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SYNOPSIS: All formational units of the Kinderhook, Osage and Meramec Series are represented in Iowa. No rock units of the Chester Series are present in the state. The Mississippian sequence of rocks is dominated by cherty marine carbonates, but thin fossiliferous shale units occur in the Osage and Meramec. Sandstone and sandy carbonate are dominant within the Meramec in the northwest portion of southeast Iowa and occur locally within the basal Osage. Siltstone occurs within the lower portion of Kinderhook strata. The maximum thickness of the Mississippian System across south-central Iowa represents the main axis of Mississippian deposition.

INDEX DESCRIPTORS: Stratigraphy, Mississippian, Iowa, Meramec Series, Osage Series, Kinderhook Series.

Mississippian formations constitute the bedrock in a diagonal belt twenty to forty miles wide from Lee and Des Moines Counties in the southeast corner of the state northwestward to southern Cerro Gordo and Hancock Counties in north-central Iowa.

The standard sections of Mississippian age rock units are along the Mississippi Valley from southeastern Iowa into southern Illinois and southeastern Missouri. All formational units of the Kinderhook, Osage and Meramec Series are represented in Iowa. Because the Kinderhook varies lithologically from place to place and many of the formations originally correlated as Mississippian are now placed in the Devonian, no standard section has been established for the Kinderhook. The type sections of the Burlington and Keokuk Formations are located near those cities in southeast Iowa. The Warsaw Formation derives its name from exposures at Warsaw, Illinois, nearly opposite Keokuk, Iowa. The Spergen, St. Louis, and Ste. Genevieve Formations are represented in Iowa by marginal facies of formations which are thicker and more uniform in composition farther south in the Mississippi Valley.

None of the Chester Formations are represented in the state and it is probable that the Chester seas never extended this far north.

The Mississippian-Devonian boundary is placed at the base of the North Hill Group by the Iowa Geological Survey. A discussion of the Mississippian-Devonian boundary in Iowa has been presented by Dorheim, Koch, and Parker (1969).

Along the eastern and northeastern edge of the outcrop belt, Kinderhook strata occur above formations of the Yellow Spring Group (uppermost Devonian). Along the northern boundary in Hancock and Kossuth Counties, Kinderhook strata occur above the Lime Creek Formation (lower Upper Devonian). In western Iowa and eastern Nebraska, Kinderhook strata occur above Middle Devonian rocks. For the most part, the boundary is a transgressive, nonconformable contact.

The Mississippian System is unconformably overlain by Lower Pennsylvanian (Cherokee Group) sediments in most of southeastern Iowa. Jurassic (?) (Fort Dodge Beds) and Lower Cretaceous units were deposited upon the eroded Mississippian surface in north-central and northwestern Iowa. Pleistocene deposits mantle the Mississippian rocks along the outcrop belt in eastern Iowa. The general thinning to the northwest reflects the transgressive conditions present in the early Mississippian.

The stratigraphic succession of the Mississippian rocks in southeastern Iowa is shown in Table 1. The thickness of the Mississippian sequence and the thickness of each series in southeastern Iowa is shown in Figure 1.

SERIES	GROUP	FORMATION	MEMBER
Meramec		Ste. Genevieve	
		St. Louis	
		Spergen	
Osage		Warsaw	
		Keokuk	
		Burlington	Cedar Fork
			Haight Creek
			Dolbee Creek
Kinderhook		Hampton	Wassonville
	North Hill	Starrs Cave	
		Prospect Hill	
		McCraney	

Table 1. Stratigraphic succession of the Mississippian rocks in southeastern Iowa.

STRATIGRAPHY—KINDERHOOK SERIES

The Kinderhook Series in southeastern Iowa includes the North Hill Group and the overlying Hampton Formation. The Kinderhook is composed dominantly of carbonate rocks. Siltstone occurs in the North Hill Group and chert in the Hampton.

