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CONODONT FAUNAS IN THE HUGHES CREEK SHALE AND BENNETT SHALE OF RILEY AND WABAUNSEE COUNTIES, KANSAS

by 866

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INTRODUCTION

Purpose of the Investigation

This investigation was undertaken in an attempt to compile a stratigraphic inventory of conodonts present in the Hughes Creek Shale Member of the Foraker Limestone Formation and the Bennett Shale Member of the Red Eagle Limestone Formation of the Council Grove Group of the Lower Permian in Riley and Wabaunsee Counties, Kansas.

Since there are no living counterparts of conodonts, any information on the conditions in which they existed would be obtained from the sediments in which they are deposited and their faunal associations. It was hoped that a lithologic and paleontologic relationship could be established, thereby contributing additional information on the ecology of conodonts.

The majority of outcrops sampled were limited to a relatively small area, in order to observe local changes in the abundance and position of the conodonts. Additional outcrops were selected at a great distance from the area of intensive study to observe any large scale variations with distance.

Previous Investigations

Few conodont faunas have been described from Permian strata. There have been various works in which the presence of conodonts in the Lower Permian was mentioned. Some of the reported occurrences are from the Lower Permian of Kansas.

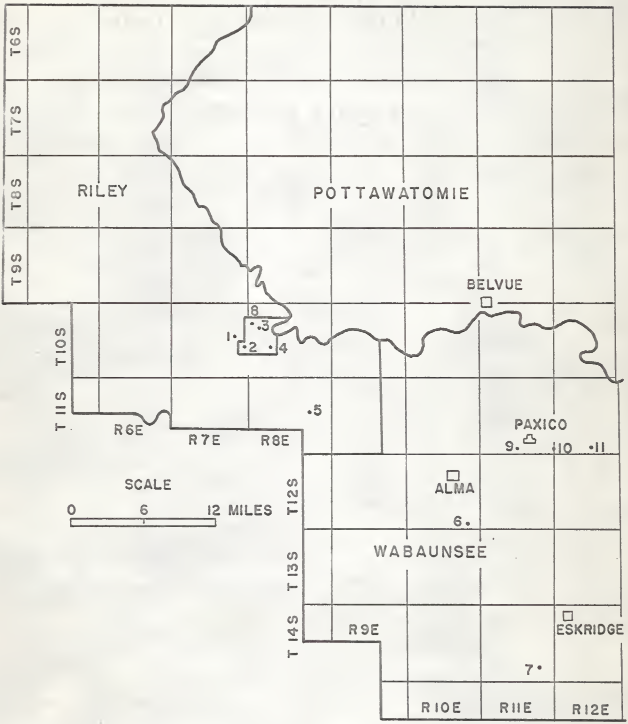
EXPLANATION OF PLATE I

Index Map of Measured Section Locations

Measured Section No.	Location		
1	Road cut in	SE$\frac{1}{4}$ SW$\frac{1}{4}$ SW$\frac{1}{4}$	13-10S- 7E
2	Railroad cut in	NW$\frac{1}{4}$ SW$\frac{1}{4}$ NE$\frac{1}{4}$	24-10S- 7E
3	Road cut in	SW$\frac{1}{4}$ SE$\frac{1}{4}$ SE$\frac{1}{4}$	7-10S- 8E
4	K-Hill near cen. N. line	NW$\frac{1}{4}$	20-10S- 8E
5	Road cut in	NW$\frac{1}{4}$ SW$\frac{1}{4}$ SW$\frac{1}{4}$	14-11S- 8E
6	Stream bank in	SE$\frac{1}{4}$ SW$\frac{1}{4}$ SW$\frac{1}{4}$	36-12S-10E
7	Stream bank in	Center	36-14S-11E
8	Excavation cut in	SW$\frac{1}{4}$ SE$\frac{1}{4}$ SE$\frac{1}{4}$	7-10S- 8E
9	Road cut in	SW$\frac{1}{4}$ SE$\frac{1}{4}$	27-11S-11E
10	Road cut in	SW$\frac{1}{4}$ SW$\frac{1}{4}$	30-11S-12E
11	Road cut in	NW$\frac{1}{4}$ SW$\frac{1}{4}$	27-11S-12E

Detailed descriptions given in the Appendix.

PLATE I


T6S
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RILEY
POTTAWATOMIE
WABAUNSEE
BELVUE
PAXICO
ALMA
ESKRIDGE
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Conodonts are less abundant in the Permian than any Paleozoic Period since the Cambrian.

Gunnell (1933) described conodonts and fish remains from the Cherokee, Kansas City, and Wabaunsee Groups of Missouri and Kansas. He described a number of specimens from the "Americus Limestone," three miles west of Belvue, Kansas. The Americus Limestone was, at that time, included within the Wabaunsee Group by Prossor (1902).

Ellison (1941), in his revision of Pennsylvanian conodonts, described some specimens from the Hughes Creek Shale Member and Americus Limestone Member of the Foraker Limestone. Ellison's Americus Limestone samples were collected from Gunnell's (1933) locality and his Hughes Creek Shale samples were collected a few miles north of Manhattan, Kansas.

Kellett (1943) reported conodonts from the Herington Limestone Member of the Nolans Limestone Formation of Kansas and Nebraska. These conodonts were found associated with otoliths, large pelecypods, and a few ostracodes.

Youngquist, Hawley, and Miller (1951) described conodonts from the Phosphoria Formation (Middle Permian) of southeastern Idaho. Three new species were reported.

Hattin (1957) noted conodonts in the Shroyer Limestone Member of the Wreford Limestone Formation and in the Speiser Shale Formation in Geary and Chase counties, Kansas. The occurrence in the Schroyer Limestone was listed as "a single blade type conodont." This conodont was found in a thin shale bed which is directly below the top limestone of the Schroyer Limestone Member. The Speiser Shale listing is described as a "cone-type conodont." This may be a fish tooth, as fish teeth are also listed in the interval.

Verville (1958) recorded conodonts from the Florena Shale Member of the Beattie Limestone Formation and the Foraker Limestone Formation of southcentral Kansas.

Lane (1958) reported conodonts in the Neva Limestone Member of the Grenola Limestone from northeast Cowley County, Kansas. They were listed as sparse and occurring in a shale overlying the basal limestone of the Neva Limestone member.

Bergquist (1960) described conodonts which were found in a sample of presumed Permian age from northern Alaska. The specimens appeared to be much like the species from the Phosphoria Formation of Idaho. At the time of Bergquist's report, this was the only known occurrence of conodonts in the late Paleozoic of Alaska.

McCrone (1961) identified conodonts in the Bennett Shale Member of the Red Eagle Limestone Formation in Nebraska and Kansas; however, his identifications were only carried to the generic level.

Garber (1962) reported the presence of conodonts in the limestones of the Americus Limestone Member and Hughes Creek Shale Member of the Foraker Limestone Formation in Wabaunsee, Lyon, and Chase counties, Kansas. Most of the occurrences were in trace amounts.

Sloan (1963) reported the presence of conodonts in the Bennett Shale Member of the Red Eagle Limestone from Riley, Wabaunsee, and Pottawatomie Counties, Kansas.

Rhodes (1963) described a conodont fauna from the uppermost part of the Tensleep Sandstone Formation (Lower Permian) of the eastern Big Horn Mountains, near Mayoworth, Wyoming. The fauna is dominated by specimens of *Streptognathodus elongatus*. A new species was also described from this fauna.

The Nature of Conodonts

Conodonts are small, tooth-like objects which were discovered and named by Pander in 1856. These fossils range from a fraction of a millimeter to about 3 mm. in length. In their natural state, conodonts are composed chiefly of calcium phosphate and contain the mineral apatite (Rhodes and Wingard, 1957). Conodonts are transparent to opaque and range from light brown to amber in color. Some conodonts have a fibrous internal structure and others have concentric lamellae.

Growth of the conodont is achieved by addition of lamellae around a growth axis. The lamellae are open toward the aboral side of the fossil. The earliest growth stages in all conodonts are similar. In later growth stages, there was more active growth in certain directions, producing the different species (Hass, 1962).

Conodonts have world-wide distribution. Most investigations of conodonts have been in Europe and North America. Their stratigraphic range is Upper Cambrian to Upper Triassic.

Conodonts have been used to determine the age and correlation of various formations in which few other fossils are present. The small size of conodonts makes them especially useful in correlating stratigraphic intervals from exploration wells.

Zoological Affinities of Conodonts

The first work on conodonts was by Pander in 1856. Pander considered conodonts as the remains of shark-like fish (Scott, 1934).

Harley (1861) disagreed with Pander and postulated that conodonts are crustacean fragments.

Hinde (1879) stated:

> It has been shown that whilst conodont teeth do not correspond in minute structure with, and are far more varied in form than, the teeth of any known fish, they yet approach closest to those of the Myxinods.

He does not reject the possibility that they may have belonged to a low type of fish. Many types of conodonts were found associated with annelid jaws. When comparing the chemical composition, he found them to be radically different. He was unable to find any crustaceans which might have possessed spines resembling conodonts. He was in doubt as to their origin but placed them with the vertebrates.

Scott (1934) examined eighteen conodont assemblages from the Quadrant Shale (Pennsylvanian) of Montana. He compared the assemblages with tooth structures of various types of vertebrates. From his observations he concluded that it was impossible for conodonts to belong to any group of animals other than worms. In studying the assemblages, he noted eighteen points of similarity that suggest a relationship to annelid jaws. He summarized the annelid-like characteristics as follows:

> Annelid jaws are paired, various structural forms occur in one mouth, they are commonly rights and lefts, or laterals; fewer pairs of teeth are contained in the mouth of an annelid than in the mouth of a fish; individual parts seldom show any essential wear; a muscular attachment is present, and there are no other parts present to be preserved.

On the relationship of conodonts with scolecodonts, Scott (1934) concludes the following:

> It is probable that one family of Paleozoic annelids possessed a jaw apparatus composed of teeth which we call conodonts; whereas, a second family possessed teeth known as scolecodonts. Those possessing conodonts died out at the close of the Paleozoic; whereas, that family having the scolecodont type of teeth lived on to the present, giving rise to such forms as the modern <u>Nereis</u> and relatives.

Hass (1941) concluded that, "Conodonts functioned as internal supports for tissues located at a place exposed to stress upon the exterior of or within the bodies of some genetically related group of animals." Hass also noted that numerous conodonts at all stages of growth show that parts of their structure were broken away and later restored. The mending of parts could have taken place only so long as the conodont was actually covered by a secreting medium.

Du Bois (1943) noted the occurrence of certain brown carbonaceous films associated with conodonts which he concluded represents a fossilized portion of the cuticle of some worm-like creature. He regarded worm trails and burrows which were present in the shales as also being associated with conodonts. He concluded that conodonts are related to the Annelida.

From evidence afforded by the study of assemblages, Rhodes (1952) supports their association with an extinct group of annelids.

Fay (1952) considered conodonts to be some kind of fish-like chordate because of their association with scales and teeth of fish in Paleozoic rocks.

Hazel (1955) concludes that jawless fish belonging to the class Agnatha or some similar organism gave rise to conodonts. These fish are represented today by the lamprey and hagfish.

Hazel credits conodonts with the possibility of serving a dual purpose. Some species may have served as dentition and others as gill-supporting structures referred to as branchial arches.

In 1938, Jones (1956) examined many conodont assemblages of the Upper Pennsylvanian of Oklahoma. He concluded that, "Conodonts are the remains of some worm-like

Paleozoic invertebrate whose conodont assemblages were used for grasping or hooking, rather than for tearing or masticating food."

Acknowledgments

The author wishes to express appreciation to Dr. C. P. Walters for assistance and advice given during the investigation; to Mr. W. K. Clark, who suggested this problem, for advice on various phases of the investigation; to Mr. Verne E. Dow for advice in concentrating conodonts with the Frantz Isodynamic Magnetic Separator; to Dr. D. G. Brookins for his advice in the use of the above separator; and to Mr. Darrell D. Huber for assistance in photographing the conodonts.

STRATIGRAPHY

General Statement

The Hughes Creek Shale Member of the Foraker Limestone Formation and the Bennett Shale Member of the Red Eagle Limestone Formation are in the lower one-third of the Lower Permian Council Grove Group. In Riley and Wabaunsee Counties these two shale members are separated by approximately 32 feet of limestone and shale.

In Kansas the Hughes Creek Shale Member of the Foraker Limestone Formation and the Bennett Shale Member of the Red Eagle Limestone Formation crop out in a north-south trending belt from the Nebraska border to the Oklahoma border. In the area of investigation the outcrop belt varies from 10 to 30 miles in width. The belt extends in a north-south direction through the central part of Wabaunsee County. Only the southeast part of Riley County is in this belt. Younger rocks are present west of the belt and older rocks are east of the belt.

The axis of the Nemaha Anticline trends north-south through the area of outcrop in Wabaunsee County.

