Conodonts and Stratigraphy of the Meramecian Stage (Upper Mississippian) In Kansas

By Thomas L. Thompson
and Edwin D. Goebel

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THOMAS L. THOMPSON, *Missouri Division of Geological Survey and Water Resources*[1]
EDWIN D. GOEBEL[2]

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ABSTRACT

The Warsaw, Salem, St. Louis, and Ste. Genevieve formations in Kansas (all subsurface) are correlative with the type section in the Mississippi River Valley on the basis of their conodont fauna. Total thickness exceeds 850 feet, but formations thin to 0 at erosional edges beneath the Pennsylvanian unconformity. Fifteen well cores are the basis of lithologic determinations augmented by acetate peels, thin sections, insoluble residues, and well cuttings. Carbonate rock types which predominate are of biogenic origin. Locally, diagenesis has altered the rocks. The restricted outcrops in southeastern Kansas are identified as Keokuk Limestone of late Osagian age.

An abundant conodont fauna (1500 specimens) recovered as insoluble residues fixes the age of the Meramecian Stage in Kansas. The fauna includes 40 named species representing 14 genera; nine additional doubtful species are referred to seven genera; two possible new species are included; one specimen representing a possible new genus is described.

INTRODUCTION

Mississippian rocks are widely exposed in the Midcontinent and have been studied locally and regionally in great detail. Outcrops in Kansas are confined to a small area of less than two townships in Cherokee County in the extreme southeastern part of the State. Westward, the Mississippian rocks in Kansas are preserved in basinal areas and are the source of much oil and gas. Accelerated exploration for petroleum reserves in Kansas in recent years has vastly increased the information on Mississippian rocks. The new data include cores and improved electrical, radioactivity, acoustical, and mechanical logs.

Early workers, such as Lee (1940), worked mostly with cable tool samples and used hydrochloric acid insoluble residues in establishing equivalence of Mississippian rocks in Kansas with outcrops in Missouri and in the type section in the upper Mississippi River Valley. When acetic acid is used to digest carbonate rocks, phosphatic material is preserved. Collinson, Scott, and Rexroad (1962) used this recovery technique for conodonts in rocks from the type area of the Mississippian. Thompson and Goebel (1963), in a pilot study of conodonts, used acetic acid on cores of dominantly Meramecian carbonates from western Kansas.

It was judged that the definitive lithic features and the distribution of conodont zones in the Meramecian in Kansas were best tested by studies of cores. This investigation was primarily concerned with and based upon information gained from the study of cores. Drilling companies seldom take long cores. It was necessary, therefore, to assemble a collection of cores, in order to provide a complete Meramecian section.

Although abundant in certain parts of the Meramecian rocks, megafossils, because of their larger size and limited occurrence, have not been used extensively in delineating biostratigraphic zones in the subsurface Mississippian rocks in Kansas. Use of conodonts as guide fossils within the type area of the upper Mississippi River Valley demonstrates the practicality of these forms as tools for correlation. Phylogenetic relationships of the conodonts are controversial. These fossils constitute one of the more important groups of microfossils used as guide fossils. Conodonts have special significance because they are found in a wide variety of depositional environments and are, therefore, useful in correlating facies.

Some of the cores used in a preliminary study of conodonts from western Kansas Meramecian rocks (Thompson and Goebel, 1963) were restudied by Thompson (1965) and Goebel

[1] Based on a Ph.D. dissertation in 1965 by Thomas L. Thompson, Department of Geology, The University of Iowa, Iowa City, Iowa.

[2] Based in part on a Ph.D. dissertation in 1966 by Edwin D. Goebel, Department of Geology, The University of Kansas, Lawrence, Kansas.

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(1966, 1968a). Thompson described and appraised the Meramecian conodont fauna of all of Kansas, and Goebel reported on the stratigraphy of western Kansas Mississippian rocks. This paper incorporates the findings of these two investigations of the Meramecian Stage in Kansas.

ACKNOWLEDGMENTS

Special thanks are extended to the late Louise Jordan, Oklahoma Geological Survey, who made Sinclair Research Company cores available to the State Geological Survey of Kansas and the authors, and Mobil Oil Company for their contribution of cores. Other cores on file at the State Geological Survey of Kansas Well Core Library were utilized, also.

Acknowledgment is extended to Brian F. Glenister, Department of Geology, University of Iowa; Charles W. Collinson, Illinois State Geological Survey; and Carl B. Rexroad, Indiana State Geological Survey, for their interest and assistance and to H. Andrew Ireland, Department of Geology, The University of Kansas.

MATERIAL STUDIED

An attempt was made to secure cores of Meramecian rocks from all portions of the State. The material was chosen for its stratigraphic interval and geographic distribution. The locations of materials used in this study are shown in Figure 1.

Many cores (Table 1) were available from the Hugoton embayment (wells A-I), so only those that enabled complete coverage of the Meramecian section in that region were chosen, care being taken to secure as complete a geographic distribution over the area of the embayment as possible. Three of the cores were originally studied by Thompson and Goebel (1963) for their conodont content: No. 1-A Mark (C), No. 1 Watchorn (D), and No. 1 Collins (F). Sampling procedures were improved by utilizing half of the core (pilot study consisted of 200-gm samples at 1-foot intervals). A higher conodont yield from these cores was expected and achieved.

The central portion of the State presented a more difficult problem in selection of material. No cores were available from the Salina basin. All cores chosen from the Sedgwick basin were from the area containing the "Cowley Formation" of Lee (1940). In this south-central region there is generally no differentiation by lithostratigraphic units between Osagian and Meramecian rocks. Wells J-L are from the Sedgwick basin.

Material available from the Forest City basin of northeastern Kansas was judged not suitable for this investigation. Several cores (M-O) and samples from two outcrops (P and Q) in the Cherokee basin were utilized.

Both cores and outcrops were sampled in an attempt to recover Meramecian conodonts (Table 1), and cores were studied for lithology.

TABLE 1.—Registry of cores from Meramecian rocks. Letters refer to cores in Figure 1 and in the Appendix. (The number of samples processed and identifiable specimens recovered from each well or outcrop are listed in parentheses after their locations.)

A—No. 1 Cunningham Est., Mobil Oil Co., C SW SE sec. 13, T 34 S, R 37 W, Stevens County, Kansas (19 samples, 172 specimens).
B—No. 1 Kells "B," Cities Service Oil Co., C NW NW sec. 5, T 28 S, R 34 W, Haskell County, Kansas (58 samples, 77 specimens).
C—No. 1-A Mark, Atlantic Oil Co., SE SE SE sec. 28, T 20 S, R 33 W, Scott County, Kansas (34 samples, 38 specimens).
D—No. 1 Watchorn, Alma Oil Co., and Robert B. McNeeley, C SW NE sec. 13, T 15 S, R 33 W, Logan County, Kansas (65 samples, 40 specimens).
E—No. 1 Winans, Mobil Oil Co., C SE NW sec. 32, T 20 S, R 27 W, Lane County, Kansas (30 samples, 38 specimens).
F—No. 1 Collins, Mid-Continent Petrol. Corp., C NW NW sec. 24, T 20 S, R 26 W, Ness County, Kansas (31 samples, 117 specimens).
G—No. 1 Elsasser Heirs, Mobil Oil Co., C SE SW sec. 29, T 18 S, R 22 W, Ness County, Kansas (31 samples, 147 specimens).
H—No. 1 Matkin, Mull Drlg. Co., Mobil Oil Co., C NE NW sec. 16, T 27 S, R 21 W, Ford County, Kansas (23 samples, 127 specimens).
I—No. 1 Exchange Bank, Sinclair-Prairie Oil Co., C SE SW sec. 27, T 33 S, R 19 W, Comanche County, Kansas (61 samples, 127 specimens).
J—No. 1 Colburn "A," Sinclair Oil and Gas Co., NE SW NE sec. 9, T 33 S, R 11 W, Barber County, Kansas (33 samples, 41 specimens).
K—No. 1 Helmley, Sinclair Oil and Gas Co., SW SW SE sec. 3, T 35 S, R 10 W, Barber County, Kansas (36 samples, 217 specimens).
L—No. 1 Wolfie, Kessler and Their, Inc., C SW SW NE sec. 17, T 33 S, R 6 W, Harper County, Kansas (9 samples, 7 specimens).
M—No. 1 Dalton "B," Western Petroleum Co., SW NE SE sec. 11, T 24 S, R 12 E, Greenwood County, Kansas (52 samples, 120 specimens).
N—No. 6 H. G. Collins, Sinclair Oil and Gas Co., C SE NE sec. 30, T 23 S, R 14 E, Woodson County, Kansas (29 samples, 107 specimens).
O—No. 12 W. P. Headley "A," Sinclair Oil and Gas Co., C W½ SE NW NW sec. 32, T 23 S, R 14 E, Woodson County, Kansas (28 samples, 270 specimens).
P—Mississippian outcrop, SE NW sec. 1, T 35 S, R 25 E, Cherokee County, Kansas (13 samples, 56 specimens).
Q—Mississippian outcrop; NE NE SW sec. 33, T 34 S, R 25 E, Cherokee County, Kansas (10 samples, 21 specimens).

MERAMECIAN ROCKS

The Meramecian lithostratigraphic units recognized in Kansas (Fig. 2) are, in ascending order, the Warsaw, Salem, St. Louis, and Ste. Genevieve limestones (equivalent to the Warsaw, Salem, St. Louis, and Ste. Genevieve formations of the Mississippi River Valley). Meramecian stage and formation names were extended into the subsurface of Kansas from outcropping areas in Missouri and the upper Mississippi River Valley by Lee (1940). Carbonate rocks are dominant in these strata. In western Kansas, the Salem, St. Louis, and Ste. Genevieve limestones were collectively termed the "Watchorn Formation" (Lee, 1940) before it was possible to differentiate the subdivisions.

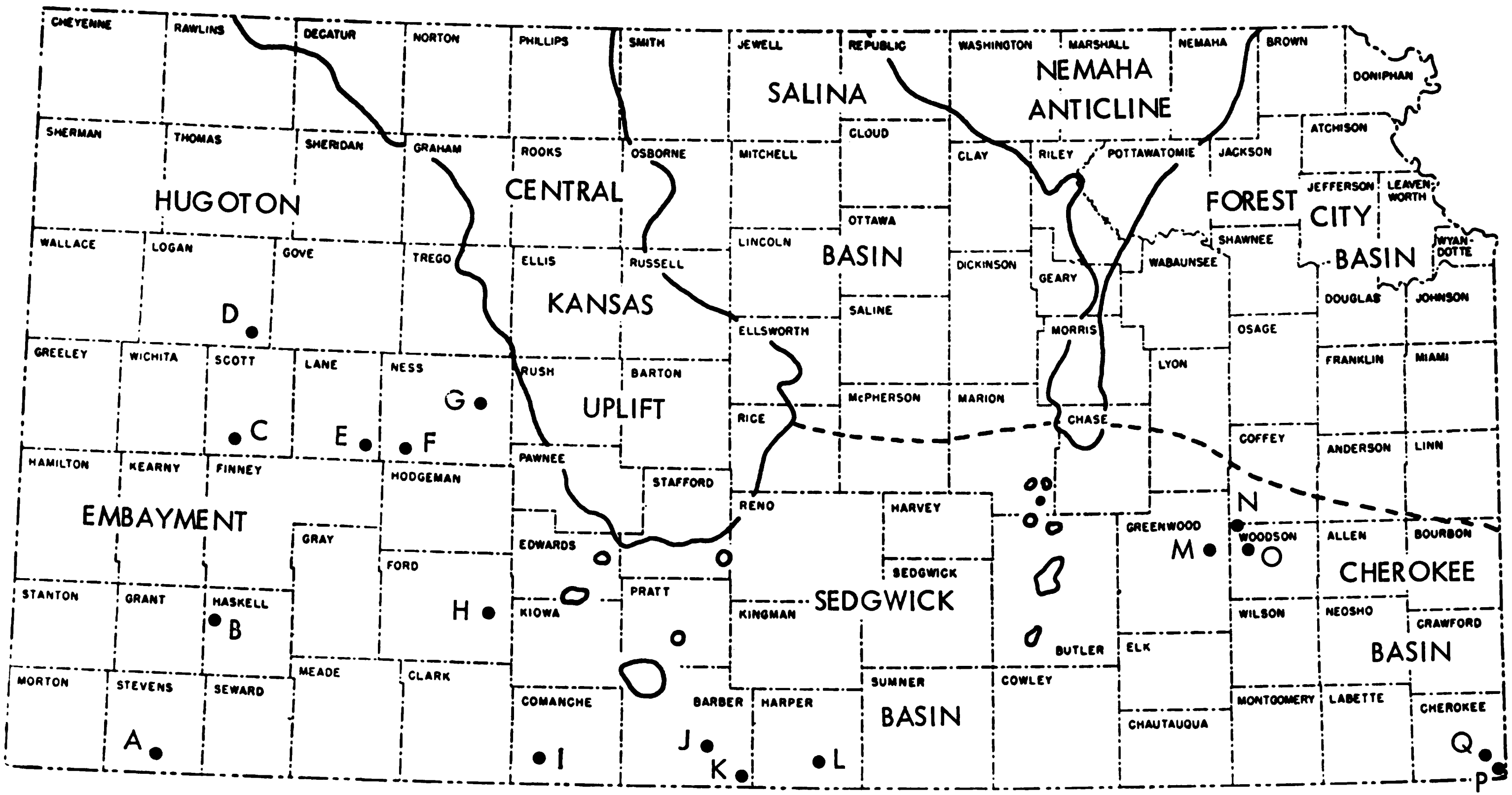


FIGURE 1.—Index map of Kansas, showing early Pennsylvanian structural features and distribution (letters) of cores studied. Locations are listed in Table 1, distribution of conodonts in the *Appendix*.

Lee did not identify the Watchorn in south-central Kansas, where he mapped the Cowley Formation. Later, Lee (1949, 1953) recognized subdivisions of the Watchorn in a limited area of south-central and southwestern Kansas. Data from many more wells than were available to Lee makes possible the subdivisions used in this report.

The thickness of Meramecian rocks ranges from zero in certain places along the trend of the Central Kansas uplift to a known thickness of more than 850 feet in the Hugoton embayment. Meramecian rocks, except for the Ste. Genevieve Limestone, probably originally extended throughout Kansas but were eroded from post-Mississippian highs in early Pennsylvanian time. The distribution pattern of Meramecian formations roughly outlines early Pennsylvanian structural features (Fig. 3). Possible regression of the Meramecian sea in late Meramecian time provided an environment in which some upper Meramecian rocks were eroded before the deposition of Chesteran rocks.

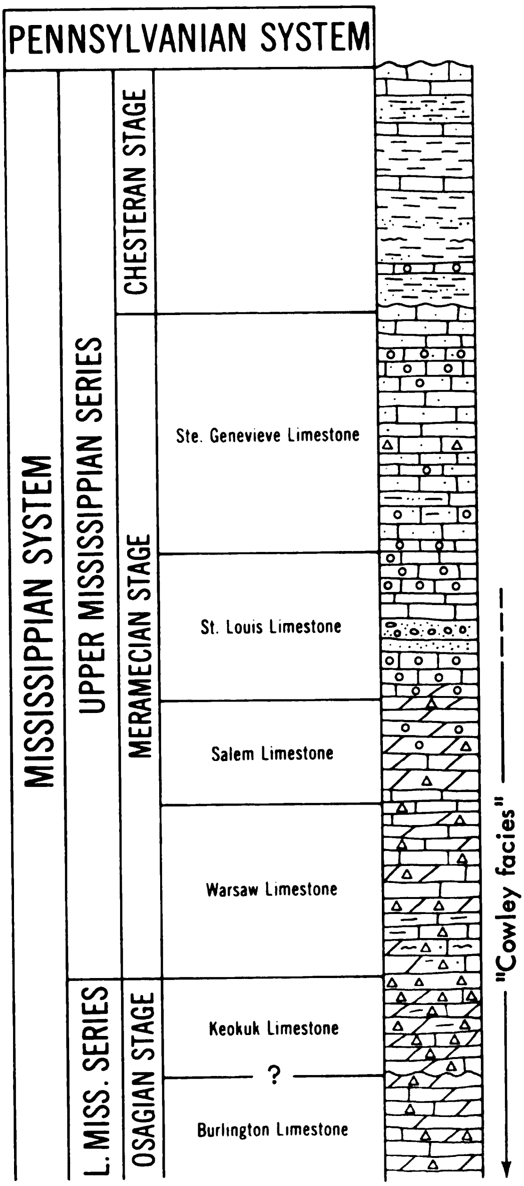


FIGURE 2.—Lithostratigraphic units of the Meramecian Stage recognized in the subsurface in Kansas.

In extreme southwestern Kansas, Meramecian rocks unconformably underlie Chesteran rocks. Elsewhere in Kansas, Meramecian rocks unconformably underlie Pennsylvanian rocks. The unconformity between Meramecian rocks and Osagian rocks is obscure in northeastern and southwestern Kansas.

Maher and Collins (1949) reporting on the Hugoton embayment of southwestern Kansas, southeastern Colorado, and the Oklahoma Panhandle observed:

> The group [Meramecian rocks] thins at both the top and bottom—the thinning at the top is due to the removal by erosion of the Ste. Genevieve, St. Louis, and part of the Spergen [Salem] limestone to the north and east—the thinning at the bottom is due to onlap of the group to the west, north and east, probably resulting in the loss of the Warsaw limestone in the northern part of the embayment and the loss of the Warsaw, Spergen, and most of the St. Louis strata in the southwestern part.

Thinning of formations toward the north and east due to late Mississippian and early Pennsylvanian erosion was observed in western Kansas. No thinning at the bottom was mapped.

Removal by late- and post-Mississippian erosion of rocks from structural highs in Kansas and the widespread development of a residual cherty surface where Mississippian rocks were preserved inhibits lithologic comparisons of formations in distantly separated areas. This erosion reduced the Mississippian surface, preserving greater thickness of Mississippian deposits in synclines (Lee, 1940), or in topographic lows. Reworked chert deposited on the eroded surface of Mississippian limestones is difficult to differentiate from chert weathered in place (residual chert). Locally the residual chert at the top of the Mississippian sequence is as much as 50 feet thick. Osagian rocks are dominantly chert. Difficulty in discerning Mississippian formations has led to widespread use by geologists concerned with oil and gas exploratory drilling of the term "Mississippi lime" for cherty Mississippian rocks.

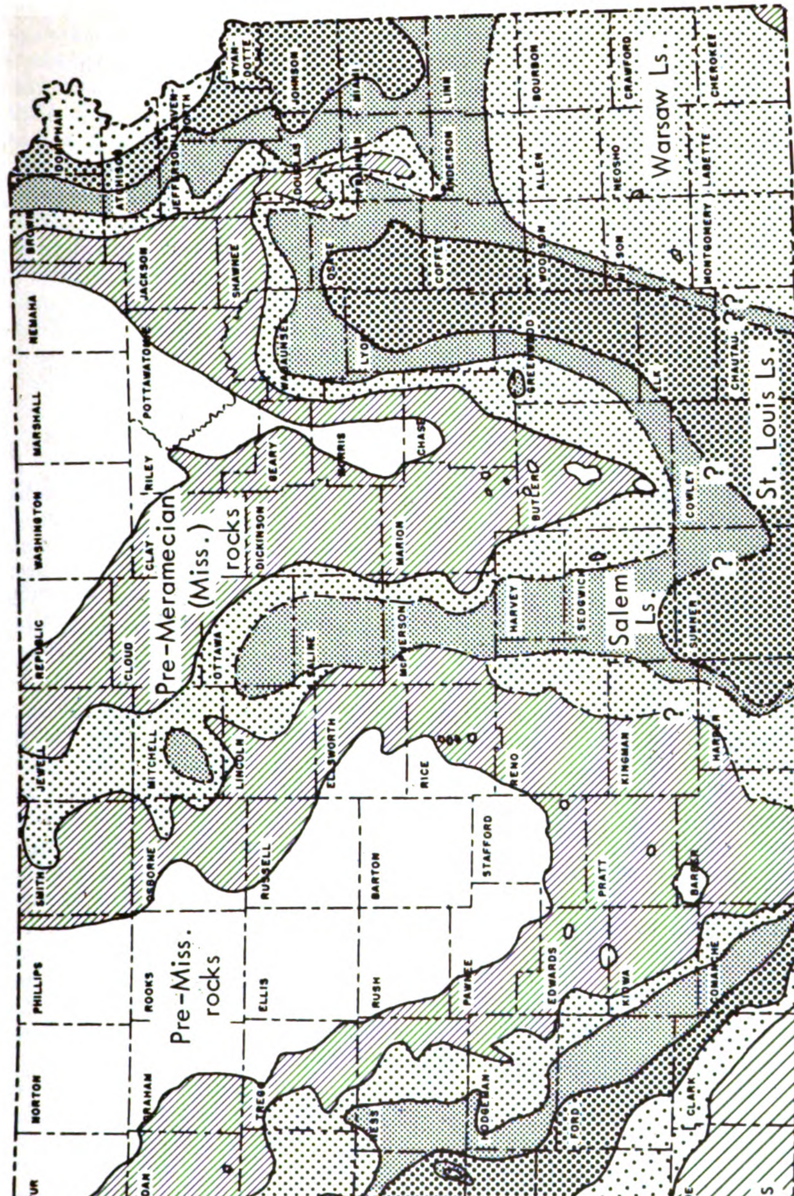


FIGURE 3.—Areal geologic map of Mississippian rocks in Kansas.

WARSAW LIMESTONE

Outcrops.—The Warsaw Limestone was named by Hall (1857) from outcrops near Warsaw, Illinois. Scattered exposures of the Warsaw occur throughout Missouri. In southwestern Missouri, it has been subdivided into numerous units designated by letters (Fowler, Lyden, Gregory, and Agar, 1935).

The position of the boundary between the Osagian Stage and the Meramecian Stage has long been a point of dispute. Spreng (1961, p. 66) reported that some workers regarded the Warsaw in the outcrop areas as the lowest formation in the Meramecian Stage because its clastic (quartz sand and silt) character differed from the calcareous composition of the Keokuk (Osagian) and also because its fauna contained many new species not present in the Keokuk. The Warsaw has been placed in the uppermost Osagian by other geologists because its fauna resembles the Keokuk fauna in many respects, and the boundary between the two formations is obscure in many places. Spreng, however, regarded the Warsaw as the basal formation in the Meramecian and considered it to be in conformable relationship with underlying Osagian rocks. In eastern Missouri, the Warsaw Formation is separated from the overlying Salem (Spergen) Formation by an unconformity and is considered as late Osagian in age, according to Harris and Parker (1964). Hayes (1961) reported a conformable relationship between the Warsaw and Keokuk and a local unconformity between lower and upper Warsaw strata in the Keokuk, Iowa, region. An unconformity above the "Warsaw-like material" in southwestern Missouri has been reported by Fowler and Lyden (1935).

In the type area in the upper Mississippi River Valley, the Osagian and Meramecian are not recognized and the rocks between the Kinderhookian and Chesteran are designated the Valmeyeran Series, which includes the Warsaw. There is general similarity of conodont faunas from late Osagian rocks (Keokuk) and early Meramecian rocks (Warsaw-Salem) in Kansas and in the type area, but the proportion of species in the two is quite different.

Moore, Frye, Jewett, Lee, and O'Connor (1951) placed the Warsaw in the Meramecian in Kansas. The pre-Pennsylvanian section of that report was prepared by Lee and follows earlier work by Lee (1940, 1949). Lee (1956) placed the Warsaw in the Meramecian on the grounds of an identified unconformity at the base of the Warsaw in the subsurface, and because there was no evidence for an unconformity with overlying rocks.

Correlation of the little-known Mississippian outcrops in the extreme southeastern corner of Kansas has been in dispute. Some workers in Missouri and Oklahoma have mapped these strata as Keokuk (Lee, 1940, p. 55). The basal 20 feet of outcrop (Loc. P) in sec. 1, T 35 S, R 25 E (Cherokee County) consists of thick beds of white, fossiliferous chert, containing thin gray limestone beds capped by 30 to 35 feet of gray, dense limestone, partly crinoidal and coarsely crystalline to very finely crystalline. In this outcrop the basal chert and limestone beds previously have been assigned to the Keokuk and the overlying limestone to the Warsaw. This Mississippian outcrop was identified by Fowler and Lyden (1932) as a portion of the "M bed," lying beneath the Short Creek Oölite Member of the Keokuk Limestone.

The abundant occurrence of ***Gnathodus texanus*** Roundy in about a 50:2 ratio with ***Taphrognathus*** recovered from residue studies of outcrop samples, indicates a late Osagian age (*G. texanus-Taphrognathus* Zone). The Warsaw Limestone in Kansas is considered to be entirely Meramecian (Goebel, 1968).

"Cowley facies."—In the southern tier of Kansas counties, from Cherokee on the east to Barber on the west, Lee (1940, p. 66) reported that a concentration of glauconite occurs progressively lower stratigraphically westward in pre-Meramecian rocks. He stated that the glauconite is overlain by thick deposits of gray and dark-colored silty and cherty dolomitic limestone beds that are stratigraphically below the base of the Warsaw. These rocks, together with a glauconitic zone at the base, Lee designated as the "Cowley Formation." Lee mapped the Cowley Formation as cutting out in different areas the Keokuk, Burlington, Reeds Spring, and St. Joe limestones (see Lee, 1940, cross-section F-F′, pl. 7). Lee mapped the Cowley as resting in places on the Northview Shale, Compton Limestone, Chattanooga Shale, and even on pre-Chattanooga beds. The Cowley is not present in Missouri (Lee, 1940, p. 68) but the "J-bed" of the Warsaw in the Tri-state Mining District is an eastward continuation of the transgressive basal portion of the Cowley. Lee (1953, p. 14) traced the "Cowley Formation" as far west as Meade County where no glauconite is present at the base.

Lee (1940) recognized no break between the Cowley and the Warsaw in western Kansas. In a cross-section from Meade County to Smith County, Kansas, Lee (1953) showed the Warsaw as conformable upon the Cowley Formation. The Cowley Formation as reported by Lee

(1940, 1949, 1953, 1956) is characterized by "discontinuity of sedimentation," and its most distinctive rocks are silty and siliceous dolomite, limestone, and dolomitic siltstone. In some areas large quantities of gray and dark-colored opaque fossiliferous chert are present (Lee, 1940, p. 15).

These variations in sedimentary sequence have led some geologists to conclude that the Cowley is a facies of the Keokuk-Burlington-Fern Glen limestones and the Chattanooga Shale. A possible explanation of the discontinuity of sedimentation typical of the Cowley, suggested from sample and core examinations, is that selective and partial chertification locally of rocks from this interval has occurred.

In a footnote, Lee (1940, p. 109) described cores from the Kessler and Thier, Inc. No. 1 Wolfje in Harper County (Core L) as "lithologically and stratigraphically from the Cowley Formation" (Fig. 4, *A, B, C*). Residues from the Wolfje core included specimens of *Cavusgnathus*, indicative of late Meramecian age, mixed with *Gnathodus texanus*. These conodonts and others from cores J and K in the area of the "Cowley" are listed in Table 1 and the distribution given in the Appendix. *Cavusgnathus* first appears in the *Apatognathus? gemina-Cavusgnathus* Zone of the type area. Collinson, *et al.* (1962) referred this zone to the upper part of the St. Louis Limestone. *Gnathodus texanus* seemingly does not range above the *Taphrognathus varians-Apatognathus?* Zone of the type area. The biostratigraphic zone represented by the mixed fauna from the Wolfje core is correlated with the *A.? gemina-Cavusgnathus* Zone. The rocks of the Wolfje core are no older than late Meramecian.

