975). Swann (1963, p. 17-18) stated,

"Whether the Ste. Genevieve Limestone should be placed in the Valmeyeran or Chesterian Series was the subject of a heated debate that lasted over two decades and was not resolved until 1938 (Wilmarth) when the Ste. Genevieve was placed in the Valmeyeran. Many of the arguments presented on both sides are still valid, and it is doubtful that a unanimous decision

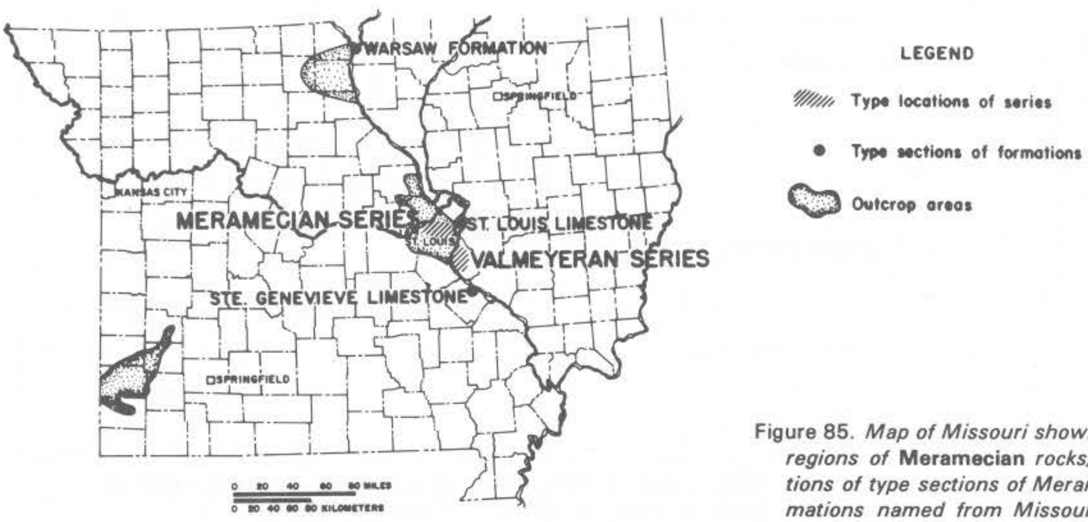


Figure 85. *Map of Missouri showing outcrop regions of* **Meramecian** *rocks, and locations of type sections of Meramecian formations named from Missouri sections.*

> could be reached in any revival of the controversy. It is clearer today that the Ste. Genevieve is very closely allied to the Chesterian in its mode of origin and that there was no important 'time break' following Ste. Genevieve deposition. However, there also is more support today for the view that the geologic time units are somewhat arbitrary divisions of continous time rather than natural episodes. Biostratigraphic zonation allows more precise determination of an isochronous surface at the top of the Ste. Genevieve than at its base, at least in the central and eastern United States. The Ste. Genevieve, therefore, is retained in the Valmeyeran."

Swann (1963, p. 18) placed the Valmeyeran-Chesterian boundary (Meramecian-Chesterian boundary in Missouri) between the Levias and Shelterville Members of the Renault Formation, thereby raising the boundary to include, in the Valmeyeran Series, the former lower Chesterian Aux Vases Sandstone and the Levias Limestone Member of the Renault Formation.

Although in eastern Missouri the Aux Vases and Renault Formations overlie the Ste. Genevieve, eastward into Kentucky and Indiana, the entire upper Meramecian sequence is considered to be Ste. Genevieve. The Aux Vases and lower member of the Renault (Levias) are identified as western facies of upper Ste. Genevieve strata to the east (fig. 86). Swann (1963, p. 20) included as uppermost Valmeyeran

> "... all the units deposited contemporaneously with the Ste. Genevieve Limestone where its top corresponds with the last occurrence of *Platycrinites penicillus.*"

This corresponds to the top of the Levias Limestone Member of the Renault Formation (the Shelterville Limestone Member of Renault Formation is characterized by the earliest appearance of the crinoid *Talarocrinus*). Swann (1963, p. 21) concluded,

> "The top boundary of the Genevievian [uppermost stage of the Valmeyeran Series] is the Valmeyeran-Chesterian or *Platycrinites penicillus-Talarocrinus* boundary . . ."

Series	Weller and Sutton (1940)		Swann (1963)	
CHESTERIAN	Renault Limestone		Yankeetown Sandstone	
CHESTERIAN	Renault Limestone		RENAULT	Shelterville Member
MERAMECIAN	STE. GENEVIEVE	Levias Member	RENAULT	Levias Member
MERAMECIAN	STE. GENEVIEVE	Rosiclare Member	Aux Vases Sandstone	
MERAMECIAN	STE. GENEVIEVE	Fredonia Member	STE. GENEVIEVE	Joppa Member
MERAMECIAN	STE. GENEVIEVE	Fredonia Member	STE. GENEVIEVE	Karnak Member
MERAMECIAN	STE. GENEVIEVE	Fredonia Member	STE. GENEVIEVE	Spar Mountain Member
MERAMECIAN	STE. GENEVIEVE	Fredonia Member	STE. GENEVIEVE	Fredonia Member

Figure 86. *Comparison of named units that are contiguous to the Meramecian-Chesterian boundary and are recognized in the southern Illinois "fluorspar district" by Weller and Sutton (1940) and Swann (1963).*

The Meramecian Series initially consisted of four formations: the Warsaw, Salem, St. Louis, and Ste. Genevieve. In Illinois, it is now defined as composed of five formations and the lower member of a sixth, with the addition of the Aux Vases Sandstone and the Levias Limestone Member of the Renault Formation. In Missouri, it is composed of five formations. Pryor and Sable (1974, p. 296) suggested that in Missouri the Meramecian-Chesterian boundary is between the Aux Vases and Renault. In Missouri the Renault is represented only by the upper member (Shelterville Limestone Member); the basal member, the Levias, is not present.

With the exception of the Warsaw and part of the Salem, which in eastern Missouri are partly shales, Meramecian formations are principally limestone and some dolomite. Chert is uncommon but occurs in all the formations. The entire series is present in southeastern Missouri. East-central and southeastern Missouri contain the type localities for the St. Louis and Ste. Genevieve Limestones, respectively. The Warsaw and Salem are the only Meramecian formations that have been identified in central Missouri.

In southwestern Missouri, Warsaw, Salem(?), and St. Louis have been identified in the center of an anticlinal structure (Clark, 1937). In the subsurface of western Missouri, north of this small outcrop area, pre-Pennsylvanian erosion left the upper Osagean Burlington-Keokuk Limestones as the most commonly preserved youngest Mississippian. Meramecian strata, however, have been identified on this uneven surface as the uppermost Mississippian formations in some logs from Vernon and Bates Counties, and are widespread in the subsurface of eastern Kansas (Thompson and Goebel, 1969). In the subsurface of northwestern Missouri, the complete sequence of Meramecian formations (excluding the Aux Vases and Levias) has been identified in studies of drill cuttings.

The Meramecian is overlain by the Chesterian Series in southeastern Missouri. In the subsurface of northwestern Missouri and throughout central Missouri, Chesterian strata are absent, and remnants of the Meramecian are directly overlain by Pennsylvanian strata. The maximum thickness of the Series is in east-central Missouri, where the unit is between 300 and 450 ft thick. The Series thins northward to 150 ft. In central and southwestern Missouri, where the Series is incomplete, the thicknesses range from 60 ft in central Missouri to 185 ft in the southwest.

Formations in the Meramecian Series in Missouri include the following:

Western Missouri	**Eastern Missouri**
	Aux Vases Sandstone
	Ste. Genevieve Limestone
St. Louis Limestone	St. Louis Limestone
Salem Formation	Salem Formation
Warsaw Formation	Warsaw Formation

Conodont zones defined for the Meramecian Series (Collinson et al., 1971) are shown in table 2.

Warsaw Formation
Hall, 1857

Original description — (Hall, 1857, p. 191) In discussing the horizon he was calling Warsaw, Hall stated "The central and principal portion is highly fossiliferous, abounding in the reticulate bryozoa; and among these the axis of a species of *Archimedes* occurs in great numbers and of extraordinary size and perfection. So abundant is it that a dozen individuals may sometimes be seen in the space of a few feet . . ."

"This *second* Archimedes limestone seems not to have been recognized in the section of Dr. Owen; and judging from localities cited, it appears to have been confounded with the *lower* Archimedes or Keokuk limestone. The position however of the Warsaw Archimedes limestone is above the geode bed . . ."

Type section — The type section for the Warsaw Formation (fig. 87) is an exposure along a creek at the northeastern edge of the town of Warsaw, extending upstream on the southeast side of the highway bridge, SE¼ sec. 4, NE¼ NE¼ sec. 9, and NW¼ sec. 10, T. 4 N., R. 9 W., Hancock County, Illinois, Warsaw 7½' Quadrangle. This section has been described by Rexroad and Collinson (1965, p. 5) and Collinson et al. (1979, p. 17).

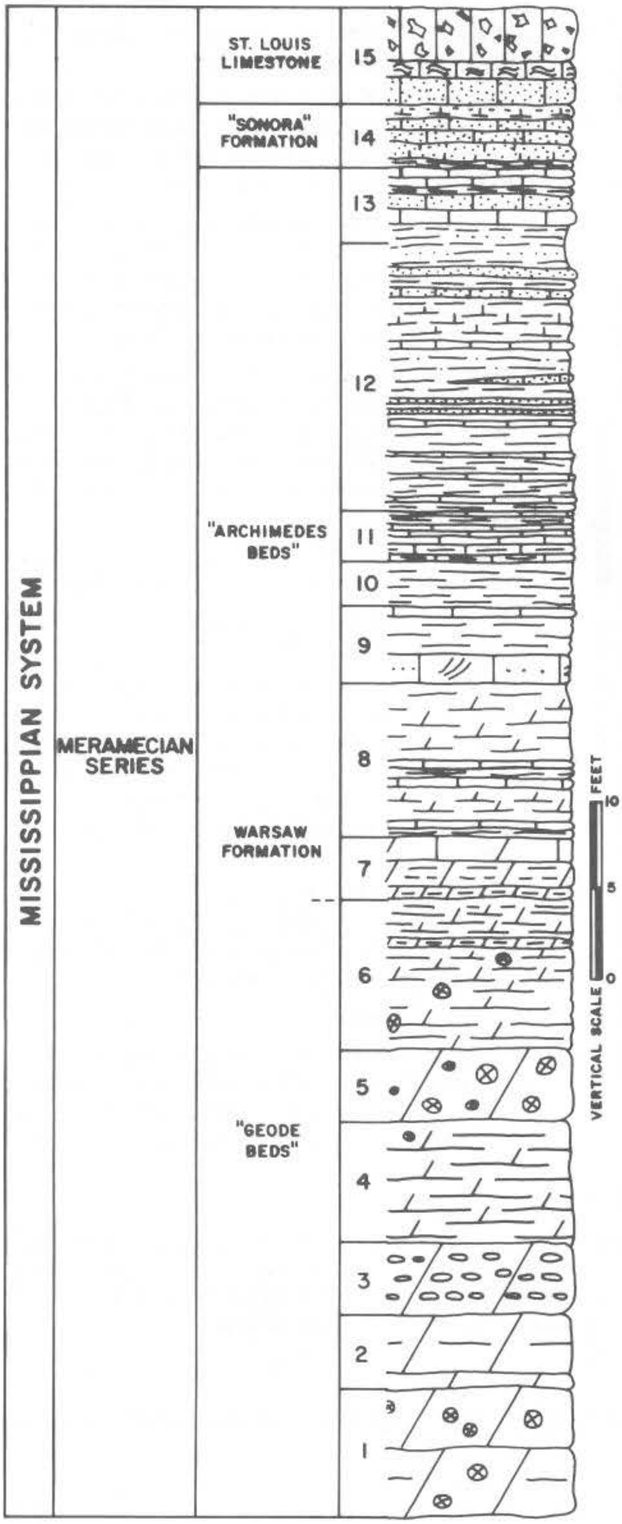
Reference sections — Warsaw strata can be seen in eastern St. Louis County on Missouri Highway 141, in the center N½ sec. 14, T. 43 N., R. 5 E., where approximately 30 ft of Warsaw shale and underlying limestone are exposed in a series of roadcuts. Warsaw is also present in roadcuts at the junctions of I-44 and I-270 (fig. 88), a few miles north of the first sections (SE¼ NW¼ sec. 14, T. 44 N., R. 5 E.), and along the west-facing bluffs of the Meramec River Valley, immediately north of the I-44 bridge over the Meramec River.

Nearly the entire Warsaw section can be seen in cuts on the Missouri Pacific and Frisco Railroads (fig. 89) from the SE¼ NW¼ to the NW¼ SW¼ sec. 9, T. 44 N., R. 5 E., near the Museum of Transportation, St. Louis County, Missouri, Kirkwood 7½' Quadrangle, (Brill et al., 1960).

History of nomenclature —

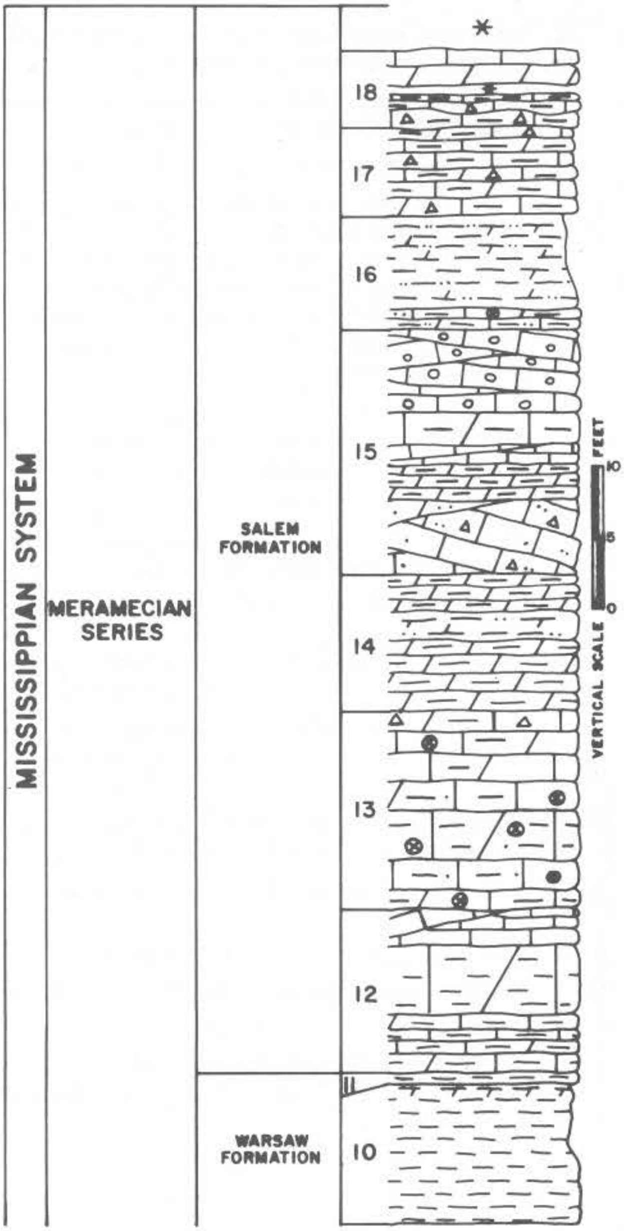
1852	Owen	Third Archimedes limestone and geodiferous beds
1855	Shumard	Third Archimedes limestone (distinct from St. Louis limestone)
1857	**Hall**	**Warsaw or second Archimedes limestone (lower part)** geode beds
1859	Shumard	Archimedes limestone (part)
1863	Englemann	Warsaw limestone
1866	Worthen	St. Louis group (lower part)
1874	Broadhead	Warsaw limestone of St. Louis group
1891	Williams	Warsaw stage of Genevievian age
1894	Keyes	Geode bed Warsaw shales
1898	Gallaher	Carthage limestone (upper part)
1902	Weeks	Augusta limestone (upper part) Warsaw limestone
1904	Ulrich	Warsaw limestone (and shales)
	Buckley & Buehler	Burlington limestone (Carthage limestone) (part)
1907	Buehler	Warsaw limestone
1928	Moore	Warsaw limestone member of Boone formation
1935	Giles	Warsaw (Carthage) limestone
1944	Branson	Warsaw limestone
1959	Barney	Warsaw limestone of Boone group
1961	Spreng	Warsaw formation
1979	Thompson (a)	Warsaw Formation
	Collinson et al.	Warsaw Shale (northeastern Missouri)

Remarks — The Warsaw Formation is present in many Mississippian outcrop regions of Missouri, and has been identified throughout most of the subsurface of northern and western Missouri. The Warsaw Formation does not possess lithologic features diagnostic of the formation. It varies lithologically from eastern to western Missouri. In western and southwestern Missouri, the Warsaw is a "typical" middle Mississippian carbonate, lithologically similar to the underlying Keokuk Limestone, and the Short Creek Oolite Member of the Keokuk is used to identify the Warsaw-Keokuk boundary. Warsaw strata in eastern Missouri are more argillaceous, the argillaceous content having been derived from sources to the east, in the Illinois basin. Opinions differ as to the presence (or absence) in the eastern Missouri region of an oolitic limestone bed equivalent to the Short Creek



15. Limestone, gray, dense, brecciated in upper bed, crenulate and laminated in lower. (5 ft)
14. Limestone, brownish-gray, dolomitic, hard, sandy, grading to sandstone or siltstone. (4 ft)
13. Limestone, brownish-gray, calcarenitic, sandy. (4 ft)
12. Shale, gray, sandy, calcareous. Sandstone, gray, in thin beds with pyritic burrow fillings. Limestone, gray, calcarenitic, thin with abundant *Archimedes wortheni, Lioclema puncatata,* and *Fenestella* along with *Rhipidomella dubia, Spirifer subaequalis, Cytodictya lineata, Worthenopora spinosa* and *Rhombopora.* (15 ft)
11. Limestone, gray, crinoidal-bryozoan calcarenite, current-bedded; with *Archimedes,* pyrite burrow-fillings, and solitary corals. (3 ft)
10. Shale, gray, weak. (3 ft)
9. Limestone and shale. Limestone, gray, sandy, crinoidal-bryozoan calcarenite, current-bedded; with *Archimedes* and pyritic burrow-fillings. Shale, gray. (5 ft)
8. Shale and limestone. Shale, gray, blocky. Limestone, gray, bryozoan calcarenite; in thin beds. (8 ft)
7. Limestone, gray, dolomitic, crinoidal-bryozoan calcarenite, with current bedding; dolomite, very argillaceous. (4 ft)
6. Shale, buff, dolomitic, soft; few scattered geodes; argillaceous dolomite in thin bed. (8 ft)
5. Dolomite, buff, argillaceous, soft; numerous geodes. (3 ft)
4. Shale, buff, dolomitic; few small geodes. (5 ft)
3. Dolomite, brown to gray. Chert, as brown nodules. (3 ft)
2. Dolomite, buff, argillaceous, weak. (3 ft)
1. Dolomite, buff, argillaceous, weak, spalls; geodes, large, numerous. (5 ft)

Figure 87. *Columnar section of type section of the* **Warsaw Formation,** *NW¼ sec. 10, T. 4 N., R. 8 W., Hancock County, Illinois, illustrating lithologic variability of the Warsaw in adjacent eastern Missouri compared to east-central and southwestern Missouri. Adapted from Collinson et al. (1979, p. 17).*



18. Limestone, light-gray to buff; fragmental fossils, abundant brachiopods; lower part dolomitized, dark-brown, porous. (1 ft 9 in.)
17. Limestone, buff, dolomitic, argillaceous, slabby, wavy-bedded; brachiopodal wackestone to crinoidal-bryozoan packstone; bedded chert nodules in upper 2 ft; lower 5 ft appears shaly. (7 ft)
16. Shale, gray to brown, slightly silty, dolomitic, mostly inaccessible. Limestone, thin, dolomitic, at base; echinoderm wackestone to packstone; thickens laterally, calcite-filled vugs, skelmoldic porosity; abundant brachiopods, bryozoans. (7 ft)
15. Limestone, gray to buff, cross-bedded, fossil fragmental-superficial oolitic grainstone; large endothyrids, abundant brachiopods, crinoids, bivalves, corals; middle 2 ft partly dolomitized, argillaceous; light-buff, sandy and silty, with chert stringers in lower part. (14 ft 7 in.)
14. Dolomite, brown to buff, argillaceous; abundant bryozoans; silty shale, slightly dolomitic. (8 ft)

Section transferred to exposure at east end of bridge across I-270 on Cragwold Road.

13. Limestone, brown to buff upper part, light-gray lower 7 ft 6 in., dolomitic, bryozoan-crinoidal wackestone to packstone, calcite-filled vugs and brown chert nodules; scattered solitary rugose corals; lower part slightly sandy, very argillaceous, with calcite-filled vugs, brachiopods, syringoporid corals. (12 ft)
12. Limestone, brown, dolomitic, massive in middle; upper 2 ft cross-bedded, lower 3 ft 6 in. very argillaceous; medium- to fine-grained, crinoidal bryozoan packstone to grainstone; brachiopods. (10 ft)
11. Shale and claystone, brown, blocky. (0 ft 6 in.)
10. Shale, greenish-gray to dark-gray, slightly sandy, glauconitic; fine selenite crystals on shale partings in upper 9 ft; dolomitic at top; crinoidal-bryozoan packstone in lower part, slabby. (10 ft)

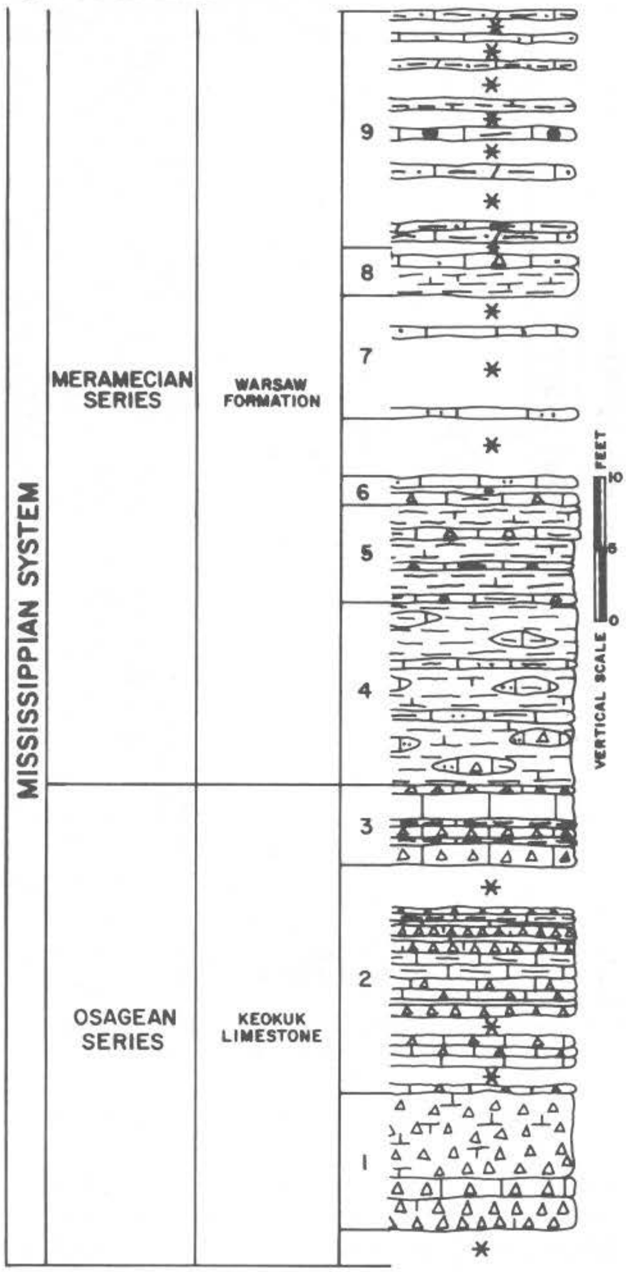
Figure 88. *Columnar section of the composite of two exposures of the* **Warsaw Formation**, *at the junction of I-44 and I-270 in eastern St. Louis County, eastern Missouri, Kirksville 7½' Quadrangle. Units 1-6 are exposed on I-270 at the Meramec River Bridge (sec. D, fig. 84), NW¼ NW¼ sec. 23, and units 7-15 are exposed in the NE quarter of the cloverleaf (sec. E1, fig. 84), NE¼ SW¼ sec. 14, T. 44 N., R. 5 E. Adapted from Lane and Brenckle (1977, p. 23-29).*

Oolite of western and southwestern Missouri; if present, it is discontinuous, and has not been used to identify the Keokuk-Warsaw boundary.

Spreng (1961, p. 66-67) stated,

"Exposures of the Warsaw formation are widely but discontinuously distributed throughout Missouri. Scattered outcrops of the formation are present in Lewis and Clark Counties in northeastern Missouri where the formation is 40 feet thick and is principally composed of finely to coarsely crystalline, fossiliferous limestone and contains geodes in its lower part. From northeastern Missouri, the Warsaw can be traced southeastward in the subsurface

Figure 88. *continued*



9. Limestone, buff to gray beds, bryozoan-crinoidal packstone, alternating with covered thin, argillaceous zones, probably shale. (13 ft)

Section continues in south side of gully near culvert.

8. Limestone, gray to buff, argillaceous, slightly sandy; crinoidal grainstone; small chert stringers, bryozoans; overlying 1 ft 6 in. buff, very calcareous shale. (2 ft 6 in.)
7. Limestone, slightly silty to sandy, medium- to coarse-grained; crinoidal-bryozoan packstone to grainstone; middle 4 ft 6 in. covered. (5 ft 6 in.)

Rest of section from exposure at I-44 bridge over Meramec River.

6. Limestone, gray to buff, slightly sandy-silty, medium-grained; crinoidal-bryozoan packstone to grainstone; partly silicified; lower half covered. (1 ft)
5. Limestone and interbedded shale. Shale, buff, fossiliferous, calcareous. Limestone, light-gray to brown, partly silicified, argillaceous, coarse-grained, crinoidal-bryozoan packstone; light-gray to white chert nodules and stringers; brachiopods. (7 ft 6 in.)
4. Shale, dark-gray to buff, slightly calcareous, fissile; with interbeds and lenses of light-gray to buff, partly silicified, silty, coarse-grained limestone, crinoidal-bryozoan packstone; scattered chert lenses, brachiopods. (12 ft 10 in.)
3. Limestone, light gray to buff; fine- to medium-grained grainstone, abundant light- to dark-gray disseminated chert; interbedded buff, shaly packstone. (5 ft 5 in.)
2. Limestone, light-gray to buff, argillaceous, thin-bedded, shaly; abundant crinoids, fenestrate bryozoans, brachiopods; abundant light-gray chert, some bedded. (11 ft)
1. Limestone and chert. Limestone, light-gray, coarse-grained, crinoidal-bryozoan grainstone to packstone; chert light- to medium-gray, speckled, calcareous, with many small limy pockets. (10 ft)

down along the southwestern flank of the Lincoln fold to St. Charles and St. Louis Counties where it again crops out. The formation also is exposed in Ste. Genevieve County and in the extreme eastern part of Perry County. In these areas, the Warsaw is about 80 to 100 feet thick and is very shaly. The lower half is composed of finely crystalline shaly, very fossiliferous, dolomitic limestone, and the upper half is a dark, fissile shale.