The North Hill Group (Workman and Gillette, 1956) includes in ascending order: McCraney Limestone, Prospect Hill Siltstone, and Starrs Cave Formation. The McCraney Limestone is dominantly a very pale-orange to pale yellowish-brown, sublithographic limestone. Brown medium-grained dolomite occurs in irregular horizontally and vertically oriented planes. The McCraney is sparingly fossiliferous except for the basal portion which consists of an oolitic, crinoidal limestone that locally contains a coarse brachiopod coquina composed almost entirely of *Chonetes*. The Prospect Hill Siltstone is dominantly a light greenish-gray, medium siltstone with discontinuous green shaley seams. The Prospect

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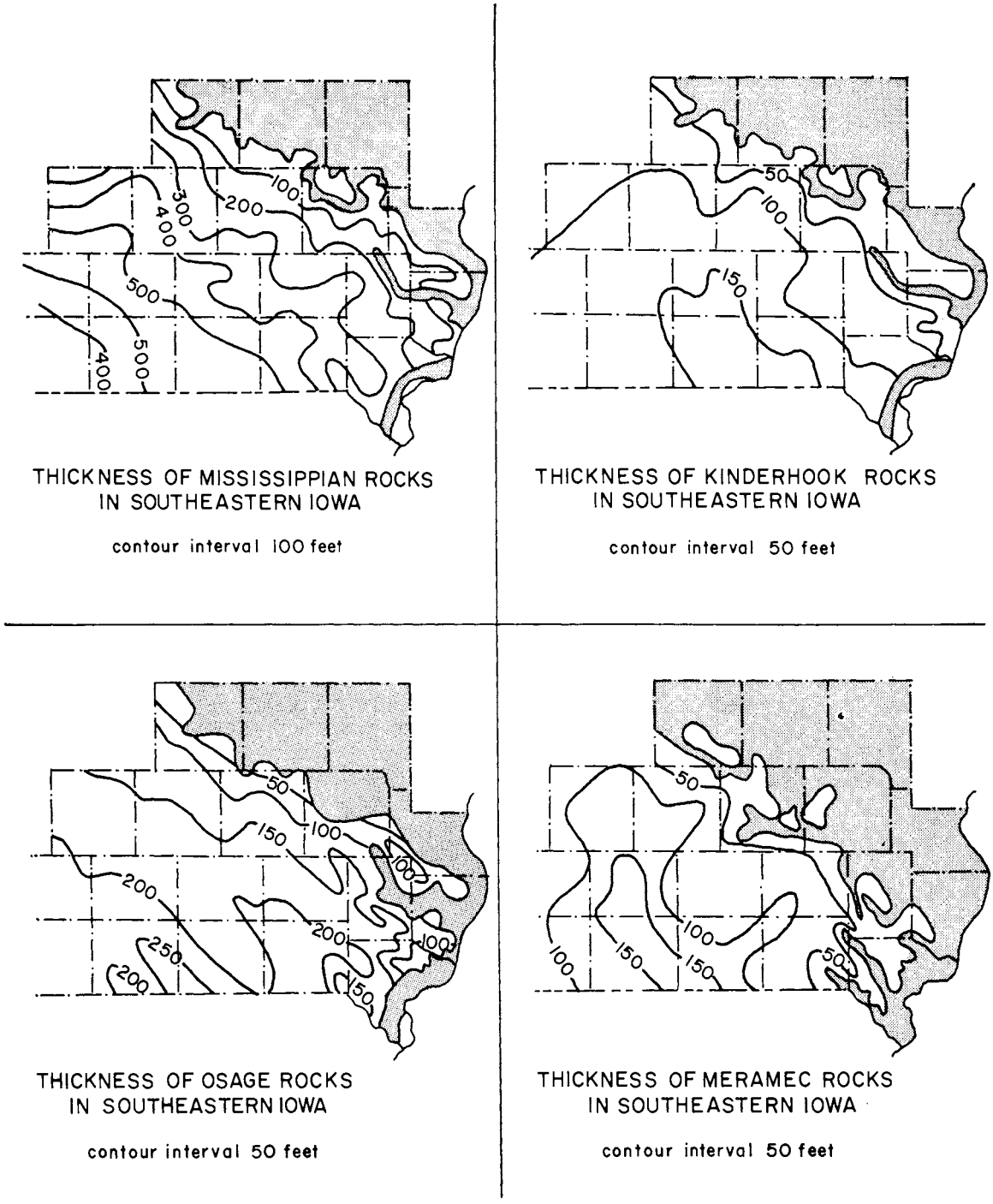