Obviously, assignment of this rock interval in the Wolfje core to the St. Louis Limestone implies its former continuity with the St. Louis Limestone elsewhere in southwestern Kansas and demands relegation of the "Cowley Formation" to "Cowley facies" in the immediate area. The term "Cowley Formation" has been abandoned (Goebel, 1968b). The "Cowley facies" "masks" the Warsaw Limestone (Fig. 4, *D*) in the Sinclair Oil and Gas No. 1 Helmley core (Core K). Locally within the area of the "Cowley facies" the Mississippian rocks are unaltered. Goebel (1966) reported such local areas of Osagian rocks in Barber County. Similarity of the "kicks" (a converging pattern downhole) occurs in the interval of the "Cowley facies" on the electric logs and other mechanical logs.

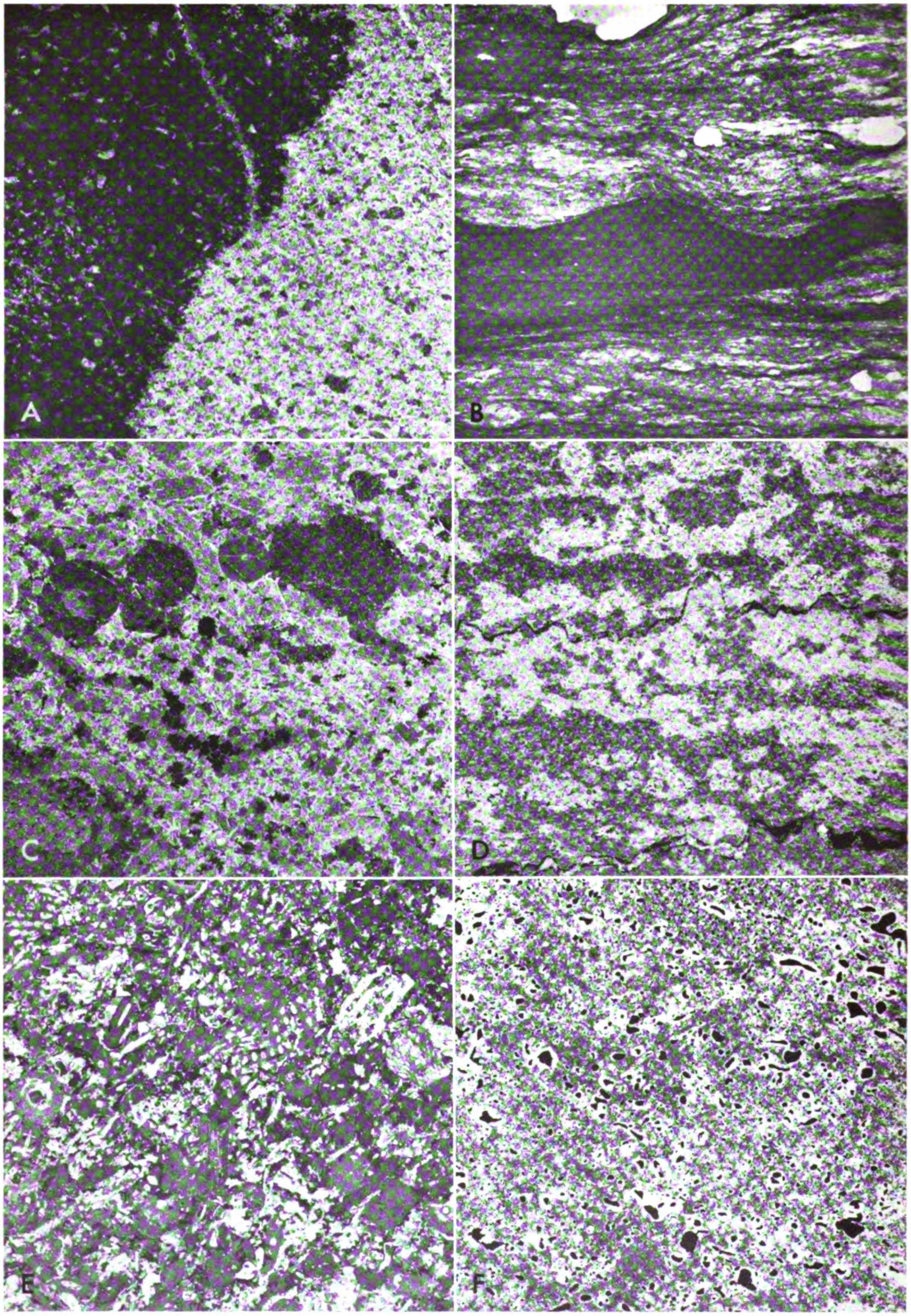
Subsurface character.—The Warsaw Limestone is described from drill cuttings in Kansas outside the area of the "Cowley facies" as semigranular to coarsely crystalline limestone interlaminated with saccharoidal dolomite. It contains varying amounts of gray, mottled, opaque, microfossiliferous chert. Geodic and drusy quartz are local constituents. The residues from the dolomite beds are spongy masses of spicules in some cases. Molds of fossils are present. Pyrite and glauconite are disseminated throughout the formation, and glauconite is locally concentrated near the base.

Core and residue data.—The "Cowley facies" of the Warsaw Limestone in Barber County in Core K (Fig. 4, *D*) is laminated, cherty limestone and chalky calcareous chert that is stylolitic. In cores from Kiowa and Hodgeman counties (Goebel, 1966), the Warsaw Limestone lies directly below Pennsylvanian rocks and is made up of conglomeratic, sandy, dolomitic shale, containing chert. Post-depositional and post-chert fracturing and faulting is exhibited in the Warsaw Limestone in Hodgeman County. In Ness County, in addition to "mixed-fossil" fragmental limestone (Fig. 4, *E*), the Warsaw Limestone is breccia with large fragments of finely crystalline limestone interspersed with green, silty, clayey shale. Fowler and Robbie (1961) defined this lithology as "quasi-breccia." Thompson and Goebel (1963) applied the term to the Warsaw Limestone in Core F. The Warsaw Limestone of Scott County consists of calcarenite as well as cherty limestone. Residues contain typical Warsaw glauconite. In Greenwood County, the Warsaw (Core M) contains beds of "fossil-casts" in siliceous dolomite (Fig. 4, *F*).

Thickness, distribution, and stratigraphic relationships.—The Warsaw thins toward structural highs such as the Central Kansas uplift and the Nemaha anticline and thickens southward toward the Oklahoma Panhandle. It is more than 250 feet thick in its maximum development in Meade County, Kansas. It is 30-40 feet thick in the Forest City and Salina basins.

Overlap of Warsaw Limestone by Salem Limestone and St. Louis Limestone from northeastern Kansas into Iowa was illustrated by Lee (1956). The Warsaw and upper Osagian rocks once probably extended over the Central Kansas uplift but were removed by pre-Chesteran or early Pennsylvanian erosion (Fig. 3).

Local concentrations of glauconite in the lower part of the Warsaw in western Kansas mark a disconformity above the Keokuk. The Warsaw seemingly is conformable below the Salem.


A
B
C
D
E
F

SALEM LIMESTONE

Outcrops.—The Salem Limestone was named by Cummings (1901) from exposures in Washington County, Indiana. Thick and nearly complete exposures of the Salem Limestone occur in southeastern and east-central Missouri. Early reference to the Salem Limestone as the Spergen Limestone is common in the literature, but adoption of Salem in Missouri and Kansas is in accord with present usage of the U.S. Geological Survey and the Illinois and Indiana Geological Surveys. The Salem is conformable above the Warsaw in outcrops.

Subsurface character in Kansas.—Lee (1943, p. 75) mapped the Salem from Missouri into northeastern Kansas and subsequently (Lee, Leatherock, and Botinelly, 1948) into the Salina basin. In the latter area, Lee noted that the Salem had a less widespread distribution than the Warsaw. Most of the Salem is preserved in structural basins as a noncherty, yellowish-gray granular limestone interstratified in the upper part with noncherty, saccharoidal dolomite. Specimens of *Endothyra* are present. Silt and masses of sponge spicules were recovered in the residues. Remnants of the Salem in the Salina basin normally overlie the Warsaw, but where the Warsaw is absent they overlap upon the Keokuk-Burlington sequence (Lee, 1956, p. 85).

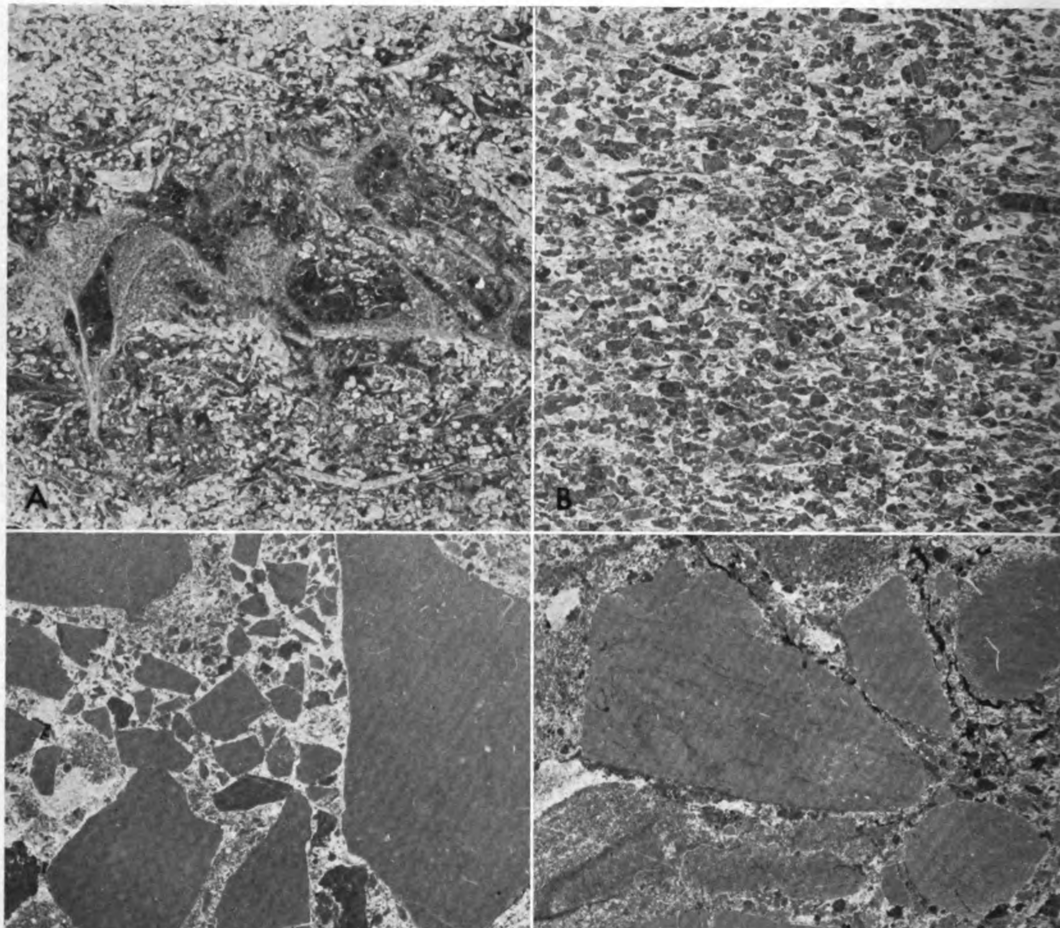
In the southwestern Kansas the Salem consists mainly of semigranular and granular limestone, in part dolomitic. This helps to distinguish it from the overlying St. Louis Limestone. Microfossiliferous chert similar to that found in the underlying Warsaw Limestone occurs in some Salem beds, but the proportion of chert in samples from the Salem is distinctly less than in the Warsaw. *Endothyra* occurs sparsely to abundantly in cuttings from the Salem Limestone and also occurs in the St. Louis Limestone. Lee (1953) described the limestone in the Salem as containing algae-coated grains and reported the lack of oölites in the cuttings from the Salem in a small area of western Kansas. Algae-coated grains were not observed in the drill cuttings or cores.

In cores and well records, the Salem Limestone was found to consist of coarsely crystalline, oölitic limestone with fragmented fossils and saccharoidal dolomite, dolomitic limestone, and chert. The distinctive salmon-pink, semi-opaque, and dark-gray chert commonly found in the Salem in the subsurface of east-central Kansas (Lee, 1956) was found only sparingly in samples from wells in western Kansas. Where the Salem Limestone is oölitic it is difficult to distinguish from the overlying oölitic facies of the St. Louis Limestone. The limestone of the Salem is lighter in color than the overlying St. Louis Limestone, and the chert is light-colored, granular, and fossiliferous. Some drusy quartzose chert and geodic quartz is present.

The Salem is differentiated from the Warsaw on the basis of smaller proportions and a different kind of chert, generally abundant *Endothyra*, sparse glauconite, local oölitic lenses, and dolomitic limestone and saccharoidal dolomite.

Core and residue data.—The lithologic description of the Salem Limestone is taken from cores from Comanche, Ford, Scott, Logan, and Lane counties. In Comanche County, the Salem consists of semicrinoidal limestone with thin oölitic beds. The Salem in Ford County is a calcarenite containing quartz sand and glauconite. In Scott County, in the deeper part of the Hugoton embayment, the Salem consists of a variety of lithologies including calcarenite, fossiliferous limestone, and dolomite with sparse chert. Uncrushed bryozoan fronds are preserved in oölitic limestone (Fig. 5, *A*), and shallower beds contain calcarenite (Fig. 5, *B*). Part of the Salem in Logan County is dolomite with calcite-filled "fossil-casts." Crystalline limestone makes up part of the Salem in Lane County. The amount of residue from the Salem Limestone is a small proportion of the original rock.

FIGURE 4.—Polished core slabs from St. Louis Limestone from Harper County (A-C), and Warsaw Limestone from Barber County (D), Ness County (E), and Greenwood County (F). *A-C*, Kessler and Thier No. 1 Wolfie, Harper County, Kansas (Core L, Table 1). Lee (1940, p. 109) described the core interval from 4,425-4,439 feet in this borehole as "lithologically and stratigraphically from the Cowley Formation." A mixed conodont fauna from residues indicates late Meramecian age. *A*, "Cowley facies" of the St. Louis Limestone (4,430 feet); peel-print of calcarenite with pieces of bluish-white microfossiliferous chert, ×3. *B*, "Cowley facies" of the St. Louis Limestone (4,436 feet); photograph of wavy-bedded, calcareous, silty shale with random pieces of chalky and chalcedonic chert, ×1. *C*, "Cowley facies" of the St. Louis Limestone (4,440 feet); peel-print of semicrinoidal limestone with pieces of bluish-white microfossiliferous chert, ×3. Groundmass is crystalline calcite. *D*, "Cowley facies" of the Warsaw Limestone (4,790 feet); peel-print of chalky, calcareous, shaly, stylolitic chert, ×3. Residues nearly 85 percent by weight. From Sinclair Oil and Gas No. 1 Helmley (Core K), Barber County. *E*, Warsaw Limestone (4,492 feet); peel-print of "mixed fossil" fragmental limestone containing little chert, ×3. From Mid-Continent No. 1 Collins (Core F), Ness County. *F*, Warsaw Limestone (1,782 feet); peel-print of "fossil-casts" in siliceous dolomite, ×3. From Western Petroleum Co. No. 1 Dalton "B" (Core M), Greenwood County.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Thickness, distribution, and stratigraphic relationships.—The Salem unconformably underlies the Pennsylvanian in places (Fig. 3). The formation increases in thickness southward from 0 feet along the outline of the Pennsylvanian subcrop pattern to more than 200 feet in the Hugoton embayment. The small amount of Salem present is attributed in great part to exposure and erosion in late Mississippian and early Pennsylvanian time. The Salem is present and conformable beneath the St. Louis throughout much of southwestern Kansas, generally thickening basinward into the Oklahoma Panhandle. The Salem is conformable upon the Warsaw. It is about 50 feet thick in the deepest part of the Salina and Forest City basins.

The Salem is mapped beneath the St. Louis in southeastern Barber County and western Harper County. This is the first report of Salem in the Sedgwick basin. Warsaw, Salem, and St. Louis equivalents are probably widespread in the southern portion of the Sedgwick basin but have not been recognized because of the "Cowley facies" and because either the chert residuum of the "Mississippi chat" or chertified rocks conceal them. A thin section of Salem rocks is reported in Woodson County in eastern Kansas (Cores N and O).

ST. LOUIS LIMESTONE

Outcrops.—The St. Louis Limestone was named by Engelmann (1847) for exposures at St. Louis, Missouri. In the type area, the formation is a gray, lithographic to finely crystalline limestone. Spreng (1961) reported that limestone breccia is common in, but is not confined to, the lower part. *Lithostrotion proliferum* (Hall) and *Lithostrotionella castelnaui* (Hayasaka) are compound corals that are diagnostic of the formation.

Subsurface character.—Lee (1943, p. 76) described the St. Louis Limestone in the Forest City basin as a lithographic to sublithographic limestone interstratified with semigranular limestone that has oölitic beds in some localities. The preservation there of part of a once-widespread formation is attributed to its protection from erosion in a post-Mississippian basin.

Westward, on the basis of the absence of lithographic limestone in the interval above the Salem Limestone in wells in the Salina basin, Lee (1956, p. 85) assigned the total thickness of post-Warsaw rocks to the Salem, even though the total thickness in one well (Auto Ordnance-Darby No. 1 Gawith, sec. 27, T 11 S, R 5 W) was double the average thickness of the Salem in that basin. Lee (1940) included the St. Louis of western Kansas in the Watchorn Formation, but did not identify St. Louis or Watchorn in south-central or southeastern Kansas.

The St. Louis Limestone in western Kansas is thought to be conformable with Meramecian rocks above and below it. The beds are characteristically noncherty, lithographic and sublithographic limestone, but also include remarkably widespread oölitic limestone and calcarenite. Semigranular limestone containing traces of translucent chert is found in some wells. In the deeper part of the Hugoton embayment the St. Louis contains coarsely crystalline limestone and dolomitic limestone. The upper part of the St. Louis is arenaceous and light colored; sand grains generally are larger than in the overlying Ste. Genevieve Limestone. Chert, which occurs sparingly in the upper part in some wells, is light colored, smooth, and semiopaque. The dolomite in the lower part is saccharoidal in texture; a few embedded sand grains were observed, and fewer oölitic beds are present. This portion of the St. Louis tends to be darker colored (tan or brown) than the upper portion.

In a study of a limited area in southwestern Kansas, Lee (1953) observed that the absence of silty limestone differentiated the St. Louis from the Ste. Genevieve. Clair[3] described the oölites in the coarsely oölitic, dense St. Louis Limestone in western Kansas as very large and spherical. Clair observed an abundance of large free oölites where the matrix was coarsely crystalline. Where the St. Louis is a finely oölitic limestone, he reported that the oölites are nearly the same color as the matrix and spherical. He distinguished the Ste. Genevieve from the St. Louis on

[3] Clair, J. R., 1948, Preliminary notes on lithologic criteria for identification and subdivision of the Mississippian rocks in western Kansas: Kansas Geol. Soc., Wichita, p. 1-14. [Mimeographed report.]

FIGURE 5.—Negative peel-prints (×3) prepared from polished core slabs of Salem Limestone (A and B) and St. Louis Limestone (C-E) (Atlantic Oil Co. No. 1-A Mark; Core C, Table 1), Scott County, Kansas. *A*, Salem Limestone (5,026 feet); bed of oölitic limestone with lens containing well preserved fenestrate bryozoan fronds. *B*, Salem Limestone (4,983 feet); bed of poorly sorted biocalcarenite exhibiting lineation of grains. *C*, St. Louis Limestone (4,898 feet); bed of chert breccia in groundmass of silty calcareous shale. Fragments consist of gray, semi-opaque ordinary chert. Residues contain silicified fossil fragments. *D*, St. Louis Limestone (4,862 feet); bed of limestone breccia containing subangular fragments of fine-grained limestone in groundmass of calcareous silty shale with sparse fine frosted sand grains. *E*, St. Louis Limestone (4,812 feet); bed of coralline limestone (*Lithostrotion proliferum*) in fine-grained calcareous groundmass.

the basis of very tiny, elliptical oölites, all darker than the containing matrix. These lithologic criteria were not found useful in our study of cores of the St. Louis Limestone.

Hundhausen (*in* Lee, 1940, p. 83), using hydrochloric acid residues, subdivided rocks of Meramecian age encountered in the Spangler well in Scott County (sec. 23, T 20 S, R 33 W) into Warsaw, Spergen, and St. Louis. Girty (1940, p. 84) said the Spangler well contained ". . . fossils definitely identified . . . as St. Louis although no limits were set"—fossils indicative of age equivalents of late Meramecian time. The residues were reported by Lee as being small in quantity and consisting mainly of gray translucent silica enclosing gray, opaque fossil fragments.

Core and residue data.—The lithology of the St. Louis Limestone is variable. In Scott County, the St. Louis contains beds of oölitic, stylolitic, arenaceous limestone and calcarenite with shale partings occurring throughout. Generally, the characteristics of the St. Louis in Scott County are common to the formation in western Kansas. Beds of limestone breccia, limestone conglomerate, and chert breccia have developed locally in the St. Louis (Fig. 5, *C, D*) providing evidence of intraformational erosion in the Hugoton embayment. Corals similar to those reported in the type area of the St. Louis (*Lithostrotion proliferum*) are preserved in Scott County (Fig. 5, *E*).

Thin section examination of limestone (Fig. 6, *A-D*) from the St. Louis reveals fragments of echinoderms, brachiopods, bryozoans, and foraminifers as skeletal elements of the calcarenites. *Endothyra,* common in the underlying Salem Limestone, is also found in the St. Louis Limestone.

Beds of anhydrite were logged in the St. Louis Limestone of Stevens and Hamilton counties. This occurrence was verified from core chips of the Mobil No. 1 Cunningham Est. (Core A) and No. 1 Alden Foster (sec. 5, T 34 S, R 36 W).

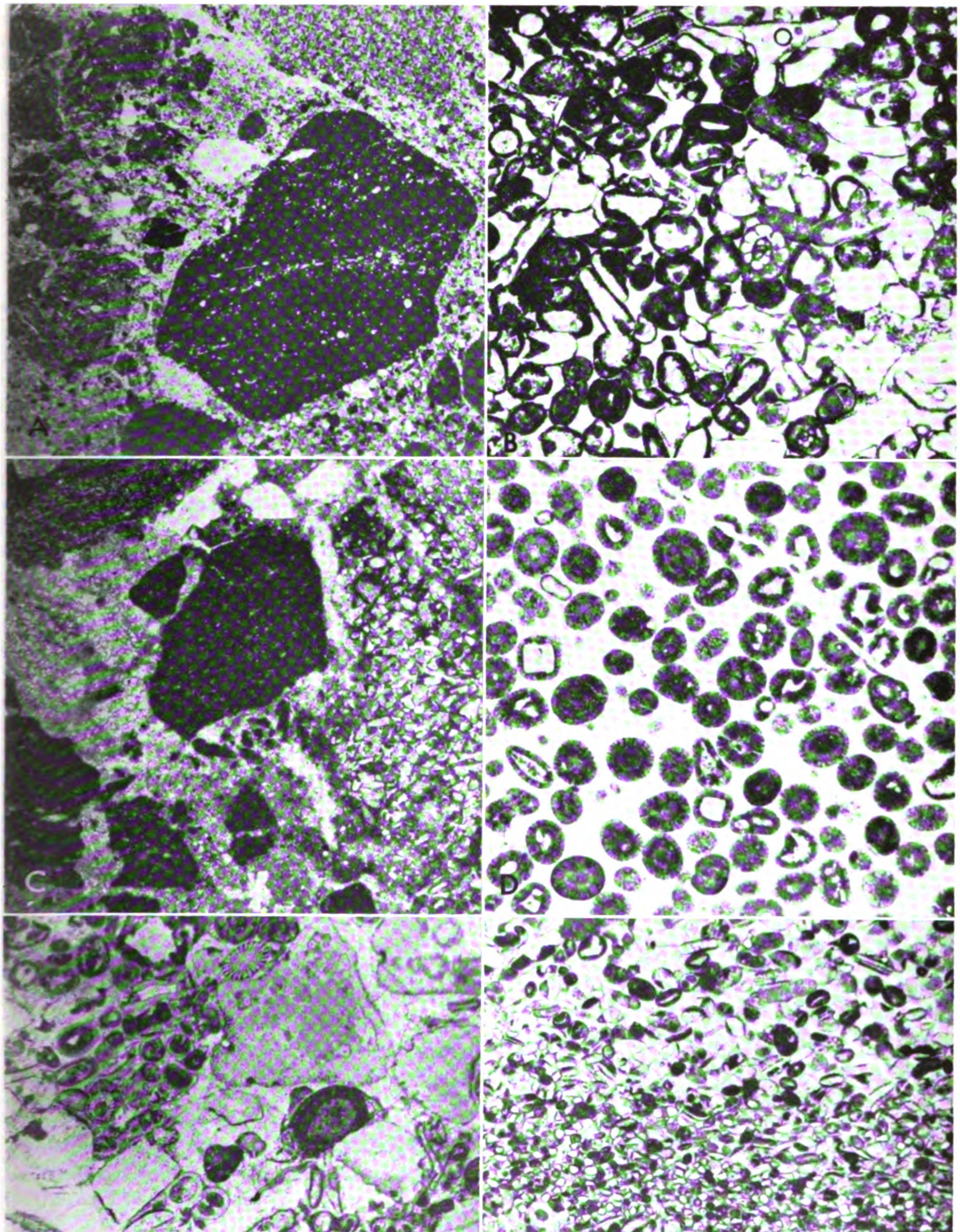
The St. Louis contains more interbedded shale in Comanche County than it does farther west. To the east, in Barber and Harper counties, the "Cowley facies" of the St. Louis is developed (Cores J and L). To the northwest in Gove County, the St. Louis contains quasi-brecciated, fossiliferous and sparsely cherty limestone (Thompson and Goebel, 1963).

Mineral and rock residues from cores from the St. Louis Limestone generally constitute less than 5 percent by weight and consist of shale, silicified fossil fragments, chert, conodonts, and trace amounts of pyrite and sphalerite. Some residues contained a few small quartz grains.

Thickness, distribution, and stratigraphic relationships.—The St. Louis Limestone in Kansas thickens from an erosional edge below the Pennsylvanian rocks to more than 250 feet in the deeper parts of the Hugoton embayment where it averages about 200 feet in thickness. It has not been recognized in the Salina basin (Fig. 3). Maximum thickness in the Forest City basin is about 50 feet. It is present in the Cherokee basin in Woodson and Greenwood counties.