"Outcrops of the Warsaw are present in central Missouri in Cooper and Howard Counties, where it is about 50 feet thick, and in many areas of southwestern Missouri in Greene, Cedar, Dade, Barton, Jasper, and Barry Counties. Throughout this area, the formation is predominantly a slightly cherty limestone in which the bryozoan *Archimedes* and the brachiopod *Spirifer pellaensis* are common. In the Tri-State area in Newton and Jasper Counties, the formation is over 150 feet thick and has been subdivided into numerous letter designated units. The Warsaw in Jasper County is the source of the 'Carthage Marble,' an

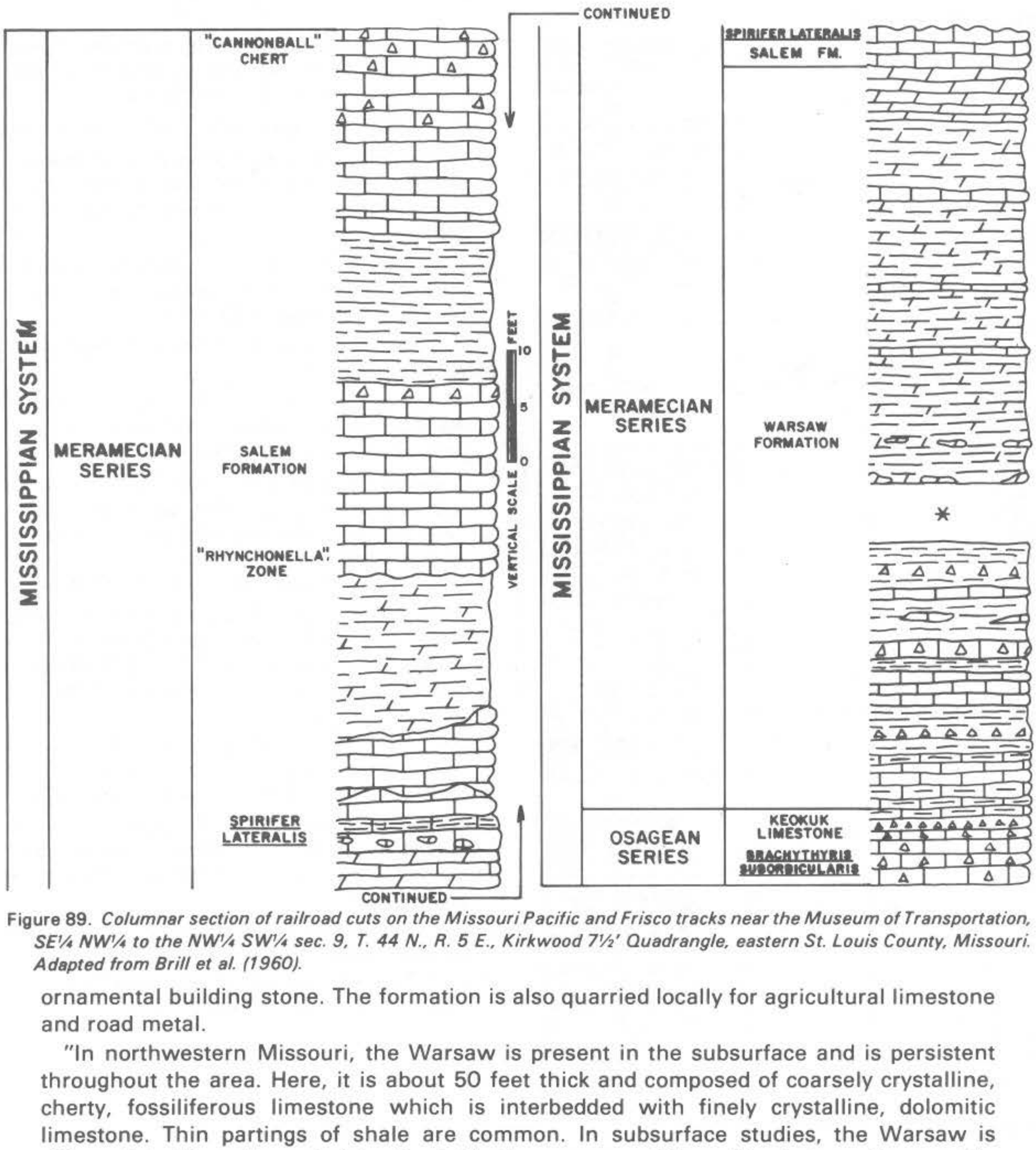


Figure 89. *Columnar section of railroad cuts on the Missouri Pacific and Frisco tracks near the Museum of Transportation, SE¼ NW¼ to the NW¼ SW¼ sec. 9, T. 44 N., R. 5 E., Kirkwood 7½' Quadrangle, eastern St. Louis County, Missouri. Adapted from Brill et al. (1960).*

ornamental building stone. The formation is also quarried locally for agricultural limestone and road metal.

"In northwestern Missouri, the Warsaw is present in the subsurface and is persistent throughout the area. Here, it is about 50 feet thick and composed of coarsely crystalline, cherty, fossiliferous limestone which is interbedded with finely crystalline, dolomitic limestone. Thin partings of shale are common. In subsurface studies, the Warsaw is differentiated from the underlying Keokuk by the presence of these thin shale partings, and by the presence of abundant bryozoan fragments in the chert."

Salem Formation

Cumings, 1901

Original description — (Cumings, 1901, p. 232-233) "Since the term Bedford as the name of a formation is preoccupied, having been applied to the "Bedford shale" of northeastern Ohio in 1870, the writer proposes the name *Salem limestone* for the rocks called Bedford limestone by Hopkins and Siebenthal . . .

"In suggesting a different name for the rocks under consideration, the writer is aware of the claims of Spergen hill. The latter place is, however, ... not so good a place for studying the stratigraphic relationships of the formation as a number of other localities...The oolitic character of the rock, ... while more pronounced at some places than at others, everywhere serves as a means of identification and is the character that is especially well developed at Salem."

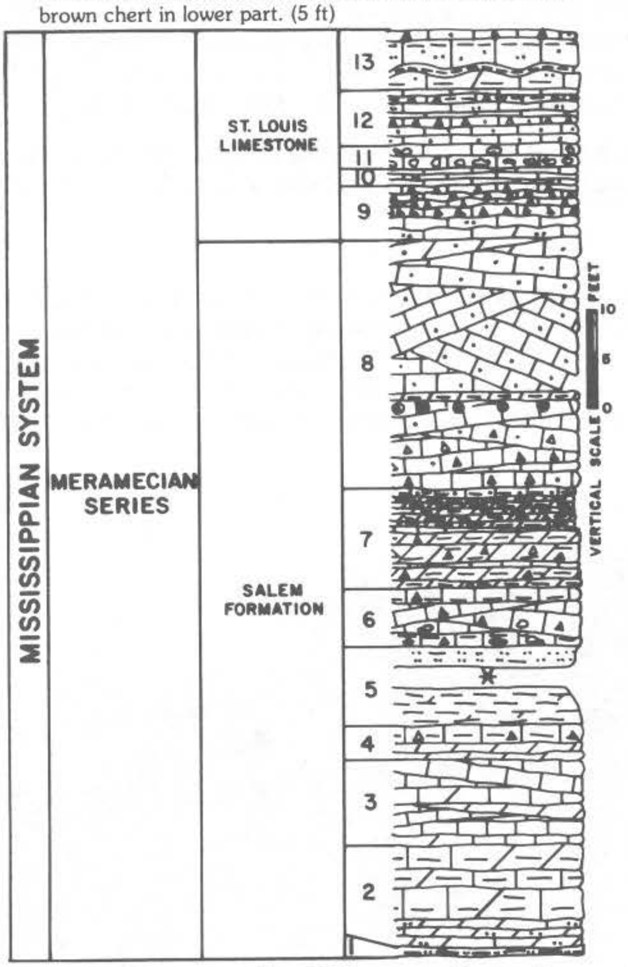
Type section — Cumings (1901) did not specify a type section; a quarry described by Gorby (1886, p. 143) served as the type section until the Salem was quarried away. Shaver et al. (1970, p. 152) designated a section at "nearly the same place in Hoosier Lime and Stone Company quarry (Perry, Smith, and Wayne, 1954, p. 47-49), 0.8 mile west of Salem in the NE¼ sec. 24, T. 2 N., R. 3 E., Washington County," Indiana as the "principal reference section" for the Salem Limestone.

The name "Spergen Hill," or "Spergen," was proposed by Ulrich (1904) for the unit, to replace "Bedford limestone." "Spergen Hill" was derived from a famous fossil locality of that name in Washington County, Indiana.

Reference sections — Roadcuts on I-270, at and north of the junction with I-44, in eastern St. Louis County, Missouri (figs. 88, 90 and 91), show excellent exposures of Salem and the adjacent Warsaw and St. Louis formations (SE¼ NW¼ sec. 14, T. 44 N., R. 5 E.). The Meramec Highlands Quarry (fig. 92), NE¼ NW¼ SE¼ sec. 10, T. 44 N., R. 5 E.), about 1 mi north of the I-270 and I-44 intersection, on the east side of I-270, shows an excellent exposure of the upper Salem and lower St. Louis Limestones.

Figure 90. ***Top of Warsaw Formation (Mw) and lower part of Salem Formation (Msa) exposed in the NE quadrant of the cloverleaf junction of I-44 and I-270 (sec. E1, fig. 84), NE¼ SW¼ sec. 14, T. 44 N., R. 5 E., St. Louis County, Missouri (units 7-15 of fig. 88). Photograph by T.L. Thompson.***

13. Limestone, light-gray, slightly sandy, fine-grained; crinoidal-bryozoan packstone; scattered light-gray chert nodules; brachiopods; capping 5 ft of limestone, brown, earthy, dolomitic mudstone to banded, sandy-silty, ostracod wackestone, with partly shaly, jointed appearance. (5 ft 8 in.)
12. Limestone, light- to medium-gray, slightly silty; sandy in lower 2 ft; ostracod packstone to grainstone interlaminated with light-gray lithographic mudstone; thin bedded, argillaceous and buff banded chert nodules in upper part; buff to brown chert in lower part. (5 ft)



11. Limestone, light-gray, laminated; intraclastic packstone with mudstone intraclasts; less intraclastic and finer grained upwards. (2 ft)
10. Limestone, light-gray, thin-bedded, laminated; fine-grained packstone; chert sparse. (2 ft 3 in.)
9. Limestone, light-gray to brown, laminated, fine-grained packstone; dolomitic at base; abundant white chert nodules and stringers in upper 3 ft; appears knobby. (5 ft)
8. Limestone, gray to buff, sandy, cross-bedded, massive, fine- to coarse-grained; crinoidal-bryozoan grainstone; locally dolomitized and silicified at top; stylolites; brachiopods near top; 10 ft above base is 8 in. buff, fine-grained laminated dolomite, with shaly parting at top; lower 10 ft has light-gray to white banded chert, with cannonball chert nodules along upper surface and stylolites near base; lower 10 in. is brown limestone, with thin-bedded, sandy, argillaceous partings. (25 ft)
7. Dolomite, brown, argillaceous, earthy, medium-bedded in lower part, recessive and thin-bedded in upper; scattered "botryoidal" limestone layers, chert nodules. (9 ft 2 in.)
6. Limestone, buff, cross-bedded, fossiliferous packstone to grainstone; partly dolomitized; interbedded fine- to coarse-grained layers in lower part becoming coarse-grained at top; mudstone intraclasts in lower part; scattered gray chert nodules; argillaceous partings; abundant brachiopods, gastropods, rugose corals. (5 ft 5 in.)
5. Siltstone, brown, laminated, dolomitic; and shale, dark-gray, slightly dolomitic; 2 ft covered interval in middle of unit. (7 ft 10 in.)
4. Limestone and dolomite. Upper unit is limestone, gray to buff, argillaceous, fine- to medium-grained, fossiliferous packstone; buff chert nodules; corals, brachiopods. Lower part is dolomite, buff, earthy, of variable thickness. (3 ft 6 in.)
3. Limestone, buff to gray, fine- to coarse-grained, cross-bedded, crinoidal-bryozoan packstone; partly dolomitized; shaly parting at base, fine-grained dolomite lens in middle; rhynchonellid brachiopods. (8 ft 3 in.)
2. Limestone, brown to gray, argillaceous, medium- to coarse-grained wackestone to packstone; locally leached and dolomitized with pinpoint porosity; rhynchonellid brachiopods, crinoids, bryozoans, syringoporid corals, burrows. Lower part more dolomitic, fine-grained. (10 ft)
1. Shale, gray, blocky, silty. (1 ft)

Figure 91. *Columnar section of* **Salem Formation** *and lower part of the St. Louis Limestone in roadcuts at the southeastern corner of the cloverleaf of I-44 and I-270 (sec. F, fig. 84), NW¼ SE¼ sec. 14, T. 44 N., R. 5 E., Kirkwood 7½' Quadrangle, eastern St. Louis County, Missouri. Adapted from Lane and Brenckle (1977, p. 29-34).*

History of nomenclature —

1843	Nicollet	"oolitic limestone of the Gabouri" (Ste. Genevieve County, Missouri)
		Archimedes limestone (part)
1847	Englemann	St. Louis limestone (lower part)
1857	Hall	Warsaw Archimedes limestone (upper part)
		"Magnesian limestone"
1859	Shumard	Archimedes limestone (upper part)
1863	Englemann	St. Louis limestone (lower part)
1873	Shumard	Third Archimedes limestone (part)
		St. Louis limestone (part)

1895	Gordon	Lower concretionary limestone gritstones magnesian limestone and shale geodiferous beds
1896	Hopkins & Siebenthal	Bedford oolitic limestone
1901	**Cumings**	**Bedford limestone**
1904	Ulrich	Spergen Hill limestone
1907	Buehler	Spergen limestone
1912	Willis	Salem (Spergen) limestone
1914	Weller	Salem limestone **(first use of "Salem" in Missouri)**
1922	Ulrich	Ste. Genevieve limestone (part, Fredonia member only)
1925	Keyes	Gabouri limestone (proposed to replace "Salem")
1928	Weller & St. Clair	Spergen (Salem) limestone
1938	Keyes (b)	Spergen limestone Gabouri oolite
1940	Weller & Sutton	Salem limestone
1944	Branson (a)	Salem limestone (Spergen limestone)
1961	Spreng	Salem ("Spergen") formation
1979	Thompson (a)	Salem Formation
1982	Brenkle et al.	Rocher Member of Salem Limestone

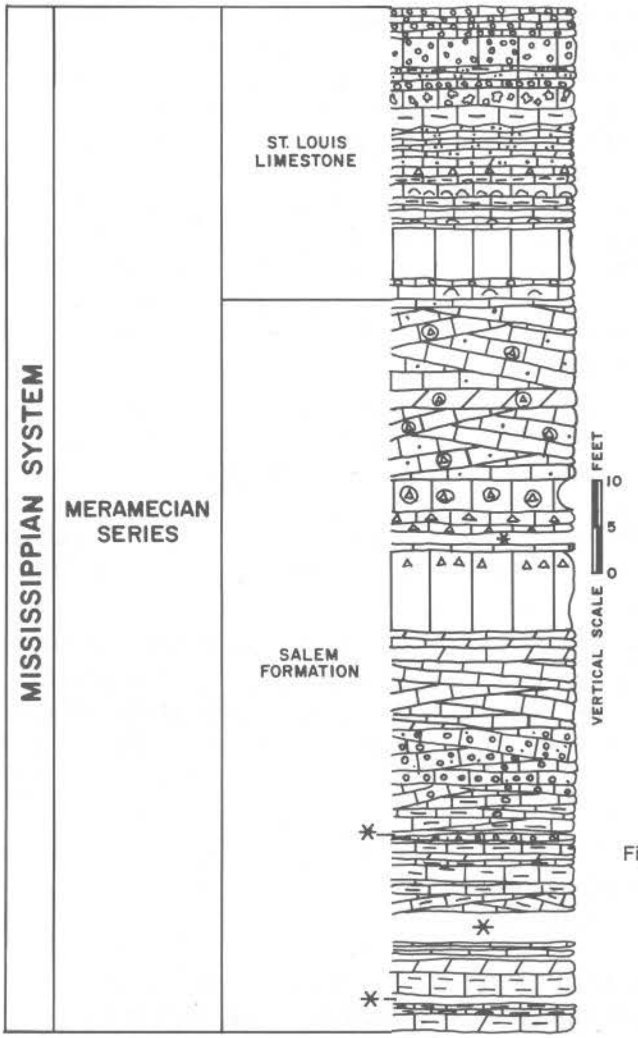


Figure 92. *Columnar section of the* **Salem Formation** *and lower part of the St. Louis Limestone exposed in the Meramec Highlands Quarry (sec. C, fig. 84), NE¼ NW¼ SE¼ sec 10, T. 44 N., R. 5 E., Kirkwood 7½' Quadrangle, St. Louis County, Missouri. Adapted from Land and Brenckle (1977, p. 19-20). Note spherical or "cannon-ball" chert nodules in cross-bedded limestone at the top of the Salem.*

Remarks — Spreng (1961, p. 67-68) stated,

"The most complete and thickest exposures of the Salem formation in Missouri are present in the east-central and southeastern parts of the state in St. Louis, Ste. Genevieve, and eastern Perry Counties. Throughout this area, the formation is 100 to 160 feet thick. In Ste. Genevieve County, the lower part of the Salem is a light gray to white, fragmentally fossiliferous, argillaceous, locally oolitic limestone, and the upper part is a bluish-gray, argillaceous, oolitic, dolomitic limestone in which the oolitic content varies considerably. The formation is commonly cross-bedded. In the St. Louis area it becomes more dolomitic. The upper part of the Salem is fossiliferous and contains blastoid, crinoid, echinoid, and bryozoan debris, as well as the coral *Syringopora*. The top of the formation grades upward into the St. Louis formation, and the intermediate beds contain the coral *Lithostrotion*. The insoluble residue from the upper 50 feet of the Salem in the St. Louis area contains a high percentage of speckled gray and tan chert. The residue from the Salem also contains the Foraminifera *Endothyra*, and echinoderm fragments. In Ste. Genevieve County, an exceptionally pure white oolitic limestone in the middle of the formation is used for making lime. Other parts of the formation in the same area have been used for riprap, agricultural limestone, and road metal.

"The Salem thins northward from St. Louis County, and in the northeastern part of the state it ranges from 20 to 40 feet in thickness. It is composed of buff weathering limestone, dolomitic limestone, and shale in this part of the state, and its contact with the underlying Warsaw is obscure because the lithologies of the two formations intergrade.

"In central Missouri, in Saline and Howard Counties, a medium to coarsely crystalline, medium bedded limestone which is interbedded with green shale and which contains distinctive red jasperoid chert in the form of lenses and nodules has been identified as the Salem. The limestone also contains brachiopod and bryozoan fragments, the Foraminifera *Endothyra* and the coral *Triplophyllites*. It is 10 feet thick at the surface and thickens to 50 feet to the north and west in the subsurface. In Dade and Jasper Counties in southwestern Missouri, a limestone which contains the brachiopods *Tetracamera acutirostris* and *Camarotoechia mutata* has been tentatively identified as the Salem. In the subsurface of northwestern Missouri, fossiliferous limestone and shale, as well as some unfossiliferous, earthy, dolomitic limestone which is usually recorded as uppermost Warsaw is considered to be Salem. These beds contain a few specimens of *Endothyra* and pink to red, chalcedonic, fossiliferous chert. The unit is about 50 feet thick."

The Salem Formation, which is more restricted in distribution than the underlying Warsaw, crops out principally in central and eastern Missouri. A small region of outcrop in western Missouri, in Dade and Jasper Counties, is associated with an anticlinal structure. North of this area, in some wells in western Missouri (Vernon and Bates Counties), the Salem is identified, unevenly preserved on the pre-Pennsylvanian erosional surface. Preservation is more complete northward in Jackson County. In Kansas, Salem limestone is recognized in the subsurface throughout most of the eastern counties of the State (Lee, 1943; Thompson and Goebel, 1969).

A distinctive "cannonball," or "bulls-eye," chert zone occurs near the top of the Salem in the St. Louis area (fig. 92), and indicates proximity to the Salem-St. Louis contact. The chert occurs as concentrically banded, spherical nodules, 4 to 6 in. in diameter. In addition, a thin shale zone that may be present just above the chert zone can also be used as a marker for the base of the St. Louis Limestone in this area.

St. Louis Limestone

Englemann, 1847

Original description — (Englemann, 1847, p. 119) "The St. Louis limestone underlies the western edge of the great Illinois coal field. It is a very hard, light yellowish or grayish rock, mostly pure carbonate of lime, in some strata mixed with sand, in others including irregular siliceous masses of a dark color, or light colored thin argillaceous strata. The limestone is perfectly compact and fine-grained in some strata, so as to furnish tolerably good lithographic stones; in other strata it is coarser and even completely crystalline."

Type section — The type area of the St. Louis Limestone is the vicinity of St. Louis, Missouri. Most of the sections that originally defined the formation have since been destroyed or buried by construction. As a result, no specific exposure has been designated the "type section" for the St. Louis Limestone. The best, most complete exposures in the vicinity of St. Louis are north across the Mississippi River Valley, in Madison County, Illinois, on the "Alton bluffs," above the River Road between Alton and Grafton, Illinois (fig. 93). A composite section of the Alton Bluffs sequence, based on one by Collinson et al. (1979) is as follows:

Ste. Genevieve Limestone

- W. Limestone, apparently algal; inaccessible (5 ft; 1.5 m)
- V. Limestone, shaly, or shale; inaccessible; usually forms vegetation-covered bench. (0-2 ft; 0-0.6 m)
- U. Limestone, extremely variable; sparingly cross-bedded within one or two 1-ft beds; partly algal, with colonies 0.5 in. to several feet in diameter; partly calcarenitic; apparently partly oolitic; difficult of access. (5-20 ft; 1.5-6.1 m)
- T. Limestone, thin-bedded, shaly to silty; may be slightly sandy; difficult of access. (1-15 ft; 0.3-4.6 m)
- S. "Sandy oolite." Limestone, coarsely oolitic, sandy (20% insoluble), cross-bedded; scour surface with general relief of 6 in. at base with 1-ft cracks filled with sandy oolite. (0-18 ft; 0-5.5 m)

St. Louis-Ste. Genevieve transition zone

- R. "White bed." Limestone, pure (99% soluble), "curdy" lithographic to pseudo-oolitic, sparingly fossiliferous; weathers very white; basal contact varies from irregular (2 in. relief) with no shale to smooth with 0.5 in. shale. (1.5-6 ft; 0.5-1.8 m)
- Q. "Chevron bed." Limestone, oolitic, pure (99% soluble) to extremely sandy (50%); cross-bedded in thin units; algal colonies toward base; locally prominent shale parting at base but elsewhere the contact is gradational. (1.5-7 ft; 0.5-2.1 m)
- P. "Algal conglomerate." Limestone; partly silty and sandy near bedding planes but pure (98-99% soluble) within beds; fine to oolitic, with algal colonies (curdy, vaguely concentric, lithographic limestone) ranging from pseudo-oolites to 3-in. biscuits and a few 1-ft cabbage heads divided into two to four very prominent beds by shale partings which extend for several hundred feet and reach thicknesses of 1-2 in. Where unit O is recognizable the basal contact is a prominent shale parting; elsewhere a scour surface with cracks up to 3 ft deep. (2-6 ft; 0.6-1.8 m)
- O. "Little White bed." Similar to unit R; lenticular base is scour surface. (0-1.5 ft; 0-0.5 m)
- N. "Bryozoan beds and chert marker." Limestone, pure (98.5% soluble) except for basal cherty zone; fine to lithographic with thin bands of fossils, especially bryozoa; thin bedded with none to four irregular bands of fossiliferous replacement chert in lower 6 ft; the next lowest band 1-ft thick in places; base is a scour surface with 6-in. relief and cracks 3 ft deep where unit M is thick; a thin shale parting occurs at base where unit M is thin. (10-16 ft; 3.0-4.9 m)
- M. "Lower oolite." Limestone, slightly silty; ranges from fine calcarenite to very slightly sandy (96-98% soluble), medium-grained cross-bedded oolite; thin, smooth shale parting at base. (1.5-9 ft; 0.5-2.7 m)

St. Louis Limestone

- L. "Two beds." Limestone; two well marked beds; lithographic at top to fine with some coarse fossil debris; slight shale parting at base. (3 ft; 0.9 m)
- K. Limestone, very silty; grades down to prominent shale break. (0.5 ft; 0.2 m)

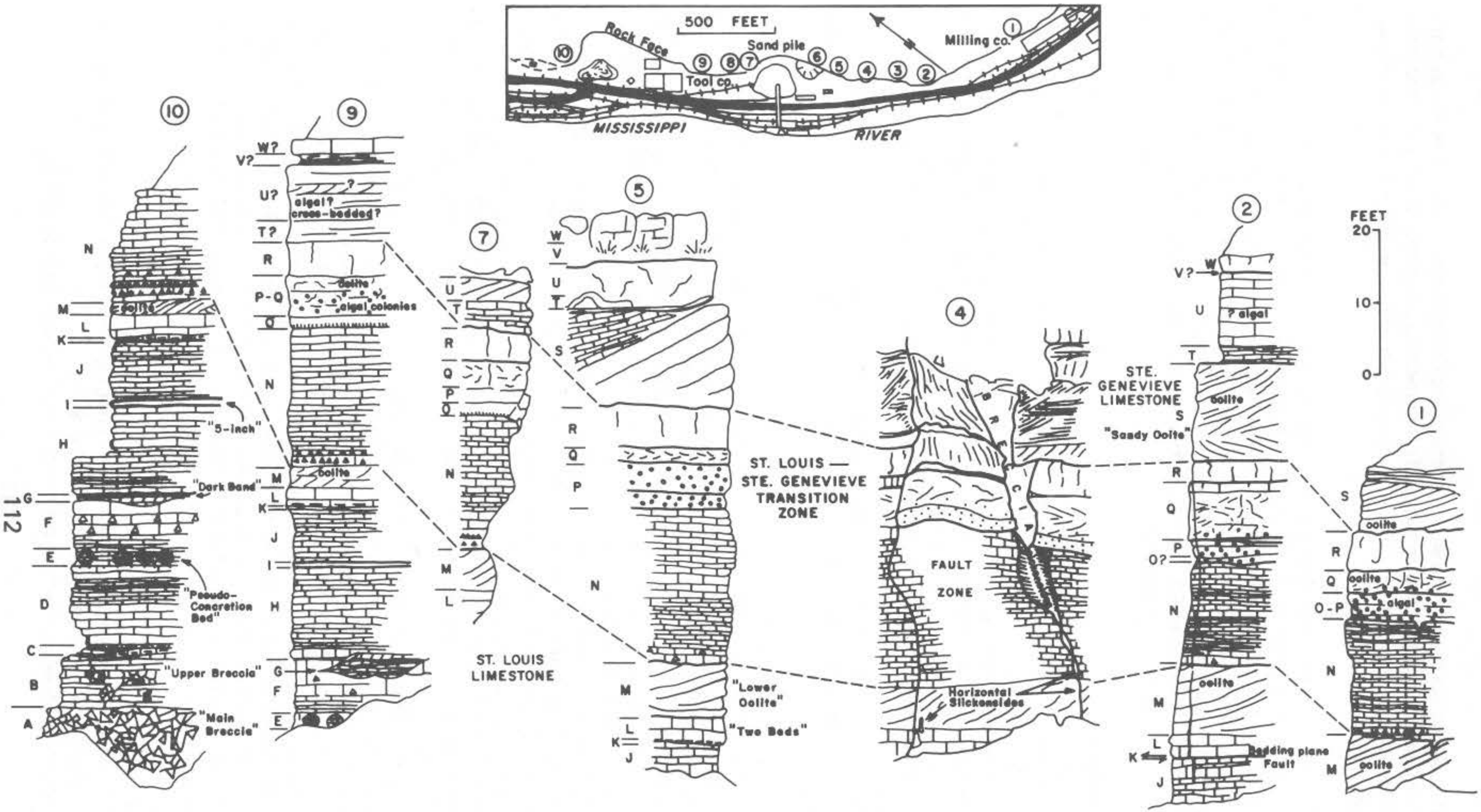


Figure 93. *Diagrammatic cross section of exposures along the Alton Bluff above roadway along the east bluff of Mississippi River Valley, NW¼ NW¼ sec. 14, SW¼ SW¼ sec. 11, and SE¼ SE¼ sec. 10, T. 5 N., R. 10 W., Alton 7½' Quadrangle, Madison County, Illinois. Adapted from Collinson et al. (1979, p. 65-66).*