Figure 1. Thickness maps of Mississippian series in southeast Iowa.

Hill contains fish teeth, brachiopods, and pelecypods. The Starrs Cave Formation is a very pale orange to pale gray, oolitic limestone which contains fragmented brachiopods, corals, and crinoids.

The Wassonville Limestone Member is the only representative of the Hampton Formation (Laudon, 1931) in southeastern Iowa. The Wassonville consists of pale to dark yellowish-orange, dolomitic limestone and pale yellowish-brown dolomite. Over most of the area of its occurrence, the Wassonville contains appreciable amounts of light gray, fossilif-

erous chert. In the extreme southeastern counties the Wassonville is relatively chert free and is dominantly a dolomitic limestone. To the west and northwest the Wassonville becomes more dolomitic and contains more chert.

Little formational facies variation occurs in the Kinderhook other than an increase of dolomite toward the west and northwest in the carbonate units and an increase in shale to the south in the Prospect Hill Siltstone.

The thickness of the Kinderhook in southeastern Iowa ranges from less than 50 feet near the outcrop area to over 150 feet in parts of Van Buren, Davis, and Wapello Counties. The variations in thickness and areal distribution of the North Hill Group formations is more marked than that of the Wassonville Member of the Hampton Formation. The thickness of the Wassonville averages 30 feet and varies from 8 feet near Burlington to over 50 feet at Centerville in Appanoose County. In contrast, the North Hill Group varies from approximately 25 feet at the type section near Burlington to over 100 feet in Davis County. The McCraney Limestone attains a thickness of 70 feet near Keokuk and 60 feet at Ottumwa. It thins to the north and northwest from the Burlington area and appears to be absent west of Davis County. South of Burlington the Prospect Hill Siltstone attains a thickness of 30 to 40 feet. West of the Burlington area the Prospect Hill becomes thinner and finer grained and appears to be absent in Monroe and Appanoose Counties. In the Burlington area the Starrs Cave Limestone is 3 to 5 feet thick. West of the Burlington area it increases in thickness to approximately 65 feet at Albia in Monroe County and 75 feet at Cincinnati in Appanoose County.

An unconformity at the top of the Kinderhook in southeastern Iowa has been described by Laudon (1937) and Harris and Parker (1964). Basal Burlington (Osage) rests on units as old as the Starrs Cave Formation. Regional distribution and thicknesses suggest the possibility of facies equivalency between the Eagle City-Iowa Falls and the Gilmore City Formations (Kinderhook) in north-central Iowa with the lower Burlington in southeastern Iowa. Detailed faunal studies are needed to clarify these Kinderhook-Osage boundary relationships.

OSAGE SERIES

The Osage Series in southeastern Iowa includes the Burlington Limestone (Hall, 1857), Keokuk Limestone (Owen, 1852), and Warsaw Formation (Hall, 1857). The Osage is composed dominantly of cherty carbonate rocks interstratified with minor amounts of fossiliferous shale. Quartz sandstone occurs only locally at the base of the Burlington Limestone and has been noted in parts of Washington, Keokuk, and Louisa Counties. The detailed stratigraphy of and conformable relationships between the Burlington and Keokuk and the Keokuk and Warsaw in southeastern Iowa were described by Harris and Parker (1964).