The St. Louis Limestone is conformable above the Salem and below the Ste. Genevieve, except locally, where the Ste. Genevieve was removed and the St. Louis is overlain by Chesteran rocks. Where younger Meramecian rocks have been removed by early Pennsylvanian erosion, the St. Louis is unconformable beneath Pennsylvanian rocks. The St. Louis Limestone probably covered most of Kansas at one time. Lee (1956, p. 83) mapped St. Louis in the Forest City basin and stated that although neither the St. Louis nor the Ste. Genevieve have been recognized in the Salina Basin, they were probably

FIGURE 6.—Photomicrographs of core slabs and chips from the St. Louis Limestone (A-D) and the Ste. Genevieve Limestone (E and F) from western Kansas. *A*, St. Louis Limestone, Logan County (Core D, Table 1, 4,576 feet); conglomerate containing lithiclasts of "mixed-fossil" lime mudstone in quartzose "mixed-fossil" lime groundmass. ×3. Skeletal fragments of echinoderms, bryozoans, brachiopods, and foraminifers and pellets and fine-grained quartz sand. *B*, St. Louis Limestone, Finney County (McKnab Lindsay No. 7 Kuhn-Devlin, sec. 19, T 26 S, R 34 W, 5,138-5,149 feet); oölitic calcarenite with skeletal fragments of echinoderms, foraminifers (*Endothyra*, center of photo), bryozoans, and brachiopods in calcite spar, ×15.6. Oöliths exhibit overgrowths reflecting shape of nuclei. Evidence of pressure solution displayed by concavo-convex relationships of grains and oöliths. *C*, St. Louis Limestone, Haskell County (Helmerich and Payne No. 1 Eubank, sec. 28, T 28 S, R 34 W, 5,642 feet); quasi-brecciated micrite in which mud blebs are separated by silty, calcareous spar, and "mixed-fossil" lime mudstone, ×15.6. *D*, St. Louis Limestone, Haskell County (No. 1 Eubank, 5,514 feet); oölitic limestone in groundmass of spar; no free skeletal grains, but skeletal fragments make up nuclei of oöliths. Little pressure solution but significant recrystallization as shown by spar stringer transecting oölites in upper right quadrant, ×15.6. *E*, Ste. Genevieve Limestone, Haskell County (No. 1 Eubank, 5,447 feet); oölitic calcarenite (60 percent grains), made up of skeletal fragments of echinoderms, brachiopods, bryozoans, foraminifers, and gastropods, ×15.6. Irregularly ellipsoidal to spherical-shaped oölites display concentric structure and are fine to coarse sand size. *F*, Ste. Genevieve Limestone, Haskell County (Core B, 5,613 feet); fine- to medium-grained calcarenite; grains mostly skeletal fragments of echinoderms, brachiopods, and bryozoans in sparry calcite groundmass, ×15.6.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deposited and subsequently removed by early Pennsylvanian erosion. Occurrence of beds of limestone breccia, limestone conglomerate, chert breccia, and anhydrite within the St. Louis Limestone in western Kansas indicates intraformational erosion and seemingly separates a younger conodont zone from an older conodont zone. The intraformational erosion also marks the first important occurrence of quartz clastic material as sediment in Meramecian rocks.

STE. GENEVIEVE LIMESTONE

Outcrops.—The Ste. Genevieve Limestone was named from Ste. Genevieve, Missouri, by Shumard (1860). It is typically developed in Ste. Genevieve and St. Louis counties in east-central Missouri (Spreng, 1961, p. 70). A locally developed basal conglomerate marks a disconformity above the St. Louis Limestone. Pre-Chesteran erosion removed some of the upper Ste. Genevieve beds.

Subsurface character.—Lee (1943, p. 77) described the Ste. Genevieve in northeastern Kansas as gray to white, finely granular to "mealy," oölitic limestone that contains 10 to 20 percent broken, angular, fine-grained quartz sand. He believed the Ste. Genevieve was conformable on the St. Louis in northeastern Kansas. The Ste. Genevieve is absent in the Salina basin in north-central Kansas (Lee, 1956).

The Ste. Genevieve in western Kansas is a silty and sandy, light-colored limestone, with interbedded fine-textured oölitic limestone. Some medium- and coarse-grained oölites occur in the lower part of the Ste. Genevieve. Beds of Ste. Genevieve strata cannot be positively identified where they overlie the finely oölitic limestone of the St. Louis. The shape of oölites which Clair[4] used as a criterion was not found useful in distinguishing the Ste. Genevieve from the St. Louis. The criterion of a larger percentage of sand (up to 30 percent) in the limestones of the Ste. Genevieve is useful in some areas. Minor quantities of pink chert occur locally. Fragments of megafossils are scarce in drill cuttings.

Core and residue data.—Cores from the Ste. Genevieve Limestone in Logan County include siltstone and calcarenite in wavy-bedded shale. Well-rounded sand grains are present in the matrix. Cores from Scott, Haskell, (Fig. 6, *E*, *F*), and Kearny counties contain similar rocks. Residues range from more than 65 percent to less than 1 percent insoluble and consist of shale, silt, quartz sand, pyrite, and chert.

[4] *Ibid.*

Thickness, distribution, and stratigraphic relationships.—The Ste. Genevieve Limestone in Kansas is more than 200 feet thick in the deeper part of the Hugoton embayment. It thins northward and eastward to 0 feet. The Ste. Genevieve Limestone locally is disconformable beneath Chesteran rocks, unconformable beneath Pennsylvanian rocks, and is seemingly conformable on the St. Louis Limestone. Locally in western Kansas it has been removed by pre-Chesteran erosion. The Ste. Genevieve is about 30 feet thick in Doniphan and Atchison counties in northeastern Kansas. Ste. Genevieve rocks have not been recognized in the Salina or Sedgwick basins (Lee, 1956), but at some time may have extended throughout Kansas. Because of regression of the late Meramecian sea, distribution of Ste. Genevieve rocks was more limited than older Meramecian units.

RESIDUE ANALYSES

Chert is considerably less common in Meramecian than in Osagian rocks. Generally, chert from Meramecian rocks is concentrated in the Warsaw, and the microfossil content is higher than in Osagian chert. Chert generally decreases upward in Meramecian rocks and is a minor constituent in the Ste. Genevieve Limestone.

Glauconite in Meramecian rocks seemingly decreases upward. It is locally concentrated in the lower part of the Warsaw. Traces of glauconite are common in many of the residues.

Traces of pyrite, sphalerite, chalcopyrite, and galena indicate secondary sulfide mineralization. Anhydrite is present as fracture fillings. Pyrite is a common residue. In general sulfide minerals are less abundant in the residues from Meramecian rocks than from Osagian rocks.

Generally, smaller quantities of clay-sized particles from Meramecian rocks were washed away through the 100-mesh screen during laboratory procedures than the quantities discarded from Osagian cores. This lesser clay content is obvious from visual inspection of Osagian and Meramecian rock cores.

Insoluble (hydrocloric acid) residues from exposed Meramecian rocks have been found useful in Missouri in identifying laterally equivalent units in some restricted areas (Grohskopf and McCracken, 1949). Lee (1940, 1949, 1953, 1956) used some of these gross residue characteristics in conjunction with sample examination to extend Meramecian units into Kansas. Some of these gross residue and sample characteristics have been found unsatisfactory when applied to western Kansas Meramecian rocks. Of these, color, texture, and transparency of cherts are thought to be locally controlled and to be of little use in mapping, even within a basin. Use of these local characteristics, however, may be feasible within one oil field where boreholes are closely spaced.

Recovery of fragments of silicified and partly silicified fossils as residue material from Meramecian rocks is common. Additional study of these fragments and of megafossils in cores is suggested and should yield information on the environment of deposition, the diagenesis, and the age of the rocks.

ENVIRONMENT OF DEPOSITION AND DIAGENESIS

Meramecian rocks, including the part of the section from the Warsaw Limestone into the St. Louis Limestone, were deposited in an environment similar to that in existence during Osagian and part of Kinderhookian time (Goebel, 1966). Shallow, warm, clear, epicontinental seas of marine salinity covered most of the central and western interior of the United States during most of this time. The main source of sediment was biogenic, including skeletal material of pelagic and benthonic invertebrate animals in great variety, especially corals, brachiopods, bryozoans, foraminifers, gastropods, conodonts, and scolecodonts. Fish remains and sharks' teeth are also preserved. Platform or shelflike conditions typify the environment of deposition. Sands and shales make up only a minor part of the preserved section of rocks below about the upper half of the St. Louis Limestone.

A great variation in lithology was revealed in study of photographs and acetate peel-prints of Meramecian cores (Fig. 4-6). The lithologies include fine-grained lime mud, pelletoid and oölitic limestone, calcareous dolomite, calcarenite, conglomerate, and brecciated limestone. These indicate changing depositional environments.

The water was probably well agitated at times, as attested to by the presence of cross-bedding in some of the Meramecian rocks. Widespread development of oölites and beds of calcarenite may be interpreted as indicating intermittant current action sustained over a long period of time in shallow and restricted seas. The lime muds probably indicate protected areas with a low level of current action.

Downwarping, coupled with accumulation of mixed-fossil and oölitic limestone beds, could account for the basinward thickening of shelf deposits. Widespread distribution of oölitic limestone beds reflects shifting of areas of accumulation or environments of deposition in time and space.

Thinly laminated glauconite in some öolitic beds may indicate shallow-water deposition. Bedded anhydrite in the St. Louis Limestone is probably indicative of local deposition in a closed or shallowing basin. Anhydrite precipitation probably occurred with progressive shallowing of waters and restriction of circulation caused by a drop of sea level or by maintenance of static sea level relative to the building up of shoals.

Diagenetic changes in Meramecian rocks are shown by the presence of sulfide minerals, dolomitized rocks and fossils, siliceous fossil fragments, and probably by chertified rocks. Molds of calcareous fossils in dolomite attest to the dolomitization of some limestone beds. Dolomitization locally destroyed much of the original texture of some of the limestone beds and fossils. Relict textures in dolomite indicate that the original rock in some places was fine- to coarse-grained fossiliferous limestone.

Bedded anhydrite and breccia and conglomerate within the St. Louis Limestone reflect a change in regimen of the Meramecian sea in western Kansas. The environment of deposition of Meramecian rocks definitely changed at the time of the deposition of the Ste. Genevieve Limestone, which is characteristically arenaceous. Quartz sand and silt became important constituents of the sediments at this time and increased in importance throughout Chesteran and into Pennsylvanian time.

It is doubtful that Ste. Genevieve rocks covered all of Kansas. Probably the Central Kansas uplift and the Nemaha anticline areas during late Meramecian time contributed important quantities of terrigenous material to the clastic and detrital content of sediments in adjoining basins of deposition. And probably at this time, rocks in the area of these upwarpings and areas of provenance included older Mississippian rocks, which had a high chert and silicified fossil content, and arenaceous pre-Mississippian rocks.

MERAMECIAN CONODONT FAUNA

The conodont fauna recovered comprises over 1,500 identifiable specimens (Appendix). They were obtained from over 500 samples processed from cores of 15 wells, and from two outcrops (Table 1). From this fauna 40 named species representing 14 genera are identified; nine additional forms of doubtful specific identity are referred to seven genera; two possible new species of two genera are included; one specimen representing a possible new genus and species is described. A complete list of specimens recovered, including stratigraphic ranges, is shown in Table 2.

Gnathodus texanus Roundy comprises over half of the specimens, and nearly half of the remaining forms are *Taphrognathus varians* Branson and Mehl. Listing the other species in numerical order would be misleading, for frequency is largely a function of the number of samples processed from each zone. Numerically insignificant species are useful in identification of some zones that are not well represented in the material processed. The following discussion of the zones established by Collinson, *et al.* (1962) includes these less numerous species where they are valuable in the identification of a zone.

The Meramecian Stage, comprising the upper part of the Valmeyeran Series in the type section in the Mississippi River Valley, is composed of two complete concurrent-range zones and the lower portion of a third. These zones are described below in ascending order.

TAPHROGNATHUS VARIANS—APATOGNATHUS? ZONE

The base of this zone is defined (Collinson, *et al.*, 1962, p. 24) by the lowest occurrence of species of questionable generic reference to "*Apatognathus?*", and by the lowest occurrence of numerous *Taphrognathus varians.* The upper limit is established where *Cavusgnathus* replaces *Taphrognathus* as the dominant form, and by the lower limit of occurrence of *Apatognathus? gemina* (Hinde) and *A.? porcata* (Hinde). The range of this zone corresponds to the Warsaw, Salem, and lower portion of the St. Louis formations in the Mississippi River Valley, from early to early late Meramecian age. The zone is characterized by *Apatognathus?* n.sp. A Rexroad and Collinson, *Gnathodus texanus* Roundy, *Neoprioniodus acampylus* Rexroad and Collinson, *N.* sp.cf. *N. cassilaris* (Branson and Mehl), and *T. varians* Branson and Mehl.

The lower portion of this zone, the Warsaw Formation in the type section, is characterized by abundant *Gnathodus texanus* and by common, but less numerous, *Taphrognathus varians. Apatognathus?* n.sp. A also appears more frequently in the Warsaw strata than in younger beds. The upper portion, the Salem Formation and lower part of the St. Louis Formation, is conspicuous in the nearly total absence of *G. texanus* and by common but less plentiful *T. varians* (*see* Rexroad and Collinson, 1965, p. 4).

TABLE 2.—Stratigraphic distribution of conodonts from the Meramecian Stage in Kansas.

	MERAMECIAN STAGE			
	Warsaw Limestone	Salem Limestone	St. Louis Limestone	Ste. Genevieve Limestone
Apatognathus? gemina			X	
A.? porcata			X	
A.? n. sp. *A*	X	X	X	
Cavusgnathus alta			X	
C. characta			X	X
C. convexa			X	X
C. regularis			X	X
C. unicornis			X	X
C. sp.			X	
Gnathodus commutatus			X	
G. girtyi?	X		X	
G. texanus	X	X	X	
Hibbardella abnormis	X		X	
H. fragilis	X	X	X	
H. ortha	X	X	X	
Hindeodelloides bicristatus			X	
Lambdagnathus fragilidens			X	
Ligonodina levis	X	X	X	X
L. roundyi	X		X	
L. sp. A			X	
L. n. sp.			X	
Lonchodina paraclarki	X			
L. paraclaviger	X			
Magnilaterella robusta	X		X	
Neoprioniodus acampylus	X			
N. camurus	X		X	
N. sp. cf. *N. cassilaris*	X			
N. ligo		X	X	
N. loxus	X	X	X	X
N. roundyi			X	
N. tulensis	X	X	X	
N. varians			X	
N.? concavus			X	
N.? inclinatus	X			
N.? sp.			X	
Ozarkodina compressa	X		X	
O. curvata	X		X	
O. sp. cf. *O. laeviposticа*	X		X	
O. recta	X		X	
O. roundyi	X			
Spathognathodus campbelli			X	
S. cristula	X	X	X	
S. penescitulus	X	X	X	
S. sp. cf. *S. pulcher*	X		X	
S. scitulus			X	X
S. spiculus			X	
S. n. sp.			X	
S. n. sp.?			X	
Synprioniodina laxilabrum	X			
Taphrognathus varians	X	X	X	
T. sp.			X	
New genus? sp.			X	

APATOGNATHUS? GEMINA—CAVUSGNATHUS ZONE

The lower limit of this zone is based on the last appearance of *Taphrognathus* and the first abundant appearance of *Cavusgnathus*, and by the lowest common occurrence of *Apatognathus?*. The upper limit corresponds to the last occurrence of *Apatognathus?*. This zone spans the range of *Apatognathus? gemina* (Hinde) and *A?. porcata* (Hinde) and is contained within the upper portion of the St. Louis Limestone (early late Meramecian in age) in the type locality. Characteristic species include *A.? gemina, A.? porcata, Cavusgnathus convexa* Rexroad, *C. regularis* Youngquist and Miller, *C. unicornis* Youngquist and Miller, *Neoprioniodus varians* (Branson and Mehl), *Spathognathodus scitulus* (Hinde), and *Taphrognathus* sp.

The transition from *Taphrognathus* to *Cavusgnathus* (Rexroad, 1958b) occurs at the base of this zone. *Taphrognathus* sp., the transitional form, is relatively common in this zone, mixed with species of *Cavusgnathus* and *Taphrognathus.*

GNATHODUS BILINEATUS—CAVUSGNATHUS CHARACTA ZONE

The lower limit of this zone is marked by the highest appearance of *Apatognathus?*. The upper limit is in the middle portion of the Chesteran Stage and is marked by the lowest appearance of *Roundya barnettana* Hass. The original description of this zone (Collinson, *et al.*, 1962, p. 25) also places the upper limit at the lowest occurrence of *Gnathodus girtyi* Hass, *Lonchodina paraclarki* Hass, and *Cavusgnathus alta* Harris and Hollingsworth. From the present study, these forms can possibly now be extended to the base of this zone, and *L. paraclarki* may range at least as far down as the Warsaw (Table 2). However, this apparent extension of ranges may be the result of reworking.

The portion of this zone within the limits of the present study is the lower part, the Ste. Genevieve Limestone of late Meramecian age. Characteristic species in this lower portion include *Cavusgnathus regularis* Youngquist and Miller, *C. unicornis* Youngquist and Miller, *Gnathodus commutatus* Branson and Mehl, *G. girtyi?* Hass, *Neoprioniodus varians* (Branson and Mehl), and *Spathognathodus scitulus* (Hinde). Other forms described in the present study, but not included in the above discussion, appear at this time to add little information to the age or significance of the fauna.

There appears to be an appreciable difference between the faunas recovered from the Meramecian section in Kansas and the Meramecian rocks in the Mississippi River Valley (Collinson, *et al.*, 1962; Rexroad and Collinson, 1963, 1965; Rexroad and Furnish, 1964; Thompson, 1966). Thirty-one species are common to Meramecian rocks of both the Mississippi River Valley and the Kansas section. Fourteen species were reported from Meramecian rocks of the Mississippi River Valley that were not recovered in the present study; eight of these are from the Pella Beds of late Meramecian age (Ste. Genevieve), in Iowa (Rexroad and Furnish, 1964). Ste. Genevieve material in the present study was not covered as completely as was older Meramecian material. Fifteen species were recovered from Meramecian rocks in Kansas that are unknown from equivalent strata in the Mississippi River Valley. These are *Cavusgnathus alta, Gnathodus girtyi?, Hibbardella fragilis, Hindeodelloides bicristatus, Ligonodina roundyi, Lonchodina paraclarki, L. paraclaviger, Neoprioniodus ligo, N. roundyi, N.? concavus, N.? inclinatus, Ozarkodina roundyi, Spathognathodus* n. sp.?, and a new genus, as yet unnamed.

Most of the above species were previously restricted to strata of Chesteran age (Hass, 1953; Elias, 1956, 1959; Rexroad, 1957, 1958a), but are found in Meramecian rocks in Kansas. Of these species, only *Spathognathodus* n. sp.? and the new genus are unknown from Chesteran strata. This difference may be one of regional variations in sedimentary history, or mixing of faunas by early Chesteran erosion. It is for this reason that the platform conodonts, *Cavusgnathus, Gnathodus, Spathognathodus,* and *Taphrognathus,* are given the greatest weight when correlating between regions.

DISCUSSION

The four Meramecian limestones in the Hugoton embayment appear to be synchronous with the equivalent formations in the Mississippi River Valley. Thus, little or no time transgression is indicated between western Illinois, eastern Missouri, and Kansas. Some additional elements appear in the Meramecian fauna of western Kansas, particularly in the bar and blade forms, but the platform species, generally considered to be more time-sensitive because of more rapid evolution, show little variation from region to region. Therefore, the Meramecian units of eastern Kansas are considered to be of the same age as corresponding strata in western Kansas, and are correlated on this basis.

The "Cowley Formation" was named and defined by Lee (1940) as early Meramecian in age, and he concluded that it rests on an erosional surface produced at the end of Osagian time. The conodonts recovered from rocks called "Cowley" indicate the upper portion to be as young as late Meramecian (Core L), whereas the lower portion may be as old as early Osagian. This information leads to the conclusion that the "Cowley Formation" is a facies variant of the typical limestone strata of early Osagian to late Meramecian age found elsewhere in Kansas.

Conodont faunas found in the St. Louis Limestone in wells in Comanche, Barber, and Harper counties (Cores I, J, L) place late Meramecian rocks where previously Warsaw strata were reported as the youngest Meramecian rocks present in the central portion of the Sedgwick basin in Kansas (Merriam, 1963, p. 171, fig. 4). Likewise, the youngest Meramecian rocks in the Cherokee basin appear to be St. Louis equivalents (Cores M, N, O), only Warsaw having been previously reported (Lee, 1940). Here, beneath St. Louis rocks, a relatively thin Salem sequence is underlain by Warsaw rocks.

The outcrop material in extreme southeastern Kansas provides information for a significant change in the interpretation of the distribution of Meramecian rocks in Kansas. This section was previously referred to the Warsaw Limestone. However, the conodont fauna recovered from these rocks indicates a late Osagian age, or Keokuk equivalence. Thus, there is some doubt that any significant amount of Meramecian rocks is present in the Mississippian outcrop belt in southeastern Kansas.

SYSTEMATIC DESCRIPTIONS

All specimens recovered in this study are deposited with The University of Kansas Museum of Invertebrate Paleontology (KUMIP), Department of Geology, Lawrence, Kansas. Cores and outcrop localities are referred to by letter designations (see Fig. 1). Locations are given in Table 1, and distribution of conodonts in each core in the Appendix. OD=original designation; SD=subsequent designation.

[Conodont genera ending in *-gnathus* require that species names used in combination with it have terminations ending in *-us,* not *-a.*[5] Since copy had already been set in type, it was not feasible at this time to make the numerous appropriate corrections.]

[5] According to the *International Code of Zoological Nomenclature,* Article 30 (a),(3): "If a genus-group name is a Greek word latinized with a change of termination, it takes the gender appropriate to that termination." (Internatl. Comm. Zool. Nomencl., 1964).

Genus APATOGNATHUS Branson and Mehl, 1934

Apatognathus Branson & Mehl, 1934, p. 201.

Type species.—Apatognathus varians Branson & Mehl, OD (1934, p. 201, pl. 17, fig. 1, 2, 3).

Diagnosis.—Unit consisting of two sharply arched, parallel or slightly divergent denticulate limbs joined at apex by thin lamella on outer side; large, inward-curved apical denticle at point of arching breaks symmetry of arch. Denticles of limbs directed upward; limbs twisted slightly at their juncture.

Remarks.—Species of *Apatognathus* are restricted to rocks of late Devonian and early Mississippian (Kinderhookian) age, except for three species found in late Mississippian (Meramecian) rocks. The gap in time of their occurrence has indicated possible homeomorphy with late Devonian-early Mississippian forms (Rexroad and Collinson, 1963). Therefore, the three Meramecian species described in the present study are placed within this genus with reservation.

Speciation of Mississippian forms is based on variations in denticulation of the limbs.

Distribution.—Apatognathus has been identified from rocks ranging in age from late Devonian to early Mississippian and in rocks of early late Mississippian age.

APATOGNATHUS? GEMINA (Hinde)

Pl. 2, fig. 2, 4.

Prioniodus geminus Hinde, 1900, p. 344, pl. 10, fig. 25.

Prioniodina? gemina (Hinde). Holmes, 1928, p. 19, pl. 5, fig. 10.

Apatognathus geminus (Hinde). Clarke, 1960, p. 4, pl. 1, fig. 1, 2; Thompson & Goebel, 1963, p. 12, fig. 3.

Apatognathus? gemina (Hinde). Rexroad & Collinson, 1963, p. 7, pl. 1, fig. 12-17.

Diagnosis.—Apatognathid with one large denticle near mid-point of posterior limb approaching length of apical denticle; remaining denticles of both limbs of nearly uniform length, about half that of prominent denticle.

Remarks.—The large denticle on the posterior limb distinguishes *Apatognathus? gemina* (Hinde) from *A.? porcata* (Hinde), which has denticles of nearly uniform length on both limbs.

Distribution.—Apatognathus? gemina has previously been recovered from rocks of early late Meramecian age. In the present study four specimens were recovered from the St. Louis Limestone in Cores A and C.

Repository.—KUMIP 1,800,076; KUMIP 1,800,136 (figured specimens).

APATOGNATHUS? PORCATA (Hinde)

Pl. 2, fig. 1; Pl. 4, fig. 23.

Prioniodus porcatus HINDE, 1900, p. 344, pl. 10, fig. 26; HOLMES, 1928, p. 22, pl. 3, fig. 26.
Apatognathus porcatus (Hinde). CLARKE, 1960, p. 5, pl. 1, fig. 3, 4.
Apatognathus? porcata (Hinde). REXROAD & COLLINSON, 1963, p. 8, pl. 1, fig. 7-11.

Diagnosis.—Apatognathid distinguished by denticles of nearly uniform length on both limbs. At maturity distinguished by increase in size of denticles toward apical denticle on one limb.

Remarks.—Clarke (1960) distinguished *Apatognathus? porcata* (Hinde) by more lateral tumidity of the inner limb than found on *A.? gemina* (Hinde). The single large apical denticle and shorter uniform denticles on the posterior limb also characterize *A.? porcata.*

Distribution.—Apatognathus? porcata has previously been recovered from rocks of early late Meramecian age. In the present study 29 specimens were recovered from the St. Louis Limestone in Cores A, B, C, D, and I.

Repository.—KUMIP 1,800,104; KUMIP 1,800,336 (figured specimens).

APATOGNATHUS? n. sp. A Rexroad and Collinson

Pl. 2, fig. 3.

Apatognathus? n. sp. A REXROAD & COLLINSON, 1965, p. 5, pl. 1, fig. 1, 2.

Diagnosis.—Sharply arched apatognathid?, denticles of limbs partly fused, long and needle-like, joined at top of arch by slightly longer apical denticle. Apical denticle often nearly indistinguishable from adjacent denticles of limb.

Remarks.—No complete specimens of *Apatognathus?* n. sp. A Rexroad and Collinson have been recovered, and thus, the relative lengths of the two limbs are unknown. The denticles of this form are longer and more slender than those of *A.? gemina* (Hinde) or *A.? porcata* (Hinde), and are partially fused, whereas those of the latter two species are unfused throughout their lengths. The apical denticle of *A.?* n. sp. A is less distinct than in other species, and the symmetry of this form appears to be less than that of more typical Mississippian species. Rexroad and Collinson (1965) suggest that this species may be intermediate between forms of *Synprioniodina* and *Apatognathus? gemina* and *A.? porcata,* substantiating homeomorphy of late Mississippian forms with late Devonian-early Mississippian apatognathids. The lack of complete specimens, however, leaves this question open.

Distribution.—Apatognathus? n. sp. A has been reported previously from rocks of early to early late Meramecian age. In the present study nine specimens were recovered from the Warsaw Limestone (Core K), Salem Limestone (Core C, D), and St. Louis Limestone (Core A).

Repository.—KUMIP 1,800,133 (figured specimen).

Genus CAVUSGNATHUS Harris and Hollingsworth, 1933

Cavusgnathus HARRIS & HOLLINGSWORTH, 1933, p. 201.

Type species.—Cavusgnathus alta HARRIS & HOLLINGSWORTH, OD (1933, p. 201, pl. 1, fig. 10a, b).