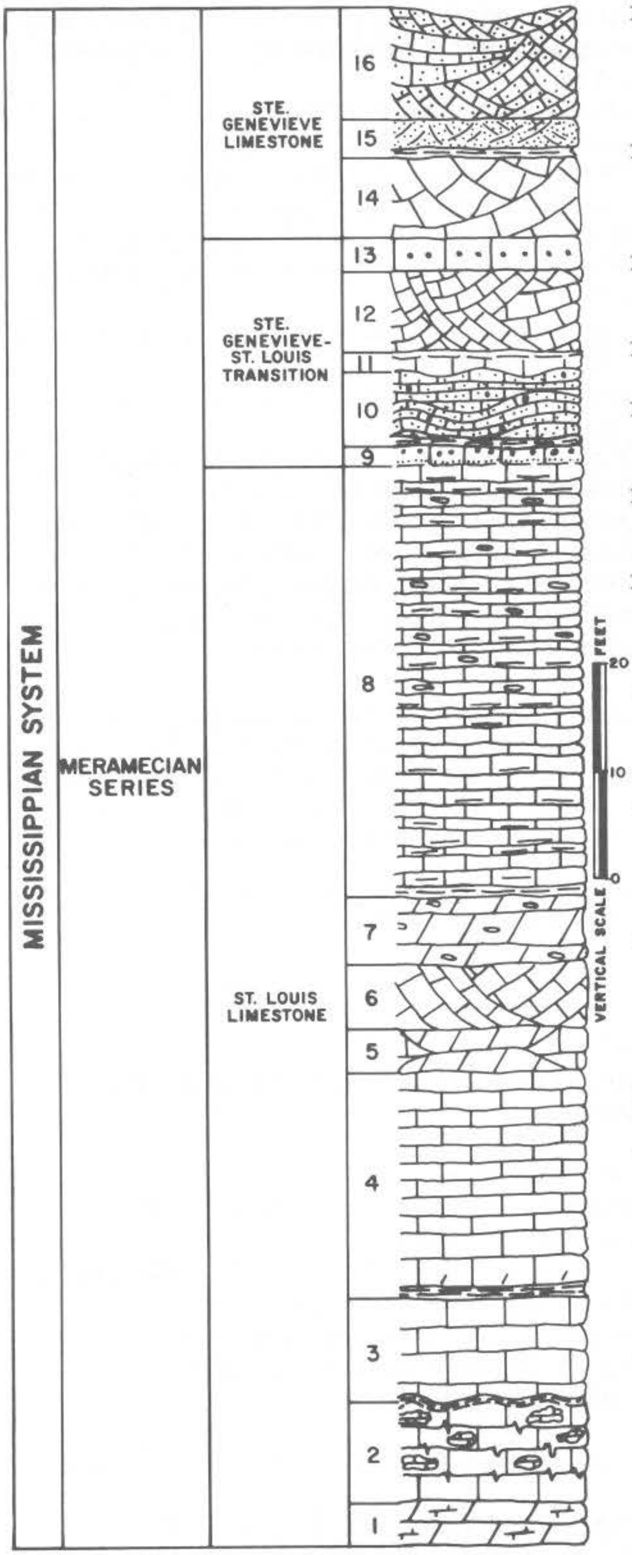
J. Limestone, slightly silty (97-98% soluble), thin-bedded, lithographic to fine; some coarse fossil streaks; purer and thicker bedded at top and just below middle; more shale streaks just above middle and toward base. (8.5 ft; 2.6 m)
I "Five-inch bed." Limestone layer between two well marked shale partings. (0.5 ft; 0.2 m)
H. Limestone; like unit J; slightly more silty (94-97% soluble). (12.5 ft; 3.8 m)
G. "Dark band." Dolomite, silty (94-95% soluble), very finely crystalline, medium-brownish-gray, pseudoconcretionary; in some places the dolomite is an irregular 1- to 24-in. bed, its variations almost entirely compensated by variations in thickness of the underlying unit F; in other places bodies of dolomite up to 4 ft thick replace the upper part of unit F with slight thickening of the section. (0-2 ft; 0-0.6 m)
F. Limestone, slightly silty (96% soluble toward base to 98% toward top); similar to unit J but more calcarenitic and with thicker beds. (6-7 ft; 1.8-2.1 m)
E. "Pseudoconcretion bed." Limestone, shaly and silty (95% soluble); numerous large oval 6-in. to 3-ft silty dolomite pseudoconcretions. (3 ft; 0.9 m)
D. Limestone; similar to unit J; more fossiliferous; purest toward top and base. (10.5 ft; 3.2 m)
C. Limestone, very silty and argillaceous (90% soluble), very fossiliferous. (2 ft; 0.6 m)
B. "Upper breccia." Limestone, lithographic to detrital, partly fossiliferous, partly cross-bedded, partly evenly bedded, partly brecciated; much lateral variation. (7 ft; 2.1 m)
A. "Main breccia." Limestone; averages 95-96% soluble; much brecciated; angular pebbles and boulders of lithographic to pseudo-oolitic limestone in somewhat silty calcarenite or clear calcite matrix; up to 22 ft thick in quarries to northwest. (11 ft; 3.4 m)

Reference sections — Although there is no type section for the St. Louis Limestone, an excellent exposure of the entire formation is in the Fort Bellefontain (formerly Missouri Portland Cement Company) quarry in north St. Louis County (figs. 94 and 95), just east of the Highway 67 bridge over the Missouri River (NW ¼ NE¼ NW¼, or center N½ sec. 9, T. 47 N., R. 7 E., Columbia Bottom 7½' Quadrangle). The section was described by Martin and Wells (1966, p. 12-13).

Another representative and easily accessible, although incomplete, exposure of the St. Louis Limestone is in a roadcut on I-44, eastern St. Louis County (fig. 96).

History of nomenclature —

	Early geologists	Lithostrotion limestone
1847	**Englemann**	**St. Louis limestone** (middle part; included Warsaw, Salem, and Ste. Genevieve)
1852	Owen	Concretionary limestone (part) "Bedded limestone of St. Louis"
1855	Swallow	Ste. Genevieve marble (according to Shumard, 1859) St. Louis limestone (middle part)
1859	Shumard	St. Louis limestone (upper part; removed Ste. Genevieve from St. Louis of Swallow; still included Salem strata)
1889	Newberry	St. Louis limestone of Mountain limestone (part)
1891	Williams	St. Louis stage of Genevievian age (middle part)
1895	Gordon	Upper concretionary limestone gritstones
1904	Ulrich	St. Louis limestone (**restricted to present definition;** removed Salem)
1907	Buehler	St. Louis limestone member of St. Louis group (part)
1911	Fenneman	St. Louis limestone (part; included Ste. Genevieve beds)
1914	Weller	St. Louis limestone (as presently defined)
1933	Keyes	Louis limestone
1944	Branson (a)	St. Louis formation
1961	Spreng	St. Louis formation



16. Limestone, light-gray to yellow-gray, thin to medium, cross-bedded, oolitic; sandy to very sandy, fine-grained quartz; fossiliferous, with brachiopods, *Pugnoides, Composita?, Girtyella*; upper part weathers to brown, cross-bedded sand. (10 ft)

15. Sandstone and shale. Sandstone, light-gray to yellow-gray; fine to medium quartz grains; thin-bedded; cross-bedded; calcareous cement. Shale, green to gray, calcareous; quartz sand grains in streaks at base. (4 ft)

14. Limestone, yellow-gray to brown-gray, medium-grained, massive, cross-bedded; fine-grained quartz sand in upper part; lower part oolitic. (7 ft 6 in.)

13. Limestone, light-gray, lithographic, partly oolitic and pelletal; massive. (3 ft)

12. Limestone, gray, mottled, sublithographic, oolitic; medium to coarse calcite spar; cross-bedded; fossiliferous, with *Spirifer, Composita*, colonial and solitary corals, algae. (7 ft)

11. Limestone, light-gray, sublithographic; thin (3-6 in.) shale and argillaceous limestone at top; very fine to fine quartz sand grains. (1 ft-1.5 ft)

10. Limestone, gray; fine- to medium-grained calcarenite; broad scale cross-bedding; bar-structure; quartz sand grains; oolitic; basal 1 ft brecciated. Basal 4-6 in. shale, green, with some quartz sand grains. (5-9 ft)

9. Limestone, light-gray, medium- to fine-grained, argillaceous; thin- to medium-bedded but appears massive; top 8 in. oolitic (?); very fine quartz sand grains; shale parting at base. (2 ft 2 in.)

8. Limestone, light-gray to gray, upper 22 ft medium-grained, lower 18-20 ft fine-grained to sublithographic; thin- to medium-bedded; flaggy, thin shale partings; abundant bryozoans. Dark-gray to black translucent chert nodules near top and middle of unit. (40 ft)

7. Dolomite, gray to brown-gray, medium-grained, medium- to massive-bedded; chert nodules. (6 ft)

6. Limestone, brown-gray, sublithographic to medium-grained, calcarenitic; cross- or inclined bedding; irregular thickness. (6 ft)

5. Dolomite, brown, fine- to medium-grained, massive; grades laterally to sublithographic limestone. (4 ft)

4. Limestone, gray to gray-white, fine- to medium-grained to sublithographic, calcarenitic, medium-bedded to massive; base at prominent 1-4 in. green shale parting. (20 ft)

3. Limestone, gray to light-gray, fine-grained calcilutite to lithographic, medium- to massive-bedded; stylolitic, irregular undulating base; prominent ½ in. blue-green shale parting at base. (6-9 ft)

2. Limestone, "solution" breccia, gray, fine-grained to lithographic, irregular medium- to massive-bedded, stylolitic; with shale partings. (5-10 ft)

1. Dolomite, dark-gray to brown, fine-grained, argillaceous, calcareous; top forms main floor of quarry. (4 ft)

Figure 94. *Columnar section of exposure of* **St. Louis Limestone** *in Missouri Portland Cement Company's Fort Bellefontaine Quarry, center N½ sec. 9, T. 47 N., R. 7 E., Columbia Bottoms 7½' Quadrangle, northern St. Louis County, east-central Missouri. Adapted from Martin and Wells (1966, p. 12-13).*

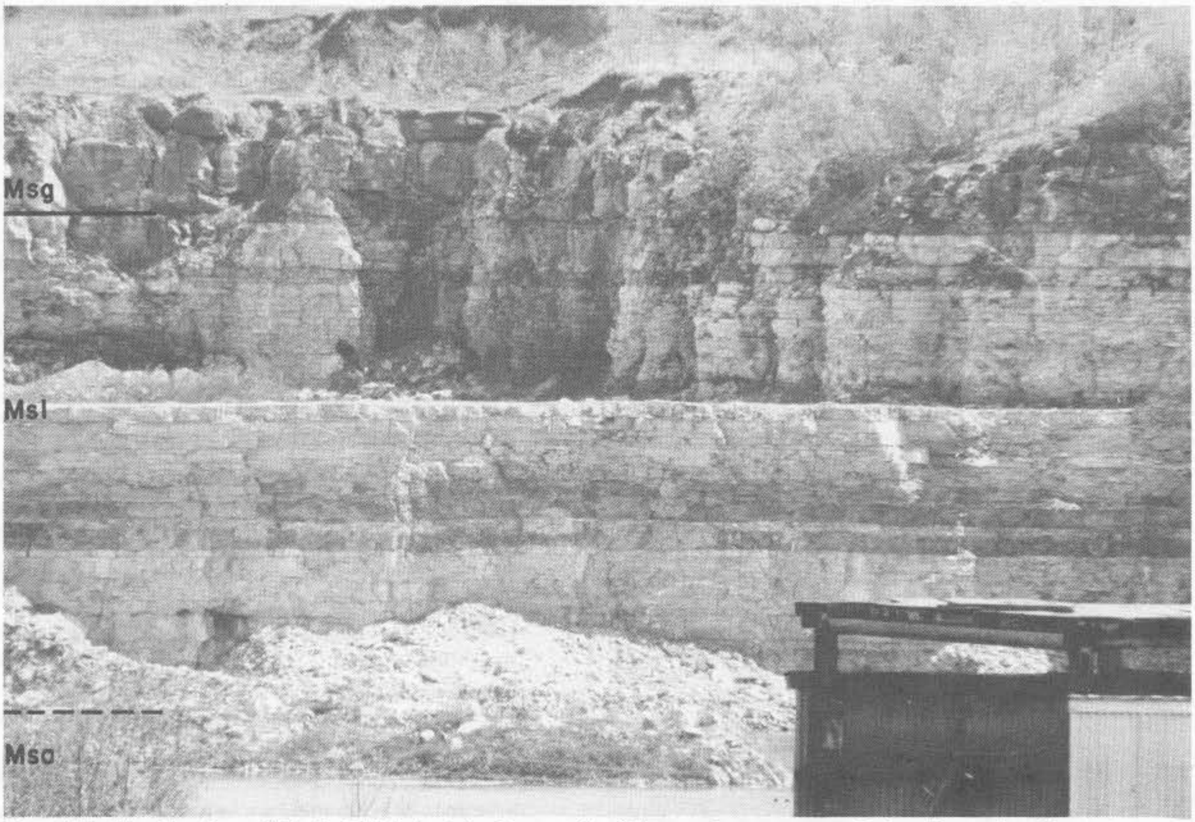


Figure 95. ***Working face of the Fort Bellefontaine Quarry (fig. 94) exposing uppermost Salem Formation (Msa), the entire*** **St. Louis Limestone** *(Msl) and lower Ste. Genevieve Limestone (Msg). Photograph by T.L. Thompson.*

1967	Yochelson & Saunders	Piasa Limestone (St. Louis County, Missouri)
1979	Thompson (a)	St. Louis Limestone

Remarks — Spreng (1961, p. 69-70) stated,

"The St. Louis formation attains its fullest expression within Missouri in its type area in St. Louis County and in adjacent parts of east-central and southeastern Missouri. Here, the formation is a gray lithographic to finely crystalline, medium to massively bedded limestone which is more than 100 feet thick. Limestone breccia is common in the lower part of the formation but is not necessarily confined to this part. Shale occurs as a matrix between the blocks of breccia. Blue and bluish-gray shale also forms thin beds throughout the formation and increases in abundance toward the northeastern part of the state. Chert is not common. Where it is present, it is usually brown and in the form of small angular fragments. Parts of the formation are locally dolomitic. The compound corals *Lithostrotionella castelnaui* and *Lithostrotion proliferum* are considered to be diagnostic, and the coral *Syringopora* is common. The percentage of insoluble residue that can be extracted from the St. Louis is generally low. The residue from the lower part of the formation normally contains small (less than 1 mm.) euhedral quartz crystals. Gray or tan quartzose chert rosettes are also common residue constitutents [sic]. The contact between the St. Louis and Salem formations appears to be conformable. The thickness of the St. Louis formation in northeastern Missouri is generally less than 50 feet. The formation is about 50 feet thick in southwestern Missouri where it is present in Dade, Cedar, and Barton Counties. In the subsurface of northwestern Missouri where the formation is a finely crystalline to lithographic limestone with some interbedded granular and oolitic limestone, its thickness varies from 0 to 75 feet. The formation's local absence in this area is the result of pre-Pennsylvanian erosion.

10. Limestone and dolomite. Limestone, buff to gray, sandy, fine-grained, crinoidal packstone; colonial and solitary corals; in thin beds with shaly partings. Dolomite, buff, argillaceous, earthy; middle 1 ft of unit. Welded contact 1 ft 4 in. above base with light-gray mudstone. Stylolitic in lower part; upper part burrowed, pyritiferous. (3 ft 6 in.)
9. Limestone, gray to buff, slightly silty, fossiliferous; upper part fine-grained grainstone; lower part packstone; graded bedding, stylolitic; crinoids, bryozoans, corals. (5 ft 6 in.)
8. Limestone, gray to buff, fine- to medium-grained, shaly; fossiliferous wackestone to packstone to grainstone; hummocky weathering and burrowed near top. (2 ft 6 in.)
7. Limestone and dolomite. Limestone, gray to buff, medium-grained, very fossiliferous; superficial oolitic grainstone, burrowed (?) at top. Lower part dolomite, buff to brown, earthy. (4 ft)
6. Limestone, light gray to buff, fine- to medium-grained; fossil fragmental packstone to grainstone; some superficial ooliths; scattered chert and shaly intervals; mudstone interclasts at base; rugose corals. (8 ft 4 in.)
5. Limestone; intraclastic packstone composed of blue-gray mudstone clasts with "birdseye" texture and matrix of buff, fine- to medium-grained, fossiliferous packstone. Lower 4 in. blue-gray, silty mudstone, with scattered fossil fragments. (1 ft)
4. Dolomite, buff to gray or mottled gray; fine-grained packstone grading upward to light gray, laminated fine-grained dolomite; chert and silicified intraclasts at top; bivalves, brachiopods, and echinoderms in middle; laminated lower 3 ft 6 in. (9 ft 6 in.)
3. Limestone, buff to gray, silty, fine-grained; crinoidal-bryozoan-brachiopodal packstone to wackestone in lower part; fissile near top, intensively burrowed; light-gray chert nodules. (1 ft 6 in.)
2. Limestone, brown, buff to gray, silty; fissile, argillaceous packstone at top, laminated silty wackestone middle, intraclastic packstone base; abundant reworked bryozoans near middle; rugose corals, brachiopods, echinoid spines. (1 ft 6 in.)
1. Shale, gray, silty, dolomitic; 4-in. limestone at base, light gray, slightly sandy, crinoidal-bryozoan packstone, abundant brachiopods. (2 ft)

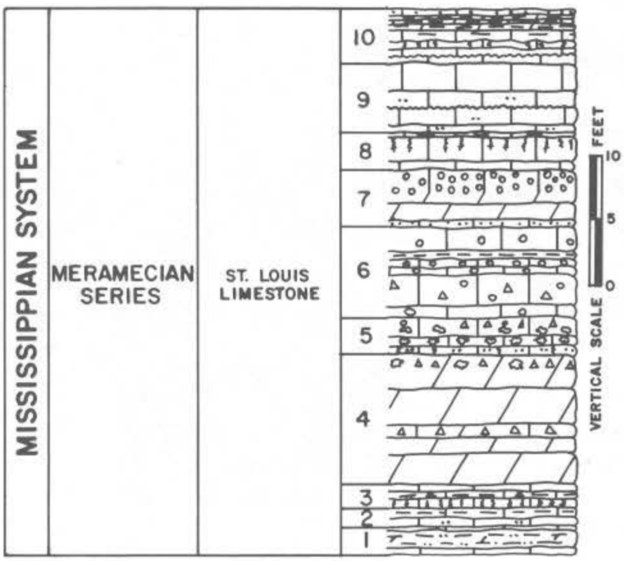


Figure 96. *Columnar section of exposure of* **St. Louis Limestone** *in a roadcut on Watson Road, adjacent to I-44, SE¼ NE¼ sec. 14, T. 44 N., R. 5 E., Kirkwood 7½' Quadrangle, eastern St. Louis County, Missouri (sec. G, fig. 84). Adapted from Lane and Brenckle (1977, p. 32-34).*

"The limestone from the St. Louis formation is quarried in the St. Louis area for cement manufacture and aggregate. In northeastern and southwestern Missouri, the limestone is used for agstone and road metal."

Lineback (1972) determined that the upper Salem strata of the eastern Illinois basin (including southern Indiana) grade laterally into the lower part of the St. Louis Limestone in west-central Illinois (Madison County region; fig. 97), a conclusion that explains a major conodont zonal break in the middle part of the St. Louis Limestone in the St. Louis region (Rexroad and Collinson, 1963; Collinson et al., 1971). The lower *Taphrognathus yarians-Apatognathus* Zone changes rapidly to the overlying *Apatognathus scalenus-Cavusgnathus* Zone, the latter characteristic of the whole St. Louis Limestone in east-central Illinois. This break correlates with the top of the Salem Formation to the east in Indiana and eastern Illinois, the Salem-St. Louis boundary of that region.

In Dade, Cedar, and Barton Counties, Salem and St. Louis strata are exposed in the axis of a small anticlinal structure. They also occur in the subsurface of eastern Kansas, just west of this area (Thompson and Goebel, 1969), but pre-Pennsylvanian erosion removed most Meramecian strata in west-central Missouri. St. Louis again appears in the subsurface of Jackson County.

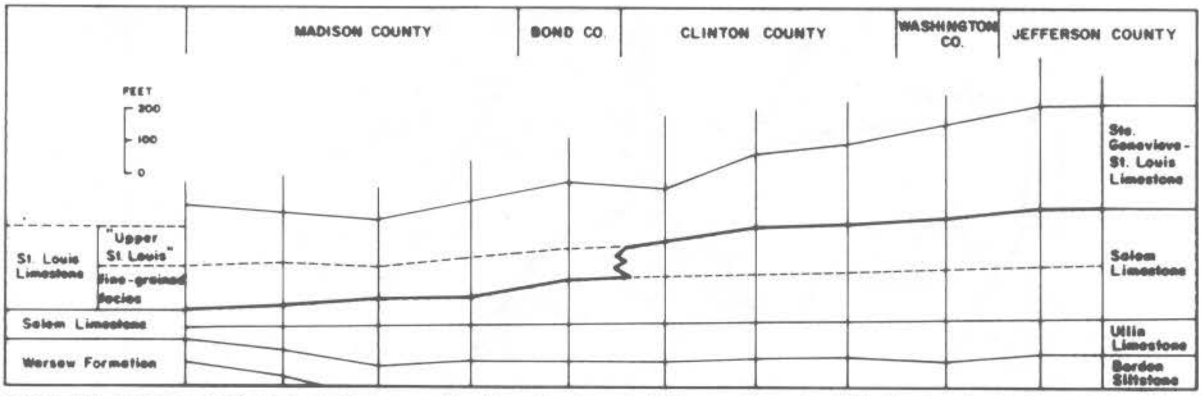


Figure 97. *Diagrammatic east-west cross section from Madison to Jefferson Counties, Illinois, showing facies relationship of the upper* **Salem Formation** *to the lower* **St. Louis Limestone**, *in the Illinois basin. Adapted from Lineback (1972, fig. 4).*

Ste. Genevieve Limestone

Shumard, 1859

Original description — (Shumard, 1859, p. 406) "Immediately beneath the ferruginous sandstone, we have a second Archimedes limestone, which, for the sake of convenience, we may designate as the *Ste. Genevieve limestone*. . . . It is very analogous, in its lithological features, to the upper Archimedes limestone, occurring, however, in thick beds, and the inferior part shades almost imperceptibly into the St. Louis limestone. It is exhibited in the bluffs of the Mississippi, commencing a mile or two below Ste. Genevieve, and from thence extends almost uninterruptedly to the mouth of Aux Vases Creek, receiving, at several points, a capping of *Ferruginous sandstone*."

Type section — This formation was named from exposures near Ste. Genevieve, Ste. Genevieve County, Missouri. Weller and St. Clair (1928, p. 217) considered the outcrops along the bluffs of the Mississippi River, mentioned by Shumard, as ". . . the typical expression of the formation" (sec. 34 (projected), T. 38 N., and sec. 2, T. 37 N., R. 9 E., Ste. Genevieve 7½' Quadrangle). An excellent exposure at a small roadside park on U.S. Highway 61, 0.5 mi south of Ste. Genevieve, in the NE¼ sec. 34, T. 38 N., R. 9 E. (figs. 98 and 99), may be regarded as the type for the Ste. Genevieve Limestone; this section was described in detail by Short (1962, p. 1918).

