KANSAS GEOLOGICAL SURVEY
OPEN-FILE REPORT 73-6

PALEOTECTONIC INVESTIGATIONS OF THE MISSISSIPPIAN SYSTEM IN THE UNITED STATES

by

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Disclaimer

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January 22, 1973

Dr. Larry C. Craig, Chief
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Dear Larry:

Enclosed is our revised version of the Kansas portion of the Mississippian Paleotectonic manuscript. Gary and I have made only minor changes or corrections. We are most appreciative of your personal help in revising our rough first draft.

Very truly yours,

Edwin D. Goebel
Professor
Dept. of Geology-Geography

ew

CC: G. S. Stewart

Larry:

1/22/73 73-6

Please show both affiliations with the Kansas Geological Survey first followed by the two [illegible], i.e.

E.D. Goebel Kansas Geol. Surv. (UMKC since 1971)

PALEOTECTONIC INVESTIGATIONS

OF THE MISSISSIPPIAN SYSTEM

IN THE UNITED STATES

Chapter F. Kansas *

By E. D. GOEBEL AND G. F. STEWART

~~Oklahoma State University~~

GEOLOGICAL SURVEY PROFESSIONAL PAPER ____

~~University of Missouri, Kansas City~~

This has been cleared as of 1/22/73

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PALEOTECTONIC INVESTIGATIONS OF THE MISSISSIPPIAN SYSTEM IN THE UNITED STATES

KANSAS

By E. D. Goebel and G. F. Stewart

ABSTRACT

In eastern and central Kansas the Mississippian rocks of this study rest disconformably on the Chattanooga Shale of Late Devonian and Early Mississippian age; in western Kansas they rest unconformably on rocks of Ordovician age.

Rocks of interval A were deposited in a single cycle of marine transgression and regression. The earliest deposits, the Boice Shale, indicate that transgression began in northeastern Kansas; unnamed rocks of Kinderhook age in southwestern Kansas also mark an early Kinderhook marine invasion. Detrital rocks, that characterize the oldest interval A deposits, were replaced by widespread carbonate rocks in the later part of interval A time. Interval A probably covered most if not all the State. Minor uplift, epeiric tilting, and regression of the strand line took place at the end of interval A.

Interval B records a gradual marine transgression beginning in southeastern and south-central Kansas (Fern Glen Limestone), then covering the entire eastern and central part of the State (Burlington Limestone), and eventually the entire State (Keokuk Limestone). Although disconformity has been reported between Osage and Meramec rocks in Kansas, no major hiatus is thought to mark this contact. ~~The~~ Southwest Kansas ~~basin~~ subsided during Osage time to receive a maximum of almost 600 feet of interval B. Interval B is dominantly cherty carbonate rock throughout the State.

Interval C is also dominated by carbonate rocks, a continuation of depositional conditions of interval B. In late interval C time minor quantities of detrital siliceous materials were deposited with the carbonate. This detrital influx and the clastic textures in upper interval C suggest~~s~~ an increase in energy of the environment, perhaps a shoaling of the sea, and a beginning of the regression of the strand line and uplift of the region to an emergence that marks the end of interval C. Subsidence continued in southwest Kansas during interval C time and a maximum of about 850 feet of interval C is preserved.

Interval D is preserved ~~only~~ in southwest Kansas, where it has a maximum thickness of more than 400 feet, and locally as sink fillings in SE Kans. In contrast to the underlying Mississippian the interval contains appreciable amounts of detrital rocks. Northern Kansas may have been emergent during much of interval D time and some of the detritus in interval D may have been derived from local erosion of older Mississippian rocks as well as from a source area outside the region.

The end of interval D time marks a change from relatively quiescent tectonic conditions during the Mississippian to more active tectonic conditions that prevailed during the Early Pennsylvanian. Kansas was uplifted and emergent at the end of the Mississippian, the Central Kansas uplift and Nemaha anticline became clearly marked positive features, and erosion stripped ~~the~~ many lower Paleozoic beds from the crests of these uplifts and beveled and partially removed Mississippian rocks from the basins. The Mississippian is overlain by rocks of Pennsylvanian age throughout the State (except for a small area in extreme southeastern Kansas.); Early Pennsylvanian (Morrow) rocks are limited to the western third, and Middle Pennsylvanian (Atoka or Des Moines) lie on the Mississippian across the eastern two-thirds of the State.

REGION DEFINED

This region is restricted to the State of Kansas. Mississippian rocks crop out only in an area of less than two townships in Cherokee County in southeasternmost Kansas (pl. 1). In the subsurface, Mississippian rocks are present in basinal areas (fig.). With exception of the lower boundary of interval A the interval boundaries used in this chapter are the same as boundaries of the series recognized by the Kansas Geological Survey: interval A (Kinderhook), interval B (Osage), interval C (Meramec), and interval D (Chester) (table 1). Some rocks of each interval are preserved in Kansas.