Diagnosis.—Elongate platform with median longitudinal trough between high lateral parapet-like sides. Blade laterally located in plane of outer parapet and connected to anterior end of this parapet. Inner parapet terminating anteriorly approximately mid-length of inner surface of blade, separated from blade by median trough. Basal cavity generally, but not invariably, asymmetric, curved outward toward anterior end beneath posterior end of blade.

Remarks.—The lateral position of the blade in *Cavusgnathus* distinguishes this genus from the form with a centrally located blade, *Taphrognathus,* from which the cavusgnathids were derived in late Meramecian time (Rexroad, 1958b). The cavusgnathids, in turn, gave rise in late Chesteran time to the adetognathodids (Lane, 1967), formerly identified as streptognathodids (Rexroad and Burton, 1961).

Speciation is based largely on the oral outline of the blade as determined by the size and arrangement of the blade denticles.

Distribution.—Cavusgnathus has been identified from rocks ranging from late Meramecian to late Chesteran in age. Those forms previously identified as *Cavusgnathus* in the Pennsylvanian have been referred to *Adetognathus* by Lane (1967).

CAVUSGNATHUS ALTA Harris and Hollingsworth

Pl. 1, fig. 19, 22.

Cavusgnathus alta HARRIS & HOLLINGSWORTH, 1933, p. 201, pl. 1, fig. 10a, b; REXROAD & LANE, 1966, p. 1391, text-fig. 1a, b.
Cavusgnathus cristata BRANSON & MEHL, 1941a, p. 177, pl. 5, fig. 26-31; HASS, 1953, p. 77, pl. 14, fig. 12-14; ELIAS, 1956, p. 115, pl. 2, fig. 1-6; REXROAD, 1958b, p. 16, pl. 1, fig. 15-17; REXROAD & BURTON, 1961, p. 1151, pl. 138, fig. 16. (not) *Cavusgnathus cristata* Branson & Mehl. COOPER, 1947, p. 91, pl. 20, fig. 4-10; BISCHOFF, 1957, p. 19, pl. 2, fig. 7a, b.
Cavusgnathus cristata var. *grandis* ELIAS, 1956, p. 115, pl. 2, fig. 12-14.

Diagnosis.—Cavusgnathid distinguished by irregular oral outline of blade, second posterior denticle commonly less than half length of first and third posterior denticles, and by bilateral symmetry of basal cavity.

Remarks.—The illustrations by Cooper (1947) indicate that his specimens referred to *Cavusgnathus cristata* Branson and Mehl should be placed in *C. navicula* (Hinde). Ontogenetic stages studied by Rexroad (1958a) invalidate the establishment of *C. cristata* var. *grandis* Elias.

Rexroad and Lane (1966) demonstrated that *C. cristata* is a junior synonym of *C. alta* Harris and Hollingsworth and thus, all forms previously placed under *C. cristata* now belong to *C. alta,* the type species of the genus.

Distribution.—Cavusgnathus alta has been recovered previously from rocks of early to late Chesteran age. In the present study six specimens were recovered from the St. Louis Limestone in Core B.

Repository.—KUMIP 1,800,114 (figured specimen).

CAVUSGNATHUS CHARACTA Rexroad

Pl. 1, fig. 1, 4, 7.

Cavusgnathus characta REXROAD, 1957, p. 15, pl. 1, fig. 1; REXROAD & COLLINSON, 1963, p. 8, pl. 1, fig. 29.

Diagnosis.—Cavusgnathid with distinctive notch located in outer parapet immediately posterior to juncture of blade to outer parapet.

Remarks.—The characteristic notch in the outer parapet is considered by Rexroad and Collinson (1963) to be a primitive feature reflecting the transition from *Taphrognathus* to *Cavusgnathus,* the notch representing incomplete juncture of the blade to the anterior end of the parapet.

Distribution.—Cavusgnathus characta has been recovered previously from rocks ranging in age from early late Meramecian to early Chesteran. In the present study six specimens were recovered from the St. Louis Limestone (Cores A, I) and the Ste. Genevieve Limestone (Core D).

Repository.—KUMIP 1,800,222 (figured specimen).

CAVUSGNATHUS CONVEXA Rexroad

Pl. 1, fig. 14, 18, 20, 21.

Cavusgnathus convexa REXROAD, 1957, p. 17, pl. 1, fig. 3-6; REXROAD, 1958b, p. 16, pl. 1, fig. 12-14; REXROAD & BURTON, 1961, p. 1151, pl. 138, fig. 4a, b; REXROAD & FURNISH, 1964, p. 670, pl. 111, fig. 1; REXROAD & NICOLL, 1965, p. 17, pl. 1, fig. 14, 15.

Diagnosis.—Cavusgnathid with convex oral outline of blade, denticles longest approximately mid-point, shortening both anterior and posterior to mid-point of blade.

Remarks.—The usual blade outlines found in cavusgnathids are either highest toward the posterior end, longest denticles at the posterior end of the blade as in *C. unicornis* Youngquist and Miller and *C. navicula* (Hinde), or the blade denticles are of nearly uniform length as in *C. regularis* Youngquist and Miller, *C. characta* Rexroad, and *C. cristata* Branson and Mehl. *C. convexa* Rexroad differs from the above configurations in that the longest denticles of the blade are located several denticles anterior to the posterior end of the blade. This oral outline closely resembles the blade outline of some specimens of *Taphrognathus varians* Branson and Mehl and may be a primitive character in cavusgnathids.

Distribution.—Cavusgnathus convexa has been recovered previously from rocks ranging from early late Meramecian to late Chesteran in age. In this study 15 specimens were recovered from the St. Louis Limestone (Cores A, B, C, D, I, M, and N) and Ste. Genevieve Limestone (Core D).

Repository.—KUMIP 1,800,105; KUMIP 1,800,266 (figured specimens).

CAVUSGNATHUS REGULARIS Youngquist and Miller

Pl. 1, fig. 3, 12.

Cavusgnathus regularis YOUNGQUIST & MILLER, 1949, p. 619, pl. 101, fig. 24, 25; REXROAD & BURTON, 1961, p. 1152, pl. 138, fig. 13, 15; REXROAD & COLLINSON, 1963, p. 9, pl. 1, fig. 28; REXROAD & FURNISH, 1964, p. 670, pl. 111, fig. 2; REXROAD & NICOLL, 1965, p. 18, pl. 1, fig. 16, 17.

Diagnosis.—Cavusgnathid with short, stout shape, high platform, deep median trough, and short blade composed of denticles of either uniform length or gradually increasing length toward posterior end.

Remarks.—The denticles of the blade of *Cavusgnathus regularis* Youngquist and Miller show a regular increase in length posteriorly, or form a nearly straight oral outline. Other species of *Cavusgnathus* have either an irregular oral outline of the blade as in *C. cristata* Branson and Mehl, a convex outline as in *C. convexa* Rexroad, or possess one or two denticles of much greater length than those adjacent as in *C. unicornis* Youngquist and Miller. *C. characta* Rexroad has a similar oral outline of the blade, but possesses a notch between the outer parapet and the blade.

Distribution.—Cavusgnathus regularis has been recovered previously from rocks ranging in age from early late Meramecian to late Chesteran. In the present study 40 specimens were recovered from the St. Louis Limestone

(Cores A, B, C, D, I, L, M, N, O) and the Ste. Genevieve Limestone (Core D).

Repository.—KUMIP 1,800,080; KUMIP 1,800,115 (figured specimens).

CAVUSGNATHUS UNICORNIS Youngquist and Miller

Pl. 1, fig. 2, 5, 6, 8.

Cavusgnathus unicornis YOUNGQUIST & MILLER, 1949, p. 619, pl. 101, fig. 18-23; REXROAD, 1957, p. 17, pl. 1, fig. 7; LYS & SERRE, 1957, p. 1042, pl. 2, fig. 3a, b; REXROAD, 1958b, p. 17, pl. 1, fig. 6-11; REXROAD & BURTON, 1961, p. 1152, pl. 138, fig. 10-12; REXROAD & COLLINSON, 1963, p. 9, pl. 1, fig. 26, 27; THOMPSON & GOEBEL, 1963, p. 12, fig. 3; REXROAD & FURNISH, 1964, p. 670, pl. 111, fig. 6; REXROAD & NICOLL, 1965, p. 18, pl. 1, fig. 18-20. (not) *Cavusgnathus unicornis* Youngquist & Miller. HIGGINS, 1961, pl. 10, fig. 3.

Diagnosis.—Cavusgnathid distinguished by hornlike appearance of posterior denticle of blade, inclined strongly toward posterior, and by short, high platform.

Remarks.—The posterior hornlike denticle on the blade of *Cavusgnathus unicornis* Youngquist and Miller is isolated from the long anterior blade denticles by a sequence of two or three short denticles of uniform length, and is distinctly inclined toward the posterior. The posterior denticle of the blade of *C. navicula* (Hinde) is the largest denticle of the blade, but is not inclined toward the posterior, and is succeeded anteriorly by a gradual decrease in denticle length. Rexroad and Burton (1961) suggested that *C. unicornis* is the ancestral form of *Streptognathodus unicornis* Rexroad and Burton. This form was later identified as *Adetognathus unicornis* (Rexroad and Burton) by Lane (1967).

Distribution.—*Cavusgnathus unicornis* has been recovered previously from rocks ranging in age from early late Meramecian to late Chesteran. In this study 64 specimens were recovered from the St. Louis Limestone (Cores A, B, C, I, J, L, N) and the Ste. Genevieve Limestone (Core D).

Repository.—KUMIP 1,800,116; KUMIP 1,800,332 (figured specimens).

CAVUSGNATHUS sp.

Pl. 1, fig. 10, 11, 13.

Description.—In oral view, outer parapet slightly convex outward and slightly curved inward where joining straight blade; blade less than one-fourth free. Inner parapet straight, paralleling blade and outer parapet until just before posterior end, where it abruptly curves toward outer parapet. Both parapets weakly grooved transversely. Median trough deep and narrow toward anterior, disappearing short of posterior end of specimen, where inner parapet bends outward.

In lateral view, platform short, blade comprising over half total length of specimen on outer side. Upper margin of outer parapet slightly convex, that of inner parapet straight anterior half, slightly convex to posterior end. Blade with low, slightly convex to nearly straight oral margin bearing six compressed denticles, anterior two broadest antero-posteriorly. Denticles of blade of nearly uniform length.

In aboral view, posteriorly located, nearly symmetrical basal cavity just one-third total length of specimen. Inner lip flared laterally, extends slightly farther antero-posteriorly than outer lip. Cavity deepest near anterior end.

Remarks.—The blade of this specimen is too long for *Cavusgnathus regularis* Youngquist and Miller and too straight orally for *C. alta* Harris and Hollingsworth. *C.* sp. may represent either a new species or a variation in the form of *C. regularis.*

Distribution.—One specimen of *Cavusgnathus* sp. was recovered from the St. Louis Limestone in Core C.

Repository.—KUMIP 1,800,141 (figured specimen).

Genus GNATHODUS Pander, 1856

Gnathodus PANDER, 1856, p. 33 (not Fieber, 1866).

Dryphenotus COOPER, 1939, p. 386.

Type species.—*Gnathodus mosquensis* PANDER. Monotypic (1856, p. 33, pl. 2A, fig. 10a, b, c).

Diagnosis.—Compound unit with deep, broad basal cavity at posterior end beneath platform. Oral surface of platform smooth to highly ornamented by nodes or ridges, divided longitudinally by denticulate carina extending to or near posterior end. Blade usually long and thin, extending anterior from platform.

Remarks.—The posterior position of the basal cavity distinguishes *Gnathodus* from *Spathognathodus,* which has a sub-centrally located basal cavity.

Speciation is based on the size, shape, and ornamentation of the platform, all of which can be extremely variable.

Distribution.—*Gnathodus* has been identified from rocks ranging from late Devonian to mid-Triassic in age.

GNATHODUS COMMUTATUS (Branson and Mehl)

Pl. 4, fig. 4, 6, 7.

Spathognathodus commutatus BRANSON & MEHL, 1941c, p. 98, pl. 19, fig. 1-4.

Gnathodus commutatus (Branson & Mehl). BISCHOFF, 1957, p. 22, pl. 14, fig. 2-15; REXROAD & FURNISH, 1964, p. 671, pl. 111, fig. 3.
Gnathodus pellaensis YOUNGQUIST & MILLER, 1949, p. 622, pl. 101, fig. 5.
Gnathodus inornatus HASS, 1953, p. 80, pl. 14, fig. 9-11.

Diagnosis.—Gnathodid with unornamented circular platform at posterior end of long straight carinate blade. Basal cavity deep and circular in lateral outline. Carina terminates just short of posterior end of platform. Platform symmetrical, oral surface bisected by high narrow carina.

Remarks.—The circular, symmetrical, unornamented platform distinguishes *Gnathodus commutatus* (Branson and Mehl) from other species of this genus.

Distribution.—*Gnathodus commutatus* has been reported previously from rocks of late Meramecian and Chesteran age. In the present study, five specimens were recovered from the St. Louis Limestone in Cores A and B.

Repository.—KUMIP 1,800,084; KUMIP 1,800,335 (figured specimens).

GNATHODUS GIRTYI? Hass

Pl. 4, fig. 8-10, 14.

Gnathodus girtyi HASS, 1953, p. 80, pl. 14, fig. 22-24; ELIAS, 1956, p. 118, pl. 2, fig. 30, 31; BISCHOFF, 1957, p. 24, pl. 4, fig. 16-23; HIGGINS, 1961, p. 224, pl. 10, fig. 4; DUNN, 1965, p. 1148, pl. 140, fig. 2, 3, 12.

Diagnosis.—Small gnathodid characterized by low, broad platform containing one row of nodes on either side of low carina, forming parapets. Parapets and carina extend nearly to posterior end of platform, where they merge.

Remarks.—Several species are similar to *Gnathodus girtyi* Hass, and the ranges of these forms are imperfectly known. Therefore, this form is placed in *G. girtyi* with reservation. *G. girtyi* differs from *G. antetexanus* Rexroad and Scott in having two parapets, one on either side of the central carina. *G. antetexanus* has only one parapet, on the inner side. *G. girtyi* is a homeomorph of *G. cuneiformis* Mehl and Thomas, an Osagian form, and *G. bassleri* (Harris and Hollingsworth), an early Pennsylvanian form.

Distribution.—*Gnathodus girtyi* has been recovered previously from rocks of early Chesteran age. In this study 12 specimens of *G. girtyi?* were recovered from the Warsaw Limestone (Core E) and the St. Louis Limestone (Cores A, B).

Repository.—KUMIP 1,800,119; KUMIP 1,800,085 (figured specimens).

GNATHODUS TEXANUS Roundy

Pl. 4, fig. 1-3, 5.

Gnathodus texanus ROUNDY, 1926, p. 12, pl. 2, fig. 7a, b, 8a, b; BRANSON & MEHL, 1941a, p. 173, pl. 5, fig. 23-25; HASS, 1953, p. 80, pl. 14, fig. 15-21; ELIAS, 1956, p. 110, pl. 3, fig. 32-36; BISCHOFF (part), 1957, p. 25, pl. 3, fig. 24, 25 only; THOMPSON & GOEBEL, 1963, p. 12, fig. 3; BURTON, 1964,[6] Chart; REXROAD & SCOTT, 1964, p. 30, pl. 2, fig. 11-14; REXROAD & COLLINSON, 1965, p. 8, pl. 1, fig. 33-38.
Gnathodus texanus var. *bicuspidus* ROUNDY, 1926, p. 12, pl. 2, fig. 9a, b.
Gnathodus linguiformis BRANSON & MEHL, 1941b, p. 183, pl. 6, fig. 18-26.
Gnathodus pretexanus ELIAS, 1956, p. 115, pl. 3, fig. 9-11.

Diagnosis.—Gnathodid distinguished by small, narrow platform ending short of posterior end on inner side. Only ornamentation is single prominent pillar-like parapet on inner side of platform, composed of one to three fused denticles.

Remarks.—Rexroad and Scott (1964) identified *Gnathodus antetexanus* Rexroad and Scott as the direct ancestor of *G. texanus* Roundy, the latter arising through the reduction of the platform with subsequent enlargement and shortening of the inner parapet to the prominent pillar-like projection, and lengthening and compression of the anterior blade. Rexroad and Scott (1964) and Rexroad and Collinson (1965) regarded *Spathognathodus deflexus* Branson and Mehl to be like *G. texanus* in lacking the pillar-like parapet.

Distribution.—*Gnathodus texanus* has been recovered previously from rocks ranging in age from late early Osagian to late early Meramecian. In the present study over 500 specimens were recovered from the Warsaw Limestone (Cores C, E, F, G, J, K, M, O), the Salem Limestone (Core H), the St. Louis Limestone (Cores D, I, L, N, O), and the Keokuk Limestone (Localities P and Q).

Repository.—KUMIP 1,800,202; KUMIP 1,800,240 (figured specimens).

Genus HIBBARDELLA Ulrich and Bassler, 1926

Hibbardella ULRICH & BASSLER, 1926, p. 37.

Type species.—*Prioniodus angulatus* HINDE (1879, p. 360, pl. 15, fig. 17). SD ULRICH & BASSLER (1926, p. 37).

Diagnosis.—Unit consisting of prominent terminal denticle with straight, short, undenticu-

[6] Burton, R. C., 1964, A preliminary range chart of Lake Valley Formation (Osage) conodonts in the southern Sacramento Mountains, New Mexico: New Mexico Geol. Soc., Guidebook 15th Field Conf., p. 73-75.

late posterior bar and two denticulate lateral processes, one inner and one outer. Whole unit roughly symmetrical through plane of terminal denticle and posterior bar.

Remarks.—Hibbardella is similar to *Ligonodina,* with the addition of an outer-lateral process attached to the terminal denticle. The posterior bar is shorter and straighter in *Hibbardella,* and usually lacks denticles.

Speciation is based on the degree of downward and posterior projection of the lateral processes and on the size and length of the denticles on the lateral processes.

Distribution.—Hibbardella has been identified from rocks ranging in age from Devonian to Pennsylvanian.

HIBBARDELLA ABNORMIS Branson and Mehl

Pl. 2, fig. 11, 15.

Hibbardella abnormis Branson & Mehl, 1941b, p. 184, pl. 6, fig. 14; Rexroad & Collinson, 1963, p. 10, pl. 2, fig. 15, 18, 20, 21; Rexroad & Collinson, 1965, p. 9, pl. 1, fig. 8, 9.

Diagnosis.—Hibbardellid characterized by steep downward arch of lateral processes (about 45 degrees), long discrete denticles of lateral processes, and broad aboral surface of posterior bar with shallow median groove to anterior end.

Remarks.—Both lateral processes were broken off in the specimens described by Branson and Mehl (1941b). Their description of *Hibbardella abnormis* Branson and Mehl indicates that the lateral processes are greatly reduced. This description was emended by Rexroad and Collinson (1963) to include specimens with long, steeply inclined processes.

Distribution.—Hibbardella abnormis has been recovered previously from rocks ranging from late Osagian to early late Meramecian age. In the present study 13 specimens were recovered from the St. Louis Limestone and Warsaw Limestone in Core O.

Repository.—KUMIP 1,800,306 (figured specimen).

HIBBARDELLA FRAGILIS (Rexroad)

Pl. 2, fig. 22, 23.

Trichonodella fragilis Rexroad, 1957, p. 40, pl. 4, fig. 6, 7.

Hibbardella fragilis (Rexroad). Rexroad & Burton, 1961, p. 1153, pl. 140, fig. 7. (not) *Hibbardella fragilis* Higgins, 1961, p. 213, pl. 12, fig. 4, text-fig. 2.

Diagnosis.—Hibbardellid characterized by long slender posterior bar and slender denticulate lateral processes bearing three slender denticles which become larger distally; downward angle of juncture of lateral processes about 120 degrees.

Remarks.—At the present time, two conodont forms carry the name *Hibbardella fragilis,* one named by Rexroad (1957), and one by Higgins (1961). By the rule of priority, the second, that of Higgins, will have to be changed by the author who next publishes a description of that form.

Distribution.—Hibbardella fragilis has been recovered previously from rocks of Chesteran age. In the present study six specimens were recovered from the Warsaw Limestone (Core M), Salem Limestone (Core I), and St. Louis Limestone (Core A).

Repository.—KUMIP 1,800,213 (figured specimen).

HIBBARDELLA ORTHA Rexroad

Pl. 2, fig. 5, 6.

Hibbardella ortha Rexroad, 1958b, p. 18, pl. 2, fig. 9-12; Clarke, 1960, p. 6, pl. 1, fig. 7; Rexroad & Burton, 1961, p. 1153, pl. 140, fig. 5, 6; Rexroad & Collinson, 1963, p. 10, pl. 2, fig. 12, 16; Rexroad & Furnish, 1964, p. 671, pl. 111, fig. 16; Rexroad & Collinson, 1965, p. 10, pl. 1, fig. 10; Rexroad & Nicoll, 1965, p. 19, pl. 1, fig. 12.

Prioniodus angulatus Hinde. Hinde (part), 1900, p. 343, pl. 10, fig. 18 only.

Hibbardella angulata (Hinde). Holmes (part), 1928, p. 11, pl. 5, fig. 32 only.

Diagnosis.—Hibbardellid with thin, compressed lateral processes forming angle of about 140 degrees at basal juncture. Denticles of processes long, thin, and fused nearly to apices.

Remarks.—The fragility of the lateral processes distinguishes *Hibbardella ortha* Rexroad from other hibbardellid species, which usually have more robust lateral processes. The fused denticles of the lateral processes also facilitate identification of this species.

Distribution.—Hibbardella ortha has previously been recovered from rocks ranging in age from early Meramecian to late Chesteran. In this study 10 specimens were recovered from the Warsaw Limestone (Cores F, K, O), the Salem Limestone (Core D), and the St. Louis Limestone (Cores A, I).

Repository.—KUMIP 1,800,286 (figured specimen).

Genus HINDEODELLA Ulrich and Bassler, 1926

Hindeodella Ulrich & Bassler, 1926, p. 38.

Type species.—Hindeodella subtilis Ulrich & Bassler, OD (1926, p. 38, pl. 8, fig. 17-19).

Diagnosis.—Unit consisting of long, straight bar containing small, straight, slender denticles often alternating in size, with larger terminal denticle at or near anterior end, and often with short aboral projection beneath terminal denticle.

Remarks.—Specimens of *Hindeodella* are commonly found extremely fragmented and specific identification is usually impossible.

Distribution.—*Hindeodella* has been identified from rocks ranging in age from Devonian to Triassic.

HINDEODELLA sp. indet.

Distribution.—In this study over 25 specimens were recovered from the Warsaw, Salem, St. Louis, and Ste. Genevieve limestones in 12 cores and at both outcrop localities.

Genus HINDEODELLOIDES Huddle, 1934

Hindeodelloides HUDDLE, 1934, p. 48.

Type species.—*Hindeodelloides bicristatus* HUDDLE, OD (1934, p. 48, pl. 7, fig. 2, 3, pl. 12, fig. 6).

Diagnosis.—Unit consisting of thin, straight to gently curved denticulate posterior bar with major terminal denticle and sharply pointed aboral projection; overall form roughtly T-shaped. Denticles also found anterior to major denticle, extending part way down anterior edge of terminal denticle-aboral projection unit.

Remarks.—The sharply pointed aboral projection distinguishes *Hindeodelloides* from *Hindeodella*. The anterior denticles on the aboral projection distinguish it from *Neoprioniodus*.

Speciation is based on the coarseness and general nature of the denticles on the posterior bar and aboral projection.

Distribution.—*Hindeodelloides* has been identified from rocks of Kinderhookian, early Osagian, and late Meramecian age.

HINDEODELLOIDES BICRISTATUS Huddle

Pl. 2, fig. 9.

Hindeodelloides bicristatus HUDDLE, 1934, p. 48, pl. 7, fig. 2, 3, pl. 12, fig. 6; ELIAS, 1959, p. 157, pl. 2, fig. 28-30.

Diagnosis.—Hindeodelloidid characterized by sharp aboral projection with approximately six closely spaced minute denticles on anterior edge, and by extremely small and closely spaced needle-like denticles on posterior bar.

Remarks.—This species has been reported previously from rocks considerably older than those of the present study. Little significance can be drawn from this specimen at this time.

Distribution.—*Hindeodelloides bicristatus* has been reported previously from rocks of Kinderhookian age. In the present study one specimen was recovered from the St. Louis Limestone in Core B.

Repository.—KU 1,800,108 (figured specimen lost).

Genus LAMBDAGNATHUS Rexroad, 1958

New genus? REXROAD, 1957, p. 41.

Lambdagnathus REXROAD, 1958b, p. 19.

Type species.—*Lambdagnathus fragilidens* REXROAD, OD (1958b, p. 20, pl. 6, fig. 10-16).

Diagnosis.—Complex unit consisting of denticulate posterior bar and bladelike anterior and inner-lateral denticulate processes, with apical denticle at juncture of three processes. Triangular basal cavity located beneath apical denticle at aboral juncture of three processes.

EXPLANATION OF PLATE 1

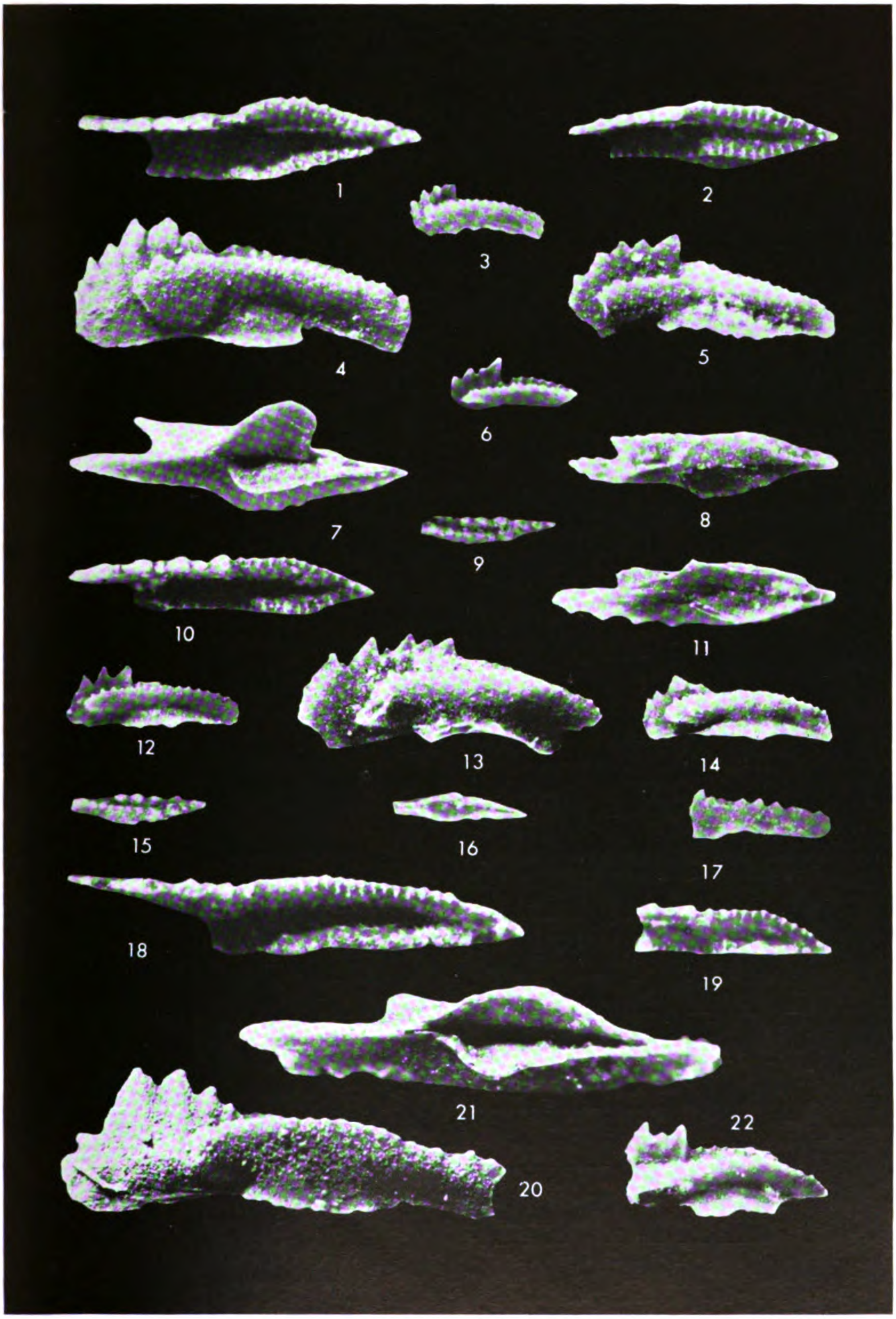
All figures × about 35

Conodonts from the St. Louis Limestone in Kansas.