History of nomenclature —

1847	Englemann	St. Louis limestone (upper part)
1852	Owen	Second Archimedes limestone
1855	Swallow	St. Louis limestone (upper part)
(not) 1855	Swallow	Ste. Genevieve marble (according to Shumard, 1859; = St. Louis Limestone)
1859	**Shumard**	**Ste. Genevieve limestone (removed from "St. Louis limestone")**
1873	Shumard	Ste. Genevieve limestone
1889	Newberry	St. Louis limestone of Mountain limestone (part)
1891	Williams	St. Louis stage of Genevievian age (upper part)
1892	Keyes	St. Louis limestone (upper part; rejected "Ste. Genevieve")
1894	Keyes	Ste. Genevieve limestone
1898	Weller	St. Louis limestone (upper part)

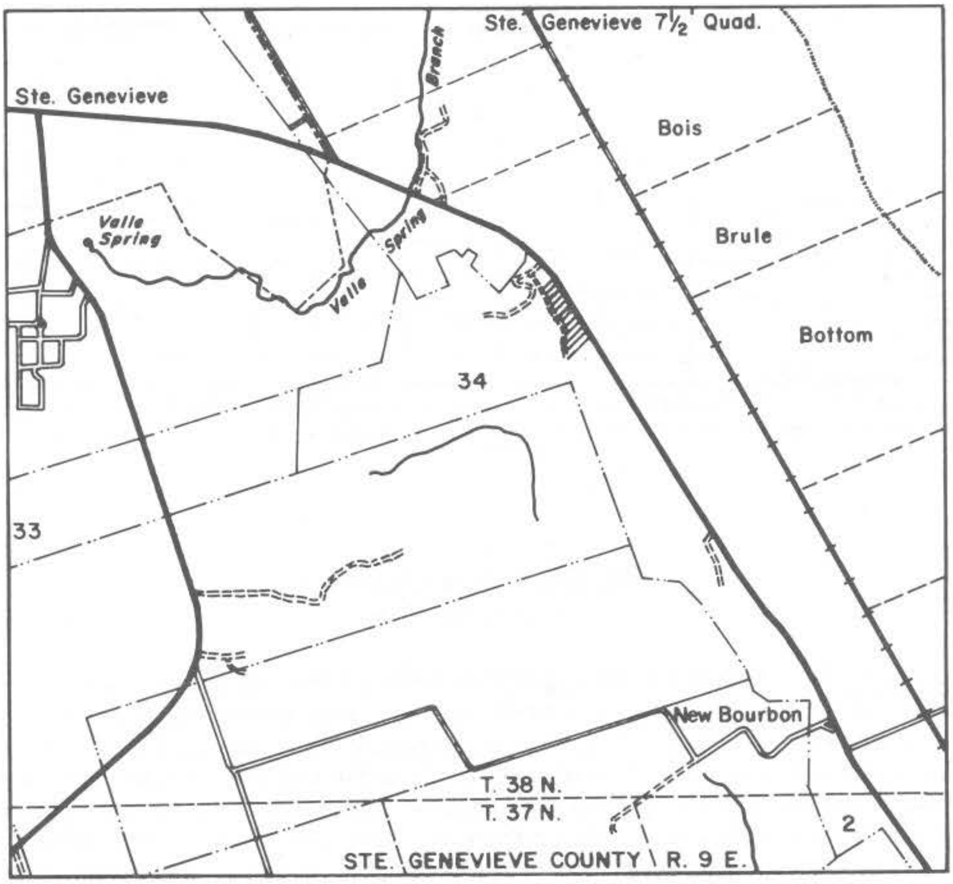
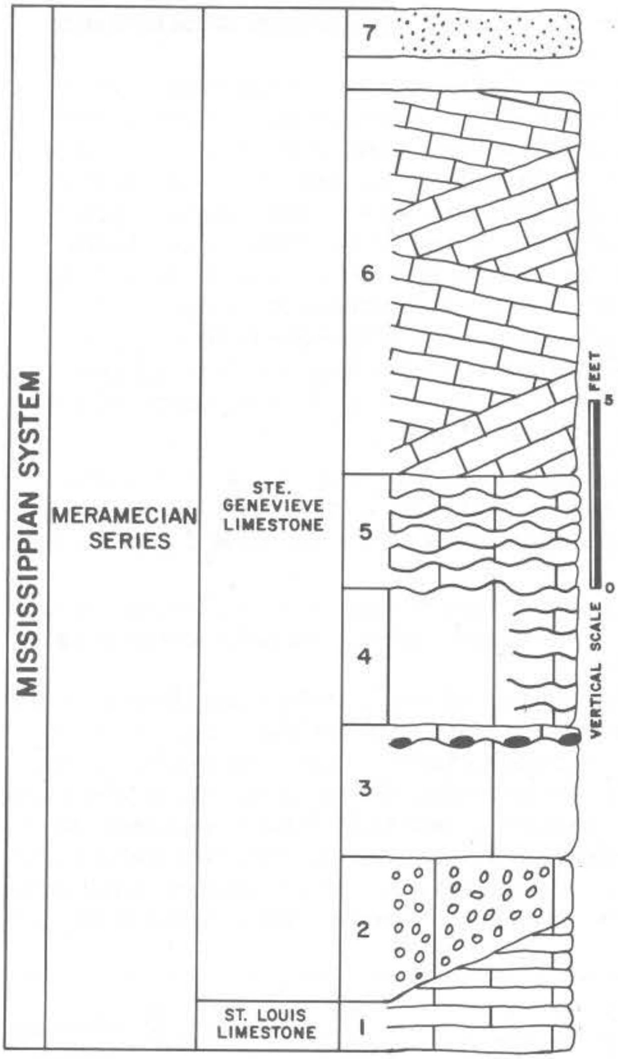


Figure 98. *Part of the Ste. Genevieve 7½' Quadrangle showing location of the type section of the* **Ste. Genevieve Limestone.**

1907	Buehler	St. Louis limestone member of St. Louis group (part)
	Weller	Ste. Genevieve limestone (excluded from "Chester group")
1911	Ulrich	Montesano limestone (= lower part of Ste. Genevieve Formation)
1931	Keyes	Genevieve limestone
1938	Keyes (b)	Genevieve oolite
1944	Branson	Ste. Genevieve formation
1961	Spreng	Ste. Genevieve formation
1963	Swann	Ste. Genevieve Limestone
		Spar Mountain Sandstone Member (Rosiclare of earlier reports; difficult to distinguish from Aux Vases Sandstone)
		Genevievian Stage (lower part; included Aux Vases Sandstone and lower member of the Renault)
1968	Johnson & Vondra	Genevievian Stage
		Pella Formation (northeastern Missouri)
1979	Thompson (a)	Ste. Genevieve Limestone

Remarks — Spreng (1961, p. 70-71) stated,
"The Ste. Genevieve formation is typically developed in the east-central and southeastern parts of Missouri in Ste. Genevieve and St. Louis Counties and in eastern Perry County. It is also present in adjacent parts of Illinois and Kentucky where it has been subdivided into



7. Sandstone, yellow-brown, soft; on gravel road west of Highway 61. (1 ft+)
6. Limestone, light-gray, very cross-bedded, dense, coarsely, crystalline. (10 ft)
5. Limestone, light-gray, finely crystalline to sublithographic; slabby, nodular bedding; some fossils. (2 ft 6 in.)
4. Limestone, light-grayish-brown, lithographic; dense when fresh, weathers to nodular beds. (3 ft 6 in.)
3. Limestone, light-gray, massive, medium-crystalline; chert at top; some lithographic matrix. (3 ft)
2. Limestone, light-gray, oolitic, coarsely crystalline; irregular thickness. (0-6 ft)
1. Limestone, light-gray, nodular; slabby 1-4 in. beds separated by thin shale partings. (1-4 ft)

Figure 99. *Columnar section to type section of* **Ste. Genevieve Limestone**, *at a small roadside park on west side of U.S. Highway 61, 1.5 mi south of Ste. Genevieve (fig 98), NE¼ sec. 34, T. 38 n., R. 9 E. (projected), Ste. Genevieve 7½' Quadrangle, Ste. Genevieve County, southeastern Missouri.*

members. Within the Missouri area, the formation is a white, massively bedded, sandy, clastic limestone. It is generally coarsely crystalline and oolitic but does contain a few beds of finely crystalline limestone. The lower part of the formation is sandy, white to light tan or light olive gray in color, and is prominently cross bedded and ripple marked. Lenses and clusters of algal material are present in this part of the formation in regularly-bedded strata. Above the cross-bedded unit and near the middle of the formation, there are some layers of red and gray chert, as well as some lenses and beds of sandstone that occur locally. The lithology of the formation changes laterally, making it difficult to trace individual units. Certain beds contain notable amounts of limonite which lines small cavities in the rock. In the upper part of the formation, various shades of yellow, green, and purple have been noted. The percentage of insoluble residue that can be extracted from the Ste. Genevieve in this area is usually low. The residue contains a proportionately large amount of pink or bluish-gray chert, some quartz sand and crystals, and silicified ooliths.

"Fossils are irregularly distributed throughout the Ste. Geneveive in the east-central and southeastern parts of Missouri. The best preserved forms are present above the cross-bedded part of the formation. The brachiopod *Pugnoides ottumwa,* the small crinoid *Platycrinites* *penicillus,* and the very large gastropod *Bellerophon* are commonly present in the formation in this area.

"In the extreme northeastern part of the State, in Lewis and Clark Counties, a white, massive, cross-bedded sandstone which is 1 to 4 feet thick and contains fragments of chert and lithographic limestone has been identified as Ste. Genevieve. In Missouri, this unit is generally overlain by Pleistocene till, and faunal evidence for the age of the unit is lacking within the state. However, in adjacent parts of southeastern Iowa, a similar sandstone is overlain by a finely crystalline limestone, *Pella beds,* which has been correlated with the type Ste. Genevieve in southeastern Missouri. The contact of this sandstone with the underlying St. Louis formation is gradational in some places and disconformable in others.

"In the subsurface of northwestern Missouri, the Ste. Genevieve is a light colored, oolitic, and sandy dolomitic limestone. Scattered wells have encountered as much as 35 feet of subangular, fine- to medium-grained sandstone in the upper part of the formation whose maximum recorded thickness in this area is less than 75 feet."

In eastern Illinois and western Kentucky, the Ste. Genevieve Limestone is divided into four members: in ascending order, the Fredonia Limestone Member, Spar Mountain Sandstone Member, Karnak Limestone Member, and the Joppa Member (fig. 100). Atherton et al. (1975, p. 142) stated,

"The contact between the Ste. Genevieve and the overlying Aux Vases Sandstone is conformable, but it is marked by a series of downward steps to the west as the upper limestone beds grade westward into sandstone."

Westward across the Illinois basin, therefore, both the Karnak and Spar Mountain Members of the Ste. Genevieve grade laterally into the Aux Vases Sandstone, separated from it by vertical cut-off (fig. 100). These, along with the Joppa Member, may be correlative with the Aux Vases Sandstone in Missouri, the base of which would then be equivalent to the Spar Mountain Sandstone Member of the Illinois basin section. The Ste. Genevieve Limestone of eastern Missouri is equivalent to the **Fredonia Limestone Member** of the Ste. Genevieve Limestone of the southeastern Illinois basin. Where the Joppa Limestone Member is present, the overlying Aux Vases Sandstone is called the Rosiclare Sandstone Member, and is the only part of the Aux Vases not equivalent to Ste. Genevieve strata to the east.

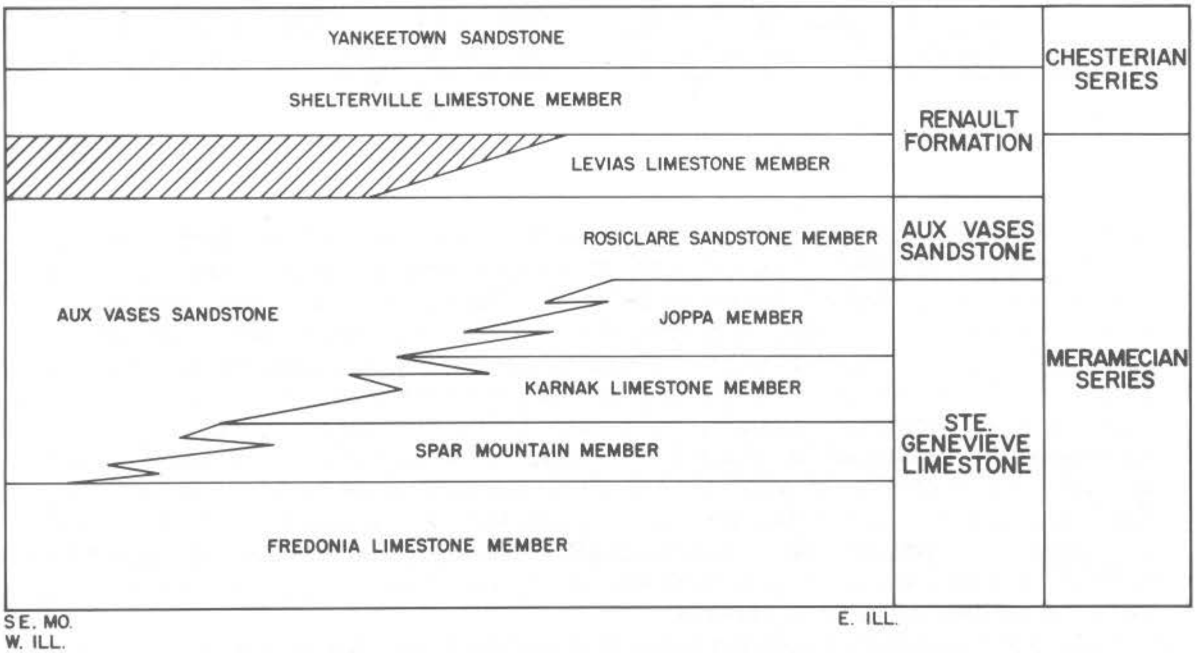


Figure 100. *Diagrammatic cross section of upper Meramecian Ste. Genevieve and Aux Vases strata and lower Chesterian Renault and Yankeetown Formations, southeastern Missouri and western Illinois to eastern Illinois, illustrating the relationship of the* **Aux Vases Sandstone** *to the upper members of the* **Ste. Genevieve Limestone.**

The thickness of the Ste. Genevieve in southeastern Missouri ranges from 85 ft to a maximum of just less than 100 ft. Because of erosion of the upper part, it is approximately 30 ft thick in St. Louis County. Ste. Genevieve strata have been identified in some logs in north-central Missouri, and appear to be present in disjunct patches on the pre-Pennsylvanian erosional surface across the subsurface in northern Missouri.

In parts of Missouri there is evidence of a period of pre-Chesterian erosion; for example, Chester strata lie on Keokuk Limestone in Barry County, in southwestern Missouri. In eastern Missouri, the contact between the Ste. Genevieve Limestone and the underlying St. Louis Limestone is marked by increased clastics (primarily medium sand) and oolites. Atherton et al. (1975, p. 143) stated that in Illinois,

> "Near the western border the Ste. Genevieve has a conglomerate bed at its base and rests unconformably on the eroded top of the St. Louis Limestone. Elsewhere the two formations appear to be conformable and, in the transition zone, beds with Ste. Genevieve lithology intertongue with beds with St. Louis lithology. The contact is placed below the lowest prominent oolitic bed."

Collinson et al. (1971) determined the Ste. Genevieve is in the lower part of the *Gnathodus bilineatus-Cavusgnathus charactus* Zone (conodonts), with a distinct zonal break between this zone at the base of the Ste. Genevieve and the upper St. Louis beds characterized by the *Apatognathus scalenus-Cavusgnathus* Zone (table 2). Thompson (1966) recorded a similar conodont faunal break between St. Louis-Ste. Genevieve strata in the region of north St. Louis County, Missouri, a break reflected in the lithologic change from clean carbonates of the St. Louis Limestone to clastic and/or oolitic carbonates of the Ste. Genevieve Limestone.

Rexroad and Furnish (1964) correlated the **Pella beds** of Iowa with the type Ste. Genevieve in southeastern Missouri. The contact of this sandstone and sandy limestone with the underlying St. Louis Limestone is gradational in some places, disconformable in others.

Aux Vases Sandstone

Keyes, 1892

Original description — (Keyes, 1892, p. 295) "In southern Illinois and southeastern Missouri the Kaskaskia comprises extensive beds of limestone and shale. Everywhere over this district these calcareous portions, which greatly predominate in the lower part of the group, are underlain by a fine grained ferruginous sandrock. This sandstone is recognizable above the City of St. Louis, where it is a dozen feet or more in thickness; southward it rapidly thickens until in the vicinity of the typical locality it attains a maximum measurement of more than 100 feet.

"For convenience in reference and in order to avoid further confusion this great sandstone will be called here the *Aux Vases sandstone,* from the river of that name in Ste. Genevieve County, Missouri, on which the rock is exposed."

Type section — The type section of the Aux Vases Sandstone consists of exposures in the bluff at the mouth of River Aux Vases, N½ NW¼ sec. 13, T. 37 N., R. 9 E., Ste. Genevieve County, Missouri, Kaskaskia 7½' Quadrangle (fig. 101).

History of nomenclature —

1857	Hall	Ferruginous sandstone
1866	Worthen	Ferruginous sandstone
1892	**Keyes**	**Aux Vases sandstone**
1899	White	"Ferruginous sandstone" ("= Millstone Grit of Illinois")
		Spring River sandstone

1900	Gallaher	Ste. Genevieve sandstone
1902	Weeks	Aux Vases sandstone ("= Ferruginous sandstone")
1904	Ulrich	Cypress sandstone
1907	Buehler	Aux Vases member of Chester group
	Weller	Cypress sandstone
1910	Schuchert	Cypress member of Kaskaskia formation
1914	Weller	Renault formation (lower part)
		Brewerville formation (Weller felt basal Chesterian strata consisted of two formations, the lower was the **Brewerville**, the upper the **Renault**
1920	Weller	Aux Vases sandstone ("Ferruginous sandstone")
1922	Cumings	West Baden formation (part)
1928	Weller & St. Clair	Aux Vases sandstone (proved "Brewerville" was a junior synonym of Aux Vases)
1950	Swann	Aux Vases sandstone ("= Brewerville sandstone of Illinois")
1961	Spreng	Aux Vases sandstone
1963	Swann	Aux Vases Sandstone (placed at top of Valmeyeran Series)
1979	Thompson (a)	Aux Vases Sandstone
	Sable	Aux Vases Sandstone ("eastern facies of Spar Mountain, Karnak, and Joppa Members of Ste. Genevieve Limestone in Kentucky and Indiana")

Remarks — Spreng (1961, p. 74) stated,

"The Aux Vases formation is composed principally of straw- to tan-colored sandstone and interbedded green to variegated shale which contains sandstone stringers in the lower and upper parts. The sandstone is fine grained and even textured. Its coarser portions occur in Perry County where it superficially resembles but differs from the St. Peter Sandstone by being finer grained and by containing mostly broken crinoid and brachiopod remains. The formation has about the same areal extent as the underlying Ste. Genevieve formation upon which it lies unconformably. Complete sections are not exposed in any one locality. In Ste. Genevieve County, the thickness of the formation ranges from 40 to 60 feet and in Perry County from 56 to 105 feet."

Spreng (1961) defined the Aux Vases Sandstone as the basal formation of the Chesterian Series in Missouri. Swann (1963), however, concluded that the Aux Vases in southwestern Illinois is equivalent to the Joppa Member of the Ste. Genevieve Limestone in Kentucky and southeastern Illinois. He stated (p. 29),

"A limestone bed marking the top of the Joppa Member in the eastern three or four rows of Illinois counties changes into a series of lenses that occur sporadically farther west. Where this prominent limestone bed occurs consistently at its top, the Joppa is assigned to the Ste. Genevieve Limestone. The base can be distinguished as a shale or shaly limestone essentially to the eastern border of Illinois. The unit is thus a distinct and useful entity within the Ste. Genevieve in the eastern third of Illinois. It can be recognized in some parts of the central third of the state, where it is assigned to the Aux Vases. The Joppa is intermediate between the extensive pure carbonates of the Karnak and the relatively pure clastics of the main body of the Aux Vases."

Swann also stated (p. 30-31),

"Where the control is too sporadic to permit bed tracing, the Aux Vases may contain one or more limestone interruptions, but it is generally impossible to tell in either subsurface or outcrop which of these represents which named unit in the Ste. Genevieve. Outcrops of this section containing much limestone . . . have been called Ste. Genevieve, whereas the sequences in which limestone was not recognized have been called Aux Vases."

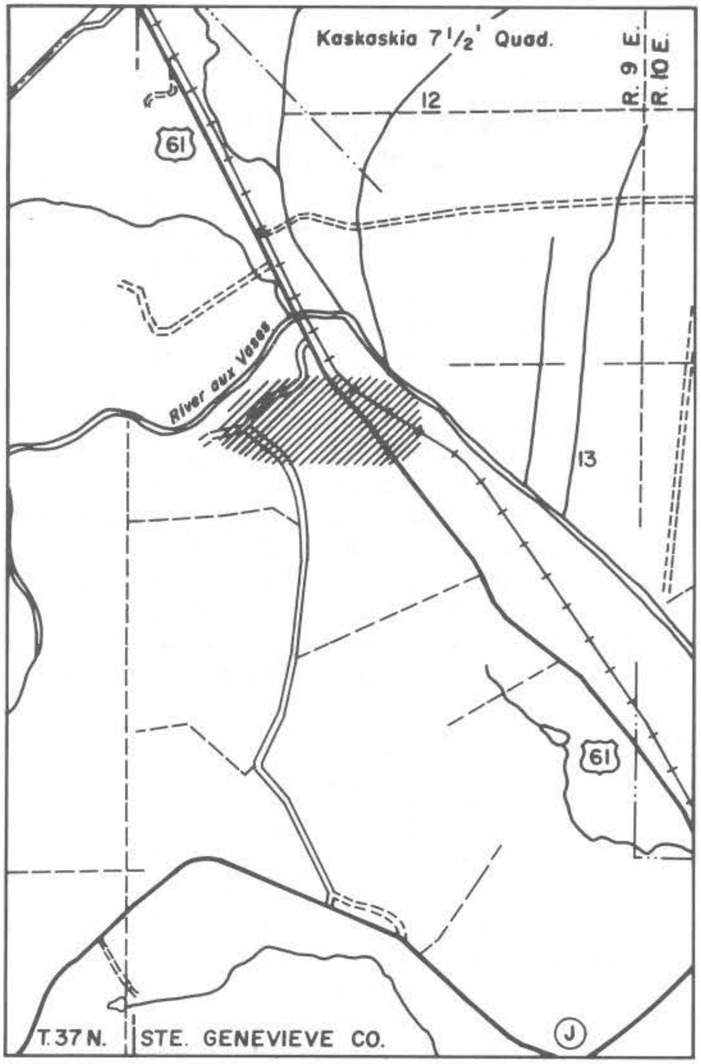


Figure 101. *Part of the Kaskaskia 7½' Quadrangle, Ste. Genevieve County, southeastern Missouri, showing location of the type section of the* **Aux Vases Sandstone.**

Atherton et al. (1975, p. 142) described the relationship of the Aux Vases Sandstone to upper Ste. Genevieve members as a "series of downward steps to the west" (fig. 100), the Joppa, Karnak, and Spar Mountain Members giving way, through facies changes, to the Aux Vases Sandstone to the west.

In Illinois, the crinoid *Platycrinites penicillus* characterizes the Levias Member of the Renault Formation, immediately overlying the Aux Vases Sandstone in the Illinois basin (Swann, 1963). The overlying Shelterville Limestone Member of the Renault contains *Talarocrinus.* Swann describes *Platycrinites penicillus* as defining the upper beds of the Meramecian Series, the Meramecian-Chesterian boundary coinciding with the *P. penicillus-Talarocrinus* faunal boundary. The Aux Vases Sandstone and the lower part of the Renault (Levias Member) are therefore designated upper Meramecian, rather than basal Chesterian, as reported by Spreng (1961). Levias strata have not been identified in Missouri; therefore, the Aux Vases Sandstone is the uppermost Meramecian formation in the state.

CHESTERIAN SERIES
Worthen, 1866

Original description — (Worthen, 1866, p. 321) "The Chester group is represented by the lower sandstone, about twelve feet in thickness, overlain by a thin band of limestone two feet thick."

Type locality — The type locality of the Chesterian Series is in the bluffs of the Mississippi River Valley, near Chester, Randolph County, Illinois, Chester 7½' and 15' Quadrangles (fig. 102).

Reference sections — An excellent exposure in northern Perry County, southeastern Missouri, representative of the Chesterian Series of that region, consists of a series of vertically dipping beds cropping out in a small valley, beginning approximately .75 mi southeast of Red Rock Landing, extending southwestward from the railroad embankment paralleling the bank of the Mississippi River (NW¼ NE¼ and SE¼ NE¼ sec. 13, T. 35 N., R. 12 E., Crosstown 7½' Quadrangle). At this section, beginning approximately 100 yards upstream from the railroad tracks, are the Chesterian Renault, Yankeetown, Paint Creek (Downeys Bluff and Ridenhower Limestone Members), and Golconda (Beech Creek and Haney Limestone Members) formations (fig. 103). In adjacent railroad cuts, Burlington-Fern Glen limestones are faulted against the Ste. Genevieve Limestone.

History of nomenclature —

	Early geologists	Pentremital limestone
1852	Owen	Archimedes limestone
1857	Hall	Kaskaskia limestone (included Aux Vases)
1858	Swallow	Upper Archimedes limestone
1859	Shumard	Archimedes group (upper part)
1861	Meek & Worthen (a)	Chester limestone
1866	**Worthen**	**Chester group**
1891	Williams	Genevieve group (upper part; replaced "Archimedes limestone")
		"Chester stage of Genevievian age"
1892	Keyes	Kaskaskia group or "Chester" beds (excluded Aux Vases)
1895	Gordon	Upper series (upper part)
1898	Weller (a)	Kaskaskia or Chester formation
		Ste. Genevieve epoch (upper part)
		Kaskaskia limestone
1904	Ulrich	Birdsville formation (upper part of Chesterian)
		Tribune limestone (between Birdsville and Aux Vases; abandoned by Ulrich in 1916)
1905	Ulrich	Tennessean series (upper part)
1907	Buehler	Birdsville group (in Missouri)
		Chester group
1915	Girty (a)	Tribune limestone
		Birdsville formation
		Kaskaskia limestone
		Chester division
1933	Keyes	Oshawanah series
1939	Weller	Chester series
		Elvira group
		Homberg group
		New Design group

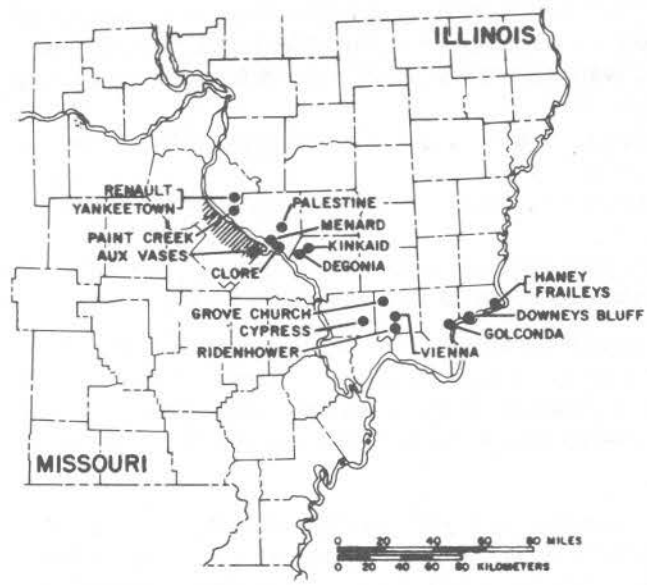


Figure 102. *Map of southern Illinois and southeastern Missouri showing areas of outcrop of Chesterian rocks in Missouri, and locations of type sections for Chesterian formations that constitute the "standard section" for the Mississippian System. Adapted from Thompson (1984, fig. 12).*

1940	Keyes	Oshwana [sic] series
1941	Keyes	Oshawanan series of late Leeic period
1944	Branson	Upper Mississippi series
1948	Weller et al.	Chesterian series
		Elvira group
		Homberg group
		New Design group
1956	Bradley	Upper Mississippian Series (upper part)
1961	Spreng	Chesterian series (Aux Vases-Vienna)
1963	Swann	Chesterian Series (in Illinois)
		Elviran Stage
		Hombergian Stage
		Gasperian Stage
1967	Yochelson & Saunders	Kaskaskia Limestone
		Chester Series
1968	Goebel	Chesteran Stage of Upper Mississippi Series (in Kansas)
1979	Thompson (a)	Chesterian Series (Renault-Vienna)

Remarks — In Missouri, there are two geographically separated, lithologically distinct successions of Chesterian strata. One, in the southeastern part of the state (table 1), includes approximately the lower half of those formations in the type region of the Chesterian Series as exposed across the Mississippi River in southwestern and southern Illinois (Atherton et al., 1975, p. 146). The other succession is in extreme southwestern Missouri, exposed in down-dropped fault blocks now appearing as northern outliers of the thick Late Mississippian-Early Pennsylvanian present in northwestern Arkansas and northeastern Oklahoma. Chesterian strata are not present in the subsurface of northern or western Missouri, but have been identified approximately 8 mi west of the Kansas-Missouri border, in extreme southern Cherokee County, southeastern Kansas (Nodine-Zeller and Thompson, 1977).

In southeastern Missouri Chesterian strata are exposed in the bluffs of the Mississippi River Valley, in a small region of Ste. Genevieve and Perry Counties (fig. 102), an area of steeply dipping beds associated with the Ste. Genevieve fault system. This region is on the western edge of a thicker and more completely developed succession in the Illinois basin sequence of southern Illinois and northern Kentucky. The Missouri exposures are not as complete as their Illinois counterparts, and earlier correlations were uncertain (members were not recognized) in some formations. Spreng (1961, p. 71-73) noted that

> "Exposures are not continuous, and identity of the formations is established only by their similarity to the better developed sections in Illinois."

The Chesterian formations consist of poorly defined cyclic repetitions of sandstone, shale, and limestone. Spreng (1961, p. 73-74) again stated,

> "Minor unconformities have been noted in many places beneath sandstones within the Series, but because of poor and limited exposures these cannot always be verified."