Hughes Creek Shale

The Hughes Creek Shale Member of the Foraker Limestone was named by Condra (1927, p. 85) from Hughes Creek, Nemaha County, Nebraska. He described the Hughes Creek Shale:

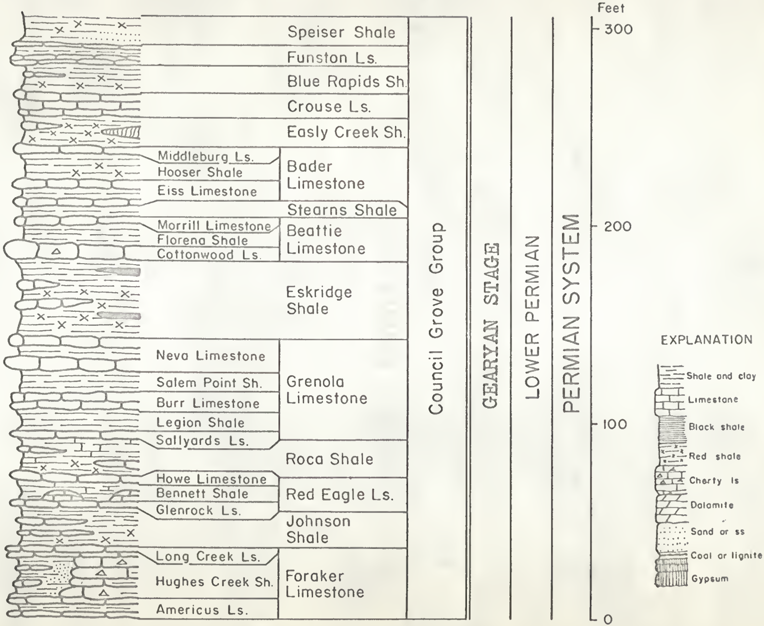

Fig. 1. Stratigraphic section of the Council Grove Group (from Imbrie, 1959).

> ... formed of blue argillaceous shale, dark shales, and thin limestones; combined thickness 35 to 50 feet; in three zones, the top one formed of three sub-zones at places.

To avoid confusion with conodont zones, the words "lithologic division" will be used in place of Condra's "zone". Condra (1927, p. 85) claims the divisions are less regular in Kansas than in Nebraska. He describes the lithologic division (C) as a bluish shale with thin, limy seams. Its thickness is 10 feet or more in Nebraska. The middle lithologic division (B) includes four or five dark gray, earthy, thin fossiliferous limestones and interbedded shales with a combined thickness of 12 to 20 feet. The upper shales of this division are fossiliferous and contain Orbiculoidea missouriensis and Chonetes granulifer. The limestones, at places, are very rich in fusulinids and contain a few bryozoans and brachiopods. The top lithologic division (A) contains three sub-zones. This division consists of two dark argillaceous shale beds separated by a 2-foot unit containing thin arenaceous and fossiliferous limestone layers.

In the area studied, the Hughes Creek Shale Member has a slight increase in overall thickness from 33.9 feet near Paxico (Measured Section No. 10) to 36.8 at the Bluemont Hill Section in Manhattan.

The thick bottom unit of the lower lithologic division stays relatively constant over the area, averaging 7.8 feet. The upper unit varies considerably; it ranges from 5.1 feet near Maple Hill (Measured Section No. 11) to 2.0 feet at

Manhattan. The lithology of this zone remains similar in all sections.

The middle lithologic division remains relatively constant, with exception of the upper part of the middle subdivision. This bed increases from 0.8 feet at Measured Section No. 10 (interval 15) to 3.9 feet at Measured Section No. 8 (interval 12).

The upper lithologic division is present in part in the measured sections of the area. The lower part of this lithologic division is represented by fossiliferous, platy limestone and dark shale. The dark gray shale increases in thickness from central Wabaunsee County to Manhattan. The middle unit is present at the Manhattan measured section.

Bennett Shale

The Bennett Shale Member of the Red Eagle Limestone was named by Condra (1927, p. 86) for exposures along the Little Nemaha River south of Bennett, Lancaster County, Nebraska. He described the Bennett Shale:

> ... formed of bluish gray and nearly black argillaceous shale, with one carbonaceous streak resembling coal and a thin yellowish to brownish limestone; combined thickness 5 to 11 feet.
>
> Fauna: *Orbiculoidea missouriensis*, *Lingula* sp., *Composita subtilata*, *Spirifer cameratus*, and a few other species.

The Bennett Shale Member shows variation in lithology and thickness in the area of investigation. This shale can be readily recognized by the *Orbiculoidea* zone at the base and its relation to the overlying and underlying limestone members.

Sloan (1963) divided the Bennett Shale Member of this area into two units. The lower unit is predominantly dark-gray shales. In some localities a moderately calcareous clay or mudstone is present. Orbiculoidea are abundant in the dark shales.

The upper unit of the Bennett Shale Member is more calcareous than the lower dark shales. The various lithologies of the upper unit consist of siltstones, mudstone, mud-shale, and thin limestones. A greater variety of fossils are in the upper unit of the Bennett Shale (Sloan, 1963).

The thickness of the Bennett Shale Member in measured sections in this report varied from 3.2 to 7.4 feet.

In the Manhattan area, the Bennett Shale Member is predominantly dark-gray to black shale, which is overlain by a mudstone or limestone. The Manhattan Outcrops, even though in a small area, vary in the thickness and position of the black shale. Orbiculoidea is usually common to sparse in these beds. Orbiculoidea is abundant at the contact of the Bennett Shale and Glenrock Limestone on Bluemont Hill and K Hill.

The Bennett Shale Member thickens to the southeast. It attains a thickness of 6.1 feet in southeast Riley County and 7.4 feet four miles south of Alma. With this increase in thickness, the bottom unit becomes a highly calcareous mudstone and claystone. The fossil content increases in both abundance and variety.

Five miles south of Eskridge, the Bennett Shale Member thins and is predominantly black shale. This bed is similar to Measured Section No. 1 in Manhattan. The thick black shale is highly organic and the overlying gray-brown shale is moderately calcareous. There are few fossils, except for *Orbiculoidea* which has a moderate occurrence in the black shale and a sparse occurrence in the gray-brown shale.

PROCEDURES

Field Procedures

Good exposures of both the Hughes Creek Shale and Bennett Shale are limited. This is especially true of the Hughes Creek Shale where the shales are thicker than the limestones. Many of the limestones are highly argillaceous and weather readily. The Bennett Shale provides somewhat better outcrops, due mainly to the resistance to weathering of the overlying Howe Limestone. These shale members commonly lie beneath shallow grass-covered slopes. The associated limestones may form minor topographic benches. Outcrops of the two shale members are confined almost entirely to road cuts and stream banks.

Except for Measured Section No. 8, all measured sections used in this investigation were taken from previous works. The Hughes Creek Shale outcrops along U. S. Highway 40 had been cut back by additional excavation of the back slope for highway construction purposes. These outcrops were fresher and better exposed than the ones described in earlier work; therefore, minor modification was necessary.

The thicknesses of the beds were checked with a tape measure and hand level. A rock color chart was used for color descriptions.

Only shale beds were sampled. The only exception to this was the top part of three limestones where abundant conodonts were found directly above. Residue studies of limestones in the Hughes Creek Shale (Garber, 1962) detected few conodonts in the limestones. Most of these conodont occurrences were only in trace amounts.

Samples were collected from the base, middle and top of most shale beds. Only one sample was collected from very thin beds. It was found desirable to collect more than three samples from thick beds containing a change in lithology. The samples were placed in sacks and numbered according to their position in the outcrop.

In Measured Section No. 8 the shale at the base of the Hughes Creek Shale was not sampled, due to a large amount of soil slump covering it.

Laboratory Procedures

Fifty-gram portions of each sample were processed in the laboratory. Several methods were used to disintegrate the shales.

The majority of the shales were calcareous and required acid treatment for disintegration. The samples were placed in plastic cups and digested in a 10% solution of acetic acid. When it was noticed that effervesence had ceased and material remained undisintegrated, the spent acid was poured off and fresh acid added. Approximately 48 hours were required for complete digestion. After digestion, the acid was poured off and the residue transferred to tin cans. The residue was then boiled slowly in a solution of Calgon. After about 15 minutes, the solution was allowed to cool and the muddy liquid decanted, allowing sufficient time for the larger particles to settle. The decanting was repeated until the wash water remained clear. As much liquid as possible was poured off without losing any of the residue. Several residues were dried at the same time on a gas hot plate. The cans were placed around the side of the hot plate and encircling the flame. A low flame was used to prevent overheating.

The black non-calcareous shales disintegrated only with great difficulty. Except for hydrogen peroxide, the shales had little, if any, reaction with the reagents ordinarily used for disintegration. A series of freeze and thaw cycles was found to be the best method for the disintegration of these shales. In this process the shale was broken apart by the physical pressure of expanding ice crystals. The number of freeze and thaw cycles depended upon the density of the material. Some of the dense, organic, black shales required up to fifteen freezings. After a sufficient number of freezings, the material was transferred to plastic cups. The clay size particles were decanted off until the wash water remained clear. A 3% solution of hydrogen peroxide was then added to the residue. This was to disperse remaining clay particles and help clean the conodonts of matrix that may have remained adhering to them. The spent hydrogen peroxide was replaced during the process when necessary. This hydrogen peroxide digestion took about 48 hours. After complete digestion, fine particles were decanted off until the wash water remained clear. The final decanting was with distilled water. This reduced the number of ions for a more effective magnetic separation. The residues were then transferred to cans and dried on a hot plate.

Soft and weakly indurated shales were placed in tin cans and disintegrated by boiling water. After about 15 minutes, the mixture was allowed to cool and the muddy liquid decanted off. The decanting was repeated until the wash water was clear. If an excess of undisintegrated particles remained in the liquid the boiling process was repeated. After the boiling process the residue was transferred to plastic cups and treated with a 10% solution of acetic acid. This treatment was to free the conodonts of matrix that may have remained adhering to them. If the adhering matrix was not dissolved by acid, a 3% solution of hydrogen peroxide was used. After the treatment with acid or hydrogen peroxide the residue was transferred to tin cans and water added. The liquid was decanted off and the residue washed with distilled water. The residues were then dried on a hot plate.

The dried residues were removed from the cans, using a soft brush to loosen any particles adhering to the cans. Each residue was separated according to size by 35 mesh and 120 mesh sieves. The conodonts passed through the 35 mesh and were caught on the 120 mesh sieve. The material caught on the 120 mesh sieve was stored in labeled glass vials, pending magnetic separation.

The conodonts were concentrated by use of a Frantz Isodynamic Magnetic Separator. Dow (1960) devised various techniques for making conodont concentrations with this separator. These concentration procedures are based on the composition of conodonts. It was noted by Rosenblum (1958) that apatite had been found to be weakly magnetic. In a detailed study of the composition of fibrous conodonts, it was determined that conodonts are composed of the mineral apatite (Rhodes and Wingard, 1957).

All substances show varying response to magnetic fields. Strongly to moderately magnetic materials, when placed in a magnetic field, will experience a force which will cause them to move from the weaker to the stronger part of the field. Weakly magnetic minerals, when placed in a magnetic field, will move from the stronger to the weaker part of the field. Conodonts, being a part of the weakly material, will pass through the chute away from the magnetic force (Dow, 1960).

In the process of concentrating the conodonts, each sample was examined with a binocular microscope to determine the dominant mineralogy. Instrument settings were then adjusted to obtain the best results from the dominant mineralogy. With some samples one run through the separator was sufficient, while others required many runs. When a considerable amount of material was caught in the non-magnetic collector, it was removed and rerun through the separator at a different setting. The magnetic portion was returned to the glass vial. Each succeeding run of the material caught in the non-magnetic fraction was passed through at a slower rate and decreased side slope. With each decrease in side slope, materials with less magnetic attraction were attracted to the magnetic chute.

The successive reruns of material depend on the composition of the sample. Almost all shale particles were caught in the magnetic collector at a 5° to 10° side slope. Most fossil fragments composed of calcium carbonate were caught in the magnetic collector at a 2° to 5° side slope. Orbiculoidea shell fragments, which are composed of calcium phosphate, were almost impossible to separate from the conodonts. Side slopes of less than 1° yielded some conodonts in the magnetic fraction. Fish teeth had a slightly wider range of magnetic susceptibility than did the conodonts. Fish teeth were collected in the magnetic fraction with a side slope of less than 3°. Some conodonts with matrix adhering to them went into the magnetic chute at greater side slopes as a result of the magnetic susceptability of the adhering material. This made it necessary for the rock material to be well disintegrated and washed.

Before using the Frantz Separator technique, five samples containing conodonts were separated by the heavy liquid method, using tetrabromoethane as the liquid medium. The Frantz Separator was found to be far superior to heavy liquid separation in both speed and efficiency. The standard heavy liquids give off toxic vapors and are a health hazard.

After separating each sample, the conodont-bearing concentrate was placed in one-dram glass vials. When all the samples had been separated, the concentrated conodonts were examined under a binocular microscope, picked, and placed in faunal storage slides.

After identification, well preserved specimens of each species were taken from each sample and mounted on numbered faunal slides. Representative specimens of each species were used for photographing.