FIGURE		PAGE
1, 4, 7.	*Cavusgnathus characta* Rexroad. 1, Oral view; 4, lateral view; 7, aboral view; Core I, 5,401 ft (KUMIP 1,800,222). St. Louis Limestone.	22
2, 5, 6, 8.	*Cavusgnathus unicornis* Youngquist and Miller. 2, Oral view; 5, lateral view; 8, aboral view; Core B, 5,631 ft (KUMIP 1,800,116); 6, lateral view, Core B, 5,657 ft (KUMIP 1,800,332). St. Louis Limestone.	23
3, 12.	*Cavusgnathus regularis* Youngquist and Miller. 3, Lateral view, Core A, 6,789 ft (KUMIP 1,800,080); 12, lateral view, Core B, 5,651 ft (KUMIP 1,800,115). St. Louis Limestone.	22
9, 15-17.	*Spathognathodus* n. sp. 9, Oral view, Core A, 6,752 ft (KUMIP 1,800,082); 15, oral view; 16, aboral view; 17, lateral view; Core A, 6,752 ft (KUMIP 1,800,333). St. Louis Limestone.	43
10, 11, 13.	*Cavusgnathus* sp. 10, Oral view; 11, aboral view; 13, lateral view, Core C, 4,826-4,828 ft (KUMIP 1,800,141). St. Louis Limestone.	23
14, 18, 20, 21.	*Cavusgnathus convexa* Rexroad. 14, Lateral view, Core B, 5,707 ft (KUMIP 1,800,105); 18, oral view; 20, lateral view, 21, aboral view; Core M, 1,762 ft (KUMIP 1,800,266). St. Louis Limestone.	22
19, 22.	*Cavusgnathus alta* Harris and Hollingsworth. 19, Oral view; 22, lateral view; Core B, 5,697 ft (KUMIP 1,800,114). St. Louis Limestone.	21

KANSAS GEOLOGICAL SURVEY

PLATE I BULLETIN 192



THOMPSON AND GOEBEL—MERAMECIAN CONODONTS FROM KANSAS

Remarks.—The triangular basal cavity of *Lambdagnathus* distinguishes it from *Centrognathus,* a similar form with a circular basal cavity.

This genus is presently monospecific.

Distribution.—*Lambdagnathus* has been identified from rocks ranging in age from late Meramecian to late Chesteran.

LAMBDAGNATHUS FR GILIDENS Rexroad

Pl. 2, fig. 12, 16.

New genus? Rexroad (part), 1957, p. 41, pl. 4, fig. 10 only.

Lambdagnathus fragilidens Rexroad, 1958b, p. 19, pl. 6, fig. 10-16; Rexroad & Burton, 1961, p. 1154, pl. 141, fig. 18; Rexroad & Furnish, 1964, p. 672, pl. 111, fig. 35; Rexroad & Nicoll, 1965, p. 21, pl. 2, fig. 9.

Diagnosis.—Lambdagnathid with triangular intersection of three processes, two in one plane, the third one inclined downward. Basal cavity triangular in outline, lying directly beneath terminal denticle at juncture of the three processes.

Remarks.—*Lambdagnathus fragilidens* Rexroad is the only species assigned to this genus.

Distribution.—*Lambdagnathus fragilidens* has been previously recovered from rocks ranging from early late Meramecian to late Chesteran age. In this study four specimens were recovered from the St. Louis Limestone in Core I.

Repository.—KUMIP 1,800,229 (figured specimen lost).

Genus LIGONODINA Ulrich and Bassler, 1926

Ligonodina Ulrich & Bassler, 1926, p. 12.

Type species.—*Ligonodina pectinata* Ulrich & Bassler, OD (1926, p. 13, pl. 2, fig. 9, 10).

Diagnosis.—Unit consisting of major terminal denticle at point of juncture of long, thin, straight denticulate posterior bar and downward and posteriorly curved denticulate inner-lateral process.

Remarks.—*Ligonodina* is similar to *Hibbardella,* except that it possesses only one lateral process instead of two.

Speciation is based on the size, direction, and degree of curvature of the inner-lateral process.

Distribution.—*Ligonodina* has been identified from rocks ranging from Devonian to Pennsylvanian in age.

EXPLANATION OF PLATE 2

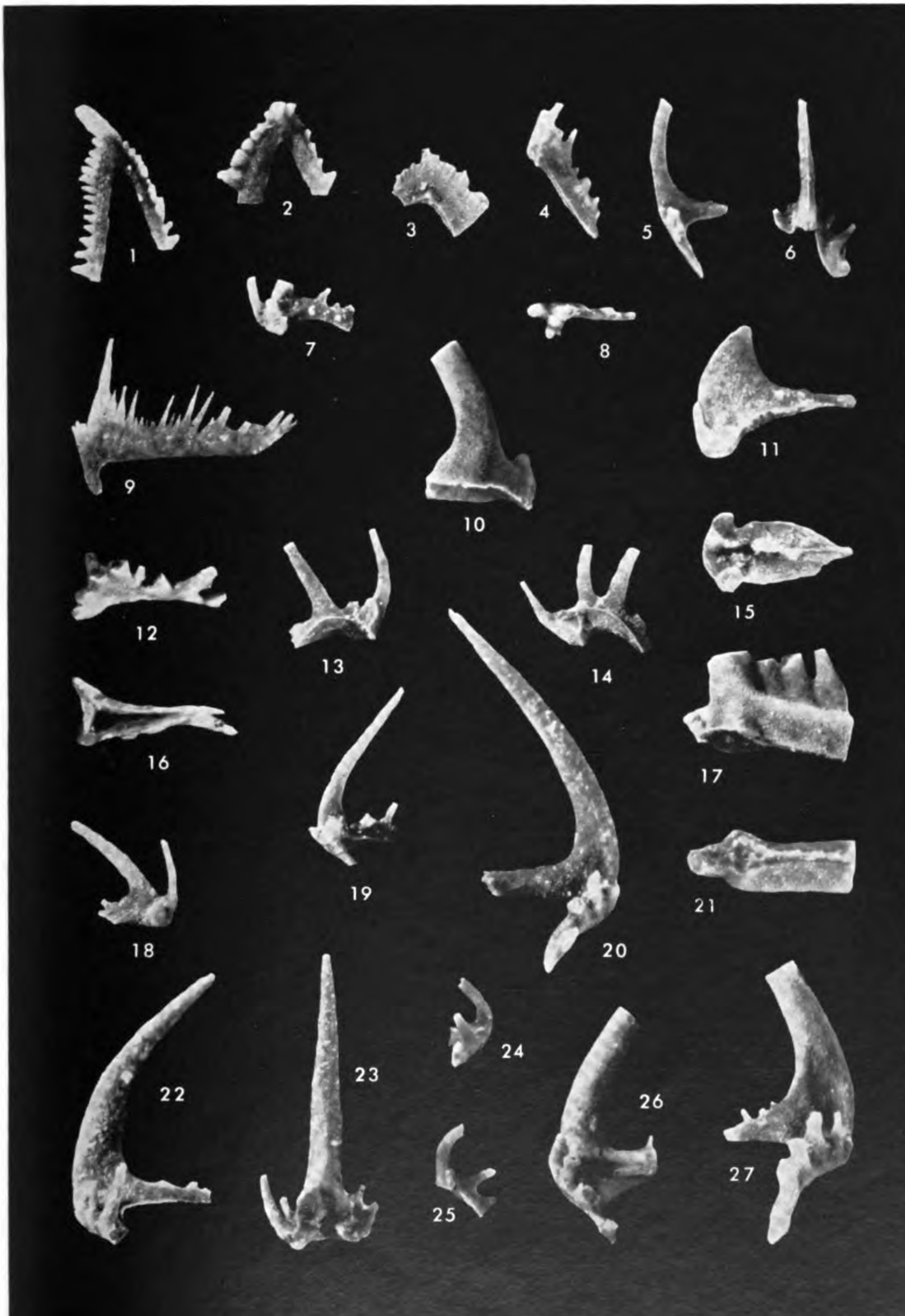
All figures × about 35

Conodonts from the Warsaw, Salem, and St. Louis limestones in Kansas.

Figure		Page
1.	*Apatognathus? porcata* (Hinde). Inner-lateral view, Core B, 5,707 ft (KUMIP 1,800,104). St. Louis Limestone.	21
2, 4.	*Apatognathus? gemina* (Hinde). 2, Inner-lateral view, Core A, 6,793 ft (KUMIP 1,800,076); 4, inner-lateral view, Core C, 4,761 ft (KUMIP 1,800,136). St. Louis Limestone.	20
3.	*Apatognathus?* n. sp. A Rexroad and Collinson. Inner-lateral view, Core C, 4,981-4,991 ft (KUMIP 1,800,133). Salem Limestone.	21
5, 6.	*Hibbardella ortha* Rexroad. 5, Lateral view; 6, posterior view; Core N, 1,667 ft (KUMIP 1,800,286). St. Louis Limestone.	25
7, 8, 18.	*Ligonodina* n. sp. 7, Inner-lateral view; 8, oral view; Core B, 5,657 ft (KUMIP 1,800,117); 18, inner-lateral view, Core A, 6,755 ft (KUMIP 1,800,083). St. Louis Limestone.	34
9.	*Hindeodelloides bicristatus* Huddle. Lateral view, Core B, 5,707 ft. Specimen lost. St. Louis Limestone.	26
10.	*Lonchodina paraclarki* Hass. Outer-lateral view, Core K, 4,735-4,737 ft (KUMIP 1,800,244). Warsaw Limestone.	34
11, 15.	*Hibbardella abnormis* Branson and Mehl. 11, Lateral view; 15, aboral view; Core O, 1,704 ft (KUMIP 1,800,306). Salem-lower St. Louis limestones.	25
12, 16.	*Lambdagnathus fragilidens* Rexroad. 12, Oral view; 16, aboral view; Core I, 5,377 ft. Specimen lost. St. Louis Limestone.	28
13, 14.	*Magnilaterella robusta* Rexroad and Collinson. 13, Posterior view, Core B, 5,672 ft (KUMIP 1,800,122); 14, posterior view, Core A, 6,793 ft (KUMIP 1,800,092). St. Louis Limestone.	36
17, 21.	*Lonchodina paraclaviger* Rexroad. 17, Lateral view; 21, aboral view; Core K, 4,742-4,744 ft (KUMIP 1,800,245). Warsaw Limestone.	36
19, 20.	*Ligonodina levis* Branson and Mehl. 19, Inner-lateral view, Core C, 4,857-4,860 ft (KUMIP 1,800,143); 20, inner-lateral view, Core B, 5,707 ft (KUMIP 1,800,109). St. Louis Limestone.	30
22, 23.	*Hibbardella fragilis* (Rexroad). 22, Inner-lateral view; 23, posterior view; Core I, 5,435 ft (KUMIP 1,800,213). Salem-lower St. Louis limestones.	25
24, 25.	*Ligonodina* sp. A. 24, Inner-lateral view; 25, posterior view; Core B, 5,697 ft (KUMIP 1,800,121). St. Louis Limestone.	32
26, 27.	*Ligonodina roundyi* Hass. 26, Inner-lateral view, Core I, 5,379 ft (KUMIP 1,800,231); 27, inner-lateral view, Core B, 5,707 ft (KUMIP 1,800,110). St. Louis Limestone.	32

KANSAS GEOLOGICAL SURVEY

PLATE II BULLETIN 192



THOMPSON AND GOEBEL—MERAMECIAN CONODONTS FROM KANSAS

LIGONODINA LEVIS Branson and Mehl

Pl. 2, fig. 19, 20.

Ligonodina levis Branson & Mehl, 1941b, p. 185, pl. 6, fig. 10; Bischoff, 1957, p. 30, pl. 5, fig. 8, 9, pl. 6, fig. 25; Rexroad & Burton, 1961, p. 1154, pl. 141, fig. 7, 8; Rexroad & Collinson, 1963, p. 11, pl. 2, fig. 24, 25; Thompson & Goebel, 1963, p. 12, fig. 3; Rexroad & Furnish, 1964, p. 672, pl. 111, fig. 38; Rexroad & Collinson, 1965, p. 10, pl. 1, fig. 23, 24; Rexroad & Nicoll, 1965, p. 21, pl. 2, fig. 24.

Ligonodina obunca Rexroad, 1957, p. 32, pl. 1, fig. 22, 23; Rexroad, 1958b, p. 21, pl. 3, fig. 7, 8. (not) *Ligonodina obunca* Rexroad. Higgins, 1961, p. 225, pl. 11, fig. 9.

Ligonodina sp. Youngquist & Miller (part), 1949, p. 620, pl. 101, fig. 12, 13 only.

Diagnosis.—Ligonodinid characterized by curved delicate inner-lateral process forming approximately 45-degree angle to direction of posterior bar as seen from inner side. From anterior, lateral process forms angle of 120 degrees with terminal denticle. Terminal denticle slender and long, moderately arched toward posterior.

Remarks.—The posterior curvature of the lateral process distinguishes *Ligonodina levis* Branson and Mehl from *L. roundyi* Hass, in which the lateral process curves strongly aborally, but curves only slightly toward the posterior, and from *L.* sp. A, in which the lateral process nearly parallels the posterior bar.

Distribution.—*Ligonodina levis* has been recovered previously from rocks ranging in age from late Osagian to late Chesteran. In the present study over 40 specimens were recovered from the Warsaw Limestone (Cores F, K, M), the Salem Limestone (Cores C, D, I), the St. Louis Limestone (Cores (A, B, C, D, M, N, O), the Ste. Genevieve Limestone (Cores B, D), and the Keokuk Limestone (Locality P).

Repository.—KUMIP 1,800,143; KUMIP 1,800,109 (figured specimens).

EXPLANATION OF PLATE 3

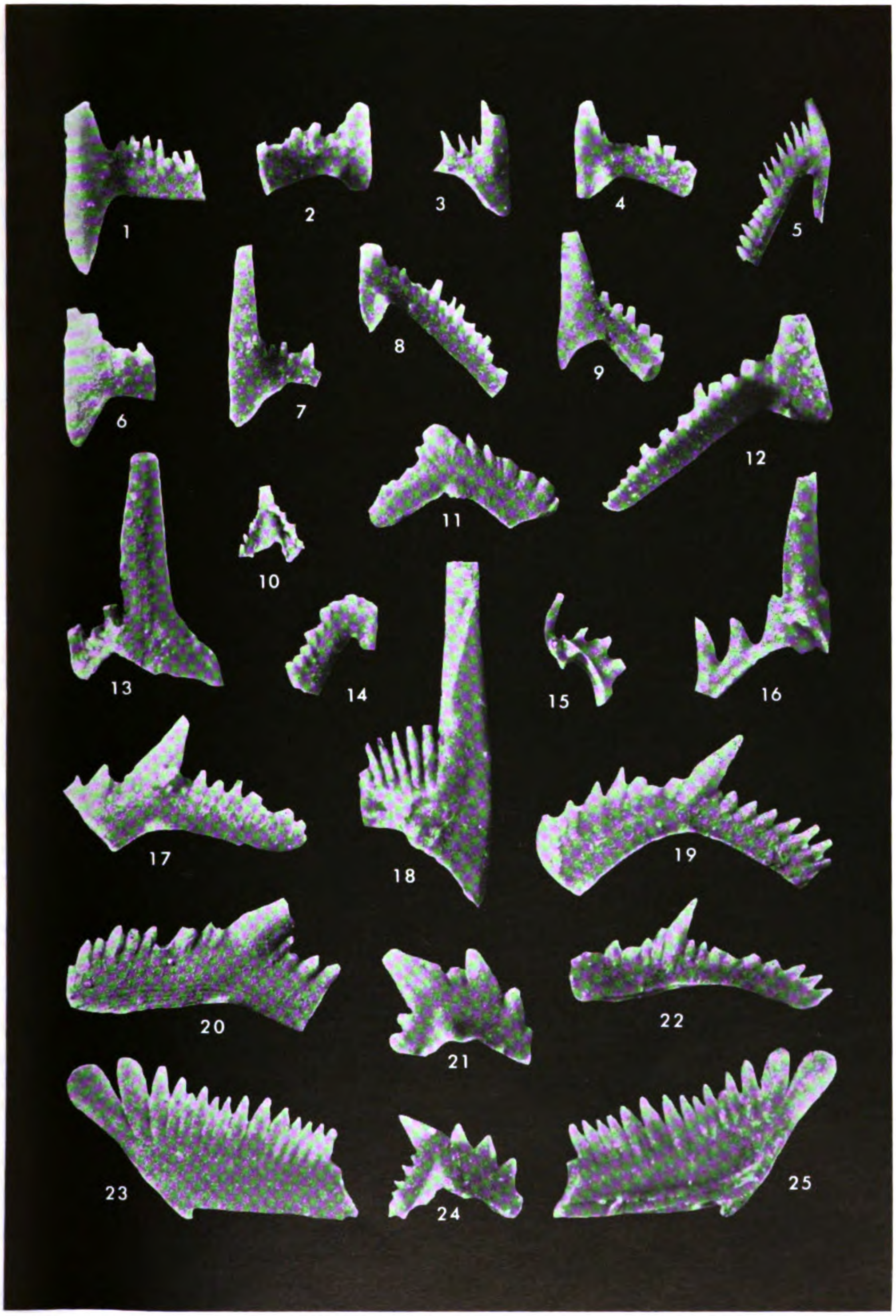
All figures × about 35

Conodonts from the Warsaw, Salem, and St. Louis limestones in Kansas.

Figure		Page
1.	*Neoprioniodus ligo* (Hass). Lateral view, Core N, 1,662 ft (KUMIP 1,800,290). St. Louis Limestone.	37
2.	*Neoprioniodus acampylus* Rexroad and Collinson. Lateral view, Core F, 4,479 ft (KUMIP 1,800,190). Warsaw Limestone.	37
3.	*Neoprioniodus* sp. cf. *N. cassilaris* (Branson and Mehl). Lateral view, Core K, 4,725-4,727 ft (KUMIP 1,800,246). Warsaw Limestone.	37
4, 12.	*Neoprioniodus loxus* Rexroad. 4, Lateral view, Core F, 4,486-4,487 ft (KUMIP 1,800,192). Warsaw Limestone. 12, Lateral view, Core I, 5,436 ft (KUMIP 1,800,217). Salem Limestone.	38
5.	*Neoprioniodus?* sp. Lateral view, Core B, 5,707 ft (KUMIP 1,800,112). St. Louis Limestone.	40
6.	*Neoprioniodus varians* (Branson and Mehl). Lateral view, Core M, 1,767 ft (KUMIP 1,800,272). St. Louis Limestone.	39
7, 18.	*Neoprioniodus tulensis* (Pander). 7, Lateral view, Core G, 4,324 ft (KUMIP 1,800,206). Warsaw Limestone. 18, Lateral view, Core I, 5,377 ft (KUMIP 1,800,232). St. Louis Limestone.	38
8, 14.	*Neoprioniodus camurus* Rexroad. 8, Lateral view, Core F, 4,479 ft (KUMIP 1,800,191). Warsaw Limestone. 14, Lateral view, Core A, 6,786 ft (KUMIP 1,800,093). St. Louis Limestone.	37
9.	*Neoprioniodus roundyi* (Hass). Lateral view, Core A, 6,754 ft (KUMIP 1,800,095). St. Louis Limestone.	38
10.	*Synprioniodina laxilabrum* Rexroad and Collinson. Lateral view, Core K, 4,772-4,774 ft (KUMIP 1,800,252). Warsaw Limestone.	44
11.	*Ozarkodina curvata* Rexroad. Lateral view, Core F, 4,487 ft (KUMIP 1,800,195). Warsaw Limestone.	40
13, 16.	*Neoprioniodus? inclinatus* (Hass). 13, Lateral view, Core O, 1,707 ft (KUMIP 1,800,303); 16, lateral view, Core K, 4,729 ft (KUMIP 1,800,249). Warsaw Limestone.	39
15.	*Neoprioniodus? concavus* (Ulrich and Bassler). Lateral view, Core N, 1,665 ft (KUMIP 1,800,294). St. Louis Limestone.	39
17, 20.	*Ozarkodina compressa* Rexroad. 17, Lateral view, Core B, 5,710 ft (KUMIP 1,800,113). St. Louis Limestone. 20, Lateral view, Core F, 4,490-4,495 ft (KUMIP 1,800,194). Warsaw Limestone.	40
19.	*Ozarkodina roundyi* (Hass). Lateral view, Core G, 4,338 ft (KUMIP 1,800,207). Warsaw Limestone.	41
21, 24.	*Ozarkodina* sp. cf. *O. laevipostica* Rexroad and Collinson. 21, Lateral view, Core F, 4,472 ft (KUMIP 1,800,196); 24, lateral view, Core F, 4,488-4,491 ft (KUMIP 1,800,334). Warsaw Limestone.	40
22.	*Ozarkodina recta* Rexroad. Lateral view, Core B, 5,651 ft (KUMIP 1,800,125). St. Louis Limestone.	41
23, 25.	New genus? sp. 23, Outer-lateral view; 25, Inner-lateral view; Core M, 1,754 ft (KUMIP 1,800,275). St. Louis Limestone.	45

KANSAS GEOLOGICAL SURVEY

PLATE III BULLETIN 192



THOMPSON AND GOEBEL—MERAMECIAN CONODONTS FROM KANSAS

LIGONODINA ROUNDYI Hass

Pl. 2, fig. 26, 27.

Ligonodina roundyi Hass, 1953, p. 82, pl. 15, fig. 5-9; Elias, 1956, p. 126, pl. 5, fig. 10-14; Rexroad, 1958b, p. 21, pl. 3, fig. 1-4; Stanley, 1958, p. 468, pl. 68, fig. 3, 4.

Diagnosis.—Ligonodinid distinguished by lateral process directed sharply downward approximately 90 degrees from posterior bar with little or no posterior curvature. Denticles of lateral process straight and long.

Remarks.—The lateral process of *Ligonodina roundyi* Hass is larger than that of *L. levis* Branson and Mehl, and curves aborally with a greater angle. *L. roundyi* closely resembles *L. tenuis* Branson and Mehl, but the lateral process of the former is heavier and curves to the posterior with a greater angle. *L. roundyi* also has larger denticles on the lateral process than does *L. tenuis.*

Distribution.—Ligonodina roundyi has been recovered previously from rocks of early Chesteran age. In the present study 15 specimens were recovered from the Warsaw Limestone (Cores E, F), and the St. Louis Limestone (Cores A, B, I, N, O).

Repository.—KUMIP 1,800,231; KUMIP 1,800,110 (figured specimens).

LIGONODINA sp. A

Pl. 2, fig. 24, 25.

Description.—Short, laterally compressed apical denticle curved sharply posteriorly, upper half nearly paralleling small posterior bar beneath it. Posterior bar broken near terminal denticle, but is small in diameter and length. Lateral process relatively large, directed outward and downward, curving slightly toward anterior near terminus. Lateral process with only one large curved denticle directed slightly toward posterior, process sharply pointed at distal end. Aboral surface of unit triangular in outline beneath apical denticle; basal pit small and indistinct.

Remarks.—This form is small. The extreme posterior curvature of the apical denticle and relatively large size of the lateral process distinguishes *Ligonodina* sp. A from *L. levis* Branson and Mehl, which has a nearly straight apical denticle, and from *L. roundyi* Hass, which has a large downward-curving lateral process.

Distribution.—Two specimens of *Ligonodina* sp. A were recovered from the St. Louis Limestone in Cores A and B.

Repository.—KUMIP 1,800,121 (figured specimen).

EXPLANATION OF PLATE 4

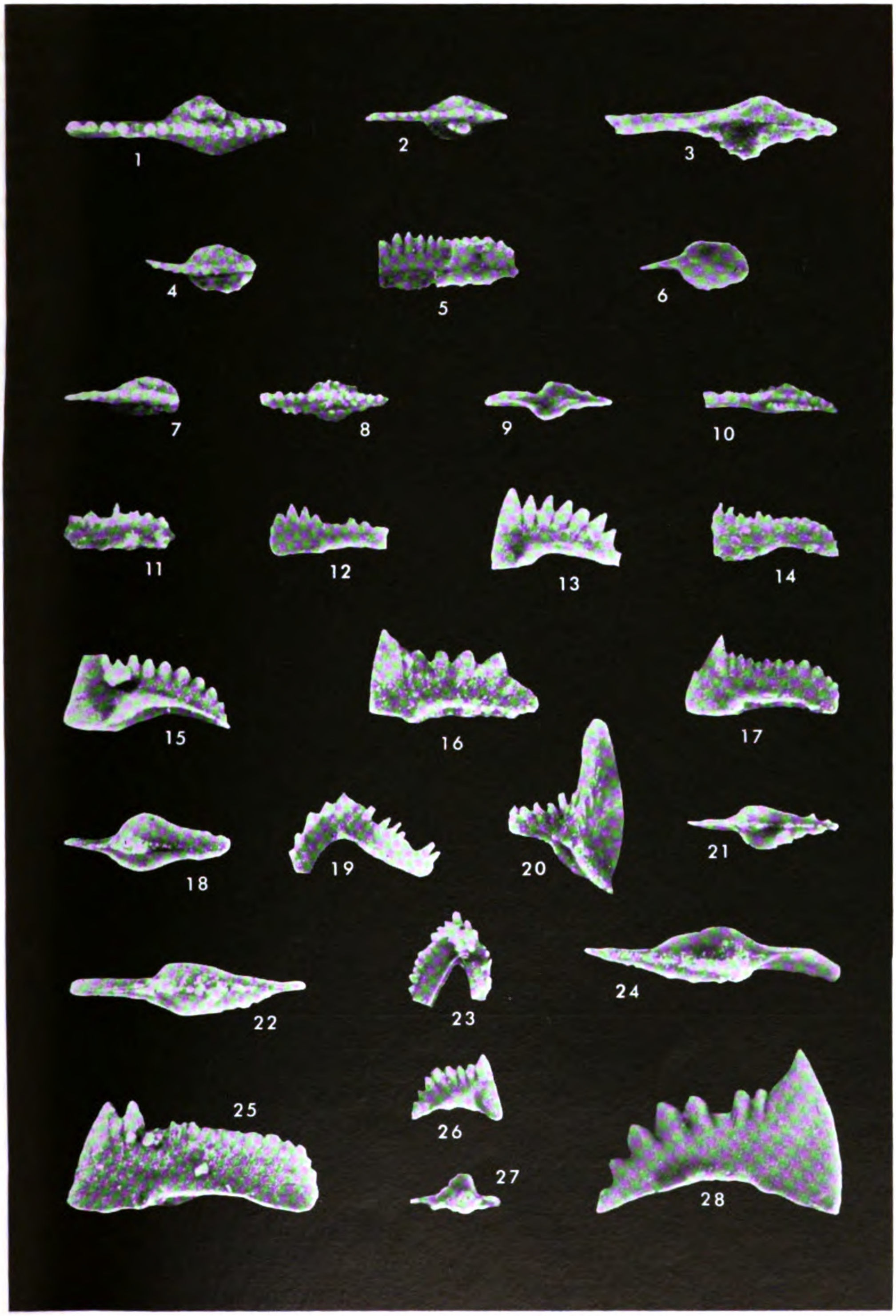
All figures × about 35

Conodonts from the Warsaw and St. Louis limestones in Kansas.