The Chesterian Series in southeastern Missouri unconformably overlies Meramecian rocks. Overlying the Chesterian rocks are residual materials and Pleistocene loess. The maximum thickness of the Series, in eastern Perry County, is 600 ft. These units have so far proved of little economic value in Missouri. In Illinois oil is produced from several horizons within the Chesterian sequence.

In southwestern Missouri, Chesterian formations crop out in a restricted area of southern Barry and McDonald Counties (fig. 109). Preserved within a down-dropped fault block, they constitute the Hindsville, Batesville, and Fayetteville formations. These outcrops are in an erosional remnant of strata formerly widespread over southwestern Missouri, northwestern Arkansas, and northeastern Oklahoma and still well exposed in the Boston Mountains and its outliers in Arkansas and Oklahoma, where they are thicker and more continuous.

Chesterian formations of southwestern Missouri, widely separated and lithologically distinct from the Chesterian formations of southeastern Missouri and southwestern Illinois, possibly represent deposition in a basin geographically isolated from the Illinois basin during time of deposition (Thompson, 1972). Thompson studied the conodont faunas recovered from the southwestern Missouri sequence, and was able, with some reservation, to correlate them with the faunas previously reported from the type region of the Chesterian Series, but he recognized a closer correlation with Chesterian strata in Oklahoma and Texas than with those of the Illinois basin. This correlation is shown below in the table of Chesterian formations.

In southwestern Missouri, the base of the Chesterian sequence lies unconformably on the Keokuk Limestone (Osagean Series) and is capped by a thick (20 to 30 ft), cross-bedded, non-marine sandstone that has been identified as the **Wedington Sandstone Member of the Fayetteville Formation** (Late Chesterian), previously identified as the lower member of the Hale Formation (Lower Pennsylvanian).

In the Joplin area of Jasper, Newton, and western Lawrence Counties, limestones and sandstones associated with collapse structures have been correlated with the Chesterian Series and collectively identified as the **Carterville Formation.** In this region, the Carterville consists of oolitic, sandy limestone blocks mixed with shale and sandstone, all occurring as collapse fill material retaining little stratigraphic integrity. Similar limestone, near Aurora, southeastern Lawrence County, associated with a fine-grained sandstone, and well-developed bedded limestones preserved as isolated outliers in northern Barry and McDonald Counties, have also been referred to the Carterville Formation. Recent studies (Thompson, 1972) have determined that the southern outcrops of Carterville, other than those in the immediate vicinity of Joplin, are probably outliers of the Hindsville Limestone, and that the sandstone near Aurora is most likely equivalent to the Batesville Formation. Near Joplin limestone blocks called Carterville are remnants of roof collapse; many are of the Warsaw Formation.

Swann (1963) and Atherton et al. (1975) divided the Chesterian Series into three stages: in ascending order, the Gasperian Stage (Shelterville Member of Renault-Beech Creek Limestone of Golconda Group), Hombergian Stage (Fraileys and Haney Formations of Golconda Group-Glen Dean Formation), and Elviran Stage (Tar Springs Sandstone-top of Kinkaid Formation). On the **Gasperian**

Stage, Atherton et al. (1975, p. 152) stated,

"The bryozoan *Cystodictya labiosa* Zone and the crinoid *Talarocrinus* Range Zone are the most definitive faunal zones of the Gasperian Stage, although the *Talarocrinus* Zone does not include the Beech Creek Limestone [basal limestone of the Golconda Group]."

In defining the **Hombergian Stage**, Atherton et al (1975, p. 156) stated

"The limestones in this stage are typically light brownish gray, light gray, or buff to gray and many of them and their associated shales are abundantly fossiliferous. Red shales in the upper part of the Rraileys and the lower part of the Hardinsburg are extensive marker beds. The bryozoan *Prismopora serrulata* and the crinoid *Pterocrinus* are typical Hombergian fossils.

Of the **Elviran Stage**, Atherton et al. (p 158) stated,

"The limestones of the Elviran Stage are generally darker and finer grained and contain more silt and argillaceous material and less abundant fossils than the older Chesterian limestones. Representative fossils include *Pentremites foshi, Pterotocrinus menardensis, Composita subquadrata, Eumetria costata*, and *Sulcatopinna missouriensis*."

Recent studies of Chesterian strata in the Illinois basin (Swann, 1963; Atherton et al., 1975) have provided new stratigraphic information with which to compare the southeastern Missouri Chesterian units, thereby permitting the Paint Creek and Golconda Formations in Missouri to be recognized as they are in Illinois, composed of three members each. The following units are identified within the Chesterian Series of Missouri:

Southwestern Missouri	**Eastern Missouri**
	<u>Elviran Stage</u>
	Vienna Limestone
Fayetteville Formation	Tar Springs Sandstone
	<u>Hombergian Stage</u>
	Glen Dean Formation
Batesville Formation	Hardinsburg Formation
Hindsville Limestone	Golconda Formation
(Carterville Formation)	Haney Limestone Member
	Fraileys Shale Member
	<u>Gasperian Stage</u>
	Beech Creek Limestone Member
	Cypress Formation
	Paint Creek Formation
	Ridenhowever Limestone Member
	Bethel Member
	Downeys Bluff Limestone Member
	Yankeetown Sandstone
	Renault Formation

Weller (1914) proposed the **Okaw limestone**, which included strata from the top of the Cypress (Ruma) sandstone to the top of the Glen Dean. Overlying the Okaw are the Menard and the Tar Springs-Vienna sequence (the latter apparently miscorrelated by Weller as Hardinsburg-Glen Dean, according to Swann, 1963, p. 47); the latter units are absent in the eastern part of the Eastern Interior basin. Sutton (1934) expanded the Okaw to include all strata from the top of the Cypress (base of the Golconda) to the top of the Waltersburg (base of the Menard). The "Lower Okaw" included the Golconda, Hardinsburg, and Glen Dean Members; the "Upper Okaw," the Tar Springs, Vienna, and Waltersburg Members.

Conodont zones defined for the Chesterian Series (Collinson et al., 1971; Thompson, 1972) are listed in table 2.

Renault Formation
Weller, 1914

Original description — (Weller, 1914, p. 24) "The formation is exceedingly variable in its lithologic characters, and includes sandstone, shale, and limestone members."

Type section — Swann (1963, p. 79) stated the Renault was "... well exposed in the valley of Horse Creek and its tributaries; a typical outcrop is in the lowest gully on the south side of Dry Fork in the SE¼ SW¼ sec. 23, T. 4 S., R. 9 W., NE¼ of Renault (15') Quadrangle, Monroe County, Illinois." The name was taken from Renault Township.

Reference section — In Missouri, Renault strata are exposed in a section in a small valley (fig. 103) that extends southwest from the bank of the Mississippi River, beginning approximately 0.75 mi southeast of Red Rock Landing (NW¼ NE¼ sec. 13, T. 35 N., R. 12 E., Crosstown 7½' Quadrangle).

Another excellent section is in a roadcut on U.S. Highway 61 about 1 mi northwest of the town of St. Marys (fig. 104), NW¼ NW¼ NW¼ sec. 29, T. 37 N., R. 10 E., Ste. Genevieve County, southeastern Missouri (Kaskaskia 7½' Quadrangle).

History of nomenclature —

1857	Hall	Kaskaskia limestone (lower part)
1858	Swallow	Upper Archimedes limestone (lower part)
1859	Shumard	Archimedes limestone (lower part)
1866	Worthen	Chester limestone (lower part)
1904	Ulrich	Tribune limestone (lower part)
1910	Schuchert	Tribune member of Kaskaskia formation (part)
1914	**Weller**	**Renault limestone (upper part)**
1922	Cumings	West Baden formation (part)
1925	Flint	Renault-Paint Creek Formation (lower part)
1928	Weller & St. Clair	Renault limestone
1944	Branson (a)	Renault formation
1961	Spreng	Renault formation
1963	Swann	Renault Limestone (Gasperian Stage)
1979	Thompson (a)	Renault Formation
	Sable	Renault Limestone ("= Levias Member of Ste. Genevieve Limestone of Kentucky and Indiana")

Remarks — Spreng (1961, p. 74-75) stated,

"The Renault formation includes a variety of rock types and is not very well exposed. The lower part contains shale and sandy limestone which is conglomeratic near the Aux Vases contact; the conglomerate is composed of limestone, chert, and sandstone fragments. The sandstone is fine grained and commonly contains worm borings. In the upper part, thin, bluish-gray to light gray limestone is interbedded with red, gray, or green, fissile shale. The formation's contact with the underlying Aux Vases is generally covered; thus, the relationship between the two formations is believed to be unconformable. The formation varies in thickness from 46 to 90 feet and is exposed in and near the Mississippi River bluffs from the Aux Vases River in Ste. Genevieve County to a point a few miles south of the Perry County line.

"Fragments of the plant *Lepidodendron* are commonly present in the lower sandy beds. In the upper limestone beds, crinoids and bryozoans are common, and the crinoid *Talarocrinus* and the bryozoan *Lyropora* are widespread markers."

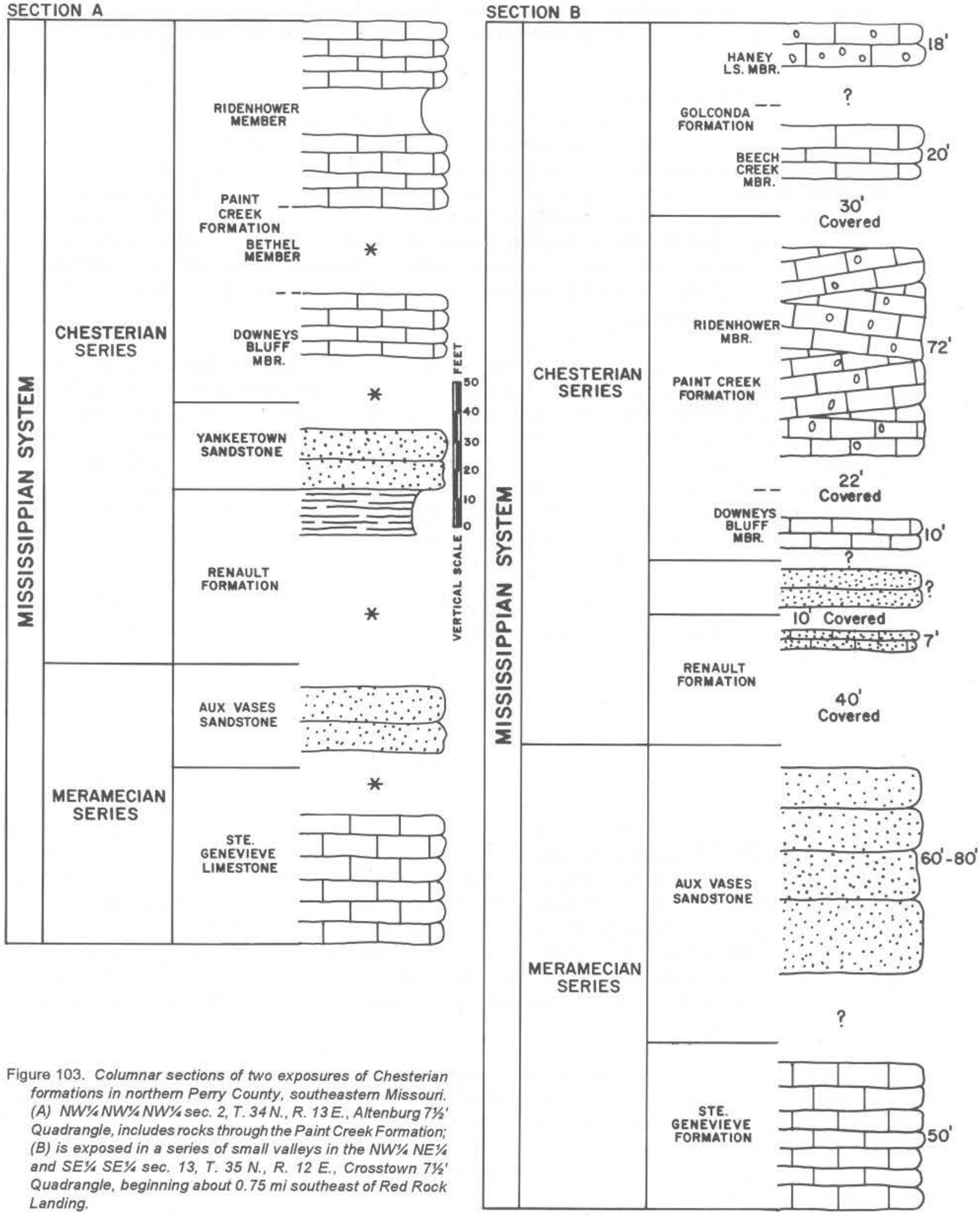


Figure 103. *Columnar sections of two exposures of Chesterian formations in northern Perry County, southeastern Missouri. (A) NW¼ NW¼ NW¼ sec. 2, T. 34 N., R. 13 E., Altenburg 7½' Quadrangle, includes rocks through the Paint Creek Formation; (B) is exposed in a series of small valleys in the NW¼ NE¼ and SE¼ SE¼ sec. 13, T. 35 N., R. 12 E., Crosstown 7½' Quadrangle, beginning about 0.75 mi southeast of Red Rock Landing.*

In southeastern Illinois, the Renault is divided into two members, the lower **Levias Member**, and the upper **Shelterville Member.** As the Levias Member contains the crinoid *Platycrinites penicillus* and the Shelterville Member the form *Talarocrinus,* Swann (1963) and Atherton et al. (1975) determined that the Meramecian-Chesterian boundary is between these two members of the Renault Formation.

Swann (1963, p. 31-32) stated,

"In western Illinois the Renault is extremely variable in both thickness and lithology. The Levias Member generally cannot be recognized, and the Shelterville Member ranges from 0 to 80 feet and includes as many as three or four alternations of sandstone and limestone units. The lower of these sandstone units may be included in the Aux Vases at some localities. . . .

"Discordant surfaces occur at the base of several units within the Renault and the adjacent formations, most abundantly in western Illinois and eastern Missouri but occasionally in other parts of the basin. Segments of several of these surfaces were treated as one surface in some earlier literature and cited as evidence for important pre-Aux Vases, pre-Renault, or pre-Chester unconformities."

Spreng (1961, p. 75) reported that in the upper limestone beds in Missouri "crinoids and bryozoans are common, and the crinoid *Talarocrinus* and the bryozoan *Lyropora* are widespread markers." Swann (1963), therefore, suggested that the Renault section in Missouri may be represented only by the Shelterville Member of the Renault; if so, the entire Renault Formation in Missouri is Chesterian in age. Spreng reported *Talarocrinus* from the Missouri section but did not report if fossils are known from the lower sandy limestone portion of the Missouri Renault Formation. He reported, however, that (p. 75) "fragments of the plant *Lepidodendron* are commonly present in the lower sandy beds." Perhaps the environment was not amenable to crinoid survival during deposition of the lower Renault in Missouri.

Using conodonts, Collinson et al. (1971) determined that the Renault is within the *Gnathodus bilineatus-Cavusgnathus charactus* Zone, which ranges from basal Ste. Genevieve strata to the top of the Cypress.

Yankeetown Sandstone

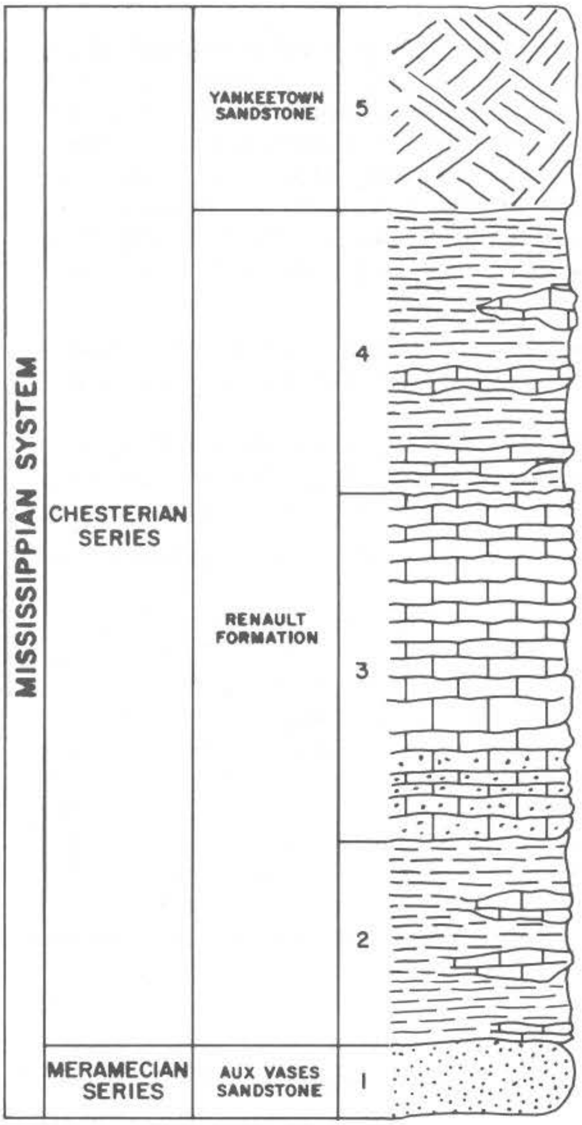
Weller, 1914

Original description — (Weller, 1914, p. 25) "Overlying the Renault formation is a thin but persistent siliceous formation of peculiar lithologic character, locally quartzitic. . . . Some of its most typical exposures may be seen in the region adjacent to the Yankeetown school, about 6 miles southwest of Red Bud, from which locality the name of the formation has been derived.

"Its color is light, commonly gray, or yellowish, or in many localities nearly white. It is very irregular, and more or less cross-bedded, having a decidedly knotty appearance, and locally is distinctly banded. It is commonly more or less arenaceous and in some localities certain beds are quartzitic. . . . Where the formation is encountered in wells it appears to be a very hard, siliceous limestone."

Type section — Swann (1963, p. 86) described the type section as ". . . located on west side of the Ames-Waterloo Road a few hundred feet south of Prairie Branch Creek and a quarter of a mile north of the southeast corner of sec. 26, T. 4 S., R. 9 W., Renault (15′) Quadrangle, Monroe County, Illinois."

Reference section — The Yankeetown Sandstone is exposed in a roadcut on U.S. Highway 61, approximately 1 mi northwest of the town of St. Marys, southern Ste. Genevieve County, southeastern Missouri, Kaskaskia 7½′ Quadrangle (fig. 104), and also can be seen as vertically dipping beds cropping out in a small streambed in the NW¼ NE¼ sec. 13, T. 35 N., R. 12 E., northern Perry County, Missouri, Crosstown 7½′ Quadrangle (fig. 103).



5. Chert, sandy, cross-bedded; floating sand grains; contorted (pseudo-crossbedding); bedding probably due to solution of calcite. (6 ft)
4. Shale, greenish-gray, to red and green. Limestone, as discontinuous lenses and thin beds. (12 ft)
3. Limestone, thin- to medium-bedded; sandy beds at base (almost a calcareous sandstone). (22 ft)

Base of roadcut section

2. Shale, green, with discontinuous limestone beds and lenses. (5-7 ft)
1. Sandstone (Aux Vases ?)

Units 1 and 2 exposed on north side of drain, just north of roadcut section. Limestone above unit 2 contains *Talarocrinus*.

Figure 104. *Columnar section of an exposure of the* **Renault Formation** *and* **Yankeetown Sandstone**, *in a roadcut on U.S. Highway 61 about 1 mi northwest of St. Marys, SW¼ SW¼ SW¼ sec. 20, or NW¼ NW¼ NW¼ sec. 29 (projected), Kaskaskia 7½' Quadrangle, Ste. Genevieve County, southeastern Missouri. Section measured by J.A. Martin.*

History of nomenclature —

1857	Hall	Kaskaskia limestone (lower part)
1858	Swallow	Upper Archimedes limestone (lower part)
1859	Shumard	Archimedes limestone (lower part)
1866	Worthen	Chester limestone (lower part)
1904	Ulrich	Tribune limestone (lower part)
1907	Buehler	Kaskaskia member of Chester group (lower part)
1910	Schuchert	Tribune member of Kaskaskia formation (part)
1914	**Weller**	**Yankeetown sandstone**
1920	Weller	Yankeetown chert
1925	Flint	Yankeetown chert
1928	Weller & St. Clair	Yankeetown formation
1939	Weller	Bethel sandstone
1944	Branson	Yankeetown formation
1961	Spreng	Yankeetown formation
1963	Swann	Yankeetown Sandstone (Gasperian Stage)
1979	Thompson (a)	Yankeetown Sandstone

Remarks — Spreng (1961, p. 75) stated,

"Throughout most of its outcrop area, the Yankeetown formation is a fine-grained, light to reddish-brown, calcareous sandstone. The sandstone is irregularly bedded and cross bedded, shows rib and furrow structure, and in many places is cemented with silica. The irregularity of some of the bedding and cross-bedding may be caused by the leaching of the calcareous cement. At many places, the formation contains gray or red shale. The contact between the Yankeetown and Renault formations is transitional. If most of the sandstone that lies below the Paint Creek formation in Missouri is assigned to the Yankeetown, the thickness of the formation in Perry County will be 60 feet, and in Ste. Genevieve County it will be somewhat less."

At many places, this formation contains gray or red shale, and thus is similar to Yankeetown strata immediately across the Mississippi River in western Illinois. Atherton et al. (1975, p. 152) stated,

"The Yankeetown is a sandstone-shale unit in western Illinois that grades into a limestone-shale unit in eastern Illinois. . . . Red shale is extensively developed near the top of the Yankeetown, but other shales present are dark greenish-gray, and variegated."

Weller and St. Clair (1928, p. 237) described Yankeetown strata in Ste. Genevieve County, Missouri:

"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."

The predominantly siliceous nature of the Yankeetown throughout much of its occurrence in Missouri has led geologists, such as Flint (1925), to call this formation the "Yankeetown chert," rather than sandstone.

The Yankeetown Sandstone is present in northern Perry and Ste. Genevieve Counties. Flint (1925) reported it absent in southern Perry and Cape Girardeau Counties; in that region the Paint Creek lies on Renault strata.

Paint Creek Formation

Weller, 1914

Original description — (Weller, 1914, p. 26) "Above the Yankeetown formation is a series of strata approximately 60 feet in thickness, which are shales below, passing into limestones above. Near the base of this Paint Creek formation, either resting directly upon the Yankeetown or separated from it by a few feet of blue or gray shales with perhaps some thin calcareous beds, is a deep-red, clay member.

"In fresh exposures this red bed exhibits little or no stratification; on being subjected to atmospheric agencies it first crumbles into small, angular fragments which eventually disintegrate into a fine, red mud. The appearance of the stratum is more that of a residual clay than anything else familiar to the writer."

Type section — Swann (1963, p. 76) stated that the Paint Creek was "named as a formation by S. Weller (1914) for outcrops in the valley of Paint Creek and its tributaries, typical of which are those in the north-flowing tributary west of McCuen school, E½ sec. 2, T. 5 S., R. 9 W., Renault (15') Quadrangle, Randolph County, Illinois."

Reference sections — The exposure described as a reference section under "Chesterian Series," NW¼ NE¼ sec. 13, T. 35 N., R. 12 E., northern Perry County, Missouri, Crosstown 7½' Quadrangle, is excellent for the limestone members of the Paint Creek Formation in Missouri (fig. 103). Limestone of the Paint Creek Formation is also exposed along the banks of a north-south stream in the NW¼ sec. 34, T. 35 N., R. 13 E., Altenburg 7½' Quadrangle.

History of nomenclature —

1857	Hall	Kaskaskia limestone (part)
1858	Swallow	Archimedes limestone (part)
1866	Worthen	Chester limestone (part)
1904	Ulrich	Tribune limestone (part)
1907	Buehler	Kaskaskia member of Chester group (part)
1910	Schuchert	Tribune member of Kaskaskia formation (part)
1914	**Weller**	**Paint Creek formation**
1922	Cumings	West Baden formation (part)
1925	Flint	Renault-Paint Creek Formation (upper part)
1928	Weller & St. Clair	Paint Creek formation (part; included Cypress)
1944	Branson	Paint Creek formation
1961	Spreng	Paint Creek formation
1963	Swann	Paint Creek Group (Gasperian Stage) (Illinois)
		Ridenhower Formation
		Bethel Sandstone
		Downeys Bluff Limestone
1979	Thompson (a)	Paint Creek Formation

Remarks — Spreng (1961, p. 75) stated,

"The Paint Creek formation is poorly exposed in Missouri and is present only in northeastern Perry County. The basal part of the formation consists of limestone and interbedded shale. The limestone is light gray, coarsely to finely crystalline, and contains distinctively pink crinoid and blastoid ossicles. This lower limestone unit varies in thickness from 8 to 20 feet. The middle part of the formation consists of shale that has a few limestone beds in the upper part and noncalcareous, red claystone in the lower part. It is from 15 to 30 feet thick. The upper part of the Paint Creek contains light buff oolitic, cross-bedded limestone and very little shale. Crinoid and blastoid debris is common, and the crinoid *Pterotocrinus* is distinctive. This part of the Paint Creek is 40 to 70 feet thick. The total thickness of the formation varies from 80 to 100 feet."

Atherton et al. (1975, p. 152-153) described the **Paint Creek Group**, recognized only in western Illinois, as comprising, in ascending order, the **Downeys Bluff Limestone, Bethel Sandstone,** and **Ridenhowever Formation.** In Missouri strata identified as Paint Creek are exposed only in northeastern Perry County, where its thickness varies from 80 to 100 ft.

Spreng (1961, p. 75) described a three-part lithologic division of the Paint Creek in Missouri. In this report the three units, corresponding to the three parts of the Paint Creek Group in Illinois, are recognized as members of the **Paint Creek Formation** in Missouri.

Conodonts recovered from the Paint Creek sequence in Illinois were identified by Collinson et al. (1971) in the upper part of the *Gnathodus bilineatus-Cavusgnathus charactus* Zone, which ranges from the base of the Ste. Genevieve Formation to the top of the Cypress Sandstone in the Illinois basin (table 2).

Downeys Bluff Limestone Member of Paint Creek Formation

Atherton, 1947

Original description — (Atherton, 1947, p. 129) "Frank Tippie [unpublished manuscript] correlates the upper part of the Renault with the basal Paint Creek of western Illinois, and has proposed the name "Downeys Bluff" for this member of the Paint Creek . . ."

Atherton (p. 131) described the type section of the Downeys Bluff as follows:

"Bethel sandstone .... 30′

Downeys Bluff

Shale, green, weathered .... 6′

Limestone, cherty, buff to gray, partly oolitic, crinoidal; few streaks of limestone, brown, dense .... 13′ 3″

Limestone, brown, crinoidal; shale green .... 0′ 6″

Limestone, silty, green to brownish, very fine to fine .... 10′ 3″

Shelterville

Shale and limestone interbedded .... 30′"

Type section — Atherton et al. (1975, p. 153) stated the Downeys Bluff was "named for Downeys Bluff, Hardin County [Illinois], and the type section is in a bluff along the Ohio River (NW SE 5, 13S-8E.)."

Reference section — Strata of the Downeys Bluff Limestone Member of the Paint Creek Formation are exposed in the NW¼ NE¼ sec. 13, T. 35 N., R. 12 E., Perry County, Missouri, Crosstown 7½′ Quadrangle (fig. 103), in a sequence of steeply dipping strata exposed in a streambed.