The specimens were photographed by the use of a 120 mm. Olympus camera. The camera was mounted on a ring stand and the lens aimed directly into the ocular of the microscope. Time exposures of 30 seconds were found to be sufficient for photographing. Exposures of $\frac{1}{2}$ second were desirable in developing the prints.

An arbitrary designation of rare (R) was given to species which were represented by from 1 to 10 specimens obtained from the initial 50 grams of field sample; an arbitrary designation of common (C) was given to species which were represented by from 11 to 50 specimens; and an arbitrary designation of abundant (A) was given to species which were represented by more than 50 specimens.

SYSTEMATIC PALEONTOLOGY

Order CONODONTOPHORIA Eichenberg, 1930

Family COLEODONTIDAE Branson & Mehl, 1944

"Pulp cavity located beneath main cusp at or near the anterior end of denticulated bladelike or barlike unit." (Hass, 1962.)

Subfamily HINDEODELLINAE Hass, 1959

"Main cusp distinct, not terminal; anterior bar or blade short." (Hass, 1962.)

Genus Hindeodella Ulrich & Bassler, 1926

Hindeodella Ulrich & Bassler, 1926, U. S. National Museum Proceedings, Vol. 68, p. 38.

Type Description: Bar long and straight, bearing as many as ten small denticles in front of the strong long main cusp and a long series of numerous small slender denticles often alternating in size behind it, those of each set approximately equal in size.

Hindeodella iowaensis Youngquist & Downs, 1949

Plate II, Fig. 3

Hindeodella iowaensis Youngquist & Downs, 1949, Journal of Paleontology, Vol. 23, p. 165, pl. 30, fig. 12.

Type Description: Bar long, slender, very gently bowed and more strongly arched. Aboral side slightly grooved or flattened medianly; oral-lateral shoulder of bar somewhat sinuous from swellings at the places of the junction of the major denticles with the bar. In general, bar is rounded in cross section. Denticles occur in

EXPLANATION OF PLATE II

(All specimens 23 X)

Fig. 1 & 2.	Hindeodella sp. Ulrich & Bassler	Lateral view.
Fig. 3.	Hindeodella iowaensis Youngquist & Downs	Lateral view.
Fig. 4.	Synprioniodina microdenta Ellison	Lateral view.
Fig. 5.	Prioniodus? conflexus Ellison	Lateral view.
Fig. 6.	Ozarkodina delicatula Stauffer & Plummer	Lateral view.
Fig. 7.	Spathognathodus minutus Ellison	Lateral view.
Fig. 8.	Lonchodus sp. Pander	Lateral view.
Fig. 9.	Lonchodus simplex Pander	Lateral view.
Fig. 10, 11, & 12.	Cavusgnathus lauta Gunnell	10 & 11. Lateral view. 12. Oral view.
Fig. 13 - 18.	Streptognathodus elongatus Gunnell	13 - 17. Oral view. 18. Lateral view.
Fig. 19.	Streptognathodus wabaunsensis Gunnell	Oral view.
Fig. 20.	Streptognathodus simulator Ellison	Oral view.


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rather regular alternating series, that is, two to four minor denticles are intercalated between adjacent larger ones. Minor denticles are partially confluent with one another and therefore are not particularly rounded in cross section; major denticles are very round, and distally (as far as can be determined) incline inward. Cusp moderate in size, and has small aboral flange-like extension on outer (figured) side. Nature of bar anterior to cusp unknown, but presumably it was denticulate and short.

Discussion: This species was represented by only one specimen. It was noticed the bar was not arched as much as the type species, otherwise it compared well with Youngquist and Downs' description.

Occurrence: This specimen was found in interval 2 of Measured Section No. 2 from the Bennett Shale Member of the Red Eagle Limestone.

Indeterminate Hindeodellids

Plate II, Fig. 1 & 2

Hindeodella sp. Gunnell, 1931, Journal of Paleontology, Vol. 5, p. 249, pl. 29, figs. 11, 12; 1933, Journal of Paleontology, Vol. 7, p. 269, pl. 32, fig. 34.

Hindeodella sp. A-F Stauffer and Plummer, 1932, Univ. of Texas Bull. 3201, pl. 1, figs. 1, 2, 11-15, 18.

Hindeodella sp. Ellison, 1941, Journal of Paleontology, Vol. 15, p. 118, pl. 20, figs. 18, 19, 23, 24, 32, 33.

Discussion: This includes hindeodellids which were broken and could not be identified to species. Many of the specimens were bar segments and fragments. An anterior cusp was not found on any of the fragments; therefore, it is believed that few if any of these indeterminate hindeodellids belong to the species Hindeodella iowaensis.

Occurrence: Hindeodella sp. occurs in the Hughes Creek Shale of the Foraker Limestone and the Bennett Shale of the Red Eagle Limestone. They were present in almost all samples containing conodonts but were few in number.

Subfamily LIGONODININAE Hass, 1959

Genus Synprioniodina Ulrich & Bassler, 1926

Synprioniodina Ulrich & Bassler, 1926, U. S. National Museum Proc., V. 68, p. 42.

Like Palmatodella except that the downturned anterior part is much smaller, bar thicker, denticles not turning forward so sharply and the main cusp proportionately very large. Probably more closely allied to Euprioniodina the essential difference being the almost complete lateral fusion of the denticles.

Synprioniodina microdenta Ellison, 1941

Plate II, Fig. 4

Synprioniodina sp. Gunnell, 1933, Journal of Paleontology, Vol. 7, p. 269, pl. 31, fig. 6.

Synprioniodina microdenta Ellison, 1941, Journal of Paleontology, Vol. 15, p. 119, pl. 20, fig. 43-46.

Two blade-like bars in a common plane meet at an angle of 40-55 degrees; posterior bar, length unknown, with many subequal closely spaced, laterally compressed, sharp-pointed denticles partly coalesced and inclined anteriorly to the base of blade about 40 degrees; aborally directed bar commonly shorter than posterior one, with denticles similar to that of the posterior bar but the inclination to base of blade is about 30 degrees; denticles all slightly curved, concave inward in vertical section. Superior fang at apex of angle formed by union of blades, about twice as long as other denticles, laterally compressed, sharp-pointed, lenticular in cross-section, curved slightly inward in vertical section, expanded at the base on the inward side into a wide flaring apron; outer side not flared.

Aboral attachment scar subelliptical, asymmetrical, traversed by longitudinal groove continued posteriorly and downward along the aboral edges of both blades, terminated in a deep conical pit below the superior fang.

Discussion: This species was represented by only three specimens in this study. In two of the specimens one of the blade-like bars had been broken near the point of juncture.

Occurrence: Synprioniodina microdenta was found to occur in the Bennett Shale of the Red Eagle Limestone. The specimens were obtained from interval 4 of Measured Section No. 7 and interval 2 of Measured Section No. 1.

Family PRIONIODONTIDAE Bassler, 1925

"Pulp cavity in middle third of bladelike or barlike unit." (Hass, 1962.)

Subfamily PRIONIODONTINAE Bassler, 1925

"Main cusp larger than denticles of blade or bar; denticulated lateral process may be present; unit is not palmate." (Hass, 1962.)

Genus Prioniodus Pander, 1856

Prioniodus Pander, 1856, Monographie der fossilen Fische des Silurischen Systems der russisch-baltischen Gouvernments, p. 29.

Prioniodus Ulrich & Bassler, 1926, U. S. National Museum, Proc., Vol. 68, Art. 12, p. 8, 9.

Prioniodus Stauffer, 1935, Journal of Paleontology, Vol. 9, p. 616.

> By this name are covered all those teeth or jaws from which a very large tooth protrudes above the surrounding tissue, and which is bordered on one side by a series of smaller teeth. The hollow of the base extends lengthwise under all these teeth and up into them to a certain height. (Translated.)

Ulrich and Bassler add somewhat to this description by the following comments:

> Typically the pick shape is well developed in this genus, the main terminal cusp relatively large with both edges sharp. The basal extension, although variable in length, is usually strong and often as long as the cusp itself, the anterior line formed by both being nearly straight. Numerous denticles on the bar, their lower half or more sometimes fused, but in some cases, although always closely arranged, they remain discrete to the junction with the bar.

Prioniodus? *conflexus* Ellison, 1941

Plate II, Fig. 5

Euprioniodina? sp. Gunnell, 1933, Journal of Paleontology, Vol. 7, p. 269, pl. 33, fig. 34.

Prioniodus? *conflexus* Ellison, 1941, Journal of Paleontology, Vol. 15, p. 114.

> Large terminal fang, laterally compressed, sharp-edged, strongly concave inward in vertical section, slightly convex cross-section on outer face, inner face strongly convex, base of fang expanded antero-posteriorly into a long, slender, pick-shaped anticusp, widely expanded on inner side into flaring apron; posterior bar thin, bearing one or two discrete laterally compressed inwardly curved denticles; attachment scar, bearing a pit beneath fang, shallow, expanded into a sublanceolate cup, anteriorly pointed, traversed by a longitudinal groove that is continued posteriorly along the aboral edge of bar.

Discussion: This species was represented by only one specimen in the samples. The terminal fang in the illustrated specimen has been broken near the end, giving a blunt point.

Occurrence: The specimen was obtained from the top of interval 14 of Measured Section No. 8 in the Hughes Creek Shale of the Foraker Limestone.

Genus Ozarkodina Branson & Mehl, 1933

Ozarkodina Branson & Mehl, 1933, Univ. Missouri, Studies, Vol. 8, p. 51.

Ozarkodina Ellison, 1941, Journal of Paleontology, Vol. 15, p. 120.

For purposes of description the specimens are oriented so that the denticles are inclined posteriorly and the posterior bar is commonly of smaller size. In laterally curved specimens the concave side is inward.

Ozarkodina delicatula (Stauffer & Plummer)

Plate II, Fig. 6

Bryantodus delicatulus Stauffer and Plummer, 1932, Univ. Texas Bull. 3201, p. 29, pl. 2, fig. 27.

Bryantodus nasutus Stauffer and Plummer, 1932, idem., p. 29, pl. 2, fig. 28.

Bryantodus sulcatus Stauffer and Plummer, 1932, idem., p. 39, pl. 2, figs. 11, 14, 30.

Bryantodus delicatus Gunnell, 1933, Journal of Paleontology, Vol. 7, p. 267, pl. 32, fig. 43.

Bryantodus rugosus Gunnell, 1933, idem., p. 268, pl. 32, fig. 44.

Bryantodus strigatus Gunnell, 1933, idem., p. 268, pl. 32, fig. 45.

Bryantodus strigillatus Gunnell, 1933, idem., p. 268, pl. 32, fig. 46.

Blade-like, thin, straight or orally arched, laterally curved, with limbs of subequal length; blade thickest slightly above the aboral edge near base of denticles; anterior limb with 12 or more laterally compressed subequal, closely spaced, coalesced denticles, discrete only near their tips, inclined at an obtuse angle with base of blade; posterior limb with nine or more laterally compressed subequal, closely spaced, partly coalesced denticles all somewhat smaller than those of anterior limb but making almost a right angle with base of blade; posterior limb of specimens of old individuals are commonly terminus; apical denticle laterally compressed, sharp-edged, pointed, two to three times as wide and nearly twice as long as other denticles; germ denticles visible in transmitted light.

Aboral edge thin; apical pit long, narrow, deep, with a slightly flaring lip, tapered into a narrow groove on the aboral edge of both limbs.

Discussion: The specimens examined had a slight variation in the size of the denticles. In most of the specimens the posterior blade has been in part broken off.

Occurrence: Ozarkodina delicatula occurs in both the Hughes Creek Shale of the Foraker Limestone and the Bennett Shale of the Red Eagle Limestone. This species was present in most of the samples containing conodonts but was of rare occurrence.

Subfamily SPATHOGNATHODONTINAE Hass, 1959

"Main cusp inconspicuous or slightly larger than denticles of either the blade or bar; unit not palmate." (Hass, 1962.)

Genus Spathognathodus Branson & Mehl, 1933

Spathodus Branson & Mehl, 1933, Univ. Missouri, Studies, Vol. 8.

Spathodus Ellison, 1941, Journal of Paleontology, Vol. 15, p. 120.

Description: (Ellison, 1941) For purposes of description these specimens are oriented with the superior denticle near the anterior end.

Spathognathodus minutus Ellison, 1941

Plate II, Fig. 7

Spathodus minutus Ellison, 1941, Journal of Paleontology, Vol. 15, p. 120, pl. 20, fig. 50-52.

Spathognathodus cf. S. minutus Rhodes, 1963, Journal of Paleontology, Vol. 37, p. 408, pl. 47, fig. 3.

Blade short, thin, laterally straight, broadly arched with aboral edge in anterior half nearly straight; oral edge crenulate with greatest height at superior denticle, gradually decreasing posteriorly to about the fourth from the last denticle, posterior to which it drops sharply to the aboral margin; anterior edge forms an angle of about 45 degrees with the aboral margin; about 12 sub-equal, laterally compressed, almost completely coalesced denticles posterior to cusp; three short denticles anterior to cusp.