Figure		Page
1-3, 5.	*Gnathodus texanus* Roundy. 1, Oral view; 3, aboral view; Core G, 4,327 ft (KUMIP 1,800,202); 2, oral view; 5, lateral view; Core K, 4,717-4,719 ft (KUMIP 1,800,240). Warsaw Limestone.	24
4, 6, 7.	*Gnathodus commutatus* (Branson and Mehl). 4, Oral view; 6, aboral view; Core A, 6,788 ft (KUMIP 1,800,084). 2, Oral view, Core A, 6,789 ft (KUMIP 1,800,335). St. Louis Limestone.	23
8-10, 14.	*Gnathodus girtyi?* Hass. 8, Oral view; 9, aboral view, Core B, 5,657 ft (KUMIP 1,800,119); 10, oral view; 14, lateral view, Core A, 6,755 ft (KUMIP 1,800,085). St. Louis Limestone.	24
11.	*Spathognathodus campbelli* Rexroad. Lateral view, Core B, 5,651 ft (KUMIP 1,800,127). St. Louis Limestone.	41
12.	*Spathognathodus spiculus* Youngquist and Miller. Lateral view, Core A, 6,793 ft (KUMIP 1,800,102). St. Louis Limestone.	43
13, 15, 18.	*Spathognathodus cristula* Youngquist and Miller. 13, Lateral view, Core I, 5,395 ft (KUMIP 1,800,233); 15, lateral view; 18, aboral view; Core B, 5,663-5,668 ft (KUMIP 1,800,128). St. Louis Limestone.	42
16.	*Spathognathodus penescitulus* Rexroad and Collinson. Lateral view, Core C, 4,930-4,946 ft (KUMIP 1,800,149). St. Louis Limestone.	42
17, 21, 22, 25.	*Spathognathodus* sp. cf. *S. pulcher* (Branson and Mehl). 17, lateral view; 21, aboral view; Core C, 4,930-4,946 ft (KUMIP 1,800,150). St. Louis Limestone. 22, Aboral view; 25, lateral view; Core F, 4,490-4,495 ft (KUMIP 1,800,199). Warsaw Limestone.	42
19.	*Ozarkodina curvata* Rexroad. Lateral view, Core A, 6,794 ft (KUMIP 1,800,098). St. Louis Limestone.	40
20.	*Neoprioniodus tulensis* (Pander). Lateral view, Core D, 4,494 ft (KUMIP 1,800,166). St. Louis Limestone.	38
23.	*Apatognathus? porcata* (Hinde). Innerlateral view, Core A, 6,788 ft (KUMIP 1,800,336). St. Louis Limestone.	21
24, 28.	*Spathognathodus* n. sp.? 24, Aboral view; 28, lateral view; Core D, 4,582 ft (KUMIP 1,800,169). St. Louis Limestone.	43
26, 27.	*Spathognathodus scitulus* (Hinde). 26, Lateral view; 27, aboral view; Core C, 4,857-4,862 ft (KUMIP 1,800,151). St. Louis Limestone.	43

KANSAS GEOLOGICAL SURVEY

PLATE IV BULLETIN 192



THOMPSON AND GOEBEL—MERAMECIAN CONODONTS FROM KANSAS

LIGONODINA n. sp.

Pl. 2, fig. 7, 8, 18.

Description.—Unit with straight, narrow posterior bar possessing several minute discrete denticles. Terminal denticle long and slender, bowed slightly toward posterior. Inner-lateral process extends first directly anterior of terminal denticle, then bends 90 degrees inward beneath first slightly curved denticle of inner-lateral process. Lateral process possesses several slightly curved discrete denticles, and has little or no aboral deflection, lying nearly in plane of posterior bar. Small basal cavity located beneath terminal denticle at juncture of this denticle with posterior bar.

Remarks.—*Ligonodina* n. sp. differs from previously described species of this genus in the initial anterior direction of the inner-lateral process, and in the near horizontality of this process as seen in lateral view. This form has been recovered from the St. Louis Limestone in St. Louis County, Missouri (Thompson, 1966).

Distribution.—Three specimens of *Ligonodina* n. sp. were recovered in the present study from the St. Louis Limestone in Cores A and B.

Repository.—KUMIP 1,800,117; KUMIP 1,800,083 (figured specimens).

Genus LONCHODINA Ulrich and Bassler, 1926

Lonchodina Ulrich & Bassler, 1926, p. 30.

Type species.—*Lonchodina typicalis* Ulrich & Bassler, OD (1926, p. 31, pl. 5, fig. 1, 2).

Diagnosis.—Unit consisting of denticulate bar arched at position of subcentral circular basal cavity. Denticles discrete and irregular in length; apical denticle above basal cavity not always distinguishable from other denticles.

Remarks.—The two limbs anterior and posterior of the apical denticle are distinctly barlike, showing little lateral compression. This distinguishes *Lonchodina* from *Elictognathus* and *Ozarkodina*, which have highly compressed bladelike limbs. The basal cavity of *Bactrognathus* is much broader, and bactrognathids do not contain an apical denticle.

Speciation is based on the degree of arching of the two limbs, the lateral angle between the limbs, the relative size of the apical denticle, and the shape of the basal cavity.

Distribution.—*Lonchodina* has been identified from rocks ranging in age from Devonian to Pennsylvanian.

LONCHODINA PARACLARKI Hass

Pl. 2, fig. 10.

Lonchodina paraclarki Hass, 1953, p. 83, pl. 16, fig. 15, 16; Elias, 1956, p. 122, pl. 5, fig. 6, 7; Stanley, 1958, p. 468, pl. 67, fig. 1.

Diagnosis.—Lonchodinid with long, curved, heavy apical denticle, small anterior and posterior bars meeting with small lateral angle and slight downward arch. Large, deep triangular basal cavity, beneath apical denticle, has highly flared outer lip and only slightly flared inner lip.

Remarks.—The majority of specimens of *Lonchodina paraclarki* Hass recovered in the present study retain only the stumps of the anterior and posterior processes, with one or two denticles near the apical denticle remaining. These specimens are identified by the lateral angle at the juncture of the two processes and by the large outward flaring, triangular basal cavity. *L. furnishi* Rexroad has no appreciable lateral angle between the two limbs, and is more highly arched downward. The anterior and posterior limbs are smaller than those of *L. paraclaviger* Rexroad.

Distribution.—*Lonchodina paraclarki* has been recovered previously from rocks of early Chesteran age. In the present study 20 specimens were recovered from the Warsaw Limestone (Cores J, K, M, O) and the Keokuk Limestone (Localities P and Q).

Repository.—KUMIP 1,800,244 (figured specimen).

EXPLANATION OF PLATE 5

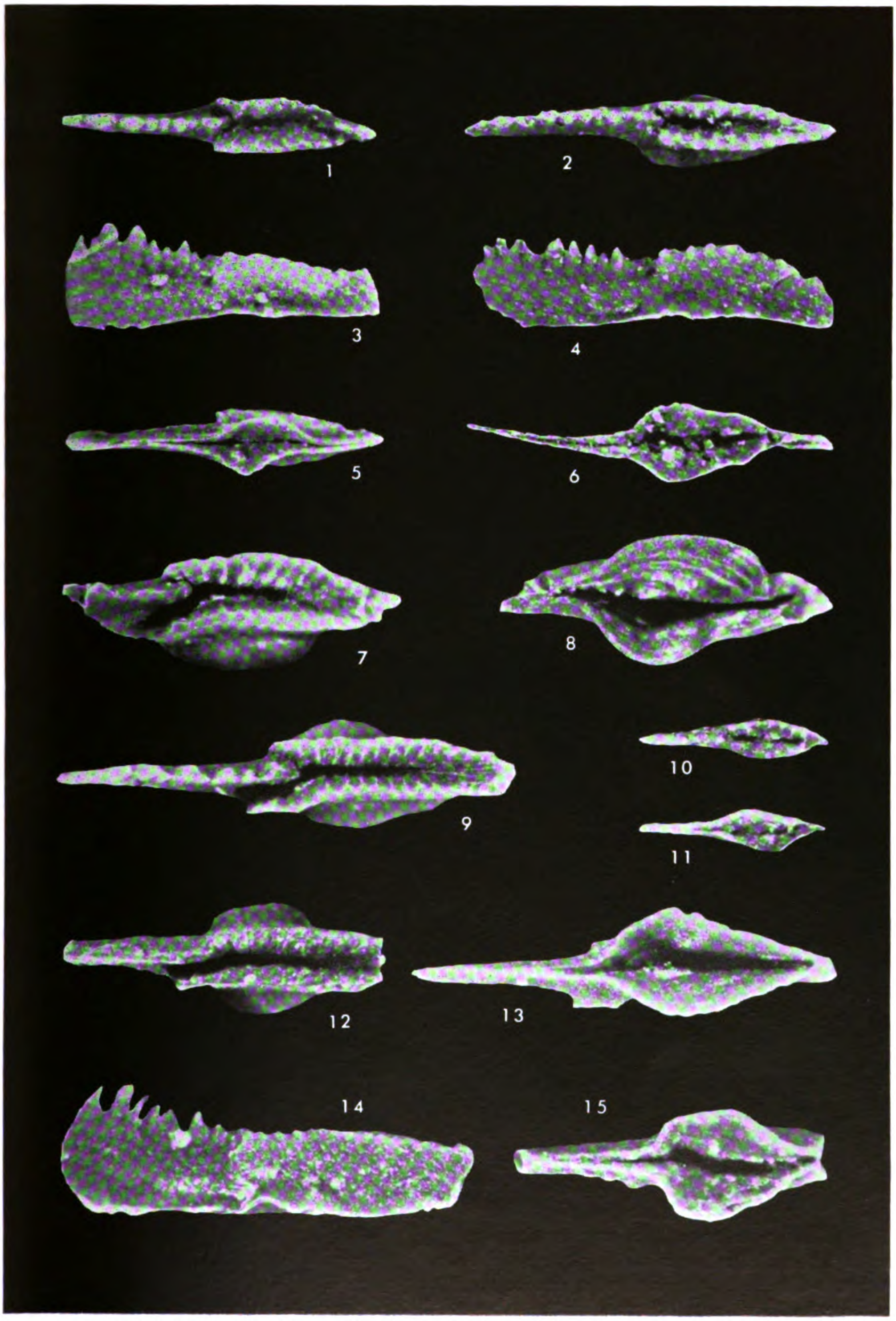
All figures × about 35

Conodonts from the Keokuk (Osagian), and Warsaw, Salem, and St. Louis limestones in Kansas.

Figure		Page
1-9, 12-15.	*Taphrognathus varians* Branson and Mehl. 1, Oral view; 3, lateral view; 5, aboral view; Core F, 4,490-4,495 ft (KUMIP 1,800,200); 2, Oral view; 4, lateral view; 6, aboral view; Core M, 1,779 ft (KUMIP 1,800,265); 9, Oral view; 13, aboral view; 14, lateral view; Core E, 4,574 ft (KUMIP 1,800,183). Warsaw Limestone. 7, Oral view; 8, aboral view; Core I, 5,444 ft (KUMIP 1,800,220). Salem Limestone. 12, Oral view; 15, aboral view; Loc. P, 20 ft below top (KUMIP 1,800,327). Keokuk Limestone.	44
10, 11.	*Taphrognathus* sp. 10, Oral view; 11, aboral view; Core C, 4,826 ft (KUMIP 1,800,153). St. Louis Limestone.	45

KANSAS GEOLOGICAL SURVEY

PLATE V BULLETIN 192



THOMPSON AND GOEBEL—CONODONTS FROM KANSAS

LONCHODINA PARACLAVIGER Rexroad

Pl. 2, fig. 17, 21.

Lonchodina paraclaviger REXROAD, 1958b, p. 22, pl. 4, fig. 7-10.

Diagnosis.—Lonchodinid with large anterior limb inclined outward from line of smaller posterior limb. Denticles of anterior limb large, those of shorter posterior limb smaller. Basal cavity located directly beneath large apical denticle; triangular in outline, with straight outer margin and sharply flared inner lip.

Remarks.—The anterior limb is larger than the posterior limb in *Lonchodina paraclaviger* Rexroad, and the denticles of the anterior limb are large relative to the large apical denticle. The anterior denticles of *L. furnishi* Rexroad and *L. paraclarki* Hass are smaller, and do not as closely approximate the apical denticle in size.

Distribution.—Lonchodina paraclaviger has been recovered previously from rocks of early Chesteran age. In the present study two specimens were recovered from the Warsaw Limestone in Core K.

Repository.—KUMIP 1,800,245 (figured specimen).

Genus MAGNILATERELLA Rexroad and Collinson, 1963

Lonchodina? Ulrich & Bassler. BRANSON & MEHL, 1941a, p. 171; YOUNGQUIST & MILLER, 1949, p. 620; BISCHOFF (part), 1957, p. 34.

Ligonodina? Ulrich & Bassler. BRANSON & MEHL, 1941a, p. 171.

Genus indeterminate REXROAD, 1957, p. 42; REXROAD, 1958b, p. 26.

Genus Novum? CLARKE, 1960, p. 15.

New Genus? REXROAD & JARRELL, 1961, p. 2014.

Magnilaterella REXROAD & COLLINSON, 1963, p. 11.

Type species.—Magnilaterella robusta REXROAD & COLLINSON, OD (1963, p. 14, pl. 1, fig. 4, 5, 9; Text-fig. 3A, B, C, 4A, B, C, D, E, F).

Diagnosis.—Unit consisting of small denticulate posterior bar and large denticulate inner-lateral bar. Lateral bar contains largest denticle, near midlength. Basal cavity near anterior end of posterior bar, at juncture with lateral bar, and extends as grooves along lower surface of either bar.

Remarks.—The basal cavity is at the point of juncture of the two bars in *Magnilaterella*, beneath the terminal denticle in *Ligonodina*. *Cladognathodus* possesses anterior, posterior, and lateral bars, and specimens missing the anterior bar closely resemble *Magnilaterella*, except that the posterior bar usually contains only one denticle, while *Magnilaterella* has two or more on the posterior bar. *Lambdagnathus* with a missing anterior bar can easily be mistaken for a magnilaterellid.

Speciation is based on the size of the lateral bar and the number of major denticles on that bar.

Distribution.—Magnilaterella has been identified from rocks of Meramecian and Chesteran age.

MAGNILATERELLA ROBUSTA Rexroad and Collinson

Pl. 2, fig. 13, 14.

Lonchodina sp. BRANSON & MEHL (part), 1941a, p. 171, pl. 5, fig. 10 only.

Metalonchodina? sp. ELIAS, 1956, p. 124, pl. 4, fig. 3.

Genus indeterminate REXROAD (part), 1957, p. 42, pl. 4, fig. 19-21 only; REXROAD, 1958b, p. 26, pl. 5, fig. 1, 2.

New genus? sp. REXROAD & LIEBE (part), 1962, p. 511.

Magnilaterella robusta REXROAD & COLLINSON, 1963, p. 14, pl. 1, fig. 4, 5, 9, text-fig. 3A, B, C, 4A, B, C, D, E, F; REXROAD & FURNISH, 1964, p. 673, pl. 111, fig. 27-31; REXROAD & NICOLL, 1965, p. 22, pl. 1, fig. 10, 11.

Diagnosis.—Magnilaterellid characterized by relatively short and thick arched inner-lateral process bearing two or three major denticles with small, straight posterior bar bearing one or more minor denticles. Largest denticle on lateral bar near midpoint of bar. Grooved basal surface broad, extending half way up posterior surface of inner-lateral process.

Remarks.—Many fragments of conodonts were recovered that could belong to *Magnilaterella*, but identification was usually impossible with any surety. *M. robusta* Rexroad and Collinson has two or more major denticles on the lateral bar, while *M. complectens* (Clarke) possesses only one, with two minor denticles. *M. recurvata* (Bischoff) has a thinner and longer inner-lateral bar than *M. robusta*.

Distribution.—Magnilaterella robusta has been recovered previously from rocks ranging from early Meramecian to late Chesteran age. In the present study six specimens were recovered from the Warsaw Limestone (Core F) and the St. Louis Limestone (Cores A, B, D).

Repository.—KUMIP 1,800,122; KUMIP 1,800,092 (figured specimens).

Genus NEOPRIONIODUS Rhodes and Müller, 1956

Prioniodus PANDER (part), 1856, p. 30.

Neoprioniodus RHODES & MÜLLER, 1956, p. 698.

Type species.—Prioniodus conjunctus GUNNELL, SD (1931, p. 247, pl. 29, fig. 7) RHODES & MÜLLER (1956, p. 698).

Diagnosis.—Unit consisting of large, straight to curved terminal denticle with distinct aboral projection and denticulate, straight to downward-curving posterior bar. Oval basal cavity located at aboral juncture of aboral process and posterior bar.

Remarks.—Neoprioniodus lacks a lateral bar, has only one posterior bar, and thus differs from *Ligonodina*. The aboral projection is not denticulated, thus distinguishing *Neoprioniodus* from *Hindeodelloides* and *Synprioniodina.*

Speciation is based on the shape and prominence of the terminal denticle, length and width of the aboral projection, length, curvature, and denticulation of the posterior bar, and size and degree of lateral flaring of the basal cavity.

Distribution.—Neoprioniodus has been identified from rocks ranging in age from Devonian to Pennsylvanian.

NEOPRIONIODUS ACAMPYLUS Rexroad and Collinson

Pl. 3, fig. 2.

Neoprioniodus acampylus Rexroad & Collinson, 1965, p. 11, pl. 1, fig. 25-27.

Diagnosis.—Small neoprioniodid laterally unbowed except for terminal fang. Aboral projection long; posterior bar forms angle of about 55 degrees with aboral projection. Denticles of posterior bar small and deeply inserted.

Remarks.—Neoprioniodus acampylus Rexroad and Collinson is similar to *N. camurus* Rexroad. However, the former is laterally unbowed, while the latter is very strongly bowed immediately posterior to the terminal denticle. The denticles of *N. camurus* are not deeply inserted as in *N. acampylus.*

Distribution.—Neoprioniodus acampylus has previously been recovered from rocks of early Meramecian age. In the present study one specimen was recovered from the Warsaw Limestone in Core F.

Repository.—KUMIP 1,800,190 (figured specimen).

NEOPRIONIODUS CAMURUS Rexroad

Pl. 3, fig. 8, 14.

Neoprioniodus camurus Rexroad, 1957, p. 34, pl. 2, fig. 8, 9, 14; Rexroad, 1958b, p. 23, pl. 5, fig. 5, 6; Rexroad & Burton, 1961, p. 1155, pl. 140, fig. 11; Rexroad & Furnish, 1964, p. 674, pl. 111, fig. 32; Rexroad & Nicoll, 1965, p. 23, pl. 2, fig. 19, 20.

Diagnosis.—Neoprioniodid characterized by short, slender terminal denticle with straight, long and narrow aboral projection. Posterior bar very long, laterally bowed, compressed, and straight, with numerous small subequal denticles. Angle between aboral projection and posterior bar sharp, nearly 45 degrees.

Remarks.—The posterior bar of *Neoprioniodus camurus* Rexroad is more highly curved aborally, contains more equal-sized denticles, and has a larger aboral projection than *N. loxus* Rexroad. It is generally smaller and has a smaller basal cavity than *N. tulensis* (Pander) and *N. varians* (Branson and Mehl), and has a smaller basal cavity than *N. cassilaris* (Branson and Mehl).

Distribution.—Neoprioniodus camurus has previously been recovered from rocks of late Meramecian and late Chesteran age. In this study four specimens were recovered from the Warsaw Limestone (Cores F, G), and the St. Louis Limestone (Core A).

Repository.—KUMIP 1,800,191; KUMIP 1,800,093 (figured specimens).

NEOPRIONIODUS sp. cf. N. CASSILARIS (Branson and Mehl)

Pl. 3, fig. 3.

Prioniodus cassilaris Branson & Mehl, 1941b, p. 186, pl. 6, fig. 11, 12, 15, 17; Youngquist, Miller, & Downs, 1950, p. 528, pl. 67, fig. 23, 24.

Prioniodina cassilaris (Branson and Mehl). Bischoff, 1957, p. 47, pl. 5, fig. 38, 39.

Neoprioniodus cassilaris (Branson & Mehl). Elias, 1959, p. 153, pl. 2, fig. 17-21.

Description.—Unit of small size with wide lateral flare to large basal cavity. Basal cavity located in broad aboral projection of terminal denticle. Posterior bar short, slightly arched aborally, with small number of large denticles.

Remarks.—Rexroad and Collinson (1963) consider *Neoprioniodus cassilaris* (Branson and Mehl) to be a synonym of *N. tulensis* (Pander), because of the variability in the former illustrated by Branson and Mehl (1941b). The specimens recovered in the present study are similar to *N. tulensis* except for their small size, which appears to be a consistent feature, and not one of immaturity. For this reason, these specimens are here referred to *N. cassilaris.*

Distribution.—In the present study five specimens of *Neoprioniodus* sp. cf. *N. cassilaris* were recovered from the Warsaw Limestone in Core K.

Repository.—KUMIP 1,800,246 (figured specimen).

NEOPRIONIODUS LIGO (Hass)

Pl. 3, fig. 1.

Prioniodus peracutus Roundy, 1926 (part), p. 10, pl. 4, fig. 7, 8 only.

Prioniodus ligo Hass, 1953, p. 87, pl. 16, fig. 1-3; Elias, 1956, p. 109, pl. 2, fig. 16-18; Elias, 1959, p. 150, pl. 2, fig. 12-14.

Diagnosis.—Neoprioniodid with short, narrow, terminal denticle, broader at base than aboral projection is at top. Aboral projection long, nearly as long as terminal denticle, and sharply pointed, with small indistinct basal cavity. Posterior bar long, thin, projecting from terminal denticle-aboral projection at a right angle.

Remarks.—The very long, narrow aboral projection and straight, small posterior bar projecting approximately 90 degrees from the terminal denticle-aboral projection distinguishes *Neoprioniodus ligo* (Hass) from other species of *Neoprioniodus* reported in the present study. The illustrations of Hass (1953) and Elias (1956, 1959) indicate some variability in the aboral projection, from straight with parallel anterior and posterior edges to long, wedge-shaped, terminating in a point at the anterior edge.

Distribution.—*Neoprioniodus ligo* has previously been recovered from rocks of late Chesteran age. In the present study two specimens were recovered from the Salem Limestone (Core I) and the St. Louis Limestone (Core N).

Repository.—KUMIP 1,800,290 (figured specimen).

NEOPRIONIODUS LOXUS Rexroad

Pl. 3, fig. 4, 12.

Neoprioniodus loxus Rexroad, 1957, p. 34, pl. 2, fig. 8, 9, 14; Rexroad, 1958b, p. 23, pl. 5, fig. 7, 9; Rexroad & Burton, 1961, p. 1155, pl. 140, fig. 12; Rexroad & Collinson, 1963, p. 18, pl. 2, fig. 28; Thompson & Goebel, 1963, p. 12, fig. 3; Rexroad & Furnish, 1964, p. 674, pl. 111, fig. 26; Rexroad & Collinson, 1965, p. 12, pl. 1, fig. 11, 19; Rexroad & Nicoll, 1965, p. 23, pl. 2, fig. 23.

Neoprioniodus tenuis Rexroad, 1957, p. 35, pl. 2, fig. 13, 16.

Diagnosis.—Neoprioniodid with long, compressed, slightly arched posterior bar bearing short denticles of unequal length in random sorting. Aboral projection short with sharp near 90-degree angle with aboral margin of posterior bar. Deep and small basal cavity located at juncture of aboral projection and posterior bar, with slight lateral flaring of inner and outer lips.

Remarks.—Some representatives of *Neoprioniodus loxus* Rexroad recovered in the present study show considerable lateral flexure of the posterior bar as seen from oral view. The unequal and random sorting of the denticles of the posterior bar distinguish *N. loxus* from *N. camurus* Rexroad. The latter also has a more acute angle between the posterior bar and aboral projection. The lateral flexure of the posterior bar distinguishes *N. loxus* from *N. acampylus* Rexroad and Collinson and *N. varians* (Branson and Mehl).

Distribution.—*Neoprioniodus loxus* has previously been recovered from rocks ranging in age from late Osagian to late Chesteran. In the present study 29 specimens were recovered from the Warsaw Limestone (Cores E, F, G, K), the Salem Limestone (Core I), the St. Louis Limestone (Cores A, C, N), the Ste. Genevieve Limestone (Core D), and the Keokuk Limestone (Locality P).

Repository.—KUMIP 1,800,192; KUMIP 1,800,217 (figured specimens).

NEOPRIONIODUS ROUNDYI (Hass)

Pl. 3, fig. 9.

Prioniodus sp. B Roundy, 1926, p. 11, pl. 4, fig. 10.

Prioniodus roundyi Hass, 1953, p. 88, pl. 15, fig. 2, 3; Elias, 1956, p. 109, pl. 11, fig. 19-21.

Diagnosis.—Neoprioniodid with slender, downward-arched slightly laterally flexed posterior bar, bearing discrete unfused denticles of uniform length. Terminal denticle long and narrow. Aboral projection pointed distally, broad and compressed at juncture with posterior bar. Aboral projection curved convexly inward, concave on outer side along posterior edge. Pit small and indistinct.

Remarks.—The marked inward curve and outer concavity of the aboral projection distinguishes *Neoprioniodus roundyi* (Hass) from *N. acampylus* Rexroad & Collinson, *N. loxus* Rexroad, and *N. varians* (Branson & Mehl), each of which has a small outward and inward flare to the posterior edge of the aboral projection.

Distribution.—*Neoprioniodus roundyi* has previously been reported from rocks of late Chesteran age. In the present study two specimens were recovered from the St. Louis Limestone in Core A.

Repository.—KUMIP 1,800,095 (figured specimen).

NEOPRIONIODUS TULENSIS (Pander)

Pl. 3, fig. 7, 18; Pl. 4, fig. 20.