Remarks — Atherton. et al. (1975, p. 153) stated the Downeys Bluff

> ". . . was originally regarded as a member of the Paint Creek Formation in southwestern Illinois and of the Renault Formation in southeastern Illinois, but it was later traced across the Illinois Basin. . . It is now a formation at the base of the Paint Creek Group in southwestern Illinois and at the top of the Cedar Bluff Group in southeastern Illinois."

The basal part of the Paint Creek Formation in Missouri consists of limestone and interbedded shale. As described by Spreng (1961, p. 75), this limestone, varying in thickness from 8 to 20 ft, is light gray, coarsely to finely crystalline, and contains distinctive **pink** crinoid and blastoid ossicles. In their description of the Downeys Bluff Limestone in western Illinois, Atherton, et al. (1975, p. 153) reported,

> "Limestone of the Downeys Bluff is white or light brownish gray and crinoidal. Many crinoid segments are replaced by pink chert. *The pink crinoids are an excellent diagnostic characteristic* [italics by the present writer] that is better developed in the western than in the eastern part of Illinois."

The lower limestone of the Paint Creek in Missouri is therefore lithologically correlative with the **Downeys Bluff Limestone** of western Illinois.

Bethel Member of Paint Creek Formation

Butts, 1917

Original description — (Butts, 1917, p. 63) "The name Bethel is here introduced for the sandstone overlying the Ohara limestone member, the lower part of the sandstone being especially thick and well displayed in the vicinity of Bethel school, 3½ miles west of Marion, Crittenden County, Ky.

"The Bethel is generally a thick-bedded, rather coarse-grained sandstone. In some sections it seems to be prevailingly flaggy. . . . This is the only sandstone of the Chester group so far as the writer is aware in which pebbles occur, and in this the pebbles are too few to constitute a conglomerate or to warrant its characterization as conglomeratic."

Type section — Atherton et al. (1975, p. 153) stated the Downeys Bluff was "named for Downeys Bluff, Hardin County [Illinois], and the type section is in a bluff along the Ohio River (NW SE 5, 13S-8'.)".

Remarks — Spreng (1961, p. 75) described the middle part of the Paint Creek Formation in Missouri as a shale with few limestone beds in the upper part and noncalcareous red claystone in the lower part. It is 15 to 30 ft thick. Atherton et al. (1975, p. 153), in describing the Bethel Sandstone in Illinois, stated,

"It is dominantly sandstone in much of Illinois, but it grades to shale to the west."

And on page 154, they added,

"As the sandstone grades westward to shale, red and green shales become more noticeable. Along the outcrop belt in southwestern Illinois, **a persistent bed of deep red, structureless clay** (underlining mine) about 15 feet thick is prominent."

The middle portion of the Paint Creek Formation in Missouri appears to correlate lithologically with the western facies of the Bethel Sandstone in Illinois.

Ridenhower Limestone Member of Paint Creek Formation
Butts, 1917

Original description — (Butts, 1917, p. 73-74) "The name Ridenhower, from Ridenhower, Ill., is applied to a predominantly shale formation between the Bethel and Cypress sandstones in Crittenden and Livingston counties, Ky., and in southern Illinois. . . .

"Between the Bethel and Cypress in Crittenden County, Ky., in Pope and Hardin counties, Ill., and below the Cypress sandstone at Ridenhower, Johnson County, Ill., is a stratum of shale or of shale, thin sandstone, and of thin sandy limestone 50 to 60 feet thick. . . .

"The Ridenhower shale in Ohio Valley and western Kentucky is almost wholly a soft dark clay shale weathering to a bluish or greenish tint. Besides shale a very little thin ferruginous and in places calcareous sandstone or sandy limestone is present."

Type section — Atherton et al. (1975, p. 153) stated the Ridenhower was "named for Ridenhower School, Johnson County [Illinois], and the type section is at Indian Point, 5 miles south of Vienna (SE SW 32, 13S-13E), where the formation is 60 feet thick and consists of shale with beds of fossiliferous limestone."

Reference section — Ridenhower Limestone beds have been identified in an exposure of steeply dipping beds in a streambed in northern Perry County, Missouri, NW¼ NE¼ sec. 13, T. 35 N., R. 12 E., Crosstown 7½' Quadrangle (fig. 103).

Remarks — Spreng (1961, p. 75) described the upper limestone of the Paint Creek in Missouri as oolitic, crinoid-bearing, cross-bedded limestone, 40 to 70 ft thick. Crinoid and blastoid debris is common, and the crinoid *Pterotocrinus,* distinctive. In western Illinois, Atherton et al. (1975, p. 154) described the Ridenhower Formation:

"The limestone includes sandy, oolitic, crinoidal, and lithographic beds, most of which are light to dark gray and brown, but buff, green, pink, and yellow beds are present. Some distinctive beds can be traced for several tens of miles. The proportion of limestone in the formation increases westward, so that near its western limit the formation is almost all limestone."

The upper limestone of the Paint Creek Formation in Missouri therefore appears to be equivalent to the **Ridenhower Formation** of western Illinois and is identified as the Ridenhower Limestone Member of the Paint Creek Formation.

Cypress Formation

Englemann, 1863

Original description — (Englemann, 1863, p. 19) "Quartzose sandstones with some shaly portions about 150 feet thick. I have distinguished them by the name of Cypress Sandstone on account of their prominent development on Cypress Creek."

Type section — Swann (1963, p. 64) stated that the Cypress Formation was "named by Englemann (1863) for massive sandstone exposures in the Bluffs of Cypress Creek in the southwestern part of T. 12 S., R. 1 E., Dongola Quad., Union County, Ill."

Reference section — Red and green shale, approximately 20 feet thick, is exposed in the second small valley south of Red Rock Landing, SE¼ NE¼ sec. 13, T. 35 N., R. 12 E., northern Perry County, Crosstown 7½' Quadrangle, close to the section described in figure 103, between discontinuous exposures of Paint Creek and Golconda limestones.

History of nomenclature —

1857	Hall	Kaskaskia limestone (part)
1858	Swallow	Archimedes limestone (part)
1863	**Englemann**	**Cypress Sandstones**
1866	Worthen	Chester limestone (part)
1892	Keyes	Kaskaskia limestone and shales (part)
1904	Ulrich	Tribune limestone (part)
(not) 1904	Ulrich	Cypress sandstone (= Aux Vases Sandstone)
1907	Buehler	Kaskaskia limestone member of Chester group (part)
(not) 1907	Weller	Cypress sandstone (= Aux Vases Sandstone)
1910	Schuchert	Tribune member of Kaskaskia formation (part)
(not) 1910	Schuchert	Cypress member of Kaskaskia formation (= Aux Vases Sandstone)
1914	Weller	Ruma formation
1917	Ulrich	Ruma sandstone
	Butts	Cypress ("Big Clifty") sandstone
1928	Weller & St. Clair	Paint Creek formation (upper part)
1939	Weller & Weller	Ruma sandstone
	Weller	Cypress sandstone
1940	Weller & Sutton	Cypress (absent in Missouri)
1944	Branson	(did not recognize in Missouri)
1948	Weller et al.	Cypress sandstone (a shale in Missouri)
1958	Potter et al.	Cypress (Elviran) sandstone
1961	Spreng	Cypress formation (a shale in Missouri)
1979	Thompson (a)	Cypress Formation

Remarks — As described by Spreng (1961, p. 75),

"The Cypress Formation is composed of gray shale and mudstone and contains some red shale layers and a few thin limestone stringers. The limited exposures in east central Perry County are poor, and the contacts of the formation with the overlying Golconda and underlying Paint Creek formations are concealed. The Cypress formation becomes silty and sandy and extends eastward into Illinois where it rapidly thickens so that 10 miles east of the Mississippi River bluffs it consists of 70 to 80 feet of sandstone which may be a channel deposit. Because this facies relationship was not noted in the past, the formation has not been previously recognized in Missouri where the thickness of the unit probably does not exceed 30 feet."

Spreng was the first to identify Cypress strata in eastern Missouri. The shale facies of the Cypress sandstone in southern Illinois, identified by Swann (1963) and Atherton et al. (1975), further substantiated identification of pre-Golconda shales in eastern Missouri as Cypress. Several previous workers (Ulrich, 1904; Weller, 1907; Schuchert, 1910), in seeking a sandstone for the Cypress interval in southeastern Missouri, misidentified the Aux Vases Sandstone as the Cypress. Swann (1963, p. 35) stated the Cypress

". . . thins somewhat and becomes largely shale at the eastern and western margins of the [Illinois] basin, where its equivalents have been named the Elwren and Ruma Formations, respectively."

Atherton et al. (1975, p. 155) added,

"In Randolph County in western Illinois, where the Cypress is almost entirely shale, the formation includes a considerable proportion of red and green shale. Beds of gray or green siltstone are present in the upper part of the Cypress, and a thin, dark green, quartzitic siltstone occurs near the top."

Conodont studies of the Chesterian Series in the Illinois basin (Collinson et al., 1971) reported that the Cypress Formation was the uppermost formation within the *Gnathodus bilineatus-Cavusgnathus charactus* Zone, the base of which corresponds to the base of the Ste. Genevieve Limestone.

Golconda Formation

Brokaw, 1916

Original description — (Brokaw, 1916, pl. 1) Brokaw described the Golconda as "Limestones and shales, variable in color and character; a red shale has been seen in places; thickness 100-215 feet."

Regarding formal definition of the Golconda, Butts (1917, p. 91) stated, "The Golconda formation is named from Golconda, Ill., just north of which the full thickness of the formation outcrops on the river bluffs. The name was first used by Ulrich in a paper read before the Geological Survey of America in December, 1915. The Golconda includes that part of the Chester section between the Cypress sandstone below and the Hardinsburg sandstone, next to be described, above. At Golconda there is, directly above the Cypress, about 20 feet of dark shale, above which is 10 feet or so of dark, argillaceous, coarsely crystalline or fragmental fossiliferous limestone called the *Pterotocrinus capitalis* zone. . . The *Pterotocrinus capitalis* zone is overlain by 80 feet of shale and limestone, the shale so far as the incomplete exposure permits one to judge, largely predominating and the limestone occurring as layers scattered through the shale. These limestone layers are argillaceous and ferruginous weathering to a lemon yellow color. A thin layer of red shale was observed. Above this shale and limestone segment of the Golconda is about 30 to 40 feet of solid limestone apparently fairly pure calcium carbonate. Directly in contact with this limestone above is the overlying Hardinsburg sandstone. . ."

Type section — Swann (1963, p. 68) stated that the Golconda Formation was defined from "... exposures in the Ohio River bluffs above Golconda, secs. 5, 8, and 18, T. 13 S., R. 7 E., Shelterville Quad., Pope Co., Ill."

Reference section — Both limestone members of the Golconda Formation are exposed in a small southwest-directed gully in the NW¼ NE¼ sec. 13, T. 35 N., R. 12 E., northern Perry County, Missouri, Crosstown 7½' Quadrangle (fig. 103).

History of nomenclature —

1857	Hall	Kaskaskia limestone (part)
1858	Swallow	Archimedes limestone (part)
1866	Worthen	Chester limestone (part)
1904	Ulrich	Tribune limestone (part)
1907	Buehler	Kaskaskia member of Chester group (part)
1910	Schuchert	Tribune member of Kaskaskia formation (part)
1914	Weller	Okaw formation (lower part)
1915	Ulrich	Golconda formation (oral presentation)
1916	**Brokaw**	**Golconda formation**
1928	Weller & St. Clair	Golconda formation (part; includes Hardinsburg)
1948	Weller et al.	Golconda formation
1958	Potter et al.	Beech Creek (Barlow) limestone
1963	Swann	Golconda Group
		Haney Limestone
		Fraileys Shale
		Beech Creek Limestone
1979	Thompson (a)	Golconda Formation

Remarks — As defined by Spreng (1961, p. 76-76),

"The Golconda formation is a limestone and shale succession that can be divided into three parts. The basal part is a dark gray to brown limestone 5 to 20 feet thick which contains an abundance of Foraminifera, small gastropods, and pelecypods. The middle part is 70 to 90 feet thick and is composed of shale which contains beds of darkly colored crinoidal limestone, and the upper part is a very light gray, oolitic, cross-bedded limestone 50 feet thick. Outcrops of the formation are confined to northern Perry County where the limestone beds in the Golconda are massive and form steep bluffs and ledges along the Mississippi River and its tributaries. Because the typical sandstone of the Cypress formation is absent in Missouri, there is a suggestion that an unconformity is present at the base of the Golconda."

The three parts of the Golconda Formation in Missouri appear to correlate lithologically with the three formations assigned to the Golconda Group in the southern part of the Illinois basin (Atherton et al., 1975, p. 155-157). In ascending order, they are the **Beech Creek Limestone** (the youngest formation of the Hombergian Stage of Swann, 1963), **Fraileys Shale**, and **Haney Limestone.** These three units are herein regarded as members of the Golconda Formation in Missouri; each is discussed separately below.

In Indiana, the sequence equivalent to the Golconda of Illinois and Missouri comprises the following units:

Golconda Limestone (= Haney Limestone Member)
Big Clifty Formation (= Fraileys Member)
Beech Creek Limestone (= Beech Creek Limestone Member)

According to Shaver et al. (1970, p. 66),

"The Golconda Limestone of Indiana usage is equivalent to the Haney Limestone of western

Kentucky (McFarlan and others, 1955, p. 18). The name Haney has also been placed in the Illinois standard section, in which the name Golconda in nearly its original sense has been raised to group rank (Swann, 1963). Thus it is clear that the name Golconda is applied in Indiana in a confusing and possibly improper sense, and despite long and consistent use in this area the name should be replaced."

Through detailed conodont biostratigraphic studies (table 2) of the Illinois basin and of related Mississippian strata in the Upper Mississippi River Valley, Collinson et al. (1971, p. 362) defined the Golconda Group, along with the overlying Hardinsburg Formation, to comprise the *Gnathodus bilineatus-Cavusgnathus altus* Zone (*Gnathodus bilineatus-Cavusgnathus cristata* Zone of Collinson et al., 1962).

Beech Creek Limestone Member of Golconda Formation
Malott, 1919

Original description — (Malott, 1919, p. 11-13) "This name is proposed for the limestone unit which has heretofore been called the "Middle" or "Second" limestone of the Chester Series in Indiana, . . . It consists of two or more massive to thin bedded ledges with a total thickness of 8 to 24 feet, and a typical thickness of 12 feet. . . . It is a gray, compact to sub-oolitic, and often semi-crystalline limestone, frequently locally quite completely oolitic, and contains large numbers of brachiopods, especially of the genus *Productus.* Of the succession of Chester limestones, none contains such a number of large, well-preserved crinoid stems standing out prominently on the weathered faces as the Beech Creek. This feature along with the hackly, cubical weathering gives it such distinguishing characteristics that it can be easily told from any of the other Chester limestones in the state. . . . In the "American Bottoms" region, there is an added thickness at the top. This added thickness consists of coarse, crinoidal ledges with a considerable admixture of sand and clay. These upper ledges weather a distinct yellow. . . . These upper yellow ledges contain a number of species of *Archimedes."*

Type section — Shaver et al. (1970, p. 10) stated, "The Beech Creek Limestone was named by Malott (1919, p. 11-15) for exposures along Beech Creek in Greene County [Indiana]. Later he (1952, p. 73-75) designated a type section at Ray's Cave in the NE¼ NW¼ sec. 13, T. 7 N., R. 4 W."

Reference section — Beech Creek strata are exposed in a small valley extending southwestward from the bank of the Mississippi River in northeastern Perry County, Missouri (fig. 103), beginning 0.75 mi southeast of Red Rock Landing, in the NW¼ NE¼ and SE¼ NE¼ sec. 13, T. 35 N., R. 12 E. (Crosstown 7½' Quadrangle).

Remarks — Shaver et al. (1970, p. 10) stated,

"The Beech Creek Limestone was considered by Malott (1931, p. 222; 1952, p. 15) to be equivalent to the upper part of the Paint Creek Formation in Illinois. The stated basis for this assignment was paleontologic affinity, but a prominent and widespread sandstone bed above each of these formations was also considered to be significant. Subsurface information, however, has demonstrated physical continuity of the Beech Creek Limestone (Barlow) into the lower part of the Golconda Formation in southwestern Illinois (Swann and Atherton, 1948), and the name Beech Creek has now been accepted as part of the Illinois standard section (Swann, 1963, fig. 20)."

In describing the Beech Creek Limestone in the Illinois basin, Swann (1963, p. 35) stated,

"The Beech Creek Limestone is a relatively thin but very persistent unit which is most useful in stratigraphic work and in structural mapping. It is generally darker colored than other limestone units with which it may be confused. It commonly has pellet or 'pseudo-oolitic' structure. It carries two somewhat unusual faunas, one of relatively large brachiopods (*'Productus inflatus'* Zone) that are common in the upper part, and the other of small snails, small clams, and foraminifera (a 'recurrent Salem' fauna) that are more abundant near the base."

The lower limestone in the Golconda Formation in northern Perry County, Missouri has been defined (Spreng, 1961, p. 75) as

". . . a dark gray to brown limestone 5 to 20 feet thick which contains an abundance of Foraminifera, small gastropods, and pelecypods."

This description is nearly identical to that of the Beech Creek in Illinois, including the pelecypod-gastropod-foraminifera fauna. For this reason, the lower limestone of the Golconda Formation in Missouri is now recognized as the **Beech Creek Limestone Member** of the Golconda Formation.

Fraileys Shale Member of Golconda Formation
McFarlan et al., 1955

Original description — (McFarlan et al., 1955, p. 21) "The Fraileys is typically 70 to 90 feet thick in southeastern Illinois, with extremes of about 45 to 140 feet. In nearly all of the Illinois Chester area the Fraileys consists largely of shale. Only at the southwestern edge of the Basin do limestones become important, and differentiation of the Fraileys from the Haney limestone here is not easy. The presence of much oolite in the Haney of the southwestern area then becomes of diagnostic importance."

Type section — Atherton et al. (1975, p. 156) stated,"The Fraileys Shale . . . is named for Fraileys Landing (abandoned), Hardin County [Illinois], about a mile northeast of the type section in a bluff along Haney Creek (NE NE SE 9, 12S-10E), where the formation is 94 feet thick. It is dominantly shale, with minor amounts of limestone and, locally, sandstone."

Remarks — The middle portion of the Golconda Formation in Missouri (Spreng, 1961, p. 75) corresponds in position to the Fraileys Shale in the Golconda Group of Illinois (Atherton et al., 1975, p. 156-157). As in Illinois, this shale in Missouri contains beds of "dark colored crinoidal limestone" (Spreng, 1961, p. 75) lithologically similar to the underlying Beech Creek limestone. In Illinois, Atherton et al. (1975, p. 157) identified the **Big Clifty Sandstone Member** of the Fraileys Shale, but this sandstone appears to be restricted to the southeastern part of Illinois, and does not extend westward into southwestern Illinois or southeastern Missouri. The Big Clifty Sandstone, originally incorrectly identified as the Cypress sandstone (Malott, 1919) is still recognized in Indiana between the Beech Creek Limestone and the overlying Golconda (= Haney Limestone Member) Limestone (Shaver et al., 1970).

About the fauna of the Fraileys, Atherton et al. (1975, p. 157) stated,

"The corkscrew-like axes of the bryozoan *Archimedes* reach a peak in number of species and abundance of specimens in the Fraileys and Haney Formations. A brachiopod faunal zone, the *"Camarophoria"-Stenoscisma explanata* Range Zone, extends from the Fraileys upward to the top of the Chesterian strata. The *Pterotocrinus capitalis* Range Zone is equivalent to the lower half of the Fraileys Shale."

The Fraileys Shale is the basal unit of the Hombergian Stage in the Illinois basin (Swann, 1963; Atherton et al., 1975, p. 156). The latter authors state that "The bryozoan *Prismopora serrulata* and the crinoid *Pterotocrinus* . . . are typical Hombergian fossils."

Haney Limestone Member of Golconda Formation

McFarlan et al., 1955

Original description — (McFarlan et al., 1955, p. 21) "The upper shale unit of the Haney reaches a maximum of 30 to 40 feet in thickness but occurs only as sporadic remnants beneath the pre-Hardinsburg unconformity. The main Haney limestone unit with minor shale interruptions is typically 40 to 50 feet thick, with extremes of 20 to 70 feet along the south-central border of the Illinois Basin. It thins slightly but retains its essential limestone character to the eastern and western outcrops. . . . Both oolite and silicified fossils occur in the Haney type section. The oolite increases westward . . ."

Type section — The type sections of the Fraileys and Haney members of the Golconda Formation are exposed at the same place. Atherton et al. (1975, p. 157) stated,"The Haney Limestone is . . . named for Haney Creek, Hardin County [Illinois]. It is 35.5 feet thick in the type section, which overlies the type section of the Fraileys Shale (NE NE SE 9, 12S-10E). It is dominantly limestone, with a little interbedded shale."

Reference section — Haney strata are exposed at the same section as the Beech Creek Limestone Member, described above (fig. 103).

Remarks — Swann (1963, p. 36) stated,

> "The Haney Limestone is a relatively massive limestone formation containing moderate amounts of shale. It ranges from about 80 feet thick at a few places along the southern outcrop belt to a few feet at its northern margin in the subsurface. It is largely fossiliferous, somewhat crinoidal limestone and contains much oolite, particularly along the western margin of the basin, and some chert, particularly at the eastern margin."

This description compares favorably with that of the upper limestone unit of the Golconda Formation in Missouri, which Spreng (1961, p. 76) described as "a very light gray, oolitic, cross-bedded limestone 50 feet thick." The upper limestone of the Golconda Formation in Missouri is therefore identified as the **Haney Limestone Member** of the Golconda Formation.

In Illinois the Hardinsburg Sandstone disconformably overlies the Golconda Formation, locally cutting through the entire Golconda and into the upper part of the Cypress Sandstone. However, in Missouri the Hardinsburg is poorly exposed, and the relationship with the underlying Golconda Formation is not clear.

Hardinsburg Formation

Brokaw, 1916; Butts, 1917

Original description — (Brokaw, 1916, pl. 1) Brokaw described the Hardinsburg as "Moderately fine-grained, yellowish-brown sandstone; small amount of shale; thickness 80-100 feet."

Butts (1917, p. 96) appears to have independently proposed the name, and stated, "The Hardinsburg is here introduced for the third persistent sandstone stratum from the bottom of the Chester group or the fourth if the Fredonia oolite with the Rosiclare sandstone are included in that group. The name is from Hardinsburg, Breckinridge County, Ky., which is located upon the sandstone. At Hardinsburg a thickness of about 30 feet is exposed. As the sandstone is the highest rock exposed and extends upward to the cover of soil, it is not known how much thicker it may have been originally. It is composed of shaly sandstone above, a coarse-grained massive bed about 10 feet thick in the middle, and 10 feet of somewhat thinner bedded rock below, resting upon limestone in the top of the Golconda formation. . . . The usual condition of the sandstone is thin-bedded and flaggy, rather fine-grained and hard, and somewhat argillaceous and ferruginous."

Type section — Swann (1963, p. 69) located the type section at ". . . exposures in the vicinity of Hardinsburg in 13 and 18-P-57, Hardinsburg Quad., Breckinridge Co., Ky."

History of nomenclature —

1857	Hall	Kaskaskia limestone (part)
1858	Swallow	Archimedes limestone (part)
1866	Worthen	Chester limestone (part)
1904	Ulrich	Tribune limestone (part)
1907	Buehler	Kaskaskia member of Chester group (part)
1910	Schuchert	Tribune member of Kaskaskia formation (part)
1914	Weller	Okaw limestone (middle part; in Illinois)
1916	**Brokaw**	**Hardinsburg sandstone (in Kentucky)**
(not) 1917	Ulrich	Hardinsburg sandstone (= Tar Springs Sandstone)
1928	Weller & St. Clair	Hardinsburg sandstone member of Golconda Formation
1934	Sutton	Hardinsburg Member of Lower Okaw Formation (in Illinois)
1940	Weller & Sutton	Hardinsburg ("absent in Missouri")
1944	Branson	(did not recognize in Missouri)
1948	Weller et al.	Hardinsburg sandstone ("not present in Missouri")
1961	Spreng	Hardinsburg formation ("shale in Missouri"; facies of sandstone in Illinois)
1963	Swann	Hardinsburg Sandstone of Okaw Group (Hombergian Stage)
1979	Thompson (a)	Hardinsburg Formation

Remarks — Spreng (1961, p. 76) first described the Hardinsburg Formation in Missouri:

"The Hardinburg formation consists of dark gray shale or plastic clay which contains quartzose sandstone streaks in the upper part. A thin coal streak has been noted to be present within the unit in one Missouri exposure. This shaly succession between the Glen Dean and the Golconda limestones apparently represents the westward extension of a more typical, thicker, sandy shale and sandstone of western Illinois. This shale has not been differentiated as Hardinsburg in older reports of the Missouri Geological Survey. Limited and poor exposures of the formation are present in east-central Perry County near the Mississippi River bluffs. Its thickness ranges between 13 and 20 feet but may reach 30 feet, a thickness which is comparable to that observed in wells across the river in Illinois."

Swann (1963, p. 37) described the Hardinsburg Sandstone in the Illinois basin:

"The Hardinsburg Sandstone is best developed at or just east of the central part of the basin, where it contains much sandstone and is typically 60 to 100 feet thick but reaches 200 feet in a few small areas. Both east and west of the area of maximum development it becomes much shalier, particularly to the west where in the Chester district it is represented at some places by 20 feet or less of shale with thin limestone and dolomite interbeds and a few or no sandstone layers. Several very thin coal beds are known, largely in the upper part of the formation in the central region. Red shale occurs most abundantly toward the eastern and western margins of the basin."

In Illinois (Atherton et al., 1975, p. 157-158), the Hardinsburg rests disconformably on the Golconda Formation, down-cutting into upper Cypress strata in some places. The facies of the Hardinsburg constitute a complex deltaic system originating in Indiana and Kentucky and extending westward into Illinois in an expanding distributary system. The westernmost sediments are shales and occasional coal and sandstone beds; sandstone increases eastward. Upper Hardinsburg deposition has cut through lower Hardinsburg, so that in some areas sandstones lie directly on Golconda strata.

The Hardinsburg Formation in Missouri, which represents the extreme western termination of the delta complex, comprises shales, with minor coal seams and sandstone stringers in the upper part. Collinson et al. (1971) assigned the Hardinsburg of the Illinois basin to the upper part of the *Gnathodus bilineatus-Cavusgnathus altus* Zone (conodonts), the lower part of which constitutes the Golconda Group (table 2).

Glen Dean Limestone

Butts, 1917

Original description — (Butts, 1917, p. 97) "The Glen Dean limestone is named from Glen Dean in the southern part of Breckinridge County, Ky. This name is adopted because of the excellent exposure of the limestone along the railroad on both sides of the Glen Dean.

"The Glen Dean is composed of varying proportions of limestone and shale and includes locally, at least, a little sandstone."

Type section — Swann (1963, p. 68) described the type section as ". . . cuts along abandoned tracks of the Louisville and Nashville Railroad on either side of the town of Glen Dean in the southern part of 3-N-36 Glen Dean Quad., Breckinridge Co., Ky."