Outline of aboral cavity lachrymoform, broadly rounded anteriorly with posterior point reaching near posterior end of blade, deepest point near anterior end slightly back of superior cusp; cavity traversed by a longitudinal groove which extends along the aboral edge of blade anteriorly and posteriorly.

Discussion: In the three specimens examined, the superior denticle rose slightly above the shorter denticles.

These specimens compare favorably with the specimen described and illustrated by Rhodes.

Occurrence: Spathognathodus minutus was found only in the Hughes Creek Shale. The specimens were obtained from intervals 4 and 18 of Measured Section No. 9.

Family IDIOGNATHODONTIDAE Harris & Hollingsworth, 1933

"Pulp cavity not greatly restricted so that aboral side of unit is partly or entirely opened up into a large concavity; platforms may flank part or all of axis." (Hass, 1962.)

Subfamily IDIOGNATHODONTINE
Harris & Hollingsworth, 1933

"Blade present, denticulated, well formed; expanded pulp cavity restricted, more or less to anterior end of unit." (Hass, 1962.)

Genus Cavusgnathus Harris & Hollingsworth, 1933

Cavusgnathus Harris & Hollingsworth, 1933, Am. Jour. Science, Ser. 5, Vol. 25, p. 200.

> This genus is erected to include those lanceolate plated conodonts with no semblance of a median crest in the median oral channel. Outline of plate lanceolate to claviform; oral face of plate with complete, deep, median longitudinal channel without crest and bordered by marginal rims ornamented with denticles, nodes, corrugations, or combination of the same; posterior bar denticulate.

Cavusgnathus lauta Gunnell, 1933

Plate II, Fig. 10, 11, & 12

Cavusgnathus lauta Gunnell, 1933, Journal of Paleontology, Vol. 7, p. 286, pl. 31, figs. 67, 68, pl. 33, fig. 9.

Cavusgnathus missouriensis Gunnell, 1933, idem., pl. 33, figs. 10, 11.

Cavusgnathus lauta Ellison, 1941, Journal of Paleontology, Vol. 15, p. 126, pl. 21, figs. 47, 48.

Plate sublanceolate. Oral surface of plate bearing row of transverse ridges on each side of median furrow. Bar high and bearing six denticles of rather uniform size. Flanges on basal portion of plate sides. Anterior and sharp.

Description (Ellison, 1941):

Platform long, lanceolate, posteriorly pointed; inner and outer parapets ornamented with regularly spaced parallel transverse ridges obsolescent toward the deep oral trough; trough deepest at posterior end of platform; outer parapet continued into blade bearing laterally compressed closely spaced subequal denticles rising only a short distance above elevation of platform; aboral attachment scar very slender, shallow, and not widely flared; sides of platform almost vertical, constricted only slightly.

Discussion: The specimens agree better with Ellison's description. The denticles of the blade vary from 4 to 6. The blade connects with the inner parapet in most of the specimens.

Occurrence: Cavusgnathus lauta was found to occur infrequently in both the Hughes Creek Shale and the Bennett Shale.

Genus Streptognathodus Stauffer & Plummer, 1932

Streptognathodus Stauffer & Plummer, 1932, Univ. of Texas Bull. 3201, p. 47; Gunnell, 1933, Journal of Paleontology, Vol. 7, p. 269; Ellison, 1941, Vol. 15, p. 127.

Description (Ellison, 1941):

The blade is the anterior denticulate process. This attaches in a median position to the platform. The platform may bear laterally directed nodose processes called accessory lobes. The large excavated aboral surface of the platform is the attachment scar. For purposes of description the blade is directed anteriorly. The side of the aboral attachment scar having the greatest lateral extension near the anterior portion of the platform is designated the inner side. If the axis of the tooth is curved laterally, the concave side is inward.

Streptognathodus elongatus Gunnell, 1933

Plate II, Fig. 13-18

Streptognathodus elongatus Gunnell, 1933, Journal of Paleontology, Vol. 7, p. 283, pl. 33, fig. 30.

Streptognathodus simplex Gunnell, 1933, idem., p. 285, pl. 33, fig. 40.

Streptognathodus elongatus Ellison, 1941, Journal of Paleontology, Vol. 15, p. 130, pl. 22, fig. 9.

Streptognathodus elongatus Rhodes, 1963, Journal of Paleontology, Vol. 37, p. 405, pl. 47, figs. 1, 5, 6, 16-24, 29-34.

Plate gently curving toward left side. Length to width ratio of plate oral surface 4 to 1. Median groove on oral surface increasing gradually in strength from anterior extremity to posterior end of plate on either side of which occur nodes or transverse ridges, and in which occur few small nodes in anterior half with nodose carinal ridge occurring in posterior one-third of groove total length. Oral surface of left, lobate portion of plate bearing few nodes. Sides of plate bearing flanges on basal portion. Anterior end blunt.

Description (Ellison, 1941):

> Outline of platform in oral view very long, slender, lanceolate, slightly flexed, posteriorly pointed, greatest width near mid-length; if accessory lobe is present it commonly has only one or two nodes; transverse section of oral surface deeply V-shaped; oral surface ornamented with 10 or more parallel transverse ridges ending abruptly in the oral trough; blade of average length consisting of 10 to 18 denticles continued posteriorly as a carina in the oral trough for about one-fourth the length of the platform; row of nodes posterior to the carina generally absent; carina set off from platform on either side by deep sulci that merge into the trough posteriorly so that the lateral margins of the anterior portion of the platform extend as free edges.

Discussion: The specimens assigned to this species agree with Gunnell's and Ellison's descriptions. They agree exceptionally well with the variations described by Rhodes. The increase in width and shallow trough is well represented in many of the specimens. The majority of the specimens are the smaller type with a narrow platform and deep trough.

Occurrence: Streptognathodus elongatus occurred abundantly in certain zones of the Hughes Creek Shale and the Bennett Shale. This species was present in most samples which contained conodonts.

Streptognathodus wabaunsensis Gunnell, 1933

Plate II, Fig. 19

Streptognathodus wabaunsensis Gunnell, 1933, Journal of Paleontology, Vol. 7, p. 285, pl. 33, fig. 32.

Streptognathodus walteri Gunnell, 1933, idem., p. 284, pl. 33, fig. 31.

Streptognathodus acuminatus Gunnell, 1933, idem., p. 285, pl. 33, fig. 33.

Streptognathodus farmeri Gunnell, 1933, idem., p. 285, pl. 33, fig. 34.

Streptognathodus flangulatus Gunnell, 1933, idem., p. 285, pl. 33, fig. 35.

Streptognathodus wabaunsensis Ellison, 1941, Journal of Paleontology, Vol. 15, p. 131, pl. 22, fig. 18, 19, 21, 22.

Oral surface with nine transverse ridges anterior to anterior extremity of carinal ridge; posterior eight being cut by small median groove. Greatest width of oral surface anterior to mid-length of plate. Oral surface to right of carinal ridge bearing nodes; left postero-lateral area bearing nodose, longitudinal ridge. Anterior end sharp.

Description (Ellison, 1941):

Outline of platform in oral view long, lanceolate, posteriorly pointed, greatest width near mid-length; accessory lobe on one side only and situated far forward; surface of lobe nodose or ridged, nodes commonly not more than 10 in number; transverse section of oral surface flat to slightly concave having a shallow median trough; oral surface ornamented with 8 to 15 parallel transverse ridges ending abruptly at the median trough and slightly radiating from the trough near the posterior end; blade of average length consisting of 10 to 16 denticles continued posteriorly on the anterior one-fourth of the platform as a low carina set off from the platform on either side by rapidly descending sulci so that the lateral margins of the anterior portion of the platform extend as free edges. Apron commonly widely flaring on outer side.

Discussion: The specimens varied in size, being mostly the larger forms. Some of the specimens contained nodes on the outside of the platform. Most of the specimens had a moderately flaring lobe and trough.

Occurrence: Streptognathodus wabaunsensis occurred rarely in both the Hughes Creek Shale and the Bennett Shale. This species was found in all samples containing S. elongatus.

Streptognathodus simulator Ellison, 1941

Plate II, Fig. 20

Streptognathodus simulator Ellison, 1941, Journal of Paleontology, Vol. 15, p. 133, pl. 22, fig. 25, 27-30.

Outline of platform in oral view long, slender. lanceolate, asymmetrical, posteriorly pointed, greatest width near anterior one-third; accessory lobe on inner side only and situated far forward; surface of lobe nodose or ridged, number of nodes varies from three to 10; transverse section of oral surface concave; oral surface bearing a shallow longitudinal trough parallel, but on the inner side of the median line; oral surface ornamented with six to 18 parallel transverse ridges, ending abruptly in the trough and slightly radiating from the trough in the posterior portion of the platform; some transverse ridges may completely bridge the trough; blade of average length consisting of 10 to 16 denticles continued posteriorly as a carina on the anterior one-fourth of platform; carina ends abruptly against a transverse ridge and is set off from the platform by deep sulci so that the lateral margins of the anterior portion of the platform extend as free edges, sulcus on inner side continuous posteriorly into the eccentric oral trough.

Discussion: The specimens agreed favorably with the type description. There was a slight variation in the number of nodes and transverse ridges.

Occurrence: Streptognathodus simulator occurred rarely in both the Hughes Creek Shale and the Bennett Shale. This species was found in all samples containing S. elongatus

Family UNCERTAIN

"Genera included in this division are not classified into families because their relationships are obscure, being based either on inadequate material or on eccentric specimens." (Hass, 1962.)

Genus *Lonchodus*

Lonchodus Pander, 1956, Monographie der fossilen Fische des Silurischem Systems der russisch-baltischen Gouvernments, p. 32.

Lonchodus Stauffer, 1935, Journal of Paleontology, Vol. 9, p. 607.

Very slender vertical, inclined or curved denticles which point in several different directions and which rise from a horizontal base...Smaller denticles may occur between the larger ones...The general characters of the genus may be given as slender pointed or lamellar denticles occurring as a uniform series or alternating with smaller denticles of varying size and number, all of which originate in a horizontal or convex base. (Translated.)

Lonchodus simplex? Pander, 1856

Plate II, Fig. 9

Lonchodus simplex Pander, 1856, Mon. foss. Fische Silur. Systems russ.-balt. Gouv., p. 31, pl. 2A, figs. 2, 3, 5, 6.

Lonchodus simplex Roundy, 1926, U. S. Geol. Survey Prof. Paper 46, p. 15, pl. 3, figs. 1-5.

Lonchodus simplex Gunnell, 1931, Journal of Paleontology, Vol. 5, p. 248, pl. 29, figs. 13, 14.

Lonchodus simplex Stauffer & Plummer, 1932, Univ. Texas Bull. 3201, p. 38, pl. 2, fig. 1.

Lonchodus? sp. Youngquist & Heezen, 1949, Journal of Paleontology, Vol. 22, No. 6, p. 771, pl. 118, fig. 12.

Bar elongate, straight, with a wide groove along the center of the under side. The bar appears to be formed by a fusing of the bases of the teeth, which are sturdy, long, sharp, lenticular in cross-section, and make an angle of about 50° with the bar and are united by a web near the base, although the teeth are not confluent.

Discussion: Only a single specimen was complete enough to be assigned to this species. The specimen contained two long denticles and part of another fused to the bar.

Occurrence: This specimen was recovered from interval 4 of the Bennett Shale in Measured Section No. 7.

Lonchodus sp.?

Plate II, Fig. 8

Discussion: Specimens placed in this group were fragments of denticles resembling *L. simplex* in shape and texture. However, the specimens placed in this group were not complete enough to be classified to species.

Occurrence: All the specimens classified under *Lonchodus* sp.? were from the Bennett Shale Member of the Red Eagle Limestone.

SUMMARY

Stratigraphic Distribution of Conodonts

The variety of genera and species found during the course of this study was small. Most of the species have little value as guide fossils due to the fact that they have a large stratigraphic distribution. Platform-types tend to serve as the most useful stratigraphic markers in Pennsylvanian and Permian rocks. One of the most common platform-types is *Streptognathodus*.

This conodont fauna is dominated by the species *Streptognathodus elongatus*. The upper conodont zone of the Hughes Creek Shale has by far the greatest abundance of this species. The largest occurrence consisted of 278 specimens in sample number 17a of Measured Section No. 10. This species averaged 217 specimens per 50 gram sample from the upper conodont zone in the four Hughes Creek Shale measured sections.

In the Bennett Shale *Streptognathodus elongatus* was the only species present in greater than rare amounts. The greatest concentration of *S. elongatus* in the Bennett Shale was at the base where 165 and 156 specimens were counted from Measured Sections 3 and 4 respectively.

A minor concentration of *Streptognathodus elongatus* was found in the upper part of the Bennett Shale at localities where it was predominantly a black shale. This concentration occurred directly above the black shale. At Measured Sections 1 and 7 this position contained 70 and 66 specimens respectively.

Conodonts were not found in the upper part of the thicker Bennett shales.