Prioniodus tulensis Pander (part), 1856, p. 30, pl. 2A, fig. 1 only; Holmes (part), 1928, p. 22, pl. 3, fig. 18 only.

Neoprioniodus tulensis (Pander). Rexroad & Collinson, 1963, p. 18, pl. 2, fig. 17, 22, 23; Rexroad & Collinson, 1965, p. 12, pl. 1, fig. 28, 29.

Neoprioniodus scitulus (Branson & Mehl). Thompson & Goebel, 1963, p. 12, fig. 3.

Diagnosis.—Large neoprioniodid distinguished by long aboral projection with large laterally flared basal cavity, and short coarsely denticulate aborally curved posterior bar meeting terminal denticle at a nearly 90-degree angle.

Remarks.—Considerable confusion exists about the differences between *Neoprioniodus tulensis* (Pander) and *N. scitulus* (Branson and Mehl). It appears that they are the same form, and that *N. tulensis* is a junior synonym of *N. scitulus.* This confusion is expressed by Rexroad and Collinson (1963), and both names have been used by various authors for seemingly the same morphologic form. There is little difference between *N. tulensis* and *N. cassilaris* (Branson and Mehl), except for the generally smaller size of the latter.

Distribution.—Neoprioniodus tulensis has previously been recovered from rocks ranging in age from late Osagian to late Meramecian. In the present study 77 specimens were recovered from the Warsaw Limestone (Cores E, F, G, K, M, N, O), the Salem Limestone (Cores H, I), the St. Louis Limestone (Cores A, B, C, D, I, L, M, N, O), and the Keokuk Limestone (Locality P).

Repository.—KUMIP 1,800,206; KUMIP 1,800,232; KUMIP 1,800,166 (figured specimens).

NEOPRIONIODUS VARIANS (Branson and Mehl)
Pl. 3, fig. 6.

Prioniodus varians Branson & Mehl, 1941a, p. 174, pl. 5, fig. 7, 8; Elias, 1956, p. 110, pl. 2, fig. 7, 8.

Prioniodina varians (Branson & Mehl). Bischoff, 1957, p. 49, pl. 5, fig. 35; Flügel & Ziegler, 1957, p. 50.

Neoprioniodus varians (Branson & Mehl). Rexroad, 1957, p. 35, pl. 2, fig. 10; Rexroad, 1958b, p. 24, pl. 5, fig. 3, 4; Higgins, 1961, p. 226, pl. 11, fig. 1; Rexroad & Burton, 1961, p. 1155, pl. 140, fig. 9, 10; Rexroad & Collinson, 1963, p. 19, pl. 2, fig. 26; Rexroad & Nicoll, 1965, p. 24, pl. 2, fig. 18.

Prioniodus barbatus Branson & Mehl, Ellison & Graves (part), 1941, p. 19, pl. 1, fig. 27 only.

Diagnosis.—Neoprioniodid with laterally compressed posterior bar forming a nearly 90-degree angle with terminal denticle at aboral juncture. Inner lip flared on small basal cavity in large aboral projection.

Remarks.—Neoprioniodus varians (Branson and Mehl) is similar to *N. loxus* Rexroad, but has a smaller angle between the terminal denticle and posterior bar and a larger basal cavity. The denticles of the posterior bar are an alternation of one large and several very small fused units.

Distribution.—Neoprioniodus varians has previously been recovered from rocks ranging in age from early late Meramecian to early Pennsylvanian. In the present study five specimens were recovered from the St. Louis Limestone in Cores B, C, M, and N.

Repository.—KUMIP 1,800,272 (figured specimen).

NEOPRIONIODUS? CONCAVUS (Ulrich and Bassler)
Pl. 3, fig. 15.

Prioniodus concavus Ulrich & Bassler, 1926, p. 10, pl. 9, fig. 11.

Diagnosis.—Short unit with strong, straight apical denticle and highly arched posterior bar containing several large denticles paralleling direction of apical denticle. Aboral projection very short and highly arched.

Remarks.—This form may be placed in *Neoprioniodus,* but is unlike any typical representative of this genus in the extremely short aboral projection of the terminal denticle and the flat, highly curved aboral surface of the posterior bar.

Distribution.—Neoprioniodus? concavus has been previously recovered from rocks of early Kinderhookian age. In this study one specimen was recovered from the St. Louis Limestone in Core N.

Repository.—KUMIP 1,800,294 (figured specimen).

NEOPRIONIODUS? INCLINATUS (Hass)
Pl. 3, fig. 13, 16.

Prioniodus sp. D Roundy (part), 1926, p. 11, pl. 4, fig. 12 only.

Prioniodus inclinatus Hass, 1953, p. 87, pl. 16, fig. 10-14.

Prioniodus? inclinatus Hass. Elias, 1956, p. 112, pl. 4, fig. 4-7.

Neoprioniodus inclinatus (Hass). Stanley, 1958, p. 462; Higgins, 1961, p. 226, pl. 11, fig. 3.

Diagnosis.—Unit with short, stout, terminal denticle with thick base and short posterior bar containing several discrete, relatively large denticles, well separated at their bases. Posterior bar makes a nearly 90-degree angle with base of aboral projection. Basal cavity broad, shallow, and oval.

Remarks.—Some of the illustrations of *Prioniodus inclinatus* Hass by Hass (1953) appear to show a broken denticle stump anterior to the terminal denticle. Because of the anterior denticle, coupled with the gross size of the basal cavity, this form closely resembles those of *Lonchodina,* and places this form in doubtful taxonomic position. The specimens recovered in the present study do not show a broken surface on the anterior surface of the terminal denticle. These specimens are, therefore, placed in *Neoprioniodus* with reservation.

Distribution.—Neoprioniodus? inclinatus has been previously recovered from rocks of early Chesteran age. In the present study two specimens were recovered from the Warsaw Limestone in Cores K and O.

Repository.—KUMIP 1,800,303; KUMIP 1,800,249 (figured specimens).

NEOPRIONIODUS? sp.

Pl. 3, fig. 5.

Description.—Unit highly arched and sharply bowed. Posterior limb long, slightly curved, containing short, sharply pointed unfused denticles of equal length along entire length. Terminal denticle very long and slender, curved slightly posteriorly and strongly inward. Aboral projection long and slender, highly compressed laterally, reflecting aboral extension of terminal denticle; no posterior extension beneath posterior bar. Basal cavity indistinct. Angle of aboral projection and posterior bar less than 30 degrees.

Remarks.—This specimen closely resembles *Apatognathus? porcata* (Hinde), but differs in that the anterior bar contains no denticles, and this anterior bar is actually an aboral projection of the terminal denticle. The actual affinities of this form are unknown, and it is placed in *Neoprioniodus* with reservation.

Distribution.—In the present study, one specimen of *Neoprioniodus?* sp. was recovered from the St. Louis Limestone in Core B.

Repository.—KUMIP 1,800,112 (figured specimen).

Genus OZARKODINA Branson and Mehl, 1933

Ozarkodina Branson & Mehl, 1933, p. 51.

Type species.—*Ozarkodina typica* Branson & Mehl, OD (1933, p. 51, pl. 3, fig. 43-45).

Diagnosis.—Unit consisting of thin, denticulate arched blade with large major denticle near midpoint of blade; approximately equal number of subequal denticles on either side. Small, deep basal cavity found directly beneath major denticle, at point of arch in blade.

Remarks.—*Ozarkodina* is similar to *Elictognathus,* but does not possess lateral ridges near the basal margin that characterize the latter genus.

Speciation is based on the degree of arch in the blade and on the oral outline of the denticles.

Distribution.—*Ozarkodina* has been identified from rocks ranging in age from Devonian to Pennsylvanian.

OZARKODINA COMPRESSA Rexroad

Pl. 3, fig. 17, 20.

Ozarkodina compressa Rexroad, 1957, p. 36, pl. 2, fig. 1, 2; Rexroad, 1958b, p. 24, pl. 6, fig. 1, 2; Rexroad & Burton, 1961, p. 1156, pl. 141, fig. 16, 17; Rexroad & Furnish, 1964, p. 674, pl. 111, fig. 9; Rexroad & Nicoll, 1965, p. 24, pl. 2, fig. 3, 4.

Diagnosis.—Ozarkodinid with thin, blade-like, slightly laterally curved unit containing fused denticles, large apical denticle, and small basal cavity with weakly flared lips.

Remarks.—The forms recovered in this study are placed in *Ozarkodina compressa* Rexroad, but possess a small basal cavity with less lateral flare than specimens previously reported.

Distribution.—*Ozarkodina compressa* has previously been recovered from rocks ranging in age from late Meramecian to late Chesteran. In the present study three specimens were recovered from the Warsaw Limestone (Core F) and the St. Louis Limestone (Cores A, B).

Repository.—KUMIP 1,800,113; KUMIP 1,800,194 (figured specimens).

OZARKODINA CURVATA Rexroad

Pl. 3, fig. 11.

Ozarkodina curvata Rexroad, 1958b, p. 24, pl. 4, fig. 1-3; Rexroad & Burton, 1961, p. 1156, pl. 141, fig. 13, 14; Rexroad & Collinson, 1963, p. 18, pl. 2, fig. 11; Rexroad & Furnish, 1964, p. 674, pl. 111, fig. 10, 11; Rexroad & Nicoll, 1965, p. 25, pl. 2, fig. 1, 2.

Diagnosis.—Ozarkodinid distinguished by strongly arched anterior limb with large compressed denticles. Posterior limb smaller than anterior limb; nearly straight, with small denticles. Basal cavity small and deep, with flared outer lip and nearly straight inner lip.

Remarks.—The arching of *Ozarkodina curvata* Rexroad is greatest anterior to the position of the basal cavity, and the arching of this species is greater than in *O. recta* Rexroad, which has almost no arching in the aboral margin.

Distribution.—*Ozarkodina curvata* has previously been recovered from rocks of late Meramecian and late Chesteran age. In this study three specimens were recovered from the Warsaw Limestone (Core F) and the St. Louis Limestone (Core A).

Repository.—KUMIP 1,800,195 (figured specimen).

OZARKODINA sp. cf. O. LAEVIPOSTICA Rexroad and Collinson

Pl. 3, fig. 21, 24.

Ozarkodina cf. *O. laevipostica* Rexroad & Collinson. Rexroad & Collinson, 1965, p. 13, pl. 1, fig. 12.

Diagnosis.—Ozarkodinid with large basal cavity, denticulate posterior limb, and unfused denticles on anterior limb. Unit highly arched beneath curved apical denticle.

Remarks.—These specimens resemble *Ozarkodina laevipostica* Rexroad and Collinson, but differ in the larger basal cavity, denticulate posterior limb, and unfused denticles of the anterior limb. Rexroad and Collinson (1965) consider this form to represent members of a lineage from

Subbryantodus radians Branson and Mehl to *O. laevipostica.* Immature specimens of the latter form do have a denticulate posterior limb, and this reflects the phylogeny.

Distribution.—Ozarkodina sp. cf. *O. laevipostica* has been previously recovered from rocks of early Meramecian age. In the present study eight specimens were recovered from the Warsaw Limestone (Core F) and the St. Louis Limestone (Cores A, D).

Repository.—KUMIP 1,800,196; KUMIP 1,800,334 (figured specimens).

OZARKODINA RECTA Rexroad

Pl. 3, fig. 22.

Ozarkodina recta REXROAD, 1957, p. 36, pl. 2, fig. 5, 6; REXROAD & FURNISH, 1964, p. 674, pl. 111, fig. 8.

Diagnosis.—Ozarkodinid distinguished by thin, long, slightly curved blade with straight anterior limb containing straight, nearly vertical, closely spaced denticles and shorter, slightly arched posterior limb with wide, compressed denticles inclined posteriorly; this inclination increasing toward posterior end. Small, deep basal cavity with little lateral flare lies beneath apical denticle.

Remarks.—Ozarkodina recta Rexroad has less arching than *O. curvata* Rexroad, and has a straighter apical denticle than *O. compressa* Rexroad.

Distribution.—Ozarkodina recta has previously been recovered from rocks ranging in age from late Meramecian to early Chesteran. In the present study six specimens were recovered from the Warsaw Limestone (Core K) and the St. Louis Limestone (Cores B, C).

Repository.—KUMIP 1,800,125 (figured specimen).

OZARKODINA ROUNDYI (Hass)

Pl. 3, fig. 19.

Subbryantodus roundyi HASS, 1953, p. 89, pl. 14, fig. 3-6.
Ozarkodina roundyi (HASS). REXROAD, 1957, p. 37, pl. 2, fig. 7; BISCHOFF, 1957, p. 66, pl. 1, fig. 29-32, p. 68, pl. 2, fig. 1-3; MÜLLER, 1962, p. 1390, text-fig. 3; DUNN, 1965, p. 1149, pl. 140, fig. 19, 20.

Diagnosis.—Long, thin, arched ozarkodinid with long, broad, sharply pointed denticles, largest on anterior limb. Lowest point of oral outline just posterior to apical denticle, above point of greatest arch. Basal cavity small, with little or no lateral flare.

Remarks.—The broad denticles on the anterior limb and the increasing height of the blade toward the anterior distinguishes *Ozarkodina roundyi* (Hass) from other ozarkodinids in this study.

Distribution.—Ozarkodina roundyi has previously been recovered from rocks of Kinderhookian and early Chesteran age. In the present study two specimens were recovered from the Warsaw Limestone in Core G.

Repository.—KUMIP 1,800,207 (figured specimen).

Genus SPATHOGNATHODUS Branson and Mehl, 1941

Ctenognathus PANDER, 1856, p. 32 (not Fairmair, 1843).
Spathodus BRANSON & MEHL, 1933, p. 46 (not Boulenger, 1900).
Spathognathodus BRANSON & MEHL, 1941c, p. 98.
Mehlina YOUNGQUIST, 1945, p. 363.
Branmehla HASS, 1959, p. 381.
Ctenognathodus FAY, 1959, p. 195.
Spathognathodus (Bispathodus) MÜLLER, 1962, p. 114.

Type species.—Spathodus primus BRANSON & MEHL, OD (1933, p. 46, pl. 3, fig. 25-30). See Klapper, 1966.

Diagnosis.—Unit bladelike, axis straight or flexed inward; aboral edge straight to arched. Basal cavity in middle one-third of unit, but extending in some forms to posterior tip.

Remarks.—Spathognathodus is presently considered to be a valid generic name (Rexroad and Scott, 1964, p. 46), and is ancestral to several platform genera, including *Pseudopolygnathus* and *Taphrognathus.*

Speciation is based on the oral outline of the blade and on the shape and location of the basal cavity.

Distribution.—Spathognathodus has been identified from rocks ranging in age from Devonian to Pennsylvanian.

SPATHOGNATHODUS CAMPBELLI Rexroad

Pl. 4, fig. 11.

Spathognathodus campbelli REXROAD, 1957, p. 37, pl. 3, fig. 13-15; REXROAD, 1958b, p. 25, pl. 6, fig. 9; REXROAD & BURTON, 1961, p. 1156, pl. 141, fig. 15; REXROAD & FURNISH, 1964, p. 674, pl. 111, fig. 23, 24; REXROAD & NICOLL, 1965, p. 26, pl. 1, fig. 6.

Diagnosis.—Spathognathodid distinguished by delicate blade composed of many small compressed denticles forming straight oral outline, and by small, narrow basal cavity.

Remarks.—The forms referred to *Spathognathodus campbelli* Rexroad recovered in the present study are quite small, with thin blades and denticles. The oral outline tends to be irregular, due to several of the denticles being broken.

Distribution.—*Spathognathodus campbelli* has been previously recovered from rocks ranging in age from late Meramecian to late Chesteran. In the present study two specimens were recovered from the St. Louis Limestone in Core B.

Repository.—KUMIP 1,800,127 (figured specimen).

SPATHOGNATHODUS CRISTULA Youngquist and Miller

Pl. 4, fig. 13, 15, 18.

Spathognathodus cristula YOUNGQUIST & MILLER, 1949, p. 621, pl. 101, fig. 1-3; REXROAD, 1957, p. 38, pl. 3, fig. 16, 17; REXROAD, 1958b, p. 25, pl. 6, fig. 3, 4; REXROAD & BURTON, 1961, p. 1156, pl. 141, fig. 9; REXROAD & FURNISH, 1964, p. 674, pl. 111, fig. 15; REXROAD & NICOLL, 1965, p. 26, pl. 1, fig. 1, 2.

Diagnosis.—Spathognathodid characterized by short, slightly arched blade with subequal denticles fused nearly to apices; posterior-most two to three denticles small, anterior-most denticles longer and wider; anterior-most denticle very large and broad at base. Oral margin convex toward posterior end, straight anteriorly. Broadly flared basal cavity bilaterally symmetrical, deepening near anterior end into anteriorly inclined pit; cavity extends to posterior end of blade and two-thirds to three-fourths total length of blade.

Remarks.—The bilateral symmetry of the basal cavity distinguishes *Spathognathodus cristula* Youngquist and Miller from *S. scitulus* (Hinde), a species with a strongly asymmetric cavity. The large anterior denticle of the blade distinguishes *S. cristula* from *S. campbelli* Rexroad, which does not have a prominent anterior denticle. The posterior denticles of *S. penescitulus* Rexroad and Collinson are unfused and much broader than the denticles just posterior to the anterior denticle, whereas the denticles of *S. cristula* become gradually smaller toward the posterior end of the blade.

Distribution.—*Spathognathodus cristula* has been previously recovered from rocks ranging in age from late Meramecian to early Pennsylvanian. In the present study 36 specimens were recovered from the Warsaw Limestone (Cores F, K), the Salem Limestone (Core I), the St. Louis Limestone (Cores A, B, C, D, I, M, N), and the Keokuk Limestone (Locality Q).

Repository.—KUMIP 1,800,233; KUMIP 1,800,128 (figured specimens).

SPATHOGNATHODUS PENESCITULUS Rexroad and Collinson

Pl. 4, fig. 16.

Spathognathodus regularis Branson & Mehl. BRANSON & MEHL, 1941b, p. 187, pl. 6, fig. 7.

Spathognathodus penescitulus REXROAD & COLLINSON, 1965, p. 22, pl. 1, fig. 13-15.

Diagnosis.—Spathognathodid characterized by short blade with large basal cavity extending three-fourths length of blade. Prominent anterior denticle followed posteriorly by eight denticles, three small and deeply inserted, three large and broad, two small and unfused.

Remarks.—The shape of *Spathognathodus penescitulus* Rexroad and Collinson is like that of *S. scitulus* (Hinde), but the basal cavity is more symmetrical, and extends to the posterior tip of the specimen. In *S. penescitulus,* the denticles of the blade increase in width on the posterior portion, while those of *S. cristula* Youngquist and Miller gradually decrease in size posteriorly from the anterior denticle.

Distribution.—*Spathognathodus penescitulus* has been previously recovered from rocks of early Meramecian age. In the present study three specimens were recovered from the Warsaw Limestone (Core F), the Salem Limestone (Core H), and the St. Louis Limestone (Core C).

Repository.—KUMIP 1,800,149 (figured specimen).

SPATHOGNATHODUS sp. cf. S. PULCHER (Branson & Mehl)

Pl. 4, fig. 17, 21, 22, 25.

Spathognathodus cf. *S. pulcher* (Branson & Mehl). REXROAD & COLLINSON, 1965, p. 23, pl. 1, fig. 16.

Spathodus pulcher BRANSON & MEHL, 1938, p. 139, pl. 34, fig. 7, 8.

Description.—Spathognathodid with two denticles at anterior end, either one small denticle at anterior end and one larger denticle posterior to small one, or two large anterior denticles of uniform length. Posterior eight or nine denticles uniform in length, which broaden posteriorly. Posterior-most four denticles decrease in length to posterior end of unit. Cavity symmetrical, broadest at midpoint of unit, tapering to gradual point posteriorly, tapering more abruptly to anterior. Aboral margin straight beneath anterior two denticles, slightly arched downward beneath basal cavity.

Remarks.—The oral outline posterior to the major anterior denticles of these specimens is like that of *Spathognathodus* cf. *S. pulcher* as illustrated by Rexroad & Collinson (1965). The anterior denticles are the same in number, but different in relative sizes. This feature appears to be quite variable in *S. pulcher.*

Distribution.—Two specimens of *Spathognathodus* sp. cf. *S. pulcher* (Branson & Mehl) were recovered in the present study from the

Warsaw Limestone (Core F) and the St. Louis Limestone (Core C).

Repository.—KUMIP 1,800,150; KUMIP 1,800,199 (figured specimens).

SPATHOGNATHODUS SCITULUS (Hinde)

Pl. 4, fig. 26, 27.

Polygnathus scitulus HINDE (part), 1900, p. 343, pl. 9, fig. 9, 11 only.
Panderodella scitulus (Hinde). HOLMES (part), 1928, p. 16, pl. 6, fig. 26, 28 only.
Spathognathodus scitulus (Hinde). CLARKE, 1960, p. 21, pl. 3, fig. 12, 13; REXROAD & COLLINSON, 1963, p. 20, pl. 2, fig. 14, 19, 29-31.

Diagnosis.—Spathognathodid distinguished by short, high blade with sharply pointed major anterior denticle and 10 to 12 posterior denticles forming straight anterior oral outline. Aboral outline straight; nearly 120-degree angle formed between aboral and oral surface juncture at posterior end. Short, deep basal cavity sharply asymmetric, outer lip widely flared laterally, inner lip weakly flared.

Remarks.—The strong asymmetry of the basal cavity distinguishes *Spathognathodus scitulus* (Hinde) from *S. campbelli* Rexroad, *S. cristula* Branson and Mehl, and *S. penescitulus* Rexroad and Collinson, which have symmetrical basal cavities.

Distribution.—Spathognathodus scitulus has previously been recovered from rocks of late Meramecian age. In the present study 11 specimens were recovered from the St. Louis Limestone (Cores A, B, C), and the Ste. Genevieve Limestone (Core D).

Repository.—KUMIP 1,800,151 (figured specimen).

SPATHOGNATHODUS SPICULUS Youngquist & Miller

Pl. 4, fig. 12.

Spathognathodus spiculus YOUNGQUIST & MILLER, 1949, p. 622, pl. 101, fig. 4; REXROAD, 1957, p. 38, pl. 3, fig. 18-21; REXROAD, 1958b, p. 25, pl. 6, fig. 5-7; REXROAD & FURNISH, 1964, p. 674, pl. 111, fig. 20-22; REXROAD & NICOLL, 1965, p. 26, pl. 1, fig. 3-5.
Spathognathodus bidens YOUNGQUIST & MILLER, 1949, p. 621, pl. 101, fig. 5.

Diagnosis.—Spathognathodid with three to four prominent anterior denticles followed to posterior by uniform discrete denticles gradually tapering in length to posterior end. Oral outline nearly straight to convex upward, aboral outline straight to convex upward.

Remarks.—The prominent anterior denticles of *Spathognathodus spiculus* Youngquist & Miller show considerable variation in number, from two to five. The oral outline of these denticles also varies considerably in shape, from straight to convex, becoming more convex as the number of denticles increases.

Distribution.—Spathognathodus spiculus has previously been reported from rocks of late Meramecian and Chesteran age. In the present study, one specimen was recovered from the St. Louis Limestone in Core A.

Repository.—KUMIP 1,800,102 (figured specimen).

SPATHOGNATHODUS n. sp.

Pl. 1, fig. 9, 15-17.

Cavusgnathus muricata DUNN, 1965, p. 1147, pl. 140, fig. 1, 4.

Description.—Viewed orally, curved blade has four to six inner-lateral denticles forming parapet parallel to blade; parapet merging with blade near posterior end of specimen. Free anterior portion of blade short; broken in specimens from present study.

Laterally, oral outline straight, highest at anterior end. Denticles short and broad on free blade and parapet except for three or four denticles at posterior end of free blade that are narrow.

Aborally, basal cavity elongate and narrow, tapering rapidly to sharp point at posterior end of specimen; lateral flare restricted to anterior half of cavity.

Remarks.—Dunn (1965) described and illustrated as *Cavusgnathus muricata* Dunn, n. sp., specimens like those herein referred to *Spathognathodus* n. sp. Several homeomorphic cases of spathognathodids with lateral denticles exist, widely separated in time (late Devonian to Pennsylvanian) (personal communication, Gilbert Klapper with Thompson, 1967). The basal cavity tapers to the posterior more rapidly than does that typical of cavusgnathids, and the long, free blade (broken from specimens in the present study) illustrated by Dunn (pl. 140, fig. 1) is quite unlike the short, free blade of *Cavusgnathus*.

Distribution.—In the present study, five specimens of *Spathognathodus* n. sp. were recovered from the St. Louis Limestone in Core A.

Repository.—KUMIP 1,800,082; KUMIP 1,800,333 (figured specimens).

SPATHOGNATHODUS n. sp.?

Pl. 4, fig. 24, 28.

Description.—Unit large, consisting of extremely large anterior denticle and eight subequal posterior denticles that become broader toward posterior. Oral outline nearly straight immediately posterior to anterior denticle, highly convex toward posterior end. Aboral outline arched slightly anterior to midpoint. Basal cavity shallow and narrow, deepest at point of greatest width, and extends from posterior tip to directly beneath posterior edge of anterior denticle. Widest point of cavity at midpoint of blade, and cavity decreases to sharp point at posterior end. Groove extends entire length of cavity.

Remarks.—This form bears closest similarity to *Spathognathodus cristula* Youngquist & Miller, but differs in the extremely large anterior denticle and the narrow and shallow basal cavity.

Distribution.—In the present study one specimen of *Spathognathodus* n. sp.? was recovered from the St. Louis Limestone in Core D.

Repository.—KUMIP 1,800,169 (figured specimen).

Genus SYNPRIONIODINA Ulrich and Bassler, 1926

Synprioniodina Ulrich & Bassler, 1926, p. 42.

Type species.—*Synprioniodina alternata* Ulrich & Bassler, OD (1926, p. 42, text-fig. 4, no. 22, p. 16).

Diagnosis.—Unit consisting of sharply arched bar with prominent apical denticle above point of arch. Posterior limb long and denticulate; anterior limb short, containing several small denticles. Basal cavity small and deep.

Remarks.—Ulrich and Bassler (1926) named and described several new genera of conodonts similar to *Synprioniodina*. *Euprioniodina* has coarser and unfused denticles and a flat aboral surface beneath the limbs, *Prioniodina* is gently curved aborally, not arched, *Lonchodina* possesses a large, widely flared basal cavity, and *Palmatodella* has large numerous denticles on the posterior limb and a strongly curved apical denticle.

Speciation is based on the degree of arching of the unit, the size and shape of the basal cavity, and the denticulation of the anterior limb.

Distribution.—*Synprioniodina* has been identified from rocks ranging in age from Devonian to Pennsylvanian.

SYNPRIONIODINA LAXILABRUM Rexroad and Collinson

Pl. 3, fig. 10.

Synprioniodina laxilabrum Rexroad & Collinson, 1965, p. 23, pl. 1, fig. 3-5.

Diagnosis.—Small synprioniodinid characterized at juncture of posterior and anterior limbs by small basal cavity with widely flaring inner lip. Angle of arch nearly 45 degrees. Terminal denticle small and bowed.