PALEOGEOLOGY

Units underlying Mississippian

Through most of eastern Kansas (pl. 2) the rocks included in this report are underlain by the Chattanooga Shale of Late Devonian-Early Mississippian age. The Mississippian part of the Chattanooga is indistinguishable lithologically from the Devonian portion almost everywhere in the State. Locally on the southern part of the Nemaha anticline (fig. 1) the Chattanooga is absent and Mississippian rocks

Figure 1.--NEAR HERE

overlie Ordovician rocks, but these areas are so small that they are not shown on plate 2. The term "Kinderhook" has been used by petroleum geologists for the Chattanooga Shale and Boice Shale when both are present, in spite of the fact that a disconformity separates the units (Lee, 1957, p. 67). Erosion of the Chattanooga prior to deposition of the Boice is suggested by inverse thickness relations of the two formations.

In western Kansas, Mississippian rocks overlap older rocks northward; they rest successively on locally occurring unnamed Late Devonian rocks (Goebel, Sweet, and Hilpman, 1969) in southwestern Kansas (not shown on pl. 2), and on Middle Ordovician Viola Limestone and Early Ordovician and Late Cambrian Arbuckle Group farther north. No Mississippian rocks are preserved on the crest of the Central Kansas uplift (fig. 1), but along the entire west flank of the uplift Mississippian rocks overlie Ordovician rocks.

Figure 1.--Mississippian and post-Mississippian structures mentioned in the text (from Merriam, D. F., 1963).

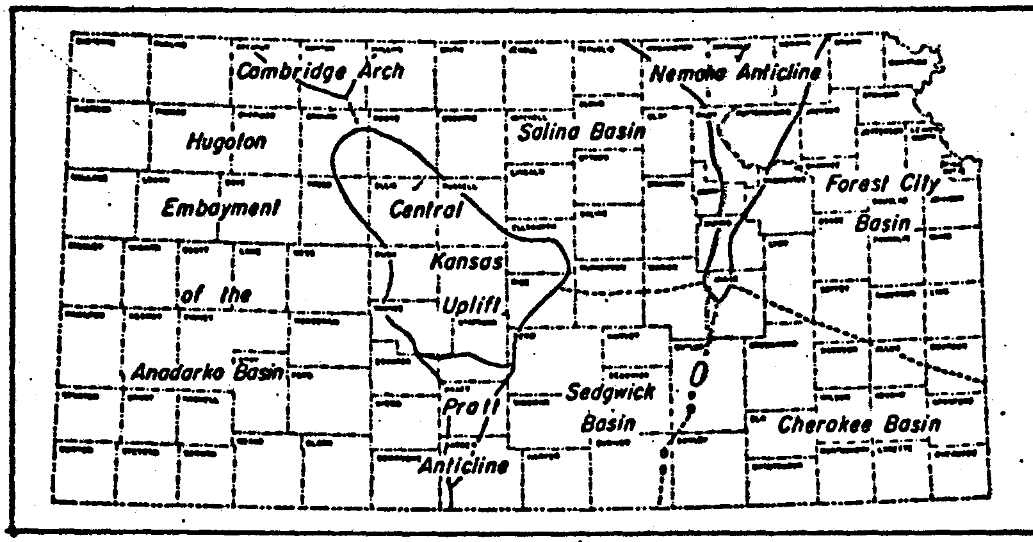

Figure 1.-- Map showing Mississippian and post-Mississippian structures mentioned in text. (From Merriam, D.F, 1963).

Lower boundary of Mississippian

The lower boundary of the Mississippian, as used in this study, is a disconformity throughout the State. The minimum hiatus at this contact is probably in northeastern Kansas where the Boice Shale, the oldest unit assigned to interval A, rests on the Chattanooga Shale of Devonian and Mississippian age (table 1, col. 67). The hiatus is greatest in northwestern Kansas where the Gilmore City Limestone, the uppermost unit of interval A, overlaps the upper Sedalia Dolomite and rests on the Arbuckle Group of Early Ordovician and Late Cambrian age.

The disconformity has intermediate values elsewhere in the State. In southeastern Kansas the Compton Limestone (table 1, col. 68) rests on the Chattanooga, in central and north-central Kansas the upper Sedalia Dolomite (table 1, col. 66) rests on Chattanooga, and in southwestern Kansas an unnamed detrital unit assigned to interval A (table 1, col. 65) rests on the Viola Limestone of Middle Ordovician age. In south-central Kansas interval A is missing and the Fern Glen Limestone (interval B) rests directly on the Chattanooga Shale.

The "Meisener" Sandstone is distributed erratically through central and eastern Kansas at the base of the Chattanooga Shale. West of the central Kansas uplift where the black shale of the Chattanooga is absent the term "Meisener" is applied probably incorrectly to sandstone below rocks of Mississippian age and above rocks of Ordovician age. This sandstone may have been deposited at any time from Middle or Late Ordovician to Early Mississippian and the extension of the name "Meisener" does not seem justified. This sandstone, where present, has been included in interval A of western Kansas.