The bar and blade types such as Hindeodella, Ozarkodina and Spathognathodus had a rare occurrence throughout the Hughes Creek Shale Member and Bennett Shale Member. Except for the base of the Bennett Shale Member, Hindeodella sp. and Ozarkodina delicatula were present in almost all samples containing conodonts. Hindeodella sp. and Ozarkodina delicatula were most numerous in the upper conodont zone of the Hughes Creek Shale Member. Spathognathodus minutus was represented by only three specimens and was confined to the Hughes Creek Member.

The two specimens of Synpriodina microdenta were found in the upper part of the Bennett Shale Member. These specimens occurred with a moderate amount of other conodonts.

Cavusgnathus lauta had a rare occurrence throughout the Hughes Creek Shale Member and Bennett Shale Member. This species was present in some samples which contained few streptognathodids.

Lonchodus sp. was confined to the Bennett Shale Member, where it occurred rarely. This genus was represented by fragmental specimens. They were most numerous at the base of the Bennett Shale Member. Many writers have labeled this as a "catch-all genus" which contains a large variety of types and is of no stratigraphic value.

Table 1. Distribution and abundance of conodonts in the Hughes Creek Shale.

Measured Sects.	8							9						
Lithologic Divisions	6	8	10	14a	14b	14c	16	4	9	11	18a	18b	18c	20
Hindeodella sp.	R	R	R	C	R	R	R	R		R	R	R		
Prioniodus conflexus						R								
Ozarkodina delicatula	R	R		R	R	R	R	R	R	R	R	R	R	
Spathognathodus minutus	R							R				R		
Cavusgnathus lauta	R							R	R			R		
Streptognathodus elongatus	R	C	R	A	C	R	R	C	R	C	A	R	R	R
Streptognathodus wabaunsensis				R							R			
Streptognathodus simulator				R							R			

R = 1 - 10 specimens

C = 11 - 50 specimens

A > 50 specimens

Table 1. Distribution and abundance of conodonts in the Hughes Creek Shale (continued).

Measured Sects.	10							11						
Lithologic Divisions	4	7	9	11	17a	17b	17c	4	9	11	18a	18b	18c	20
Hindeodella sp.	R	R	R	R	R	R	R	R	R	R	R	R	R	
Ozarkodina delicatula	R				R	R			R		C			
Spathognathodus minutus	R													
Cavusgnathus lauta	R	R							R					
Streptognathodus elongatus	C		R	R	A	R	R	C	R	C	A	C	R	R
Streptognathodus wabaunsensis					R						R			
Streptognathodus simulator					R						R			

R = 1 - 10 specimens

C = 11 - 50 specimens

A > 50 specimens

Table 2. Distribution and abundance of conodonts in the Bennett Shale.

Measured Sections	1			2			3			4	5	6		7				
Lithologic Divisions	1	2	3	2	4	5	2	3a	3b	7a	5	8	9	3a	3b	3c	3d	4
Hindeodella sp.	R	R	R	R	R	R		R						R		R	R	R
Hindeodella iowaensis				R														
Synprioniodina microdenta		R																
Ozarkodina delicatula	R	R		R		R	R							R			R	R
Cavusgnathus lauta	R	R		R	R	R												
Streptognathodus elongatus	R	A				R			A	A	C	R	C	A	R	R	R	C
Streptognathodus wabaunsensis		R							R	R				R				
Streptognathodus simulator		R							R	R				R				
Lonchodus sp.	R								R		R		R					
Lonchodus simplex																		R

R = 1 - 10 specimens

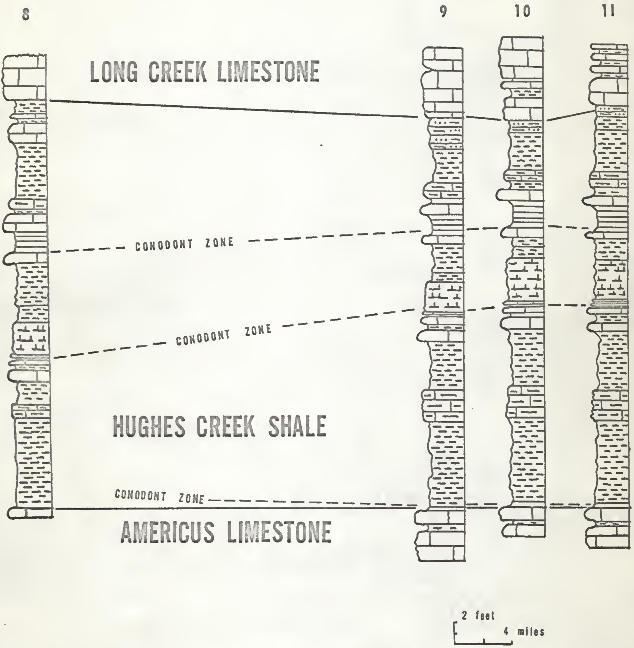
C = 11 - 50 specimens

A > 50 specimens

EXPLANATION OF PLATE III

Columnar sections and conodont zones of the Hughes Creek Shale Member of the Foraker Limestone Formation in Riley and Wabaunsee Counties. Locations of columnar sections are given in Plate I.

PLATE III



EXPLANATION

The Hughes Creek Shale Member contained two species which were not present in the Bennett Shale Member. *Prioniodus? conflexus* was represented by a single specimen and *Spathognathodus minutus* was represented by three specimens. The Bennett Shale Member contained three and possibly four species which were not present in the Hughes Creek Shale Member. *Hindeodella iowaensis* and *Lonchodus simplex* were each represented by a single specimen, *Synprioniodina microdenta* was represented by two specimens, and *Lonchodus* sp. was represented by seven specimens.

Other Fossils Occurring with Conodonts

Conodonts had their most abundant occurrence with *Orbiculoidea* and fish teeth. In many conodont-bearing samples the number of conodonts increased with an increase in the amount of *Orbiculoidea*. However, *Orbiculoidea* were not present at the base of the Hughes Creek Shale where conodonts had a moderate occurrence.

Ambocoelia were associated with minor amounts of conodonts in the Hughes Creek Shale.

Conodonts were not as commonly occurring as fish teeth. Many of the shales contained a moderate amount of fish teeth but no conodonts. Fish teeth were present in almost all samples containing conodonts. The most common fish teeth were cone shaped.

Brachiopod spines were present in some samples containing conodonts. In these samples the conodonts were of a moderate to rare occurrence.

Conodonts and ostracodes were rarely found together. Where occurring together, both the ostracodes and conodonts were few in number.

In only one place were conodonts found with fusulinids. This was at the top of the Glenrock Limestone Member of the Red Eagle Limestone and both were few in number. This appeared to be a transition from conditions favoring fusulinids to conditions favoring conodonts.

Scolecodonts were found to be present in the two shale members. In the Bennett Shale at Measured Section No. 3 scolecodonts were present in samples barren of conodonts. Two scolecodonts were identified in the Hughes Creek Shale from unit 11 of Measured Section No. 11. Scolecodonts may have been present in other samples. Because of their low specific gravity, scolecodonts are easily lost during the decanting process.

Paleoecology

The occurrence of conodonts in these two shale members indicates that the conodonts were selective in their environment. The majority of samples examined were barren of conodonts. The barren samples show that no conodonts existed in the environment or they were not preserved in the sediment. The presence of other fossils in samples which were barren of conodonts suggests the preservation of conodonts was possible.

In almost all instances the conodonts were associated with dark gray to black shale; that is, directly below, above, or within the shale. The greatest concentration of conodonts was at the base of black shales which overlie limestones. At this position the shales are more calcareous than the part above. Within the black shale the amount of conodonts was greatly reduced from that at the base. It was also noted that there were trace amounts of conodonts in the top of the underlying limestones. The conodont organism possibly preferred an environment intermediate between the black shale and limestone conditions. The large number of conodonts at the base of black shales may represent populations that perished in a mass mortality resulting from the change in conditions to a black shale environment. It appears from their position, that the most favorable conditions for conodonts may have been a depth intermediate between those suitable for limestone deposition and black shale deposition. This position could supply both calcium carbonate and organic material to the conodont organisms. The stratigraphic intervals of conodont concentrations are thin. This means these zones may represent a rapid regression of the sea. With this regression of the sea the black shale conditions moved into areas which were previously occupied by greater depths of water and a different environment.

The conodont habitat would then be invaded by the advancing toxic conditions.

The depth in which these conodonts were deposited was between 30 and 160 feet. Elias (1937) gives the depth of his fusulinid phase as 160 - 180 feet and the Lingula phase as 30 - 60 feet. Orbiculoidea occur with Lingula in the black shales and possess similar depth ranges. There is a marked change from the fusulinid-rich Glenrock Limestone Member to the black Orbiculoidea-bearing shales of the Bennett Shale Member. This indicates a rapid shallowing of the sea which is diagrammed by McCrone (1961). McCrone interprets the black shales of the Bennett Shale as being deposited in a depth of approximately 40 feet. A rare occurrence of conodonts with fusulinids was found in the top of the Glenrock Limestone Member. This last appearance of fusulinids in the top of the Glenrock Limestone may have been at a depth somewhat less than 160 feet. As the waters shallowed the fusulinids possibly reached their toleration limit with the inflow of muddy toxic conditions. The conodonts then began to occupy a depositional environment that was becoming undesirable for fusulinid habitation.

Conodonts were present in the upper part of the Bennett Shale in two of the measured sections. In both instances there was a black shale immediately below. The conodont-bearing shale was lighter in color, silty, and more calcareous. Orbiculoidea were present in rare to moderate amounts. The Orbiculoidea suggest a depth of 30 - 60 feet.

The top conodont zone of the Hughes Creek Shale is similar to the conodont zone at the base of the Bennett Shale. Orbiculoidea and conodonts were very abundant at the base of the shale, but there were few conodonts within the black shale. Fusulinids were present in the limestone below but were not noted in the upper part of the limestone. The top of the limestone yielded 12 specimens of Streptognathodus elongatus. These factors indicate conditions similar to those of the Glenrock - Bennett transition. The absence of fusulinids in the top of the underlying limestone suggests the shoaling conditions may not have been as rapid as during the Glenrock - Bennett transition.

Conodonts and Orbiculoidea were present in sparse amounts in the upper part of the bed which contains the uppermost conodont zone of the Hughes Creek Shale. Ambocoelia is present in moderate amounts. The fact that Ambocoelia is present together with decreasing numbers of Orbiculoidea suggests a change to deeper sea conditions. In this horizon conodonts are rare.

The middle conodont zone in the Hughes Creek Shale Member contained both Orbiculoidea and Ambocoelia in the thin black shale and the dark-gray limestone above. Ambocoelia was the more numerous of the two. Conodonts were of moderate to rare occurrence in this zone. Ambocoelia represents a greater depth than does Orbiculoidea. The greater abundance of the Ambocoelia suggests that the depth may have been 60 feet or slightly more (Elias, 1937). This would be at the outer limit of the *Lingula* phase.

The conodont-bearing shale at the base of the Hughes Creek Shale differs from the other conodont zones in that *Orbiculoidea* are not present. A moderate amount of *Ambocoelia* were present in the light gray to tan, calcareous shale. Conodonts occurred in moderate amounts in this zone. These factors suggest that conditions at the beginning of Hughes Creek time may have been too deep for *Orbiculoidea* but marginally favorable for the existence of conodonts.

Comparison with Other Faunas

This conodont fauna correlates well with the conodont fauna described by Rhodes (1961) from the highest 3 inches of the Tensleep Sandstone of northcentral Wyoming. Rhodes (1961) supports a Lower Permian age suggested by Verville (1957) for the highest Tensleep near Mayoworth, Wyoming. The species contained in both conodont faunas were present in approximately the same proportions. *Streptognathodus elongatus* was more abundant in this investigation. *Ligondia* sp. and *Spathognathodus whitei* were the only species reported from the Tensleep Sandstone which were not found in this investigation.

The stratigraphic associations of conodonts in this investigation agree with various other studies. Moore (1951) and Jones (1956) suggest that conodonts maybe lag concentrates because they are commonly concentrated into zones near the bottom and top of lithologic units.

Hibbard (1927) worked with the Upper Devonian Rhinestreet Shale of western New York. The Rhinestreet Shale consists of 12 feet of black shale. Hibbard noted that fossils were scarce in the upper layers of the shale but in the lower 10 inches they were extremely abundant. Well preserved conodonts were found in the lower horizon. Associated with the conodonts were fish remains and an abundance of *Lingula*. He noted that species of *Lingula* occur with conodonts in other geological formations of the Devonian and Mississippian at various localities. These faunal and stratigraphic relationships are supported by results of this investigation.

CONCLUSIONS

The conodont fauna in this investigation is represented by 9 genera and 12 species and is dominated by the species Streptognathodus elongatus. Species confined to one shale member were of a rare occurrence. Two species were confined to the Hughes Creek Shale and three species were confined to the Bennett Shale.

In the area of study conodonts were associated with black shales. Conodonts had an abundant occurrence with Orbiculoidea and fish teeth at the base of black shales.