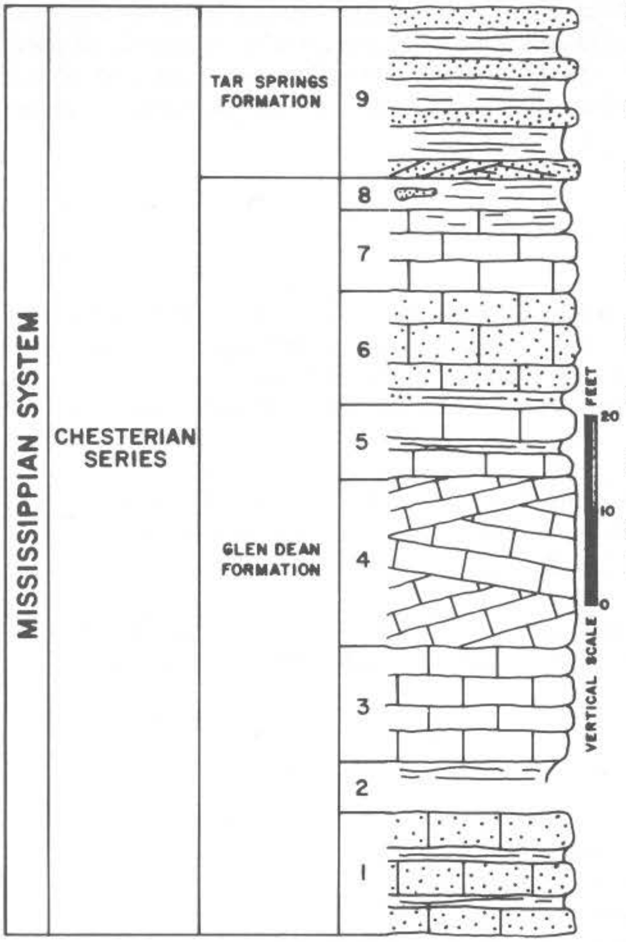
Reference section — Flint (1925, p. 132) located "an excellent exposure in the river bluffs in the SW¼ of sec. 18, T. 35 N., R. 13 E." This section (fig. 105) is in Perry County, Missouri, Crosstown 7½' Quadrangle.

History of nomenclature —

1857	Hall	Kaskaskia limestone (part)
1858	Swallow	Archimedes limestone (part)
1866	Worthen	Chester limestone (part)
1904	Ulrich	Tribune limestone (part)
1907	Buehler	Kaskaskia member of Chester group (part)
1910	Schuchert	Tribune member of Kaskaskia formation (part)
1914	Weller	Okaw limestone (upper part; in Illinois)
1916	Brokaw	Sloan Valley formation
1917	**Butts**	**Glen Dean limestone (in Kentucky)**
(not) 1917	Ulrich	Glen Dean limestone (= Vienna Limestone)
1925	Flint	Glen Dean limestone (unpublished; **first use in Missouri**)
1933	Keyes	Okaw limestone
1934	Sutton	Glen Dean Member of Lower Okaw formation (in Illinois)
1961	Spreng	Glen Dean formation
1963	Swann	Glen Dean Limestone of Okaw Group (Hombergian Stage)
1979	Thompson (a)	Glen Dean Limestone

Remarks — Spreng (1961, p. 76) wrote the following about the Glen Dean in Missouri:

"The Glen Dean formation consists of limestone and numerous interbedded layers of shale. The limestone is light gray and coarsely to finely crystalline or oolitic. Stratification is very irregular. The bedding planes undulate, and cross-bedding is common. The formation weathers buff to gray. Both the shale and limestone are fossiliferous. The large blastoid *Pentremites spicatus* is characteristic but not common, and the bryozoan *Prismopora serratula* is commonly present in the upper part of the formation. Brachiopods, horn corals, and crinoids also occur. The formation's contact with the underlying Hardinsburg appears to be conformable. Its outcrop belt is confined to a band along the Mississippi River bluff in east-central Perry County. The Glen Dean is 65 to 80 feet thick and contains numerous local disconformities."



9. Sandstone and shale, massive thin-bedded (top covered). Basal 1 ft sandstone bed very fine-grained, argillaceous, gray to buff, platy, cross-bedded. (54 ft)
8. Shale, plastic, blue, fissile, containing small lenses of cross-bedded sandstone. (3 ft)
7. Limestone, blue-gray, shaly, laminated, containing small phosphatic nodules upper 2 ft; gray, buff coarse-grained lower 7 ft. (9 ft)
6. Limestone, bluish, coarse grained, sandy; 1 ft of sandy shale at base. (11 ft)
5. Limestone, gray buff, coarse crystalline, massive; with interbedded shale. (7 ft)
4. Limestone, pinkish-gray, crystalline, strongly cross-bedded; with thin shales. (16 ft)
3. Limestone, lower 9 ft purplish, upper 3 ft bluish, dense, compact; forms ledge. (12 ft)
2. Covered interval, probably includes shale. (6 ft)
1. Limestone, dense, massive, sandy, with interbedded shale; base concealed. (13 ft)

Figure 105. *Columnar section of* **Glen Dean Formation** *exposed in the Mississippi River bluff, NE¼ SW¼ sec. 18, T. 35 N., R. 13 E., Perry County, southeastern Missouri, Crosstown 7½' Quadrangle. Description from unpublished manuscript of Flint (1925).*

This description is quite similar to that of Glen Dean strata in the Illinois basin. Atherton et al. (1975, p. 158) stated,

> "The bryozoan *Prismopora serrulata* is abundant and the blastoid *Pentremites spicatus* is also characteristic of the Glen Dean. The *Pterotocrinus acutus-P. bifurcatus* Assemblage Zone is equivalent to the Glen Dean."

Detailed descriptions of the conodont faunas of the Chesterian Series of the Illinois basin and definition of conodont assemblage zones for the Mississippian System in the Upper Mississippi Valley (Collinson et al., 1962; Collinson et al., 1971) identify the *Gnathodus bilineatus-Kladognathus mehli* Zone as confined to the Glen Dean Formation.

Tar Springs Sandstone

Owen, 1857

Original description — (Owen, 1857, p. 87) "The Tar Springs sandstone . . . is very nearly one hundred feet above low water of the Ohio river, at Cloverport. At this point the sandstone is about fifty-five feet in thickness, and the top of it one hundred and fifty feet approximately above low water on the Ohio river. This sandstone is remarkable in Breckinridge County on account of the five springs of petroleum which issue at its base, close to its junction with the Archimedes limestone."

Type section — Owen (1857, p. 87) described the Tar Springs from rocks located "... near where the railroad intersects the line of separation between Breckinridge and Hancock Counties ..." Tar Springs, NW¼ 13-P-35, Cloverport Quadrangle, Breckinridge County, Kentucky.

Reference section — Flint (1925, p. 139-140) located two sections where Tar Springs could be examined in Missouri, one in the SW¼ sec. 26, T. 35 N., R. 13 E., the other in the SE¼ sec. 18, T. 35 N., R. 13 E., Perry County (just southeast of fig. 105), Missouri, Crosstown 7½' Quadrangle.

History of nomenclature —

1856	Owen	Tar Springs sandstone
1857	**Owen**	**Tar Springs sandstone**
	Hall	Kaskaskia limestone (part)
1858	Swallow	Archimedes limestone (part)
1866	Worthen	Chester limestone (part)
1904	Ulrich	Tribune limestone (part)
1907	Buehler	Kaskaskia member of Chester group (part)
1910	Schuchert	Tribune member of Kaskaskia formation (part)
1914	Weller	Okaw formation (upper part; in Illinois)
1916	Brokaw	Tar Springs sandstone (first use in Illinois)
1917	Ulrich	Hardinsburg sandstone
1925	Flint	Tar Springs sandstone (unpublished; **first use in Missouri**)
1934	Sutton	Tar Springs Member of Upper Okaw formation (in Illinois)
1939	McQueen	Tar Springs sandstone (**first published reference to Missouri**)
	Weller	Tar Springs sandstone (Perry County, Missouri)
1961	Spreng	Tar Springs formation
1963	Swann	Tar Springs Sandstone (base of Elviran Stage)
1979	Thompson (a)	Tar Springs Sandstone

Remarks — Swann (1963, p. 37) stated that the Tar Springs Sandstone is one of the more important clastic units in the Illinois basin and possesses recoverable oil in some regions. It lies disconformably on the Glen Dean Formation in many places, but on the eastern and western edges of the basin appears to be conformable on, and even gradational with, the Glen Dean. The overlying Vienna Limestone is conformable on the Tar Springs in much of the basin but is missing in the northern reaches of Chester distribution, where the Waltersburg Formation lies on Tar Springs.

In Illinois the Tar Springs may be all sandstone or shale; where it is thickest (150 ft) the ratio of sandstone to shale is relatively high (Atherton et al., 1975, p. 158). The Tar Springs is a deltaic deposit, and thus, can vary considerably in lithology in a very short distance.

About Missouri (Spreng, 1961, p. 76) stated,

"The Tar Springs formation consists chiefly of sandstone and contains shale and shaly sandstone near the middle of the unit. It is buff to rust-brown and red in color, is dominantly fine grained, even textured, and friable except it is locally an orthoquartzite. The formation is generally thin bedded but is thicker bedded at the top and bottom. Asymmetrical ripple marks and tabular cross-bedding are persistently well developed, especially in the thinner beds. The thicker beds weather to slabs and blocks. Fossils are not abundant and usually consist of plant remains such as ferns, twigs, and pieces of bark from scale trees. The Tar Springs is about 90 feet thick in Missouri."

The contact with the overlying Vienna Limestone in Missouri is usually not exposed and its nature not known. The Tar Springs appears to be more lithologically consistent in Missouri, being principally sandstone, and the small region of exposure may represent a channel within the delta system.

Vienna Limestone

Weller, 1920

Original description — (Weller, 1920, p. 396) "The Vienna limestone is named from Vienna, Johnson County, Illinois, where the formation is exposed in some of the streets of the town, and in an old quarry just west of the town. As it is commonly exposed, the Vienna exhibits two rather distinct facies, an exceedingly siliceous limestone in the lower portion of the formation, and a shale member above.... As already stated the limestone is remarkably siliceous. The silica is in part in the form of chert layers, and in part is finely disseminated through the limestone. . . The chert of the formation is quite persistent in character, the beds commonly being from one to four inches thick and quite regular. . . . As the limestone with the chert layers is removed by weathering, the cherts fracture into subcubical masses with two light-colored surfaces, and occur in abundance in the residuum. . . . The peculiar character of the weathered products of the Vienna limestone make it about the easiest to recognize of any of the limestone formations of the whole Chester series. The shales of the Vienna are black, fissile, and non-calcareous."

Type section — Swann (1963, p. 84-85) stated that the Vienna Limestone was "Named by S. Weller (1920a) for exposures in and around Vienna, the particular outcrop generally cited being 14 feet of limestone in a small roadside quarry west of Vienna on the south side of Illinois Highway 146 0.9 mile west of its junction with U.S. 45, NE¼ SW¼ NW¼ sec. 5, T. 13 S., R. 3 E., Vienna Quad., Johnson Co., Ill."

Reference section — Flint (1925, p. 138) located two exposures of Vienna Limestone and Tar Springs Sandstone "(1) the NE¼ of sec. 35, T. 35 N., R. 13 E., and (2) the E½ of sec. 36, in the same township" (Perry County, Missouri, Crosstown 7½' Quadrangle).

History of nomenclature —

1857	Hall	Kaskaskia limestone (part)
1858	Swallow	Archimedes limestone (part)
1866	Worthen	Chester limestone (part)
1904	Ulrich	Birdsville formation (lower part)
1907	Buehler	Birdsville member of Chester group (lower part)
1910	Schuchert	Birdsville member of Kaskaskia formation (part)
1917	Ulrich	Glen Dean limestone
1920	**Weller**	**Vienna limestone**
1925	Flint	Vienna limestone (unpublished; **first use in Missouri**)
1934	Sutton	Vienna Member of Upper Okaw formation (in Illinois)
1939	Weller	Vienna limestone (**first published reference to Missouri**)
1944	Branson	(did not recognize in Missouri)
1948	Weller et al.	Vienna formation
1961	Spreng	Vienna formation
1979	Thompson (a)	Vienna Limestone

Remarks — Atherton et al. (1975, p. 159) described the Vienna Limestone of the Illinois basin as containing "chocolate-brown chert nodules in the outcrop," and described the fauna as containing "the bryozoan *Prismopora serrulata,* which is also abundant in the Glen Dean, and the pelecypod *Sulcatopinna missouriensis,* which is abundant in the Menard."

In Illinois, the Vienna is rarely more than 8 ft thick, often only 3 to 4 ft, and is basically a dark-brownish-gray to brown or dark-gray, fossiliferous limestone. Shale beds are common and some limestone beds are sandy. In Missouri (Flint, 1925, p. 142) stated,

"The [Vienna] formation appears only as a loose cherty residual material capping two high points on the Owl Creek-Mississippi divide. The chert consists of both original material and spongy, silicious [sic], highly-weathered [sic] limestone. It occurs in small blocky and sub-cubical fragments colored white, mottled gray, and bluish. No fossil remains save a few crinoid stems have been found in any of the material. The present thickness of the formation cannot be greater than 30 feet in the larger of the two exposures. Since the Vienna limestone occurring in places across the river in the Alto Pass Quadrangle is only 20 to 30 feet thick, probably no remnant of the overlying Menard formation occurs in the Missouri section; although if present here, it could not be separated from the Vienna, in its present weathered state. The contact with the Tar Springs sandstone is concealed."

Spreng (1961, p. 76-77) added,

"The Vienna formation is present on only a few hilltops along the Mississippi River bluffs in east-central Perry County. Here, the formation is principally represented by loose, residual fragments of dark colored chert and spongy, siliceous, highly weathered limestone. Chert is more conspicuous than in the older Chesterian formations, but fresh exposures of the formation on the Illinois side of the Mississippi River indicate that the chert is not as abundant in the limestone as the residuum would indicate. The formation's thickness of 10 to 15 feet is comparable to its thickness across the river in Illinois where it is more complete. There is no indication of any younger Chesterian units such as the Waltersburg sandstone or the more persistent Menard limestone above this formation. Its contact with the underlying Tar Springs formation is concealed."

Conodont studies of Chesterian strata in the Illinois basin (Collinson et al., 1971) defined the Vienna Limestone, along with the underlying Tar Springs and overlying Waltersburg formations (table 2) to be within the *Kladognathus primus* Zone.

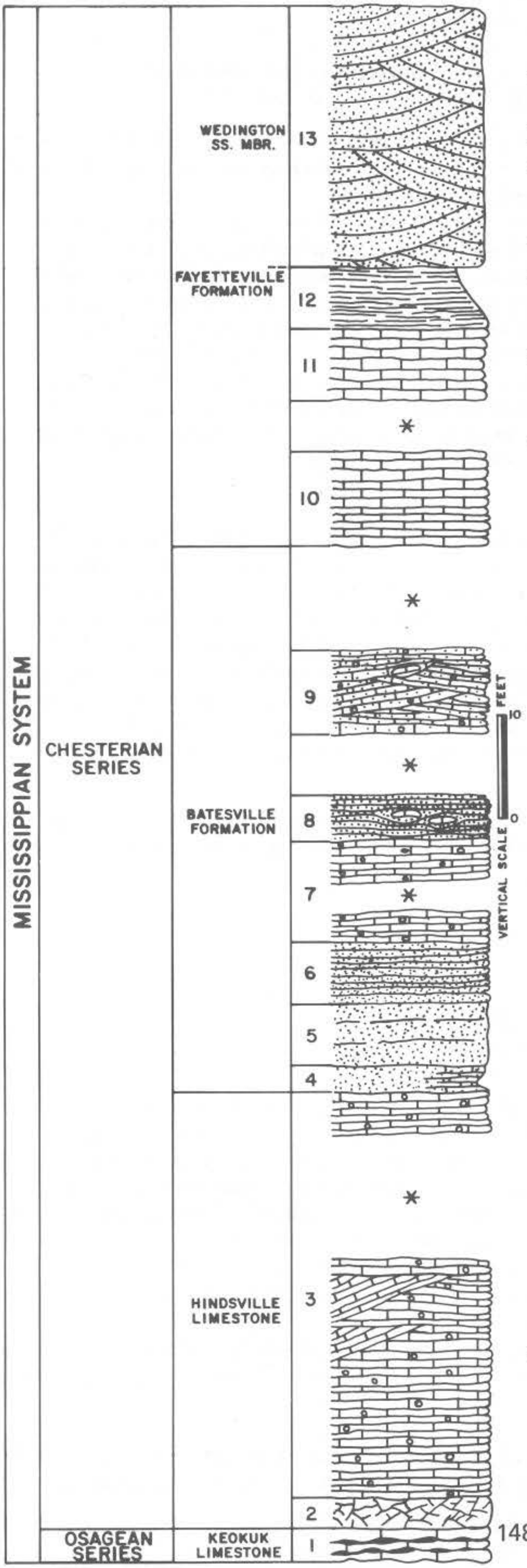
Hindsville Limestone

Purdue and Miser, 1916

Original description — (Purdue and Miser, 1916, p. 12) "The Hindsville member consists mainly of limestone interbedded with some sandstone. The limestone is dark gray on fresh surfaces, but on weathering it becomes lighter. . . . In most places it occurs in rather heavy layers and is coarsely crystalline, compact, and of homogeneous texture. . . . In places it contains fossils in abundance and in others it is oolitic to pisolitic. . . . Parts of the limestone are cross-bedded. . . . A bed of conglomerate a few feet thick commonly occurs at the base of the member. . . . The sandstone forms thin layers and platy beds, some of them 3 to 4 feet thick. It is soft, yellow to brown, porous, and fine grained, and before weathering is calcareous, thus resembling the sandstone of the Batesville."

Type section — The Hindsville Limestone was named from exposures near the town of Hindsville, Madison County, Arkansas. The exposure nearest the town is on the north end of Keefer Mountain, NW¼ NW¼ sec. 22, T. 17 N., R. 27 W. (Hindsville 7½' Quadrangle).

Reference section — An excellent exposure of Hindsville Limestone in Missouri is on Oakleigh Mountain (fig. 106), in the NW¼ NE¼ sec. 7, T. 21 N., R. 28 W., Barry County, southwestern



13. Sandstone, brown, cross-bedded; numerous plant fossils. (25 ft)
12. Shale, black, platy; mostly slump. (6 ft+)
11. Limestone, dark-gray to black, very finely crystalline, medium (6 in.-1 ft) beds; large white fossils (productid brachiopods). (7 ft)

Covered interval. (5 ft)

10. Limestone, gray to dark-gray, medium to coarsely crystalline, in even 4-8 in. beds; upper 3 ft finely crystalline; very fossiliferous. (9 ft)

Covered interval. (10 ft)

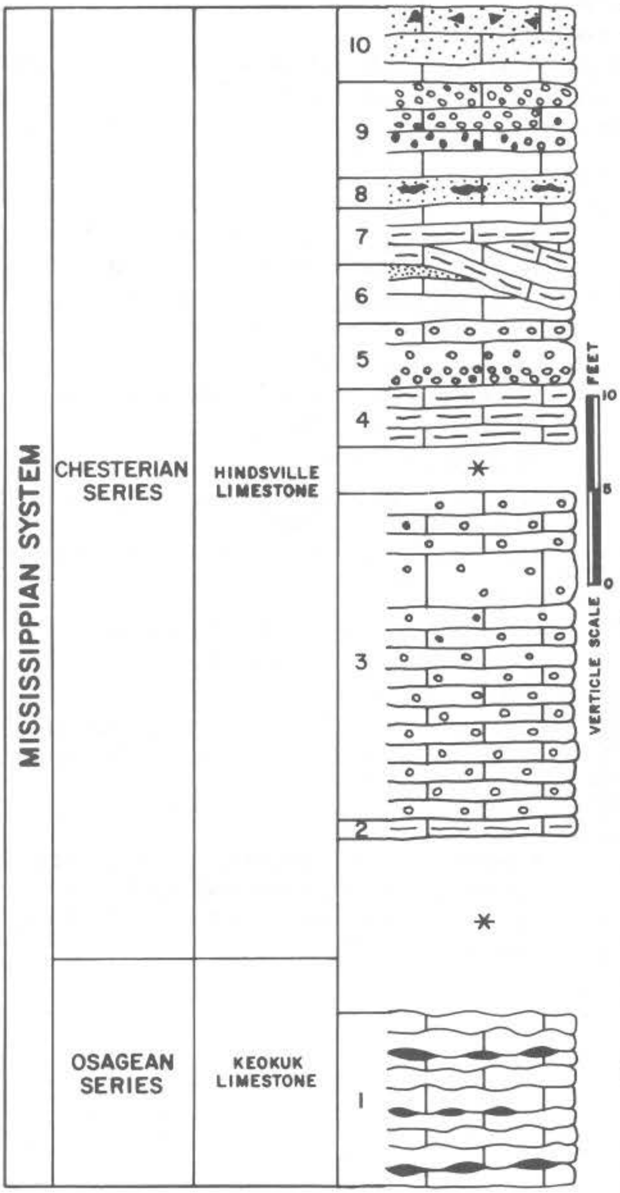
9. Limestone, sandy, oolitic, cross-bedded; coarsely crinoidal lenses. (8 ft)

Covered interval. (6 ft)

8. Sandstone, brown, black at base, in part calcareous; friable at top; contains lenses of coarsely crinoidal limestone. (4 ft)
7. Limestone, light-gray, medium-crystalline, sandy, oolitic; in thin, slabby beds; very coarsely crinoidal lenses in top 4 ft; middle 3 ft covered. (10 ft)
6. Sandstone, brown, dark-gray to light-gray, calcareous; in thin, slabby beds. (6 ft)
5. Sandstone, brown, thick-bedded, mostly covered. (6 ft)
4. Siltstone, green, calcareous, slabby, hard. (2 ft 6 in.)
3. Limestone, light-gray, finely to medium-crystalline, oolitic, fossiliferous; middle 9 ft thick to slabby bedded and cross-bedded; upper and lower part in thin, slabby beds; 12 ft covered interval 4 ft below top. (30 ft)
2. Limestone breccia, finely to medium-crystalline; light gray matrix; coarse 1-3 in. chert fragments included. (3 ft)
1. Limestone, dark gray, medium-crystalline; thick beds. (10 ft+)

Figure 106. *Columnar section of an exposure of the* **Hindsville Limestone, Batesville Formation,** *and* **Fayetteville Formation,** *on the southwest side of Oakleigh Mountain, NW¼ NE¼ sec. 7, T. 21 N., R. 28 W., Seligman and Jacket 7½' Quadrangles, Barry County, southwestern Missouri. Adapted from Thompson (1972, (fig. 1).*

Missouri, Seligman and Jacket 7½′ Quadrangles. Two other notable exposures include an abandoned quarry 100 yds east of Missouri Highway 37, immediately south of the town of Washburn (fig. 107), Barry County, Missouri, NE¼ SE¼ sec. 33, T. 22 N., R. 28 W., Seligman 7½′ Quadrangle, and a roadcut on Missouri Highway 90 just west of the town of Washburn (fig. 108), near the north end of Oakleigh Mountain, center north line sec. 32, T. 22 N., R. 28 W., Barry County, southwestern Missouri. These sections were illustrated by Thompson (1972, p. 4).



10. Limestone, gray to brownish-gray, finely to medium-crystalline, oolitic, fossiliferous; angular chert shards. (3 ft)

9. Limestone, light-gray, finely crystalline, dense, stylolitic; upper ¾ oolitic. (6 ft)

8. Limestone, gray, finely crystalline, sandy, laminated; includes chert in top half. Chert, brown and light blue, replacing limestone. Single bed. (1 ft 6 in.)

7. Limestone, greenish-gray, finely crystalline, very argillaceous, cross-bedded; alternating argillaceous and pure limestone beds; truncates units 5 and 6; base uneven, wavy. (2-4 ft)

6. Limestone, greenish-gray; lower 2 ft medium crystalline, upper 2 ft very finely crystalline; upper 2/3 truncated by unit 7; upper 1 ft sandy. (2-4 ft)

5. Limestone, light-gray, very oolitic; single bed; bottom half more oolitic than top. (2 ft 6 in.)

4. Limestone, greenish-gray, finely crystalline, very argillaceous; 2 in. shale seam at top. (3 ft)

Covered interval. (2 ft 6 in.)

3. Limestone, gray; finely crystalline with medium-crystalline lenses; sparsely oolitic; fossiliferous zones and beds; very coarsely crystalline 6 ft below top; thick (1 ft) beds; no chert. (17 ft)

2. Limestone, light-bluish-gray, argillaceous, very finely crystalline; single bed. (1 ft)

Covered interval. (8 ft 6 in.)

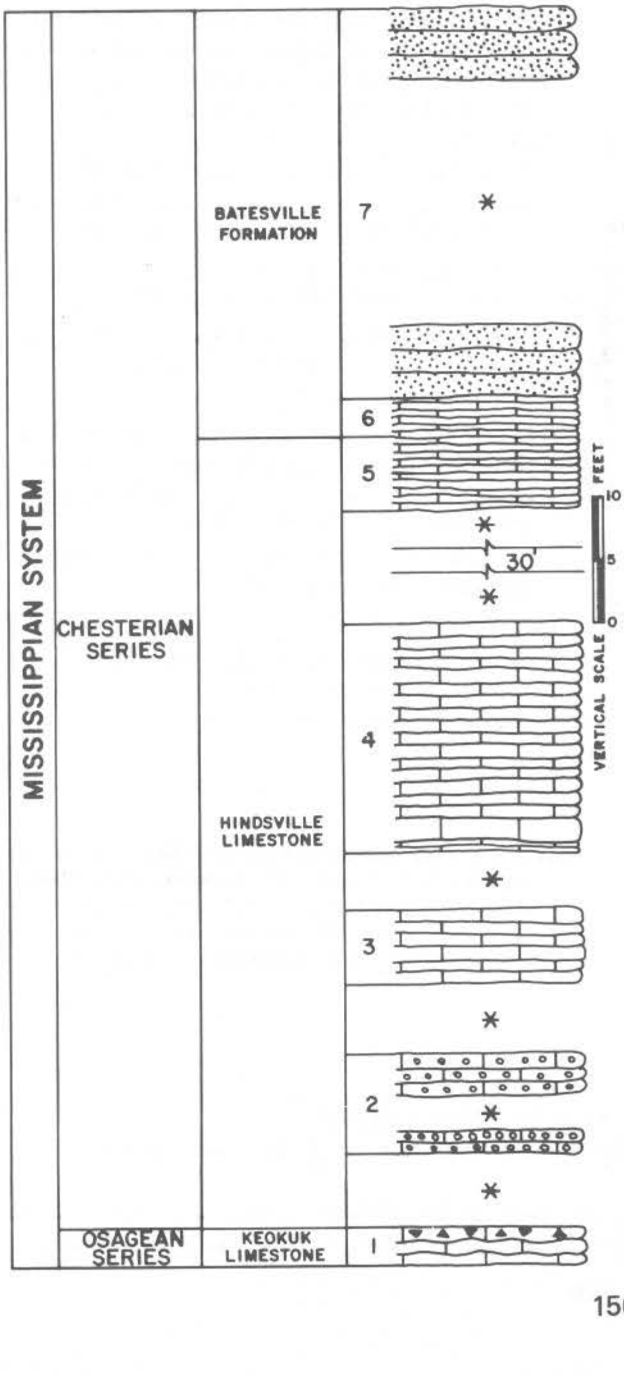
1. Limestone, light-gray, medium-crystalline, dense, thick-bedded (1 ft); chert (15%), brown, tripolitic; nodular 6 in. beds every 2-3 ft. (9 ft+)

Figure 107. *Columnar section of* **Hindsville Limestone** *in a small quarry ½ mi south of Washburn, 100 yd east of Highway 37, NE¼ SE¼ sec. 33, T. 22 N., R. 28 W., Seligman 7½′ Quadrangle, Barry County, southwestern Missouri. Adapted from Thompson (1972, fig. 1).*

History of nomenclature —

1907	Smith & Siebenthal	Carterville formation (some sections)
1916	**Purdue & Miser**	**Hindsville limestone member of Batesville sandstone (in Arkansas)**
1930	Croneis	Hindsville limestone member of Batesville sandstone
1941	Clark	Hindsville formation (unpublished; **first use in Missouri**)

1944	Branson (a)	Hindsville limestone **(first published reference to Missouri)**
1948	Weller et al.	Hindsville limestone member of Carterville formation
1952	Beveridge & Clark	Hindsville limestone
1961	Spreng	Hindsville formation
		Carterville formation (some sections)
1967	Garner	Batesville formation (lower part)
1968	Ogren	Limestone facies of Batesville Sandstone
1972	Thompson	Hindsville Limestone
		Carterville (Hindsville) Formation (regarded some Carterville exposures to be isolated remnants of Hindsville Limestone)
1979	Thompson (a)	Hindsville Limestone



7. Sandstone, brown to dark-gray, soft to hard, friable; middle 20 ft covered. (32 ft+)
6. Limestone, gray, medium-crystalline, very sandy; thin slabby beds; no oolites. (3 ft)
5. Limestone, gray, medium-crystalline, oolitic, sandy; thin, slabby beds, to even 6 in. beds; sand percentage increases upward. (6 ft)

Covered interval. (40 ft)

4. Limestone, gray to grayish-green, coarsely crystalline, medium-crystalline toward top; lower 6 in. argillaceous and slabby, more massive beds above. (18 ft)

Covered interval. (5 ft)

3. Limestone, medium- to coarsely crystalline, semicrinoidal; beds 6 in. to 1 ft thick. (3 ft)

Covered interval. (6 ft)

2. Limestone, gray, medium-crystalline, oolitic, fossiliferous; lower 2 ft in road ditch; middle 3 ft covered. (8 ft)

Covered interval. (6 ft)

1. Limestone, dark-brownish-gray, conglomeratic, medium-crystalline; angular and rounded white to brown chert fragments throughout; large productid brachiopods. (1 ft+)

Figure 108. *Columnar section of exposure of the* **Hindsville Limestone** *and* **Batesville Formation**, *in a roadcut on Missouri Highway 90, 1 mi west of Washburn, center north line sec. 32, T. 22 N., R. 38 W., Seligman 7½' Quadrangle, Barry County, southwestern Missouri. Adapted from Thompson (1972, fig. 1).*

Remarks — The Hindsville Limestone, named from exposures in northern Arkansas, is lithologically and chronologically associated with the Batesville Sandstone. Garner (1967) regarded the Hindsville as reef and biostromal carbonates and inter-reef limestones in an area dominated by Batesville shale and sandstone. Ogren (1968) stated that the strata were arbitrarily designated "Hindsville," where they were over 50 percent limestone, and "Batesville," where over 50 percent sandstone. He believed that the Hindsville was a northern and western equivalent (shelf facies) of the Batesville Sandstone to the south.