Paleotectonic implications

The Chattanooga Shale masks pre-Mississippian structural features. The pre-Mississippian Ellis arch in northwestern Kansas and the Chautauqua arch in southeastern Kansas probably were connected by the Central Kansas arch during part of pre-Chattanooga time (fig. 2) and

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Figure 2.--NEAR HERE

---

acted as a northwest-southeast trending positive element separating the Southwest Kansas basin and the North Kansas basin.

The western edge of the Chattanooga Shale appears to be an erosional edge and has a north-south trend across central Kansas (pl. 2). The Upper Devonian part of the Chattanooga probably was more widespread than at present and may have extended across western Kansas onto the east flank of the Transcontinental arch in eastern Colorado. Reworked Late Devonian conodonts in the Mississippian rocks in part of western Kansas are supporting evidence to the former presence of Upper Devonian strata in this area (Goebel, 1968), and locally in southwestern Kansas sandy carbonate rocks of probable Late Devonian age are preserved beneath the Mississippian rocks (Goebel, Sweet, and Hilpman, 1969).

Uplift of the Transcontinental arch in early Kinderhook time may have allowed erosion and removal of the Chattanooga from western Kansas and provided an eastward-sloping surface upon which the beds of interval A were deposited, first in northeastern Kansas, but later across most of the State.

Figure 2.--Map showing geographic features and pre-Mississippian structures mentioned in the text. (Modified from Merriam, D. F., 1963, and Goebel, E. D., 1968.)

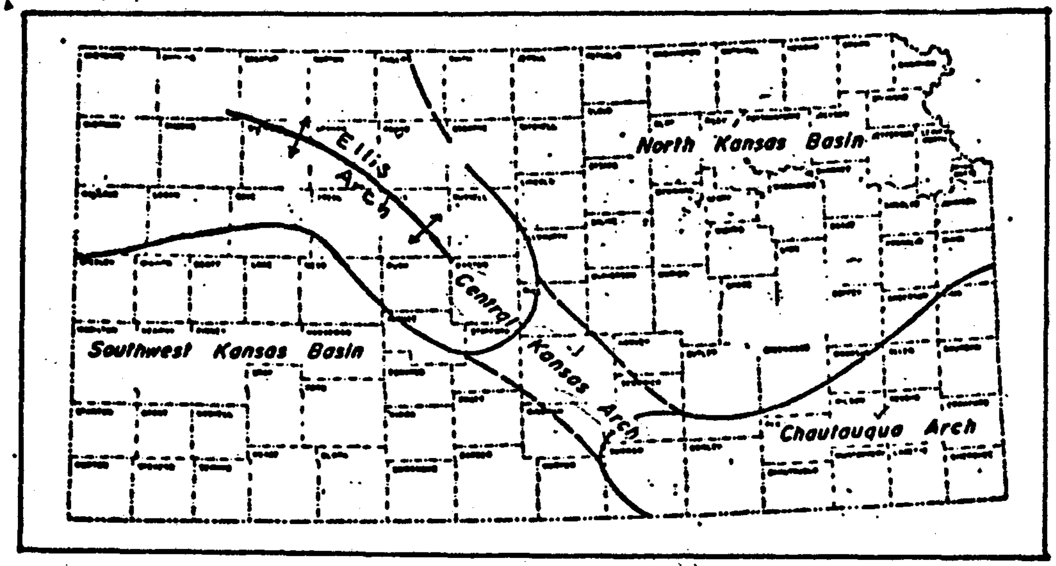

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Figure 2.-- Map showing geographic features and pre-Mississippian structures mentioned in the text. (Modified from Merriam, D.F., 1963, and Goebel, E.D., 1968).

INTERVAL A

Formations included

The formations included in interval A are given in table 1 (cols. 65-68). Interval A in southeastern Kansas consists of, in ascending order, the Compton Limestone and the Lower Sedalia Dolomite--Northview Shale. In northeastern Kansas interval A includes the Boice Shale, the Chouteau Limestone (equivalent of the Compton Limestone), Upper Sedalia Dolomite and Gilmore City Limestone. Interval A in central and northern Kansas includes only the Upper Sedalia Dolomite overlain by the Gilmore City Limestone. In western Kansas, unnamed rocks of Kinderhook age are overlain by the Upper Sedalia Dolomite. These in turn are overlain by the Gilmore City Limestone.

Stratigraphic relations

The Boice Shale, recognized only in northeast Kansas and adjacent states, unconformably overlies the "Chattanooga Shale" and seemingly is conformable below the Chouteau of Moore (1928). Moore and others (1951) identified the Compton Limestone as the lowest limestone formation of the Kinderhook in Kansas, and correlated the Northview Shale with the Lower Sedalia Dolomite. The Upper Sedalia Dolomite as defined by Lee (1943) is recognized only west of the Nemaha anticline.

Unnamed rocks of Kinderhook age, mostly beds of sandstone and shale, occur on the southwest flank of the Central Kansas uplift (Goebel, 1966). The rocks contain a mixed fauna of Kinderhook and Late Devonian conodonts. The unit occurs unconformably next above Ordovician and possibly Devonian carbonate units and below Kinderhook and Osage formations. Goebel (1966) regarded the unit as late Kinderhook in age, but older than the Upper Sedalia. The stratigraphic relations with Boice, Compton, Chouteau and Lower Sedalia is undetermined.