The members of the Burlington Limestone are: Dolbee Creek, Haight Creek and Cedar Fork. In general, the Dolbee Creek Member (Laudon's *Cactocrinus* zone in the type area, but including his underlying zones where the member is thick) is relatively pure, coarsely crystalline, crinoidal limestone with a small amount of chert. *Spirifer grimesi* and fragments of bryozoans are prevalent in this member. It rests unconformably on rocks which are more susceptible to weathering. This unit is thickest (17 feet) in the south near Keokuk. To the north and west it decreases in thickness and is absent north of a line across southern Washington and Keokuk Counties and west of a line from Hedrick to Centerville. In Washington, Keokuk, and Louisa Counties a sandstone occurs at the base of the Burlington which probably represents a shoreline deposit equivalent to the calcarenites of the Dolbee Creek. The Haight Creek Member (Laudon's *Physetocrinus* zone) is highly cherty and contains dolomite as well as limestone beds. The base of the Haight Creek is marked by a glauconitic dolomite. The glauconite occurs as greenish-black grains or pellets with rounded or polished surfaces. This zone extends beyond the limits of the underlying Dolbee Creek Member and rests on rocks of Kinderhook age to the north and west. The Haight Creek has a rather uniform thickness ranging from 40 to 50 feet. The Cedar Fork (Laudon's *Dizygocrinus* and *Pentremites* zones) is relatively pure crystalline limestone. The *Dizygocrinus* zone commonly contains abundant soft flakes of glauconite which gives the limestone a green color, and the *Pentremites* zone is cherty. The Cedar Fork ranges from 10 to 30 feet in thickness.

The Burlington Limestone exhibits gradational changes in lithology from the southeast to the north and west where dolomite content increases and both carbonates and cherts become darker in color.

The Keokuk Limestone consists of cherty limestone at the base, called "Montrose Cherts" by Keyes (1893), overlain by fossiliferous limestones with interbedded fossiliferous shales. The "Montrose Cherts" are easily separated from the relatively noncherty Cedar Fork Member of the Burlington Limestone. The top of the Keokuk cannot always be identified as readily. The upper portion of the Keokuk is composed of gray fossiliferous calcarenites with interbedded fossiliferous, calcareous shales. The shale beds increase in number and thickness upward grading into the gray Warsaw shales, and dolomite beds replace the limestone. In subsurface usage, the upper boundary of the Keokuk generally is placed at the top of the calcarenite.

In the extreme southeastern counties the thickness of the Keokuk averages about 75 feet. To the west it thins to an average of 50 feet and to the north in Story and Marshall Counties it averages 25 feet.

The two units of the Keokuk are typified by light gray, medium to coarsely crystalline limestone grading into calcarenite. Fossil fragments, especially of brachiopods and crinoids, are common in well cuttings. Light gray to light olive-gray, fine to medium crystalline dolomite beds constitute about 50 percent of the carbonates of the lower "Montrose" unit. Chert that is typically light gray and off-white, mottled and specked with black, gray, or brown is the dominant lithology in well cuttings through the upper portion of the Montrose unit. Spicular fragments of fossils are abundant in the chert and serve to distinguish the Keokuk from the dominantly crinoidal chert of the Burlington. The shales in the upper portion of the Keokuk generally are gray, fossiliferous, and calcareous. Glauconite, as scattered soft green spots, is associated with the Keokuk sediments, but no concentration has been noted at a single horizon over a broad area, as it has in the Burlington. To the west the Keokuk is typically brown—dark in the upper portion and lighter below. The most striking lithology is the brownish-gray chert which is mottled white and contains white spicules. The carbonate in the western portion is chiefly dolomite rather than limestone and is characteristically brown, finely crystalline, argillaceous

and highly siliceous. Brown, blocky, dolomitic shale is typical in the western counties. The lower part of the Keokuk contains a large amount of secondary siliceous material in the form of crystalline quartz and chalcedony, probably of geodal origin.