Remarks.—Rexroad & Collinson (1965) discussed several species described by Cooper (1939) that are possibly related forms of *Synprioniodina laxilabrum* Rexroad & Collinson. The number of specimens recovered is small, and knowledge of forms such as this is meager concerning species of Mississippian age.

Distribution.—*Synprioniodina laxilabrum* has been previously recovered from rocks of early Meramecian age. In the present study three specimens were recovered from the Warsaw Limestone in Core K.

Repository.—KUMIP 1,800,252 (figured specimen).

Genus TAPHROGNATHUS Branson and Mehl, 1941

Taphrognathus Branson & Mehl, 1941b, p. 181.

Type species.—*Taphrognathus varians* Branson & Mehl, OD (1941b, p. 182, pl. 6, fig. 27-33, 35-41).

Diagnosis.—Unit consisting of short posterior platform containing two lateral parapets separated by deep median trough. Anterior blade extends short distance onto platform as low carina, located between parapets on anterior end of platform. Basal cavity long, narrow, and shallow.

Remarks.—*Taphrognathus* arose during medial Osagian time, and continued to early late Meramecian time, when it evolved into, and was replaced by, *Cavusgnathus*.

Speciation is based on the size and shape of the basal cavity and the position of the posterior end of the blade with respect to the two parapets of the platform.

Distribution.—*Taphrognathus* has been identified from rocks ranging in age from early Osagian to late Meramecian.

TAPHROGNATHUS VARIANS Branson and Mehl

Pl. 5, fig. 1-9, 12-15.

Taphrognathus varians Branson & Mehl, 1941b, p. 182, fig. 27-33, 35-40; Rexroad & Collinson, 1963, p. 21, pl. 1, fig. 18-20, 22; Thompson & Goebel, 1963, p. 12, fig. 3; Rexroad & Collinson, 1965, p. 24, pl. 1, fig. 30-32. (not) *Taphrognathus varians* Branson & Mehl. Cooper, 1947, p. 92, pl. 20, fig. 14-16.

Diagnosis.—Taphrognathid with centrally located carina between lateral parapets at anterior end of platform. Basal cavity bilaterally symmetrical, long, narrow to widely flared, shallow, pointed at both ends.

Remarks.—*Taphrognathus* is presently monospecific, and considerable morphologic variation is exhibited in specimens recovered in the present study. The basal cavity varies from very narrow to widely flared; from elongate and narrow to nearly circular in outline. The platform may be short and broad or long and narrow. It is neither practical nor useful to subdivide *Taphrognathus* into new species at this time. The variations mentioned above do not show affinities to time of occurrence.

Distribution.—Taphrognathus varians has previously been recovered from rocks ranging in age from late Osagian to early late Meramecian. In the present study over 300 specimens were recovered from the Warsaw Limestone (Cores E, F, G, H, K, M, N, O), the Salem Limestone (Cores C, D, I, N, O), and the lower part of the St. Louis Limestone (Cores I, M, N, O), and the Keokuk Limestone (Locality P).

Repository.—KUMIP 1,800,200; KUMIP 1,800,265; KUMIP 1,800,183; KUMIP 1,800,220; KUMIP 1,800,327 (figured specimens).

TAPHROGNATHUS sp.

Pl. 5, fig. 10, 11.

Taphrognathus varians Branson & Mehl (part), 1941b, p. 182, pl. 6, fig. 34 only.

Taphrognathus n. sp. Thompson & Goebel, 1963, p. 12, fig. 3.

Taphrognathus-Cavusgnathus transition Rexroad & Collinson, 1963, p. 20, pl. 1, fig. 21, 23-25.

Description.—Unit consisting of short posterior platform with inner parapet ending abruptly at anterior end, outer parapet connecting to carina of anterior blade. Blade centrally located at anterior end, curving outward approaching platform to form carina lying in same plane of outer parapet of platform. Long, narrow, asymmetric basal cavity, curved outward beneath lateral carina.

Remarks.—Taphrognathus sp. can be distinguished from *T. varians* Branson & Mehl by the lateral carina and the asymmetric, narrow basal cavity. This form is interpreted to represent the transition from *Taphrognathus* to *Cavusgnathus,* achieved through the migration of the position of the carina from one of central to lateral position with respect to the platform. This form is a good index to the short time interval of this transition, and occurs in the middle portion of the St. Louis Limestone.

Distribution.—Taphrognathus sp. has been previously recovered from rocks of early late Meramecian age. In the present study nine specimens were recovered from the St. Louis Limestone in Cores C and I.

Repository.—KUMIP 1,800,153 (figured specimen).

New genus? sp.

Pl. 3, fig. 23, 25.

Description.—Unit consisting of elongate, laterally bowed bar containing numerous sharply pointed denticles, fused less than halfway to apices. Denticles alternating in length; anterior three small and equal, next posterior three long and wide, next four smaller and more slender. Posterior four denticles gradually increase in length; posterior-most denticles very broad at apices, spatulate in lateral outline, highly compressed. Inner margin of bar contains deep groove, broadening and ending just prior to posterior end, where it bends upward and parallels anterior margin of posterior-most denticle. Outer margin of bar smooth. Posterior denticle contains small, slightly flared pit halfway up posterior margin, and appears to extend aborally as very short, blunt aboral projection. Anterior end of specimen broken off.

Remarks.—This specimen is unlike any previously reported from Mississippian strata. The spatulate posterior two denticles are characteristic of this form.

Distribution.—In the present study one specimen of New genus? sp. was recovered from the St. Louis Limestone in Core M.

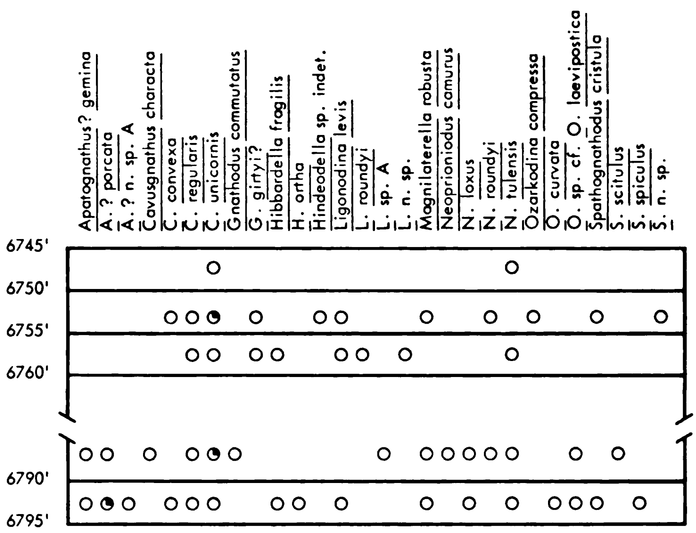
Repository.—KUMIP 1,800,275 (figured specimen).

APPENDIX

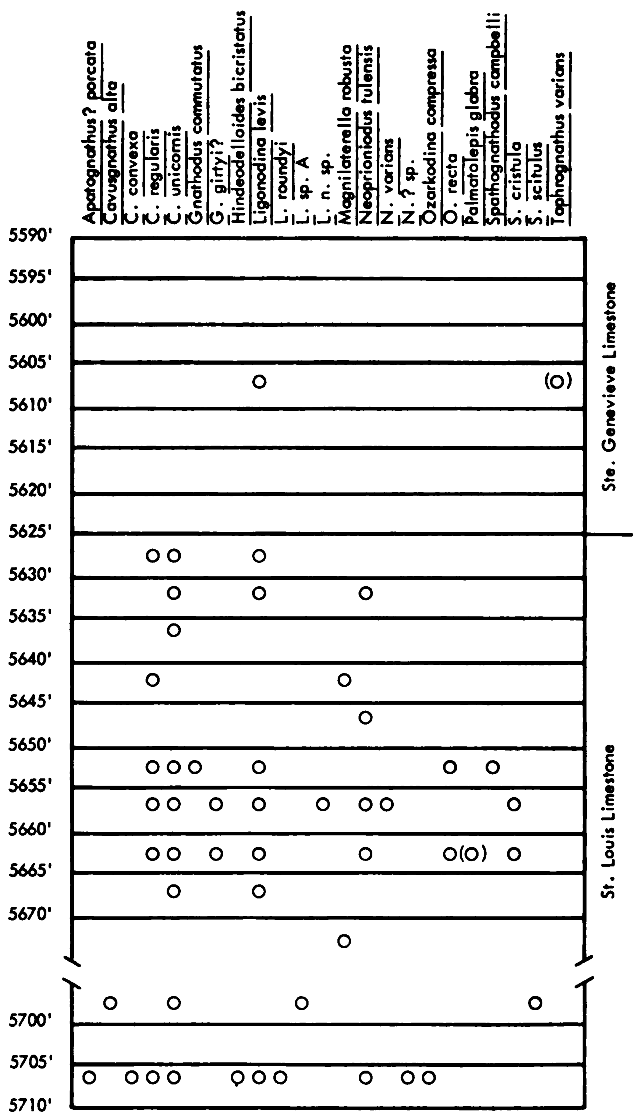
In the following illustrations, both figured and unfigured specimens are included in the compound footage increments and are plotted arbitrarily between footage lines. For example, specimens referred to in the text as from 4971 feet have been lumped together with those from 4970 to 4975, for convenience in reporting.

Explanation:

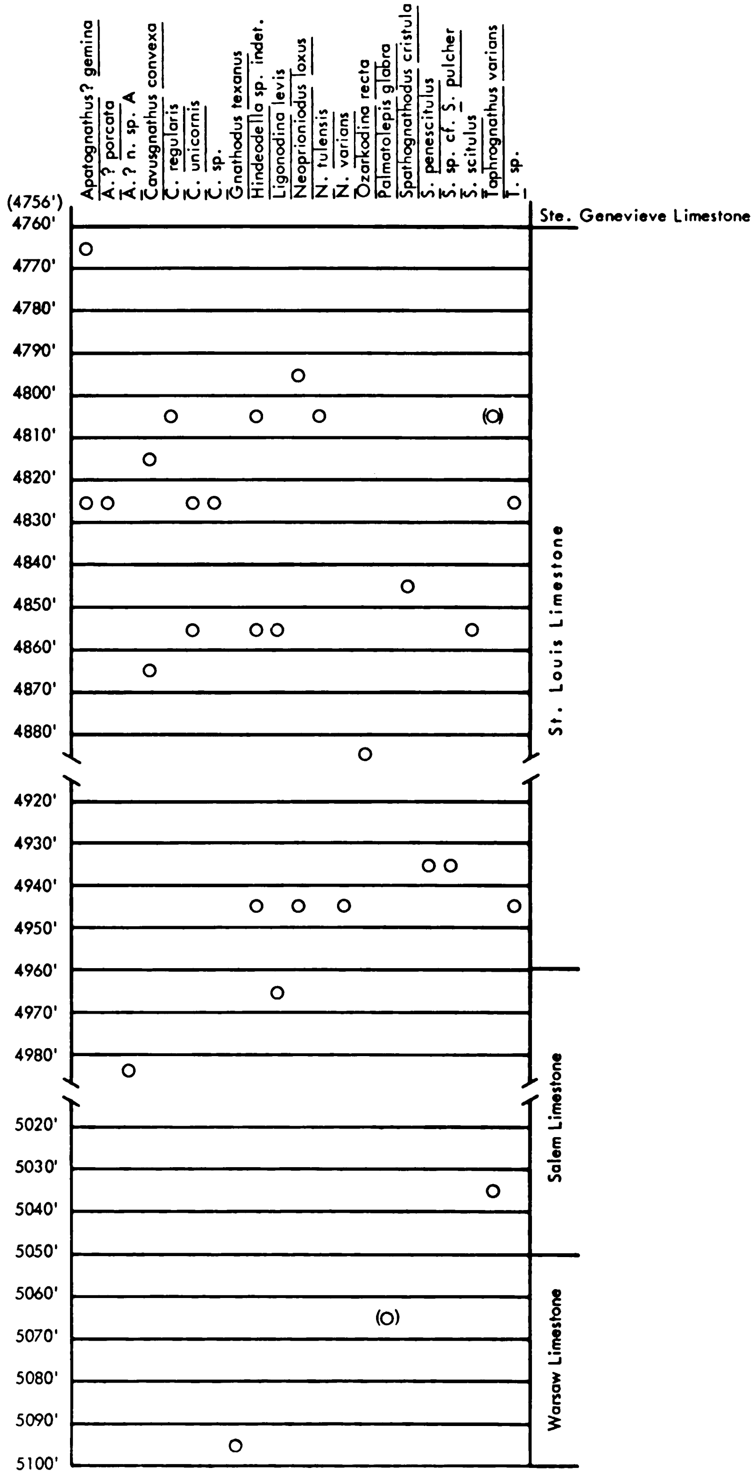
- O < 10 specimens
- ◔ 10 - 25 specimens
- ◒ 26 - 50 specimens
- ● > 50 specimens
- (O) reworked (abraded)



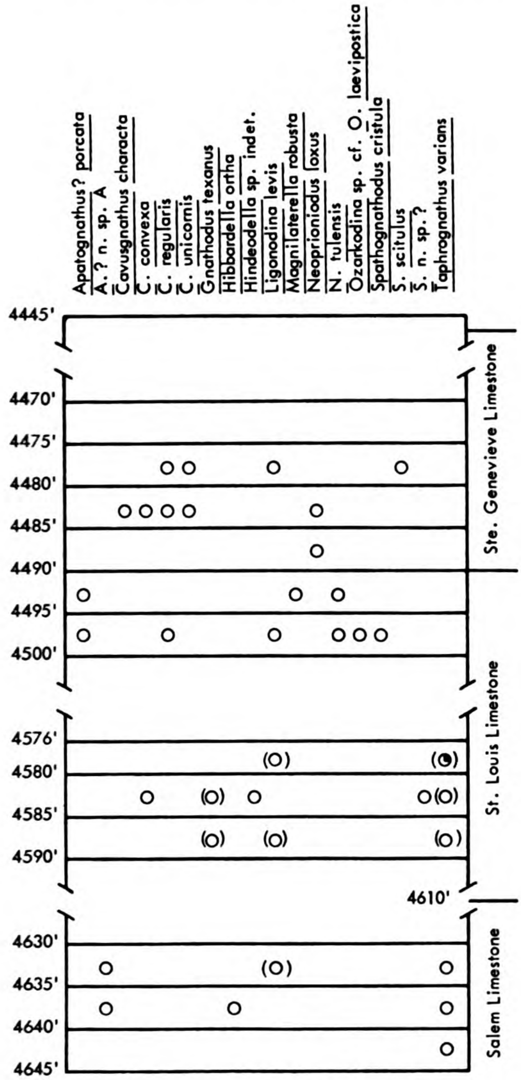
Core A.—Distribution and abundance of conodonts from the St. Louis Limestone recovered from the Mobil Oil Co. No. 1 Cunningham Est., C SW SE sec. 13, T 34 S, R 37 W, Stevens County, Kansas.



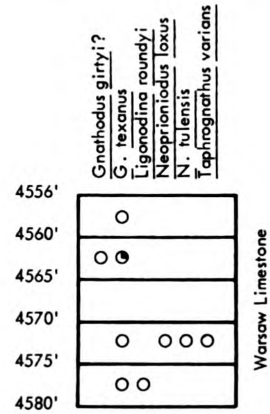
Core B.—Distribution and abundance of conodonts recovered from the Cities Service No. 1 Kells "B," C NW NW sec. 5, T 28 S, R 34 W, Haskell County, Kansas.



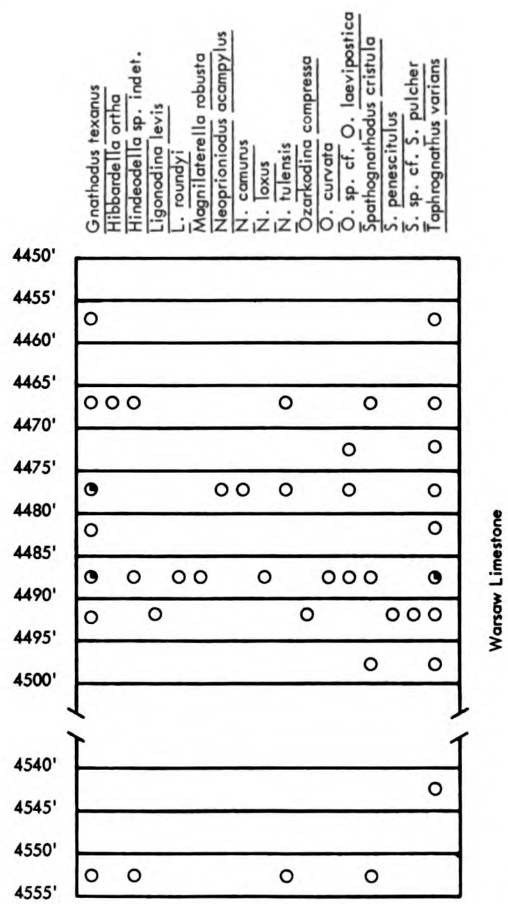
Core C.—Distribution and abundance of conodonts recovered from the Atlantic Oil Co. No. 1-A Mark, SE SE SE sec. 28, T 20 S, R 33 W, Scott County, Kansas.



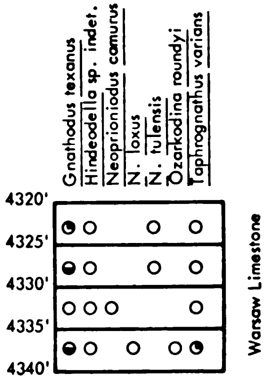
Core **D.**—Distribution and abundance of conodonts recovered from the Alma and McNeeley No. 1 Watchorn, C SW NE sec. 13, T 15 S, R 33 W, Logan County, Kansas.



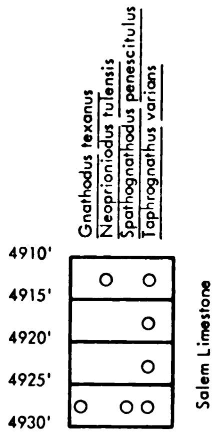
Core **E.**—Distribution and abundance of conodonts recovered from the Mobil Oil Co. No. 1 Winans, C SE NW sec. 32, T 20 S, R 27 W, Lane County, Kansas.



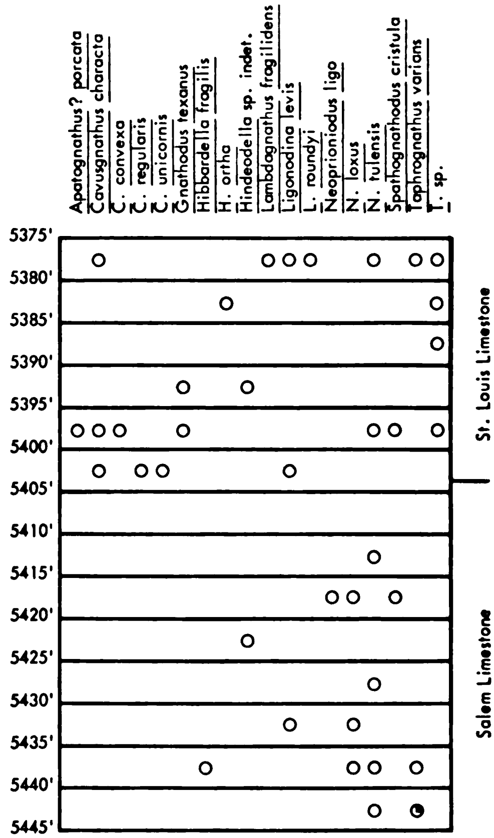
Core **F.**—Distribution and abundance of conodonts recovered from the Mid-Continent No. 1 Collins, C NW NW sec. 24, T 20 S, R 26 W, Ness County, Kansas.



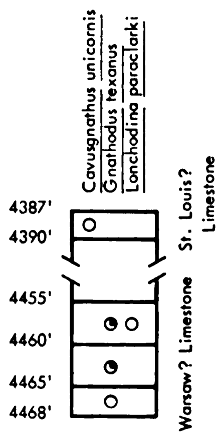
Core **G.**—Distribution and abundance of conodonts recovered from the Mobil Oil Co. No. 1 Elsasser Heirs, C SE SW sec. 29, T 18 S, R 22 W, Ness County, Kansas.



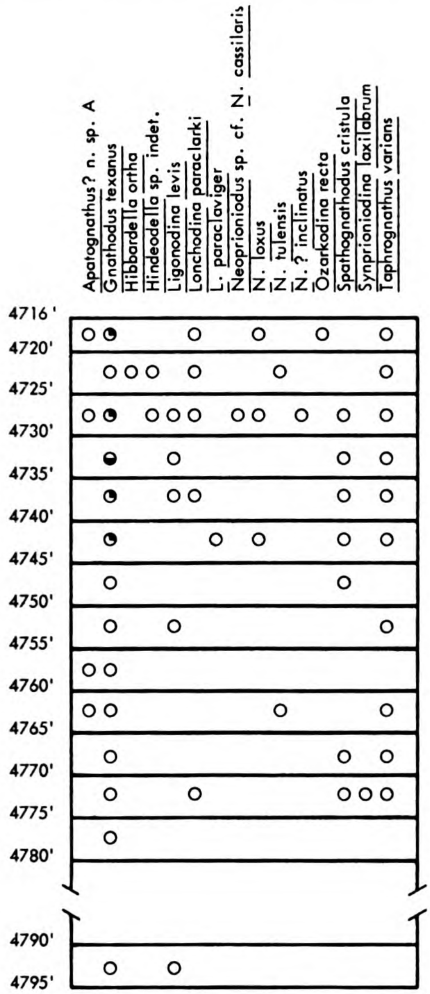
Core **H.**—Distribution and abundance of conodonts recovered from the Mull-Mobil Oil Co. No. 1 Matkin, C NE NW sec. 16, T 27 S, R 21 W, Ford County, Kansas.



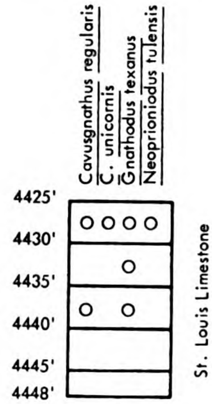
Core **I.**—Distribution and abundance of conodonts recovered from the Sinclair-Prairie No. 1 Exchange Bank, C SE SW sec. 27, T 33 S, R 19 W, Comanche County, Kansas.



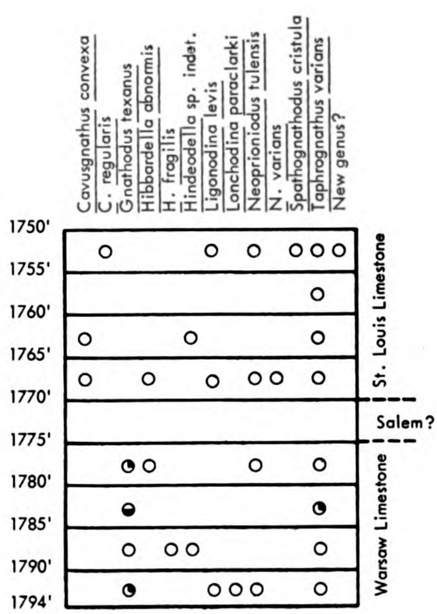
Core **J.**—Distribution and abundance of conodonts recovered from the Sinclair Oil and Gas No. 1 Colburn "A," NE SW NE sec. 9, T 33 S, R 11 W, Barber County, Kansas.



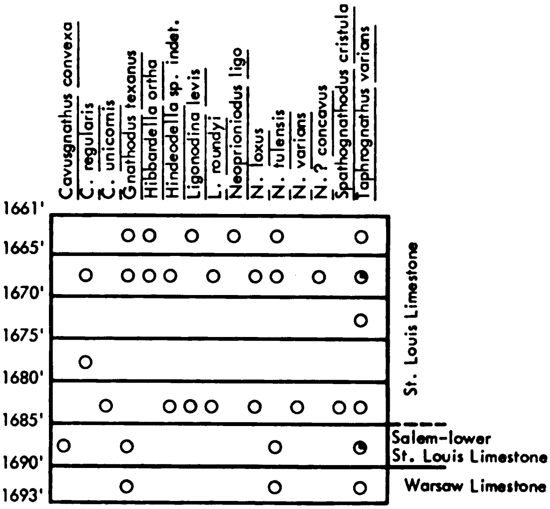
Core **K.**—Distribution and abundance of conodonts recovered from the Warsaw Limestone from the Sinclair Oil and Gas No. 1 Helmley, SW SW SE sec. 3, T 35 S, R 10 W, Barber County, Kansas.



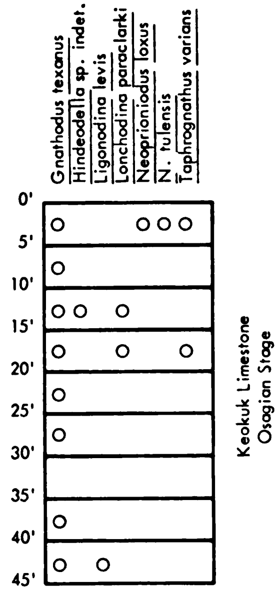
Core **L.**—Distribution and abundance of conodonts recovered from the Kessler and Thier No. 1 Wolfje, C SW SW NE sec. 17, T 33 S, R 6 W, Harper County, Kansas.



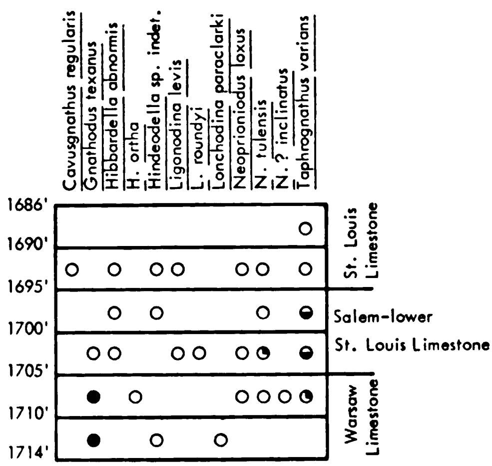
Core **M.**—Distribution and abundance of conodonts recovered from the Western Petroleum Co. No. 1 Dalton "B," SW NE SE sec. 11, T 24 S, R 12 E, Greenwood County, Kansas.



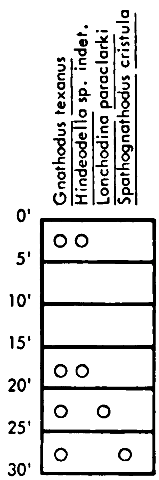
Core **N.**—Distribution and abundance of conodonts recovered from the Sinclair Oil and Gas Co. No. 6 H. G. Collins, C SE NE sec. 30, T 23 S, R 14 E, Woodson County, Kansas.



Loc. **P.**—Distribution and abundance of conodonts recovered from Mississippian outcrop of Keokuk Limestone (Osagian), SE NW sec. 1, T 35 S, R 25 E, Cherokee County, Kansas.



Core **O.**—Distribution and abundance of conodonts recovered from the Sinclair Oil and Gas Co. No. 12 W. P. Headley "A," C W½ SE NW NW sec. 32, T 23 S, R 14 E, Woodson County, Kansas.



Loc. **Q.**—Distribution and abundance of conodonts recovered from Mississippian outcrop of Keokuk Limestone (Osagian), NE NE SW sec. 33, T 34 S, R 25 E, Cherokee County, Kansas.

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