The Upper Sedalia Dolomite overlain by the Gilmore City Limestone is widespread in northeastern and north-central Kansas and locally in far northwestern Kansas. In the Salina Basin the upper member of the Sedalia Dolomite is separated by disconformities from overlying and underlying units (Lee, 1956).

Suggest changing "Formations" to "strata", or leaving as "formations." G

The stratigraphic relations and age of the Gilmore City Limestone are better known than other Kinderhook units. Late Kinderhook conodont faunas are present in both the Upper Sedalia and Gilmore City formations in west and northwest Kansas (Goebel, 1968; Klapper, 1971). Supporting the physical correlation of the Gilmore City of western Kansas with the type Gilmore City of Iowa is the presence of *Patrognathus andersoni*, a conodont found in the United States only in this formation.

Upper boundary of interval A

The Gilmore City Limestone is the uppermost unit of interval A throughout much of Kansas--and a number of different units of interval B rest on it or on lower beds in interval A indicating a disconformity at the A-B contact. Only in McPherson County in central Kansas (Lee, 1940) does the section approach completeness; there the Gilmore City underlies the oldest unit in interval B, the St. Joe Limestone Member of the Fern Glen Limestone. In northeastern Kansas the Gilmore City Limestone is overlain by the Burlington-Keokuk Limestone undifferentiated; in western Kansas the Keokuk Limestone of interval B rests disconformably on the Gilmore City Limestone (Goebel, 1968); and in parts of southwestern Kansas, west of the Central Kansas uplift and the Pratt anticline, the Fern Glen Limestone rests on the lowest Kinderhook unit, the unnamed beds of Kinderhook age.

The area in which the oldest ~~unit~~ formation of interval B, the Fern Glen, is recognized almost excludes the area in which the youngest units of interval A, the Gilmore City and Upper Sedalia, are recognized (Goebel, 1968, figs. 14 and 16) and suggests that they might be lateral facies equivalents. The presence of an Osagian Bachtrognathodid conodont fauna in the Fern Glen Limestone in south-central Kansas and a Kinderhook Siphonodellid fauna in the Gilmore City argues against this interpretation.

Suggest change because in par. 1, St. Joe Ls. Mbr. cited as "oldest unit."

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Thickness trends

The maximum thickness of interval A is more than 150 feet in western Kansas, and almost 150 feet in northeastern Kansas. The interval exceeds 100 feet in several small areas in north-central Kansas (pl. 3A).

In the east-west cross section across southern Kansas, the rocks of interval A are everywhere less than 100 feet in thickness except at the western end of the section (pl. 9, sec. E-E'). In the north-south cross section across western Kansas the interval reaches more than 150 feet in thickness (pl. 9, sec. D-D').

Lithofacies trends

The lithofacies patterns of interval A are dominated by carbonate rocks (pl. 3B). In north-central and parts of western Kansas the map has a polka-dot appearance. In part, this may be due to inadequate data, but in large part it is due to slight differences in composition of interval A. Had the Chattanooga Shale been included in interval A in this study, the lithofacies map would have been dominated by shale in central and much of eastern Kansas.

The Gilmore City is a carbonate unit in northwestern Kansas and a clastic unit in southwestern Kansas (pl. 9, sec. D-D') which accounts for the carbonate lithofacies pattern in the central and northern parts of western Kansas and the detrital pattern in southwestern Kansas (pl. 3B). The detrital lithofacies pattern in southeastern Kansas reflects the Northview Shale, a unit that was probably derived from a local sediment source ~~from~~ in Missouri.

Sources of sediment and environments of deposition

The unnamed rocks of Kinderhook age in western Kansas and the overlying Upper Sedalia Dolomite and Gilmore City Limestone are a lithologic sequence which illustrates the marine transgression described by Kischer (1965, p. 56). Detrital sediment was deposited as a thin ~~layer~~; reworking by wave action was probably effective to depth of only a few feet. Little of the transgressive sediment was derived from underlying sediments. Instead, source of the sand- and silt-sized detrital particles of interval A were probably from lower Paleozoic rocks exposed on the Ellis-Chautauqua arch. A close balance between the rate of supply of sediment and the marine transgression is one requirement of extensive transgressive deposits. In western Kansas the basal part of the sandstone sequence contains coarse~~-sized~~ particles and the sand is well sorted. Above the basal part of the sandstone the ~~clastic~~ unit grades abruptly into finer-grained and more poorly sorted rocks, which in turn grade abruptly into the overlying carbonate unit without intermediate shaly beds.

The Gilmore City Limestone of western and north-central Kansas consists of units composed of brachiopods, crinoids, and bryozoan fragments mixed with ooliths and pellets and lenticular beds of oolitic limestone. The intercalated beds of oolitic and fossil fragmental limestone indicate alternating conditions of good and poor sorting and a highly agitated shallow marine environment (pl. 11, fig. 1) in which the water was saturated with calcium carbonate. The presence of glauconite, phosphates, and chemical precipitates indicates slow sedimentation. These shallow, warm seas prevailed to the end of the Kinderhook with widespread deposition of oolitic and crinoidal limestones. The primary sediment source for the carbonate rocks of interval A was organic.