The Hughes Creek Shale Member of the Foraker Limestone Formation contains three conodont zones and the Bennett Shale Member of the Red Eagle Limestone Formation contains one conodont zone.

REFERENCES

Bergquist, H. R., 1960, Occurrence of foraminifera and conodonts in Upper Paleozoic and Triassic rocks, northern Alaska: Jour. Paleontology, v. 34, pp. 596-601.

Condra, G. E., 1927, The stratigraphy of the Pennsylvanian system in Nebraska: Nebraska Geol. Survey, ser. 2, Bull. 1, pp. 1-291.

Dubois, E. P., 1943, Evidence on the nature of conodonts: Jour. Paleontology, v. 17, pp. 155-159.

Elias, M. K., 1937, Depth of deposition of the Big Blue (late Paleozoic) sediments in Kansas: Geol. Soc. Am. Bull., v. 48, pp. 403-432.

Ellison, S. P., 1941, Revision of Pennsylvanian conodonts: Jour. Paleontology, v. 15, pp. 107-143, pls. 20-23.

__________, 1962, Annotated Bibliography and Index of Conodonts: Univ. Texas Publ. No. 6210, pp. 1-128.

__________, 1963, Supplement to Annotated Bibliography and Index of Conodonts: Texas Jour. Science, Vol. XV, No. 1.

Fay, R. O., 1952, Catalogue of conodonts: Univ. Kansas Paleontology Contri. Vertebrata, art. 3, pp. 1-206.

Garber, M. S., 1962, Stratigraphy of the Foraker Limestone in East-Central Kansas: Univ. Kansas unpublished Master's thesis, pp. 1-109.

Gunnell, F. H., 1933, Conodonts and fish remains from the Cherokee, Kansas City, and Wabaunsee groups of Missouri and Kansas: Jour. Paleontology, v. 7, pp. 261-297, pls. 31-33.

Harley, J., 1861, On the Ludlow bone-bed and its crustacean remains: Geol. Soc. London Quart. Jour., v. 17, pp. 542-552, pl. 17.

Hass, W. H., 1941, Morphology of conodonts: Jour. Paleontology, v. 15, pp. 71-81, pls. 12-16.

__________, 1962, Conodonts: Treatise on Invertebrate Paleontology, Part W, Geol. Soc. Am., pp. W3-W69.

Hattin, D. E., 1951, Depositional environment of the Wreford megacyclothem (Lower Permian) of Kansas: Kansas Geol. Survey Bull. 124, pp. 1-150, (pp. 62, 123, 134).

Hazel, H. F., 1955, The conodont fauna of the basal Clarksville member of the Waynesville Formation (southeastern Ohio): Miami Univ. unpublished Master's theses, Oxford, Ohio.

Hinde, G. J., 1879, On conodonts from the Chazy and Cincinnati group of the Cambro-Silurian and from the Hamilton and Genesee Shale division of the Devonian in Canada and the United States: Geol. Soc. London Quart. Jour., v. 35, pt. 3, pp. 351-369, pls. 15, 17.

Imbrie, John, Laporte, L., and Merriam, D. F., 1959, Beattie Limestone facies and their bearing on cyclial sedimentation theory: Guidebook, Kansas Geol. Society.

Jones, D. J., 1956, Introduction to microfossils: Harper and Brothers, New York, pp. 1-381, (pp. 124-142).

Kellet, B., 1943, Permian ostracodes: Jour. Paleontology, v. 17, pp. 615-628, (p. 619).

Lane, N. G., 1958, Environment of deposition of the Grenola Limestone (Lower Permian) in southern Kansas: Kansas Geol. Survey Bull. 130, pp. 117-164, (pp. 142, 160, tab. 7).

McCrone, A. W., 1961, The Red Eagle Cyclothem (Lower Permian): Univ. Kansas Doctorial dissertation, Lawrence, Kansas, pp. 1-286.

Moore, R. C., Lalicker, C. G., and Fischer, A. G., 1952, Invertebrate fossils: McGraw-Hill Book Co., New York, pp. 1-766, (pp. 733-738).

Mudge, M. R. and Burton, R. H., 1959, Geology of Wabaunsee County, Kansas: U. S. Geol. Survey Bull. 1068, pp. 1-210.

Muller, K. J., 1962, Taxonomy, evolution and ecology of conodonts: Treatise on Inv. Paleontology, Part W, Geol. Soc. Am., pp. W83-W91.

O'Connor, H. G., and Jewett, J. M., 1952, The Red Eagle Formation in Kansas: Kansas Geol. Survey Bull. 96, pt. 8, pp. 329-362.

Pander, C. H., 1856, Monographie der fossilen Fische des Silurischen Systems der russischbaltischen Gouvernements: Adad. Wiss. St. Petersburg, pp. 1-91, pls. 1-9, (pp. 5-34, 80, pls. 1-4).

Rhodes, F. H. T., 1952, A classification of Pennsylvanian conodont assemblages: Jour. Paleontology, v. 26, pp. 886-901, pls. 126-129.

__________, 1963, Conodonts from the topmost Tensleep Sandstone of the eastern Big Horn Mountains: Jour. Paleontology, v. 37, pp. 401-408, pl. 47.

__________, and Wingard, P. S., 1957, The structural, chemical composition and affinities of the Neurodontiforms: Jour. Paleontology, v. 31, pp. 448-454.

Scott, H. W., 1934, The zoological relationships of the conodonts: Jour. Paleontology, v. 8, pp. 448-455, pls. 58-59.

Sloan, K. W., 1963, The distribution of ostracoda and foraminifera in the Bennett Shale: Kansas State Univ. unpublished Master's theses, pp. 1-98.

Stone, D. D., 1959, Taxonomic key to the conodont genus: Compass, v. 36, no. 3, pp. 157-160.

Verville, G. J., 1958, Rock formations of Elk County, in Verville, G. J., and others, Geology, mineral resources and ground water resources of Elk County, Kansas: Kansas Geol. Survey Rept., v. 14, pp. 1-27, (pp. 15-16).

Youngquist, W. L., Hawley, R. W., and Miller, A. K., 1951, Phosphoria conodonts from southeastern Idaho: Jour. Paleontology, v. 25, pp. 356-364, pl. 54.

APPENDIX

Descriptions of Measured Sections

Measured Section No. 1

West side of U. S. 24 spur along a road cut in the SE$\frac{1}{4}$ SW$\frac{1}{4}$ SW$\frac{1}{4}$ sec. 13, T. 10 S., R. 7 E., Riley Co., Kansas. From Sloan (1963). Cumulative thickness added.

	Thickness (feet)	Cum. Thickness (feet)
Howe Limestone:		
Limestone, soft, massive; yellow-gray, weathers gray-yellow and irregular, limonite stained	2.5	8.7
Shale, clayey, calcareous; pale yellow, weathers pale yellow; laminated; limonite stained	.7	6.2
Limestone, soft, massive; gray-yellow, weathers yellow-gray, and irregular	.9	5.5
Thickness of Howe Limestone	4.1	
Bennett Shale:		
(1) Shale, clayey, calcareous; dark gray, weathers medium gray; laminated; *Orbiculoidea* sp.; Conodonts; straight blade, arched bar, and simple cone types; *Amphissites pinguis*, *Bairdia marmorea* and *Ammodiscus semiconstrictus*	.3	4.6
(2) Mudstone, slightly calcareous; light olive-gray, weathers light olive-gray and irregular; *Composita* sp., *Dictyoclostus* sp., *Marginifera* sp.; straight blade conodonts; crinoid columnals, echinoid spines, *Amphissites pinguis*, *Bairdia beedei*, *Bairdia florenaensis*, *Bairdia folgeri*, *Bairdia marmorea*, *Cavellina ellipticalis*, *Ammobaculites stormi*, *Globivalvulina cora*, *Tetrataxis corona*, and fossil fragments	.8	4.3
(3) Shale, clayey, slightly calcareous; olive-black, weathers medium dark gray; laminated; *Composita* sp., *Dictyoclostus* sp., *Marginifera* sp., *Orbiculoidea* sp., *Bairdia florenaensis*;		

Bythocypris pediformis; conodonts: straight blade and simple cone types. *Orbiculoidea* sp. is the only megascopic fossil present in the lower 15 inches	2.1	3.5
Thickness of Bennett Shale	3.2	
Glenrock Limestone:		
Limestone, hard, dense; yellow-gray, weathers gray-yellow; limonite stained; fusulinids and brachiopod fragments	1.4	1.4
Thickness of Glenrock Limestone	1.4	
Total thickness of the Red Eagle Limestone . . .	8.7	

Measured Section No. 2

North side of the Chicago Rock Island and Pacific Railroad in a cut on the NW¼ SW¼ NE¼ sec. 24, T. 10 S., R. 7 E., Riley Co., Kansas. From Sloan (1963). Cumulative thickness added.

Howe Limestone:		
Limestone, soft, massive; yellow-gray, weathers gray-yellow and irregular	4.2	10.4
Thickness of Howe Limestone	4.2	
Bennett Shale:		
(1) Mudstone, slightly calcareous; olive-gray, weathers green-gray and irregular; limonite stained; *Composita* sp., crinoid columnals, *Derbyia* sp., *Dictyoclostus* sp., *Amphissites centronotus*, *Amphissites pinguis*, *Bairdia beedei*, *Bairdia florenaensis*, *Bairdia folgeri*, *Bythocypris pediformis*, *Hollinella gibbosa*, *Monoceratina lewisi*, *Tetrataxis corona*	.7	6.2
(2) Shale, clayey; black, weathers dark gray; laminated; *Orbiculoidea* sp., straight blade and simple cone conodonts, *Amphissites pinguis*, *Bairdia florensaensis*, *Ammodiscus semiconstrictus* . .	.8	5.5
(3) Shale, clayey, calcareous; olive-gray, weathers olive-gray; laminated; *Dictyoclostus* sp., *Marginifera* sp., *Composita* sp., *Amphissites centronotus*,		

Amphissites pinquis, *Bairdia florenaensis*, *Bairdia folgeri*, *Bairdia reussiana*, *Healdia simplex*, *Globivalvulina cora*, *Tetrataxis corona* . . . 1.7 4.7

(4) Shale, clayey, slightly calcareous; black to black mottled yellow-gray, weathers dark gray; laminated; *Ammodiscus semiconstrictus*, *Tetrataxis corona* 7 3.0

(5) Shale, muddy, calcareous; medium yellow-brown with a few black laminae, weathers pale yellow-brown; laminated; *Orbiculoidea* sp., *Ambocoelia* sp., straight bar and simple cone conodonts, *Ammobaculites stormi* 7 2.3

Thickness of Bennett Shale 4.6

Glenrock Limestone:

Limestone, hard, dense; yellow-gray, weathers gray-yellow and blocky, limonite stained; Fusulinids 1.6 1.6

Thickness of Glenrock Limestone 1.6

Total thickness of the Red Eagle Limestone . . 10.4

Measured Section No. 3

West side of K-13 road in a cut along the northeast side of Bluemont Hill, Manhattan in the SW$\frac{1}{4}$ SE$\frac{1}{4}$ SE$\frac{1}{4}$ sec. 7, T. 10 S., R. 8 E., Riley Co., Kansas. From Sloan (1963). Cumulative thickness added.

Howe Limestone:

Limestone, soft, massive; yellow-gray, weathers pale yellow-brown and irregular . 1.0 9.9

Limestone, soft, massive; gray-orange, weathers pale yellow-brown; Crinoids . . . 3.5 8.9

Thickness of Howe Limestone 4.5

Bennett Shale:

(1) Mudstone, calcareous; dusky yellow to olive-gray, weathers pale gray-yellow to green-gray and irregular; *Composita* sp., *Derbyia* sp., *Orbiculoidea* sp., *Amphissites centronotus*, *Bairdia florenaensis*, *Bairdia folgeri*, *Bairdia*

nebraskensis, *Bythocypris pediformis*, *Monoceratina lewisi*, and fossil fragments	1.9	5.4
(2) Shale, clayey, slightly calcareous; black, weathers medium gray; laminated, weathers fissile; simple cone type conodont	1.3	3.5
(3) Shale, clayey, calcareous; olive-gray, weathers olive-gray; fissile; *Marginifera* sp., crinoid columnals, fenestrate bryozoans, *Bairdia florenaensis*, *Bythocypris pediformis*, and fossil fragments	.9	2.2
Thickness of Bennett Shale	4.1	
Glenrock Limestone:		
Limestone, hard, dense; yellow-gray, weathers yellow-gray; clay nodules, limonite stained, weathers blocky; echinoid spines .	1.3	1.3
Thickness of Glenrock Limestone	1.3	
Total thickness of the Red Eagle Limestone . .	9.9	

Measured Section No. 4

Near Cen. N. line NW¼, Sec. 20, T. 10 S., R. 8 E., Riley Co., on K Hill, Manhattan. From O'Connor and Jewett (1952). Cumulative thickness added.