The Warsaw Formation is characterized by shale, argillaceous dolomite and chalcedonic chert. Shale is dominant in the upper portion whereas chalcedony tends to be concentrated in the lower portion.

In the southeastern counties the shale of the Warsaw is primarily very light gray to medium gray, chunky, and dolomitic. Fenestrate bryozoans are common. Very light-gray to light medium-gray, finely crystalline, argillaceous dolomites accompany the shales. To the west and north both the shales and dolomites are darker. The chalcedony is associated with crystalline quartz and typically the color is light bluish-gray and bluish-white, but some is moderate reddish-orange or moderate pink.

The carbonate rocks interstratified with shale are more numerous in the lower portion of the formation. In the outcrop area, these are calcarenites that are somewhat dolomitic. However, in most of southeastern Iowa they have been altered to finely crystalline dolomite. Argillaceous dolomites are the dominant lithology toward the west, probably because the shaley upper Warsaw has been removed by post-Osage erosion. The average thickness is 50 feet. It thins to 25 feet to the northwest. The Warsaw is unconformably overlain by the Spergen and St. Louis Formations.

MERAMEC SERIES

The Meramec Series contains the youngest Mississippian present in Iowa: Spergen (Salem) Limestone (Ulrich, 1905), St. Louis Limestone (Engelmann, 1847), and Ste. Genevieve Limestone (Shumard, 1860). The lithologies of the Meramec units are more varied and complex than those of the Kinderhook and Osage. The Meramec overlies older Mississippian strata unconformably and overlaps formations as old as the North Hill Group (Kinderhook). The upper boundary constitutes a post-Mississippian erosional surface. This interval is unconformably overlain by the Cherokee Group of Pennsylvanian age and by Pleistocene deposits. The northward thinning is the result of truncation and overlap at the base of the St. Louis.

The Spergen (Salem) Limestone is a brownish-gray, micaceous dolomitic limestone with a minor quartz sand fraction. It is restricted to southern Iowa by the pre-St. Louis unconformity. The Spergen often has been confused with the basal St. Louis. The average thickness is 20 feet, although as much as 35 feet has been recorded in wells in Appanoose County.

The St. Louis Limestone in southeastern Iowa is dominantly a pale yellowish-brown limestone, often sublithographic, with a lower zone of brown areanaceous dolomite. It contains an upper shaley zone and a lower zone with a high percentage of anhydrite and gypsum. The absence of evaporites in the outcrop area may be due to solution, which would account for the brecciated nature of the carbonates. The shale content increases across southern Iowa with a sandy facies becoming prominent toward the north. The average thickness is 50 feet, although thicknesses of over 125 feet have been recorded in the evaporite areas.

The Ste. Genevieve is a pale yellowish-gray limestone with a high percentage of quartz sand in southern Iowa and is represented mainly by greenish-gray and pale red shales in central Iowa. The Ste. Genevieve is conformable upon the St. Louis, but varies greatly in thickness and distribution because of post-Mississippian erosion.

SUMMARY

The beginning of Mississippian time was a period of general emergence with no evidence of localized uplift. The region was a broad plain, modified somewhat by differential erosion. Shallow, restricted seas are evidenced by the distribution of the formations of the North Hill Group. Normal marine seas during deposition of the Hampton are indicated by fossiliferous carbonate rocks. The nearly pure bioclastic carbonate rocks of the Osage are the result of a shallow shelf environment. The shales of the Warsaw are the termination of a clastic wedge from the east. Carbonate deposition continued into the lower Meramec. However, an evaporite facies is present in the lower St. Louis. The normal marine carbonate rocks of the upper St. Louis and the Ste. Genevieve contain an increase in sand and shale northward culminating in a shale facies of the Ste. Genevieve in northern Iowa. No evidence of Chester deposition has been recognized. At the end of Mississippian time this region was a land mass of low relief undergoing erosion and karst development. The Mississippian surface was further modified by uplift which continued into Pennsylvanian time.

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