Paleotectonic implications

Pre-Mississippian positive elements (fig. 2), the Ellis arch-Central Kansas arch-Chautauqua arch, probably were covered by the Chattanooga Shale (Goebel, 1968, p. 1738). After a period of uplift and erosion that stripped the Chattanooga to its present erosional limit, the marine transgression of interval A time began and advanced progressively across a surface that sloped gently to the east. The seas were widespread late in interval A time and although interval A is quite thin the rocks imply either eustatic rise or epeiric subsidence in sufficient amount to accomodate their deposition (pl. 10, fig. 1). The Central Kansas uplift may have acted in a positive manner during interval A time; at least rocks of only late Kinderhook age are preserved in northern and central Kansas. To the west, the Transcontinental arch probably was neutral or slightly positive and possibly was emergent (pl. 12, fig. 1) during interval A time (Goebel, 1968, p. 1738).

At the end of interval A time, the entire region was raised above sea level and during a period of relative stability interval A was beveled. The beveled surface may have been tilted southward at the beginning of interval B deposition (Lee, 1956, p. 140) because early Osage deposits thin northward and later Osage and Meramec units (intervals B and C) overlap in succession northward on Kinderhook rocks.

INTERVAL B

Formations included and stratigraphic relations

Interval B includes the Fern Glen Limestone and the Burlington-Keokuk Limestones undifferentiated (table 1, cols. 65-68). The Fern Glen is restricted to southern and southeastern Kansas and consists of two members, the St. Joe Limestone Member and the Reeds Spring Limestone Member. The St. Joe is less widespread and is overlapped by the Reeds Spring, which in turn is overlapped by the Burlington in south-central Kansas (Lee, 1940).

The Burlington and Keokuk have not been differentiated in much of Kansas. In the Salina basin, Lee (1956) mapped the Keokuk unconformably on the Burlington. This disconformity increases in magnitude westward in the State. Although the western limit of the Burlington is unknown, only the Keokuk has been identified west of the Central Kansas uplift (Goebel, 1968) and the Keokuk rests directly on the Gilmore City Limestone (pl. 9, sec. D-D').

The lower part of the Cowley Formation in southwestern and south-central Kansas is included in interval B and is regarded as a facies equivalent to Keokuk, Burlington, and Fern Glen Limestones and also to the Chattanooga Shale (Goebel, 1966). Lee (1956) interpreted the Cowley as deposited in a basin in south-central Kansas and derived by erosion from rocks of Osage age and older; an erosion surface was reported at the base of the Meramec in the Salina basin, and no break was recognized between the Cowley and Warsaw (interval C) in western Kansas (Lee, 1956). Later studies provide both lithologic and paleontologic data that support the interpretation that the Cowley is a facies of the Osage and much of the Meramec (Goebel, 1966).

, Thompson and Goebel, 1968

Upper boundary of interval B

The contact between intervals B and C is the contact of the Warsaw and the Keokuk Limestones over a large part of the State. ~~Only in a part of southwestern and south-central Kansas, where the Cowley Formation is present, are these limestones absent~~. In this report the interval B-C boundary is placed within the Cowley ~~Formation~~. Although Lee (1940, 1953, 1956) identified a discontinuity at the interval B-C boundary in parts of the State and others (Maher and Collins, 1949) have reported disconformity in western Kansas, the disconformable relations are difficult to demonstrate. The authors believe no major disconformity is present at the interval B-C boundary in the Kansas region.

Thickness trends

Interval B rocks are thickest, almost 600 feet, in the Hugoton embayment (Maher and Collins, 1948) in Meade and Clark Counties (pl. 4A; pl. 9, sec. E-E'), and they thicken southward into the Anadarko basin. This area of thick interval B in southwest Kansas coincides with an area in which interval A is very thin or absent. Presumably interval A was removed by erosion prior to deposition of interval B.

In south-central Kansas interval B ~~attains~~ a maximum of ~~over~~ 300 feet ~~thick~~. The interval thins gradually toward the north and extends a short distance into southwestern and south-central Nebraska. The interval thins more rapidly around the margins of the Central Kansas uplift and Nemaha anticline and has been removed by post-Mississippian erosion from these Early Pennsylvanian positive features.

Lithofacies trends

The Burlington-Keokuk unit in Kansas is, in large part, a cherty, siliceous carbonate. Because of the greater thickness and more widespread occurrence of the Burlington-Keokuk, its rather constant lithofacies dominates over the Fern Glen Limestone and the lithofacies map (pl. 4B) is quite uniform. The formations of interval B, in large part, have been differentiated according to the character of contained chert and nature of the insoluble residues. Where interval B has been eroded during Late Mississippian and Early Pennsylvanian time, a thick residuum of weathered chert called "chat" has formed. These deposits, commonly included in thickness measurements of Mississippian rocks, form a broad band bordering the major tectonic or structural features of Kansas and show on the lithofacies map (pl. 4B) as a discontinuous belt of high chert content surrounding the Central Kansas uplift.