Thompson (1972, p. 9) described the Hindsville Limestone of southwestern Missouri in detail, and stated,

> "The Hindsville in southwestern Missouri consists of medium- to finely-crystalline limestone, generally oolitic and arenaceous, and commonly cross-stratified. The top . . . contains angular chert fragments and the base . . . is conglomeratic. Glauconite is common, and residues usually contain some sand-sized euhedral quartz. The Hindsville appears to be variable in thickness within the area of exposures in Barry County. In some places the [overlying] Batesville rests directly on the [underlying] Keokuk Limestone. The Hindsville rests on Osagean (Boone) strata (Keokuk Limestone in Missouri) over most of its extent. In parts of northeastern Oklahoma the Hindsville rests on Moorefield strata of late Meramecian or early Chesterian age."

In southwestern Missouri, the Hindsville Limestone, 0 to 50 ft thick, rests disconformably on the Late Osagean Keokuk Limestone. Only a thin conglomerate containing fish teeth marks the base of the Hindsville, but as the Keokuk and Hindsville are lithologically similar, this contact is not always easy to find. Regionally, the Hindsville appears to be transitional with the overlying Batesville Formation; limestone and fine-grained Batesville sandstone interfinger across this zone. Because of the transitional nature of the Hindsville-Batesville contact, the Hindsville has been considered the basal member of the Batesville in Arkansas, where both units were originally named and are more completely developed.

Hindsville strata are known to outcrop in a very small region in extreme southern Barry County, in southwestern Missouri, (fig. 109), where Chesterian units, remnants of formerly more extensive deposits, have been preserved on the down-dropped side of a fault block. Keokuk and Hindsville are in horizontal contact across the fault plane on the western edge of this block.

Spreng (1961, p. 77) noted,

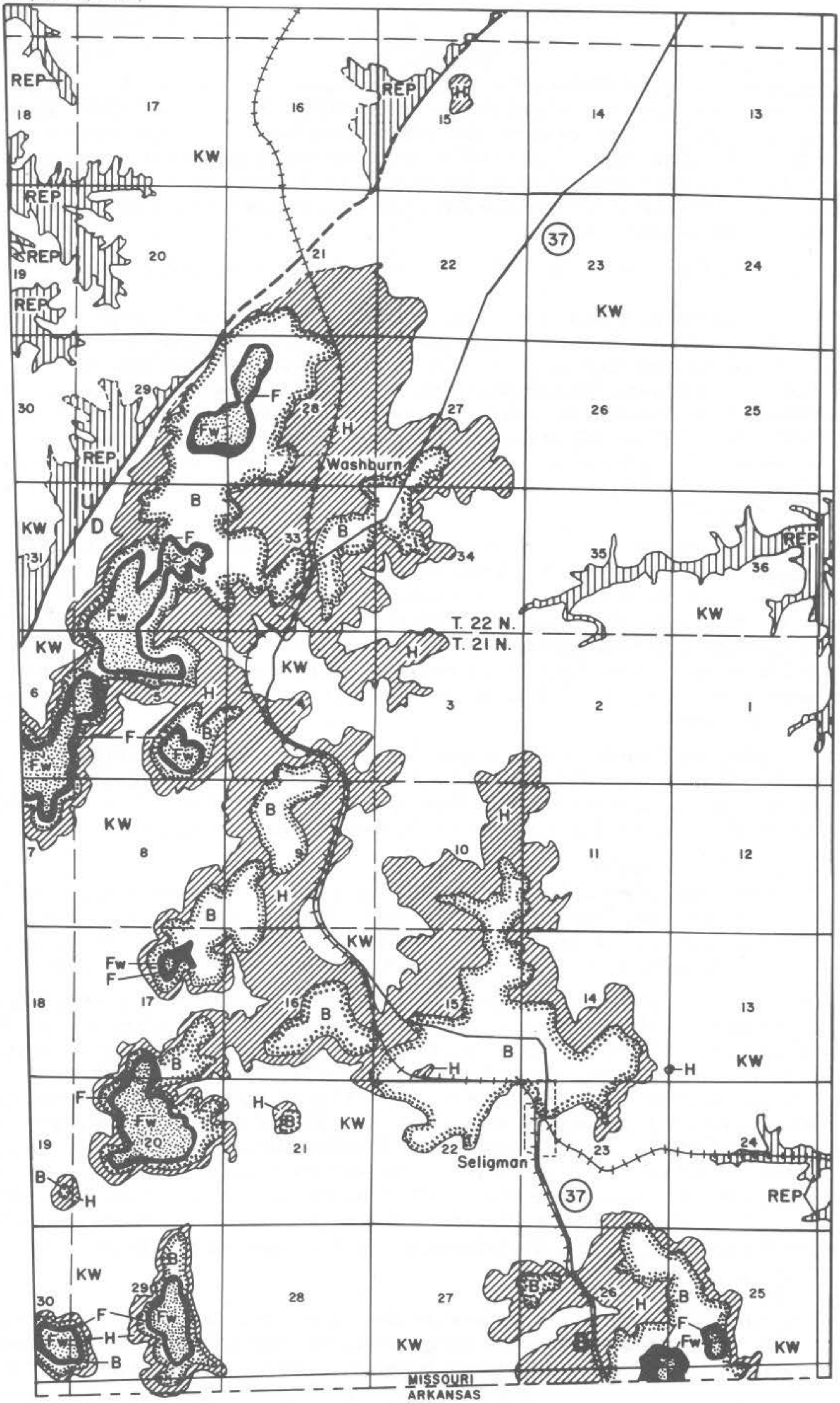
> "The Hindsville is the most fossiliferous of the three Chesterian formations in the southwestern part of the state. The fauna shows some similarities to the fauna of the Ste. Genevieve formation (Meramecian), but it is also very similar to the Chesterian fauna of the overlying formations. The formation has generally been regarded as lower Chesterian in age."

Weller et al. (1948) correlated the southwestern Missouri Hindsville sequence with the Renault and Bethel Formations of the Illinois basin, but Wright (1952) determined that the brachiopod fauna of the Hindsville was like that of the type Ste. Genevieve Formation. A detailed conodont study of Hindsville Limestone in southwestern Missouri (Thompson, 1972, p. 31) indicated that

> ". . . the faunas of Chesterian strata of southwestern Missouri are more closely related to the southern conodont province [Oklahoma, Texas, New Mexico] than the Illinois basin. The fauna of the Hindsville Limestone, containing *S.* [*Spathognathodus*] *muricatus*, is unlike any from the Illinois basin, but is similar to that recovered from western Kansas [subsurface, considered by Thompson and Goebel, 1969, to be correlative with the Ste. Genevieve Formation]. . . . although relatively close to the southeastern Missouri-southern Illinois type region, the strata of the southwestern Missouri Chesterian sequence are difficult to correlate with the type region."

On page 25, Thompson stated,

> "The Hindsville Limestone of southwestern Missouri appears to correlate with the lower part of the *G.* [*Gnathodus*] *bilineatus-Cavusgnathus altus* Zone of the southern Illinois type Chesterian. . . . However, the Hindsville conodont fauna is more representative of the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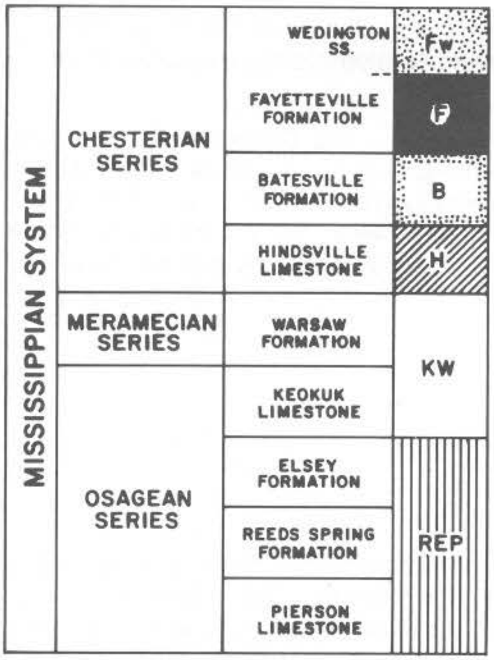

Figure 109. *Map of southern part of southwestern Missouri showing area of outcrop of Chesterian rocks. Adapted from unpublished geologic map of the Cassville 15' Quadrangle by E.L. Clark (1941).*

southern conodont province. On this basis, the Hindsville Limestone correlates with the lower part of the Barnett Shale of Texas and probably with the Golconda Group of the type region in southern Illinois. Furnish and Saunders (1971, p. 5), on the basis of ammonoids, correlate the Hindsville-Batesville with the Beech Creek Limestone."

Although Thompson (1972) correlated the Hindsville with Chesterian strata in Illinois, there are similarities of the Hindsville conodont fauna to that from the Ste. Genevieve Limestone, and the Hindsville conodont fauna is similar to that described from the "Pella beds" in Iowa (Rexroad and Furnish, 1964), which are considered a correlative of the Ste. Genevieve.

Smith and Siebenthal (1907) named the **Carterville Formation** from exposures just west of Carterville, Jasper County, Missouri (Webb City 7½' Quadrangle). Of this they said (p. 5),

"The Carterville formation occurs in isolated patches and has a most heterogeneous character. It consists of shaly, lumpy, somewhat conglomeratic, and usually oolitic limestones, calcareous shale, light to dark argillaceous shale, and arenaceous shale and shaly sandstone, massive indurated sandstone, massive hard sandstone, and quartzite; in short the whole category of sedimentary rocks, with the exception of chert and quartz conglomerate.

Spreng (1961, p. 77) added,

"Although the characteristics of the Carterville formation are known mostly from prospecting shafts and drill holes, there are a few isolated surface exposures in and around the Joplin area where the formation can be observed directly. Much of the formation is composed of clay and conglomerate and contains oolitic limestone "lumps" or boulders several feet in diameter that are embedded in a shale matrix. The formation also contains sandstone which is in part quartzite or argillaceous, and parts of it contain dark gray to black fissile shale.

"The more calcareous parts of the unit are fossiliferous and contain Chesterian fossils such as the brachiopod *Spirifer increbescens*, productids, Bryozoa (chiefly fenestellids including the genus *Archimedes*), and a few corals, trilobites, and fish teeth.

"The formation is very variable in thickness and is believed to be made up of local sink-filled deposits in older Mississippian rocks. It is present only in Jasper, Lawrence, and Newton Counties and is reported to be over 200 feet thick in some of the sinks. The three Chesterian formations, the Hindsville, Batesville, and Fayetteville, which are situated farther to the south are regarded as being the more normally and continuously developed parent succession of the Carterville formation."

Thompson (1972, p. 29-30) agreed with Spreng's contention that the Carterville Formation at most localities is a northern, isolated remnant of the Hindsville-Batesville sequence to the south. A few localities in the immediate Joplin area may represent collapse breccias that also include blocks of Warsaw limestone. South and east of the Joplin region, however, Carterville strata can be equated with Hindsville and Batesville limestones and fine sandstones, and can be correlated faunally with these units.

Batesville Formation

Penrose, 1891

Original description — (Penrose, 1891, p. 139) "Overlying the Fayetteville shale, is a sandstone formation with lenticular beds of gray, black or brown shale. This formation lies on both sides of the White River, reaching to the area of the Fayetteville shale and the chert hills on the north, . . . It is well developed at the town of Batesville and has been named by the State Geologist, the Batesville sandstone. It consists of brown or buff colored, fine grained sandstone, generally soft, though sometimes hard. . . . The shales in the sandstone occur as lenticular deposits, often ending very abruptly, though sometimes traceable for several miles. They and the sandstones appear, in many places, to be mutually replaceable."

Type section — The Batesville Formation was named from exposures near Batesville, Arkansas. Williams (1900) designated a section 1.5 mi southeast of Batesville as the type (Jamestown 7½' Quadrangle).

Reference section — Batesville strata are well exposed in an outcrop on the southern flanks of Oakleigh Mountain (fig. 106), in the NW¼ NE¼ sec. 7, T. 21 N., R. 28 W., Barry County, southwestern Missouri, Seligman and Jacket 7½' Quadrangle. A roadcut exposure of the Batesville Formation in Missouri is on Missouri Highway 90, immediately west of the town of Washburn (fig. 108), in Barry County, center north line sec. 32, T. 22 N., R. 28 W., Seligman 7½' Quadrangle, where both Batesville and Hindsville strata are present. This section was described by Thompson (1972, p. 4).

History of nomenclature —

1891	**Penrose**	**Batesville formation**
(not) 1891	Simonds	Batesville formation (= Wedington Sandstone Member of Fayetteville Formation)
1930	Croneis	Batesville sandstone (part, included Hindsville Limestone)
1941	Clark	Batesville formation (unpublished; **first use in Missouri)**
1944	Branson (a)	Batesville formation
1948	Weller et al.	Batesville sandstone member of Carterville formation
1961	Spreng	Batesville formation
1972	Thompson	Batesville Formation

Remarks — Simonds (1891) and Penrose (1891) both proposed the name "Batesville" for different stratigraphic sequences. Adams and Ulrich (1904) redefined Simond's "Batesville," a sandstone within the Fayetteville Formation, and renamed it the **Wedington Sandstone Member.** Thompson (1972, p. 10) stated, "The Batesville appears to become progressively more calcareous, containing more limestone beds and lenses, westward from the type area, the Hindsville Limestone (or Limestone Member) recognized as a facies of the lower part in the western part of its extent. Only the Hindsville is present in some areas of western Arkansas and eastern Oklahoma."

As described by Spreng (1961, p. 78), the Batesville Formation in Missouri

". . . is a yellowish-brown, finely crystalline, calcareous sandstone which contains discontinuous, thin beds of gray, medium crystalline, oolitic limestone. The beds in the formation are evenly stratified, but at some localities the sandstone is ripple marked and cross bedded. The fauna is composed chiefly of brachiopods and pelecypods.

"The contact between the underlying Hindsville and the Batesville is one of transition. Locally, where the Hindsville is absent, the Batesville lies unconformably on the Keokuk (Osagean). The formation is regarded as equivalent in age to the lower Chesterian Series of the type area, and is 35 to 50 feet thick in Missouri."

Several studies of Batesville faunas have correlated it with the Ste. Genevieve-Aux Vases sequence in eastern Missouri (Weller, 1898; Ulrich, 1905; Girty, 1915a). Croneis (1930) correlated the Batesville with the Ste. Genevieve-Paint Creek sequence; Wright (1952), with the Aux Vases-Cypress sequence; and Weller et al. (1948), only with the Paint Creek. As indicated above, in the description of the Hindsville Limestone, Furnish and Saunders (1971) correlated the Hindsville-Batesville with the Beech Creek Limestone of the Golconda Group.

As in the Hindsville, conflicting elements in the conodont faunas (Thompson, 1972) complicate correlations with the type Chesterian strata. Characteristics of Golconda *and* Ste. Genevieve faunas are present, and either correlation is possible.

Fayetteville Formation

Simonds, 1891

Original description — (Simonds, 1891, p. 42) "In Washington County the Fayetteville shale is the principal formation lying between the Boone chert and the archimedes limestone. It receives its name from its occurrence in the valleys about Fayetteville, especially those of the West Fork of the White River and its tributaries. While the prevailing color of the Fayetteville is black, as in most instances where it has been recently exposed, it may be of a bluish or evey a yellowish brown color."

Type section — The type section of the Fayetteville Formation comprises exposures in or near Fayetteville, Washington County, Arkansas.

Reference section — The exposure on Oakleigh Mountain, NW¼ NE¼ sec. 7, T. 21 N., R. 28 W., Barry County (Seligman 7½′ Quadrangle) is representative of the Fayetteville Formation in Missouri (fig. 106). This section has been described by Clark and Beveridge (1952) and Thompson (1972).

History of nomenclature —

1891	**Simonds**	**Fayetteville formation**
(not) 1891	Penrose	Fayetteville shale (= Moorefield Formation)
1930	Croneis	Fayetteville shale
1941	Clark	Fayetteville formation (unpublished; **first use in Missouri**)
1944	Branson (a)	Fayetteville formation
1948	Weller et al.	Fayetteville shale member of Carterville formation
1961	Spreng	Fayetteville formation
1972	Thompson	Fayetteville Formation

<u>Remarks</u> — In Arkansas, the Fayetteville, predominantly a black, fissile, calcareous shale, is up to 350 ft thick. In the eastern part of its outcrop region, a sublithographic black limestone in the upper part of the Fayetteville is regarded by Quinn (1966) to represent the central portion of a massive reef complex. Thompson (1972, p. 11) stated,

> "A sandstone member (Wedington) is recognized in the middle of the formation around the type area of the Fayetteville in Washington County, Arkansas, separating two thick shale units. That part of the Fayetteville exposed in Missouri was considered by Spreng (1961) to represent only the lower part of the Arkansas section."

Spreng (1961, p. 78) stated,

> "The Fayetteville formation is composed predominantly of black, fissile, carbonaceous shale which is interbedded with dark gray to black, ferruginous limestone. It occurs only in southwestern Missouri near the Arkansas border and forms the slopes of such hills as Oakleigh, Reed, and Lennox Mountains. Brachiopods and ostracodes are the most abundant faunal constituents of the formation."
>
> "In southwestern Missouri, the Fayetteville is conformable with the underlying Batesville formation. The total thickness of beds identified as Fayetteville in Missouri is about 20 feet, and the formation has been correlated with the Golconda, Hardinsburg, and Glen Dean formations of southeastern Missouri."

The shale of the Fayetteville Formation in southwestern Missouri is overlain by a massive, cross-stratified, nonmarine sandstone that forms a resistant cap on the hills of the region. This sandstone, previously identified as the Lower Pennsylvanian (Morrowan Series) Hale Sandstone (Searight and Howe, 1961, p. 79), is now identified as the Upper Mississippian (Chesterian) **Wedington Sandstone Member of the Fayetteville Formation.** Fossils collected from this sandstone at Oakleigh Mountain (fig. 110), have been identified as representing *Lepidodendron wedingtonense* White, a form considered by Lacey and Eggert (1964) to be a junior synonym of *L. volkmannianum,* a form characteristic of the Dinantian and Namurian (Lower Carboniferous) of Europe (J.M. Wood, University of Missouri-Columbia, personal communication, 1985).

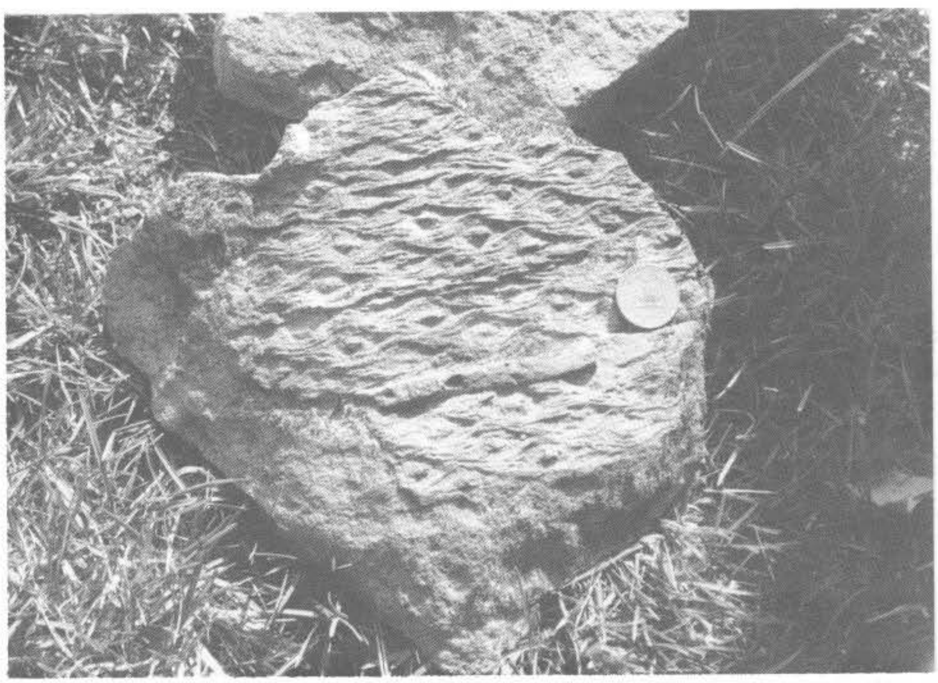

Figure 110. *Specimen of Lepidodendron volkmannianum (L. wedingtonense of White, 1936) collected from the* **Wedington Sandstone Member of the Fayetteville Formation** *in Barry County (fig. 106), southwestern Missouri. Photograph by James E. Vandike.*

Wedington Sandstone Member of the Fayetteville Formation
Adams (1904)

Original description — (Adams, 1904, p. 27) "*Wedington sandstone* — Southeast of Fayetteville and westward to the State line, the Fayetteville shale is succeeded by a sandstone formation varying in importance, but usually having a thickness of between 50 and 150 feet. It is thin bedded and heavy bedded, and carries some interstratified shale. It is not mapped in the Yellville quadrangle, although it is perhaps represented in a small area. It is described here in order to give the full sequence of the formations in the lead and zinc district."

Ulrich (in Adams, 1904, p. 107) added, "The Fayetteville formation consists of an upper and a lower shale member, with a sandstone lens or wedge between them. The middle member, which may represent the Wedington sandstone of this report, appears not to have been observed or recognized before at Fayetteville, the typical locality, but it outcrops there are several points, notably at the north end of the railroad cut, and better, 100 yards or so farther north in a gully on the west side of the track. At both of these points the bed is very calcareous, but weathers into a rusty, porous sandstone, crowded with Chester fossils."

Ulrich continued (p. 108-109), "... if the land conditions so clearly indicated in the sections about St. Joe were more widely extended ... then the Wedington sandstone requires a different explanation. A plausible view in that case would be that the Wedington sandstone is an extension and expansion of the fossiliferous sandstone member above described as dividing the Fayetteville formation into three parts, viz, a lower and an upper bed of shales and an intermediate bed of sandstone varying in thickness, so far as observed by the writer, from 3 to 60 feet. If the latter view is the correct one, then the Wedington sandstone should be considered as a member of the Fayetteville formation rather than as a distinct formation."

Type section — White (1936, p. 13) located the type section as "Wedington Mountain, in northern Washington County, Ark., in the southwest corner of the Fayetteville [30'] quadrangle."

Reference section — The exposure of Chesterian strata on the southwestern flank of Oakleigh Mountain (fig. 106), Barry County, southwestern Missouri is an excellent section for the Wedington Sandstone Member of the Fayetteville Formation in Missouri.

History of nomenclature —

1891	Simonds	Batesville sandstone (in Arkansas)
1904	Adams	Wedington sandstone (in Arkansas)
1905	Adams & Ulrich	Wedington sandstone member of Fayetteville formation (in Arkansas)
1941	Clark	Hale formation (unpublished map; in southwestern Missouri)
1952	Clark & Beveridge	Hale formation (southwestern Missouri)
1961	Searight & Howe	Hale formation (southwestern Missouri)
1972	Thompson	Cane Hill Sandstone Member of Hale Formation (southwestern Missouri)

Remarks — The following description by White (1936, p. 13) would be a good one for the Oakleigh Mountain exposure:

> "The sandstone is lenticular and is 150 feet or less in thickness. . . . It is a hard, resistant sandstone, varying from white to rusty dark gray and greenish gray, is usually rather coarse, and in places is ripple-marked and cross-bedded. Certain layers carry considerable mica, and the plant-bearing beds in the region contain numerous white to dark-blue clay pebbles of moderate size and generally well rounded, so that, locally at least, the Wedington sandstone member is conglomeratic."

This sandstone, capping the outliers of Chesterian strata in southern Barry County, Missouri, was previously assumed, because of its lack of marine fossils and similarity with deposits in northeastern Oklahoma and northwestern Arkansas, to represent the basal Pennsylvanian (Morrowan) Hale Formation. However, specimens of *Lepidodendron,* collected from the Oakleigh Mountain outcrop (fig. 106), have been identified with certainty as representative of *L. yolkmannianum* (identified as *L. wedingtonense* by White, 1936), and are Late Mississippian (Chesterian) in age (personal communication, J.M. Wood, University of Missouri-Columbia, 1985). This identification is used to designate the sandstone capping these outliers to be a northern extension of the **Wedington Sandstone Member of the Fayetteville Formation,** as outcrops of the Wedington have been identified only a few tens of miles to the south, in northern or northwestern Arkansas, by Arkansas geologists.

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V

R.I. 70 PALEOZOIC SUCCESSION IN MISSOURI
Part 4 -- MISSISSIPPIAN SYSTEM

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