Permian-Wolfcampian		
Grenola Limestone		
Sallyards Limestone Member		
20. Limestone, poorly exposed		
Roca Shale (22 feet)		
19. Shale, several shades of green, blocky; contains abundant limy nodules . . .	9.0	51.5
18. Shale, grades from dark-purple in upper part through light- and dark-green and blue-green, to burnt-red to green in basal part; blocky; contains abundant limy nodules in middle part	4.5	42.5
17. Shale, green with red tint, massive to thin-bedded; locally contains a hard mudstone	0.8	38.0

16. Limestone, medium-gray, dense; contains clear crystalline calcite specks and irregular veins; slightly laminated in basal part; where thickest, comprises two lenticular flattened discoidal beds	1.0	37.2
15. Shale, green, massive	0.5	36.2
14. Shale, bright burnt-red, thinly laminated, bedding contorted locally, silty . . . . averages	4.4	35.7
13. Shale, green, olive, and maroon, poorly exposed	1.8	31.3
Red Eagle Limestone (10.2 feet)		
Howe Limestone Member		
12. Limestone, buff to yellow peppered with black, partly dark-gray streaked with green; lower part gray to buff; porous, brecciated-appearing; crinoid and brachiopod fragments, small high-spired and low-coiled snails, algae (?)	2.8	29.5
Bennett Shale Member (5.8 feet)		
11. Limestone, medium-gray, weathers tan, shaly, ... averages	0.4	26.7
10. Limestone, medium-gray, weathers light-tan to tarnish gray, thin-bedded, somewhat oatmeal-like texture, abundantly fossiliferous; echinoid and crinoid fragments, productids, <u>Neospirifer</u> and other brachiopods	1.4	26.3
9. Shale, gray, upper part chalky, massive; <u>Ambocoelia</u>, <u>Composita</u>, productids . . . . averages	1.5	24.9
8. Shale, gray, harder and more limited than unit 9; <u>Ambocoelia</u>, <u>Composita</u>, <u>Wellerella</u> . . . . averages	1.0	23.4
7. Shale, black, gray, and tan mottled, thin-bedded to fissil, fossils more abundant in lower part; <u>Orbiculoidea</u>, Ambocoelia, <u>Wellerella</u>	1.5	22.4
Glenrock Limestone Member		
6. Limestone, light-gray, rusty splotches and streaks, tan to black at top; contains abundant <u>Orbiculoidea</u> in top crust; <u>Wellerella</u>, <u>Ambocoelia</u>, and small snails	1.6	20.9
Johnson Shale (119.3 feet)		
5. Shale, gray, tan, olive, and black, thin-bedded to blocky; contains mud cracks, poorly preserved plant fragments, and ostracodes	2.7	19.3

4. Shale, green, gray, olive, and specks of maroon, blocky, calcareous	11.0	16.6
3. Mudstone, green to gray, dense, semi-lithographic	1.3	5.6
2. Shale, green, olive, and gray, blocky, calcareous	4.3	4.3
Foraker Limestone		
Long Creek Limestone Member		
1. Limestone		

Measured Section No. 5

West side of road in a cut along county road 911, west of Deep Creek in the NW$\frac{1}{4}$ SW$\frac{1}{4}$ SW$\frac{1}{4}$ sec. 14, T. 11 S., R. 8 E., Riley Co., Kansas. From Sloan (1963). Cumulative thickness added.

Howe Limestone (part):		
Limestone, hard; gray-yellow, weathers gray-orange and cavernous; limonite stained; five inches exposed; echinoid spines . . .	.4	7.6
Thickness of exposed Howe Limestone	.4	
Bennett Shale:		
(1) Shale, muddy, calcareous; dusky yellow, weathers dusky yellow; laminated; fenestrate and twig-like bryozoans, _Naticopis_ sp., _Amphissites centronotus_, _Amphissites centronotus elongatus_, _Amphissites simplicissimus_, _Bairdia beedei_, _Bairdia eissensis_, _Bairdia florenaensis_, _Bairdia folgeri_, _Bairdia marmorea_, _Bairdia nebraskensis_, _Bairdia reussiana_, _Cavellina coryelli_, _Cavellina edmistonae_, _Cavellina ellipticalis_, _Hollinella digitata_, _Kirkbya canyonensis_, _Globivalvulina cora_, _Tetrataxis corona_ . . .	1.1	7.2
(2) Mudstone to marl; mudstone, calcareous; light olive-gray, weathers medium gray, limonite stained; approximately 12 inches thick; grades vertically to marl. Marl, laminated to thin bedded; light olive-gray, weathers light olive-gray, limonite stained; resistant to weathering, 22 inches thick; grades vertically back to olive-gray mudstone, 12 inches thick; _Allorisma_ sp., _Dictyoclostus_ sp., echinoid spines, crinoid		

columnals, Bairdia florenaensis, Bairdia nebraskensis, Hollinella moorei, Healdia simplex, Glovivalvulina cora, Tetrataxis corona	3.2	6.1
(3) Shale, muddy, calcareous; light olive-gray, weathers yellow-gray; laminated, weathers fissile; Marginifera sp., Ambocoelia sp., crinoid columnals, fenestrate and twig-like bryozoans, echinoid plates, Amphissites centronotus, Amphissites centronotus elongatus, Amphissites pinguis, Bairdia eissensis, Bairdia florenaensis, Bythocypris pediformis, Kegelites sp., Globivalvulina ovata, Tetrataxis corona, and fusulinids	.4	2.9
(4) Mudstone, calcareous; light olive-gray to olive-gray, weathers yellow-gray to gray and irregular; Bairdia florenaensis, Bairdia folgeri, and fossil fragments	.6	2.5
(5) Shale, muddy, calcareous; light olive-gray, weathers yellow-gray, laminated; Ambocoelia sp., Marginifera (?) sp. fragments, crinoid columnals, Bairdia beedei, Bairdia florensensis, Bairdia marmorea, Bairdia reussiana, Cavellina coryelli, straight bar conodonts and fossil fragments	.8	1.9
Thickness of Bennett Shale	6.1	
Glenrock Limestone:		
Limestone, hard, dense, slightly argillaceous; yellow-gray, weathers gray-yellow, fusulinids	1.1	1.1
Thickness of Glenrock Limestone	1.1	
Total thickness of the Red Eagle Limestone . .	7.6	

Measured Section No. 6

North bank of Mill Creek, in a stream bank, east of county road FAS 1682, in the SE$\frac{1}{4}$ SW$\frac{1}{4}$ SW$\frac{1}{4}$ sec. 36, T. 12 S., R. 10 E., Wabaunsee Co., Kansas. From Sloan (1963). Cumulative thickness added.

Howe Limestone:		
Limestone, hard, massive; pale yellow-orange, weathers pale yellow-brown to a gray-orange and cavernous; limonite stained; fossils not apparent	2.7	10.3
Thickness of Howe Limestone	2.7	
Bennett Shale:		
(1) Shale, muddy, calcareous; pale olive, weathers yellow-gray; fissile, weathers fissile; crinoid columnals, fenestrate bryozoans, brachiopod fragments, Amphissites pinguis, Bairdia beedei, Cavellina ellipticalis, Cavellina nebrascensis, Globivalvulina biserialis, Globivalvulina cora, Globivalvulina ovata .	.3	7.6
(2) Limestone, soft, argillaceous; medium gray to medium dark gray, weathers pale gray-yellow, limonite stained; echinoids spines, crinoid columnals, brachiopod fragments, Amphissites centronotus elongatus, Bairdia beedei, Bairdia marmorea, Bythocypris pediformis, Cavellina nebrascensis, Hollinella emaciata, Hollinella gibbosa, Globivalvulina ovata	.2	7.3
(3) Shale, muddy, calcareous; pale olive, weathers yellow-gray; fissile, weathers fissile; crinoid columnals, fenestrate bryozoans, brachiopod fragments, Amphissites pinguis, Bairdia beedei, Cavellina ellipticalis, Cavellina nebrascensis, Globivalvulina cora, Globivalvulina ovata, Globivalvulina biserials .	.3	7.1
(4) Shale, muddy, calcareous, dusky yellow mottled dark gray, weathers yellow-gray mottled medium dark gray; laminated, weathers fissile to irregular; limonite stained; Composita sp., Dictyoclostus sp. Linoproductus sp., echinoid spines, crinoid columnals, Amphissites pinguis, Bairdia beedei, Bairdia florenaensis, Bairdia marmorea, Bairdia nebraskensis, Carbonita tumid var. magna, Cavellina nebrascensis, Globivalvulina ovata, Globivalvulina cora, Tetrataxis corona	2.0	6.8
(5) Mudstone, calcareous; dusky yellow mottled pale olive, weathers yellow-gray and irregular; fenestrate bryozoans, crinoid columnals, echinoid spines,		

Amphissites centronotus, *Amphissites centronotus elongatus*, *Amphissites pinguis*, *Amphissites simplicissimus*, *Bairdia beedei*, *Bairdia florenaensis*, *Bairdia nebraskensis*, *Bairdia seminalis*, *Kirkbya canyonensis*, *Kirkbya valida*	2.6	4.8
(6) Claystone, very calcareous; dusky yellow mottled pale olive, weathers yellow-gray; slightly resistant to weathering; *Maturipupa* sp., crinoid columnals, echinoid spines, *Amphissites centronotus*, *Amphissites pinguis*, *Amphissites simplicissimus*, *Bairdia eissensis*, *Bairdia florenaensis*, *Bairdia folgeri*	1.1	2.2
(7) Shale, muddy, slightly calcareous, yellow-brown, weathers yellow-gray; laminated, weathers laminated to fissile; fusulinids rare, fenestrate bryozoans rare	.2	1.1
(8) Mudstone, very calcareous; dusky yellow mottled pale olive, weathers yellow-gray and irregular, resistant to weathering; limonite stained; *Bairdia florenaensis*, *Bairdia folgeri*	.5	0.9
(9) Shale, clay, very calcareous; moderate yellow-brown, weathers yellow-gray; laminated, weathers fissile; limonite stained; echinoid spines, fusulinids rare, *Amphissites centronotus*, *Amphissites centronotus elongatus*, *Amphissites pinguis*, *Bairdia beedei*, *Bairdia florenaensis*, *Bairdia folgeri*, *Bythocypris pediformis*	.2	0.4
Thickness of Bennett Shale	7.4	
Glenrock Limestone:		
Limestone, hard, argillaceous; pale yellow-brown, weathers pale yellow-brown; lenticular; limonite stained; fossils not apparent	.2	0.2
Thickness of Glenrock Limestone	.2	
Total thickness of the Red Eagle Limestone . .	10.3	

Measured Section No. 7

Section from the Johnson Shale through the Roca Shale in a streambank in the center Sec. 36, T. 14 S., R. 11 E. From Mudge and Burton (1949). The description of the Bennett Shale Member has been modified. Cumulative thickness added.

Soil and colluvium; about 6 feet thick.		
Roca Shale (Part)		
Limestone, hard, tan; weathers tan gray and shaly; porous; some microfossils . . .	0.5	14.8
6. Shale, silty, very calcareous, gray-green; weathers light gray; blocky to thin-bedded; some limonite nodules and stains	3.7	14.3
Red Eagle Limestone		
Howe Limestone Member		
5. Limestone, soft, tan; weathers gray; massive; weathers blocky; porous; 0.3-foot chert lens in upper part; some microfossils, including ostracodes . . .	3.4	10.6
Bennett Shale Member		
4. Shale, silty, calcareous, gray-brown, weathers tan; thin-bedded; iron stained; fossiliferous, contains a moderate amount of <u>Orbiculoidea</u>	.5	7.2
3. Shale, clayey, slightly calcareous, dark-gray to black, thin-bedded, fissile in the bottom foot; fossiliferous, contains a moderate amount of <u>Orbiculoidea</u> throughout the interval	2.3	6.7
Glenrock Limestone Member		
2. Limestone, hard, tan-gray; massive, iron-stained; weathers blocky; small fusulinids abundant; echinoid spines and brachiopods common	1.2	4.4
Johnson Shale (Part)		
1. Shale, clayey, slightly calcareous, dark-gray; weathers gray; blocky, becoming thin-bedded at the base; some iron stains	3.2	3.2
Base covered.		