Sources of sediment and environments of deposition

In Kansas, interval B rocks were deposited in a normal, shallow marine environment (pl. 11, fig. 2). ~~Benthonic marine organisms contributed their~~ shells and other calcareous hard parts (of benthonic organisms composed much of the) as sediments, and relatively uniform and widely distributed limestone formations were deposited. Slight fluctuations of sea level caused local and periodic but not intense re-working of calcareous materials on the floor of the epicontinental sea, resulting in calcarenite interspersed with crinoidal limestone beds. Only in southern Kansas, near the southern end of the Central Kansas uplift is there evidence of land-derived sediment. Here alternating reddish and greenish semi-crinoidal limestone beds make up the rocks of the lower portion of interval B, the Fern Glen Limestone.

Shale partings and mud as minor matrix material in limestones are dispersed throughout interval B. Fossiliferous and non-fossiliferous chert are present in interval B and some of the chert is clearly of secondary origin. Incompletely silicified crinoidal debris is common both in the chert and in the limestone.

Paleotectonic implications and paleogeographic interpretations

At the beginning of Osage time the Kansas region sloped southward. The oldest rocks of interval B were deposited in a transgressing sea and pinch out northward. Additional subsidence or eustatic rise allowed widespread deposition of interval B throughout the State and interval B probably covered the incipient Central Kansas uplift and extended westward on to the east flank of the Transcontinental arch (pl. 10, fig. 2). Of course, the present distribution of interval B, restricted to structural depressions, is the result of Late Mississippian and Early Pennsylvanian erosion along the positive structures, the Central Kansas uplift and Nemaha anticline.

The Hugoton embayment subsided actively during interval B time and connected southward with the subsiding Anadarko basin in Oklahoma. The Southwest Kansas basin of Devonian time may be considered ancestral to the Hugoton embayment of Mississippian and later Paleozoic time.

The paleogeographic map of interval B (pl. 12, fig. 2) indicates the wide shallow marine transgression of Osage time and shows that the State probably was entirely submerged.

INTERVAL C

Formations included and stratigraphic relations

The Warsaw, Salem, St. Louis, and Ste. Genevieve Limestones comprise interval C and are preserved in both the Hugoton embayment and the Forest City basin (table 1, cols. 65 and 67). Only the Warsaw and Salem Limestones are recognized in central and northern Kansas. In the central part of southern Kansas, some questionable St. Louis is preserved.

Local concentrations of glauconite at the base of the Warsaw suggest a disconformable relationship of the Warsaw on the Keokuk. The Warsaw is conformable below the Salem in western Kansas.

The Salem is less widely distributed than the Warsaw; it is generally preserved basinward from the Warsaw subcrop. Both units are bevelled by the regional angular unconformity developed in Early Pennsylvanian time. Remnants of the Salem normally overlie the Warsaw in the Salina basin, but locally in the absence of the Warsaw, they overlap unconformably on the Keokuk (Lee, 1956).

In western Kansas the St. Louis is conformable with the underlying Salem and the overlying Ste. Genevieve. Within the St. Louis, however, in western Kansas an intraformational erosion surface marks the initial change from carbonate to detrital (quartz sandstone) sedimentation. All the interval C formations probably extended across the Central Kansas uplift and Nemaha anticline, but were removed, along with Osage and Kinderhook rocks, by pre-Chester and Early Pennsylvanian erosion. The Salem and St. Louis increase slightly in thickness basinward. Ste. Genevieve rocks possibly were nearly statewide in their original distribution, but probably were of less areal extent originally than older Meramec rocks.

The upper part of the Cowley ~~Formation~~ facies in south-central Kansas is included in interval C and is regarded as a diagenetic alteration of the Warsaw, Salem, and part of the St. Louis Limestones. Dolomitization, chertification, and pressure solution are thought to be responsible for this ~~apparent~~ facies ~~change~~.

Upper boundary of interval C

The upper boundary of interval C is marked by a pre-Chester and Early Pennsylvanian erosion surface. This interval is overlain unconformably by Chester rocks only in southwest Kansas and by Lower to Middle Pennsylvanian rocks elsewhere (pl. 8).

A karst surface has been identified at the upper surface of interval C in the Midcontinent, including Cherokee County in southeast Kansas, and in the subsurface of Kansas (Hiestand, 1938; Lee, 1940, 1943, 1956; Shenkel, 1944; and Goebel, 1966).

Thickness trends

Interval C attains a maximum thickness of about 850 feet near the southwest corner of the State in the Hugoton embayment (pl. 5A). It thins to the north and northeast to a zero line that generally parallels the southwestern margin of the Central Kansas uplift. In eastern and central Kansas interval C is ~~quite~~ thin and irregularly distributed; it attains a maximum of about 160 feet in two small areas but it is mostly less than 100 feet thick (pl. 9, sec. E-E').

The thickness and distribution of interval C ~~is~~ are largely the result of post-Meramec erosion but in a few places part of the thinning of upper interval C units may be the result of thinning on the flanks of contemporaneous positive structures. The Ste. Genevieve may have been less widely distributed than older units of the interval, and thinning may be depositional and may mark pre-Chester regression of the strandline.

Lithofacies trends

Interval C is dominated by carbonate rock and chert in differing amounts (pl. 5B). The chert is difficult to distinguish from chert in interval B. The chert of interval C decreases in amount from bottom to top and forms only a minor constituent of the Ste. Genevieve. It seems to be more abundant in areas where the interval is relatively thin, perhaps partly because the thin areas are where only the lower beds of the interval are preserved, and partly because chert residuum is included with the interval. This residuum was produced by post-Meramec weathering and was concentrated marginal to the major positive structures.

Interval C contains less shale and claystone than does either interval B or interval D. However, from about midway in the St. Louis upward detrital sand and silt ~~is~~ are evident in interval C, especially in far western Kansas where the greatest thicknesses of the upper part of interval C are preserved. This increase in detrital material is insufficient to offset the lithofacies patterns of plate 5B.

Sources of sediment and environments of deposition

Normal marine deposition of carbonate rocks, largely biogenetic in origin, continued from interval B through more than half of interval C (pl. 11, fig. 3). This was followed by deposition of intraformational limestone conglomerates, oolite and calcarenite beds along with increasing amounts of siliceous sediments. The widespread oolite and calcarenite beds are interpreted as indicating current activity in shallow warm seas. Although the limestone was the product of direct precipitation of carbonate and the accumulation of fossil debris, the siliceous sediment probably was transported into the region from an external source; perhaps, from the Transcontinental arch to the northwest; The change in character of deposits in mid-St. Louis time appears to represent a change in energy in the environment from a relatively low energy to an environment of higher energy. Perhaps this was the result of shallowing of the sea; the Ste. Genevieve probably was deposited in a regressing sea.

or perhaps the Central Kansas Uplift was temporarily, or intermittently, exposed during the deposition of upper interval C rocks.

Paleotectonic implications

Subsidence of the region continued from interval B through interval C time and in southwestern Kansas was sufficient to accomodate more than 800 feet of sediment (pl. 10, fig. 3). The mid-St. Louis erosion surface recognized in western Kansas may mark a short period of uplift in the region accompanied by brief partial withdrawal of the sea. Subsidence may have slowed following this episode; at least, the upper part of the interval suggests an environment of higher energy, perhaps a shallower water environment than earlier. The influx of detrital materials in late interval C time may indicate minor uplift of a distant terrigenous source; perhaps the Transcontinental arch to the northwest (pl. 12, fig. 3). The entire region was uplifted slightly and was probably emergent at the end of interval C time, for interval D rests disconformably on interval C where interval D is present in the southwest part of the State and a pre-interval D karst-like surface appears to have developed on interval C in parts of eastern Kansas.

(See addition p. 36)

INTERVAL D

Formations included and stratigraphic relations

Rocks assigned to interval D are an unnamed sequence of dominantly clastic rocks of Chester age and are limited to a relatively small part of southwestern Kansas (table 1, col. 55). They consist of variegated, dominantly green, shale, lenticular sandstone beds, and lesser amounts of lithographic to crinoidal limestone; they probably include both marine and non-marine beds.

In southeastern Kansas, some dominantly detrital material preserved as sink-fillings might have been deposited during interval D time but these are of such limited extent that they are not shown on any of the maps or sections.

Interval D rests disconformably on interval C; sandstone units of interval D locally fill erosional depressions in the top of interval C.

Upper boundary of interval D

The upper boundary of interval D is a disconformity. Over most of the area of interval D the Kearny Formation of Morrow age rests on interval D, but at the eastern extremity of interval D it is overlain by unnamed beds of Atoka age, and in a small area in Clark County, is overlain by the Cherokee Group of Des Moines age.

Where the Kearny Formation rests on the unnamed rocks of interval D, they are difficult to separate because of lithologic similarities. The upper part of interval D contains common crinoidal limestone beds similar to crinoidal limestone beds in the Kearny but the Pennsylvanian rocks are more arenaceous and glauconitic. The lower beds of interval D are variegated shale and are distinct from the Kearny.

Thickness trends

A maximum of more than 400 feet of interval D is preserved in southwest Kansas (pl. 6A). Thinning of interval D on uplifts and local absence as a result of truncation was reported by Beebe (1959). The edge of preserved interval D forms an irregular arcuate pattern which suggests that the pinch out is erosional.

Lithofacies trends

Interval D is more sandy and muddy around the margin of its distribution in southwestern Kansas and more calcareous in the central and thicker part (pl. 6B). In part this is related to post-interval D erosion; around the margin only the dominantly detrital lower part of interval D is preserved, whereas, centrally where the interval is thicker, the dominantly carbonate upper part is also preserved beneath the erosion surface.

Sources of sediment and environments of deposition

Some of interval D was probably derived from erosion and reworking of exposed interval C and B in northwestern Kansas and the Central Kansas uplift. But it also seems ~~likely~~ possible that much of the material was derived from outside the region, perhaps the Transcontinental arch to the northwest.

The environment of deposition has been interpreted as both marine and nonmarine (Goebel, 1968, p. 1775). Marine deposition was probably in a relatively shallow sea (pl. 11, fig. 4) that produced considerable reworking of the detrital sediment. The strandline periodically may have migrated long distances across the region, but the northern part of Kansas probably was emergent throughout interval D (pl. 12, fig. 4).

Paleotectonic implications and paleogeographic interpretations

The 400 feet of preserved interval D in the Hugoton embayment indicates that marked subsidence took place in this part of the State during the span of interval D time (pl. 10, fig. 4). The absence of interval D in the northern part of the State, the possibility that some of the materials contained in interval D were derived from intervals B and C, and the suggestion that the strandline migrated widely during interval D time, support the possibility that northern Kansas may have been uplifted slightly and was largely emergent during much of Chester time. It is also possible that the Central Kansas uplift was a relatively positive feature at this time.

The end of interval D time marks a change from relatively quiescent tectonic conditions during the Mississippian to more active tectonic conditions that prevailed during the Pennsylvanian. Much of Kansas was uplifted before the invasion of Pennsylvanian seas and an unconformity was formed that in some places is marked by a karst surface.

Geographically (pl. 12, fig. 4) the record of interval D suggests that the southern part of the State may have been covered by a shallow sea; a general east-west trending strip of coastal plain may have extended across the northern part of the State which may in turn have passed northward into a hilly terrane on the southern flank of the Transcontinental arch.

TOTAL THICKNESS OF MISSISSIPPIAN ROCKS

Thickness trends

Mississippian rocks attain a maximum thickness of more than 1700 feet in southwestern Kansas (pl. 7) and thins to the north to about 100 feet in the northwest corner of the State. In central and in eastern Kansas the system attains maximum thicknesses between 400 and 500 feet at several scattered places. The zero isopach outlines the Central Kansas uplift in central and north-central Kansas, and the Nemaha anticline in eastern Kansas.

Paleotectonic implications

Minor movement on the Central Kansas uplift may have taken place during the Mississippian Period but the outline of the uplift, as well as the Nemaha anticline, shown by the pinchout of the Mississippian is mainly a result of post-Meramec and pre-Middle Pennsylvanian erosion.

The total thickness map combines a relatively complex history of widespread marine transgressions and deposition followed by regressions and erosion, and climaxed by major disconformity and erosion at the end of the Mississippian. All of these were related to epeiric uplift or subsidence of the craton or to eustatic rise or fall of sea level. The thick section of Mississippian rocks preserved in southwestern Kansas probably records the minimum subsidence of the Hugoton embayment during Mississippian time.

GEOLOGIC UNITS DIRECTLY ABOVE MISSISSIPPIAN SYSTEM

Units overlying Mississippian

Rocks of Pennsylvanian age rest unconformably on Mississippian throughout Kansas (pl. 8). The Kearny Formation of Morrow age rests on Mississippian intervals C and D along the western edge of the State. It is overlapped by unnamed beds of Atoka age and these beds rest on Mississippian in a narrow belt extending south-southeast from near the northwest corner of the State. The Cherokee Group of Des Moines age overlaps the beds of Atoka age and rests on Mississippian rock throughout the rest of the State.

In most places the base of the Pennsylvanian is marked by a unit of coarse or reworked material; in the western and central parts of the State this unit is a basal conglomerate or sandstone and in the eastern part it commonly is a reworked concentration of chert derived from the residuum at the top of the Mississippian (Merriam, 1963, p. 135).

Paleotectonic Implications

The unconformable contact between Pennsylvanian and Mississippian rocks marks a period of uplift and erosion that was mainly responsible for the present distribution of the Mississippian intervals. The Central Kansas uplift and Nemaha anticline must have been sharply uplifted and eroded. Between Meramec (Late Mississippian) and Des Moines (Middle Pennsylvanian) time, all the Mississippian and older Paleozoic strata were stripped from the elevated parts of these structures and Pennsylvanian rocks of Des Moines age were deposited directly on Precambrian.

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OF 73-6

FORM 9-1325
(REV. OCT. 1968)
USGS-GEOLOGIC DIVISION

MANUSCRIPT REVIEW AND APPROVAL SHEET

TRU SERIAL NO.

BRANCH PROJECT NO.

NO. OF PAGES ______
INCLUDING ______ PAGES OF TABULAR MATERIAL

AUTHOR (give name as it is to appear in publication)

E. D. Goebel and G. F. Stewart

TITLE (for chapters, give chapter and overall titles)

Kansas; Chapter F in Paleotectonic investigations of the Mississippian System in the United States

ILLUSTRATIONS

- ____ Colored maps and plates
- ____ B/W plates
- 2 Text figures
- ____ Photographs

TOTAL

FORM OF PUBLICATION (specify series, journal, meeting or similar detail)

Professional Paper

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