Measured Section No. 8

Section measured in excavation cut at the Manhattan water purification plant on the southeast side of Bluemont Hill, near Kansas Highway 13, in the SW$\frac{1}{4}$ SE$\frac{1}{4}$ SE$\frac{1}{4}$, Sec. 7, T. 10 S., R. 8 E., Riley Co., Kansas

Foraker Limestone		
Long Creek Limestone Member		
23. Limestone, mostly covered, massive, yellowish-orange (10 YR 8/6) to moderate brown (5 YR 4/4), fossiliferous; exposed	4.0+	
Hughes Creek Shale Member		
22. Shale, blocky, soft, calcareous, medium-gray (N5), weathers grayish-orange (10 YR 7/4)	1.2	36.7
21. Limestone, hard, weathers light-brown (5 YR 7/4)	0.4	35.5
20. Shale, soft, calcareous, medium-gray (N5), weathers grayish-orange (10 YR 7/4); fossiliferous	0.5	35.1
19. Limestone, platy, moderately soft, medium-gray (N5), weathers light-brown (5 YR 4/4)	1.7	34.6
18. Shale, mostly covered, blocky, weakly calcareous, dark-gray (N3), weathers to greenish-gray (5 GY 6/1); non-fossiliferous	5.0	32.9
17. Limestone, platy, moderately hard, very argillaceous, light brownish-gray (5 YR 6/1); fossiliferous, abundant fusulinids	0.8	27.9
16. Shale, fissile, soft, very calcareous, yellowish-gray (5 Y 8/1); non-fossiliferous	0.3	27.1
15. Limestone, massive, pale yellowish-brown (10 YR 6/2), small amount of medium-gray (N5) coloration mixed in randomly; fossiliferous, sparse brachiopods, bryozoans, and fusulinids	1.5	26.8
14. Shale, blocky, non-calcareous, black; lower 0.2 and upper 0.4 inch fissile, calcareous, pale yellowish-brown (10 YR 6/2); fossiliferous, abundant Orbiculoidea in the base, decreases upward, sparse Ambocoelia in the upper part	1.8	25.3

13. Limestone, massive, hard, pale yellowish-brown (10 YR 6/2); contains fossil fragments	1.0	23.5
12. Shale, contains an even parting in the bedding, thinly laminated, calcareous, medium-gray (N5), contains streaks which have weathered to grayish-orange (10 YR 7/4); non-fossiliferous	3.9	22.5
11. Shale, thinly laminated, calcareous, dark gray (N3); abundance of elongate selenite gypsum crystals; non-fossiliferous	1.5	18.6
10. Limestone, platy, weathers to an irregular surface, moderately soft, light brownish-gray (5 YR 6/1); fossiliferous, contains brachiopods and abundant fusulinids	3.0	17.1
9. Limestone, dense, hard, dark-gray (N3), weathers to grayish-orange (10 YR 7/4); fossiliferous, contains sparse _Ambocoelia_ and _Orbiculoidea_	0.2	14.1
8. Shale, fissile, brittle, slightly calcareous, black (N1), weathers to pale yellowish-brown (10 YR 6/2); fossiliferous, contains moderate _Ambocoelia_ and sparse _Orbiculoidea_	0.2	13.9
7. Limestone, massive, hard, grayish-orange (10 YR 7/4); contains a small amount of fossil fragments	0.4	13.7
6. Shale, blocky, clayey, very calcareous, medium-gray (N5), weathers to pale yellowish-brown (10 YR 6/2); fossiliferous, contains a few brachiopods . .	0.5	13.3
5. Limestone, massive, hard, medium-gray (N5), weathers dark yellowish-orange (10 YR 6/6); contains a small amount of fossil fragments	1.0	12.8
4. Shale, blocky, clayey, calcareous, medium dark-gray (N3), non-fossiliferous	2.0	11.8
3. Limestone, platy, irregularly bedded, weathers easily, dark yellow-orange (10 YR 6/6)	1.2	9.8
2. Shale, blocky, slightly calcareous, dark-gray (N3), thinly laminated, light gray, highly calcareous, stringers in some places; non-fossiliferous, exposed	3.0	

Measured section continued east of Kansas Highway 13 and in abandoned railroad cut.

2. Shale, mostly covered, top 2.0 feet exposed, lithology of exposed part same as equivalent interval west of Kansas Highway 13	7.7	8.6
1. Limestone, massive, hard, medium light-gray (N6), weathers to medium-gray (N5); fossiliferous contains brachiopod and crinoid fragments and fusulinids	0.9	0.9

Measured Section No. 9

Section measured in road cut on north side of U. S. 40 near Paxico in SW$\frac{1}{4}$, SE$\frac{1}{4}$, Sec. 27, T. 11 S., R. 11 E., Wabaunsee Co., Kansas. Modified from M. S. Garber (1962). Intervals 1, 2, 3, 5, 6, 7, 22, 23, 24, 25, from Garber; other intervals described by the present author.

Foraker Limestone		
Long Creek Limestone Member		
25. Limestone, cherty, cavernous weathering, gray to tan fresh surface, weathers tannish gray; weathered surface shows thin banding; lower 0.2 feet is a resistant fine grained limestone	2.0	45.3
24. Limestone, dolomitic, non-resistant, silty, yellowish brown fresh surface, weathers tannish yellow; contains numerous geodes near top (containing quartz and celestite), fine-grained matrix, fossiliferous, sparce pelecypods	4.0	43.3
23. Limestone, very hard, bluish gray fresh surface, weathers light gray to grayish orange; finely crystalline, weathers in large blocks thin bedded at bottom	0.6	39.3
Hughes Creek Shale Member		
22. Mudstone, platy, soft, very calcareous, yellowish gray; fossiliferous, sparse brachiopods and fusulinids	2.8	38.7
21. Shale, clayey, slightly calcareous, medium dark-gray; fossiliferous, contains fusulinids in the base, also		

sparse amounts of brachiopods, crinoid fragments and bryozoans	3.0	35.9
20. Limestone, platy, moderately hard, argillaceous, pale yellowish-brown; fossiliferous, abundant fusulinids, some crinoid fragments	1.4	32.9
19. Shale, laminated, fissile, soft, very calcareous, dark greenish-gray; nonfossiliferous	0.4	31.5
18. Limestone, massive, hard, medium-gray; fossiliferous, contains brachiopods and fossil fragments	0.9	31.1
17. Shale, blocky, moderately soft, upper 6 inches fissile, dark-gray to black, medium gray at the base; fossiliferous, abundant *Orbiculoidea* in the base, decreasing upward, sparse *Orbiculoidea* and *Ambocoelia* in the top 6 inches . .	1.8	30.2
16. Limestone, platy, moderately hard, medium-gray; fossiliferous, contains fossil fragments, brachiopods, and a moderate amount of fusulinids in the bottom	0.7	28.4
15. Shale, fissile, moderately soft, medium-gray; bottom 1.1 feet contains alternating layers of thin, light-gray calcareous shale; non-fossiliferous . .	2.5	27.7
14. Shale, laminated, fissile, moderately soft, very calcareous, medium dark-gray, contains elongate crystals of selenite gypsum; non-fossiliferous . .	0.8	25.2
13. Shale, platy, irregular surface, hardness varies, very calcareous, grayish-orange; fossiliferous, contains brachiopods and abundant fusulinids . .	2.7	24.4
12. Limestone, massive, hard, dark-gray; slightly fossiliferous, trace of *Orbiculoidea*	0.2	21.7
11. Shale, fissile, brittle, black; fossiliferous, contains a moderate amount of *Orbiculoidea* and *Ambocoelia*	0.3	21.5
10. Limestone, massive, hard, medium-gray, weathers yellowish-brown; fossiliferous, contains fossil fragments and fusulinids in the bottom	0.6	21.2
9. Shale, blocky, calcareous, medium-gray; fossiliferous, contains a sparse amount of brachiopods	0.5	20.6
8. Limestone, platy, moderately hard, medium-gray, weathers light-brown; fossiliferous, contains brachiopods and fusulinids	1.0	20.1
7. Shale, clayey, calcareous, highly weathered, medium-gray; fossiliferous,		

contains brachiopods and fusulinids . .	4.1	19.1
6. Limestone, platy, uneven surface, medium gray, weathers pale yellowish-brown, finely crystalline; fossiliferous, contains abundant fossil fragments. . .	2.8	15.0
5. Shale, clayey, calcareous, medium dark-gray, contains a few indurated layers; fossiliferous, contains brachiopods, crinoid fragments, fusulinids, fenestrate and ramase bryozoans	7.5	12.2
4. Shale, clayey, soft, very calcareous, grayish-orange to light-gray; fossiliferous, contains bryozoans and abundant _Ambocoelia_	0.3	4.7
Americus Limestone Member		
3. Limestone, massive, very hard, light bluish-gray fresh surface, weathers medium-gray; matrix is microcrystalline; glauconite, limonite, and silt pockets; fossiliferous, contains crinoid and brachiopod fragments, fusulinids, and abundant fossil debris; identifiable brachiopod genera are _Derbyia_ and _Composita_	1.2	4.4
2. Shale, non-calcareous, gray; fossiliferous, contains brachiopod fragments .	0.6	3.2
1. Limestone, platy, thin bedded, moderately hard, silty, tannish-gray fresh surface, weathers yellowish-brown; matrix is finely crystalline, silty; fossiliferous, contains abundant arenaceous foraminifera, pellets, fusulinids and sponges; brachiopod genera include _Hustedia_, _Derbyia_, _Chanetes_	2.6	2.6

Measured Section No. 10

Section measured in a road cut on the south side of U. S. 40, near a roadside park in the SW¼, SW¼, Sec. 30, T. 11 S., R. 12 E., Wabaunsee Co., Kansas. Modified from O'Connor and Jewett (1952). Intervals 3, 5, 8, and 12 from O'Connor and Jewett. Other intervals described by the present author.

Foraker Limestone		
Long Creek Limestone Member		
27. Limestone, massive, soft, red-brown, weathers orange-gray, dolomitic; contains calcite-lined cavities; 0.8 foot celestite layer at the top	3.9	43.8

26. Shale, clayey, soft, gray, weathers light-brown	0.2	39.9
25. Limestone, blocky, soft, light-gray, weathers light brown	0.6	39.7
24. Shale, clayey, soft, calcareous, grayish-orange	0.8	39.1
23. Limestone, blocky, soft, argillaceous, highly weathered, bluish-gray; fossiliferous, abundant fusulinids	2.0	38.3
Hughes Creek Shale Member		
22. Mudstone, blocky, calcareous, pale yellowish-brown	1.1	36.3
21. Shale, blocky, slightly calcareous, medium dark-gray; fossiliferous, contains sparse brachiopods and fusulinids in the base	3.3	35.2
20. Limestone, platy, highly argillaceous, medium-gray to pale yellowish-brown; fossiliferous, contains brachiopods, crinoid fragments, and abundant fusulinids	0.9	31.9
19. Shale, fissile, soft, very calcareous, grayish-orange; non-fossiliferous . . .	0.7	31.0
18. Limestone, hard, upper part weathers platy, blue-gray, weathers grayish-orange; fossiliferous, contains brachiopods, bryozoans and fusulinids .	1.0	30.3
17. Shale, blocky, moderately soft, non-calcareous, black; upper part fissile, brittle; fossiliferous, abundant <u>Orbiculoidea</u> in the base, decreasing upward, moderate amount of <u>Ambocoelia</u> in the top	2.3	29.3
16. Limestone, massive, medium-gray, weathers grayish-orange; fossiliferous, contains echinoid and crinoid fragments; sparse amount of fusulinids	0.8	27.0
15. Shale, fissile, moderately soft, dark-gray; contains about six light gray calcareous shale stringers, each is less than 0.1 inch thick; non-fossiliferous	0.8	26.2
14. Shale, fissile, very calcareous, dark-gray, limonite stains; abundance of elongate selenite gypsum crystals, ranging up to 3 mm. in length; non-fossiliferous	1.0	25.4
13. Shale, platy, irregular surface, hardness varies, very calcareous, pale yellowish-brown; fossiliferous, contains crinoid fragments, brachiopods, bryozoans and abundant fusulinids . . .	3.9	24.4

12. Limestone, weathers platy, medium-hard, dark-gray, weathers medium-gray; non-fossiliferous	0.2	20.5
11. Shale, fissile, brittle, moderately-hard, black; fossiliferous, contains a moderate amount of Orbiculoidea and abundant Ambocoelia	0.3	20.3
10. Limestone, massive, hard, grayish-orange; contains fossil fragments	0.5	20.0
9. Shale, fissile, medium-gray; fossiliferous, contains Linoproductus and fusulinids	0.5	19.5
8. Limestone, weathers platy, bluish-gray, weathers grayish-orange; fossiliferous, contains crinoid and echinoid fragments	1.0	19.0
7. Shale, thin-bedded to fissile, dark bluish-gray, weathers medium-gray; fossiliferous, contains brachiopods and bryozoans	5.0	18.0
6. Shale, thin-bedded to platy, very calcareous, medium-gray, weathers light brownish-gray; fossiliferous, contains Aviculopecten, Neospirifer, Dictyoclostus, Linoproductus, Ambocoelia, Chonetes, Marginifera	2.8	13.0
5. Shale, thin bedded to blocky, gray-brown and mottled; fossiliferous, contains brachiopods and crinoid fragments . . .	7.2	10.2
4. Shale, clayey, soft, grayish-orange, grading to medium-gray upward; fossiliferous, contains Composita, Ambocoelia, and crinoid fragments . . .	0.6	3.0
Americus Limestone Member		
3. Limestone, massive, gray to tannish-gray; fossiliferous, contains Composita, fragments of echinoderms and other fossils	1.2	2.4
2. Shale, thin-bedded, calcareous, silty, medium-gray, weathers grayish-orange .	0.2	1.2
1. Limestone, massive, light brownish-gray, weathers grayish-orange	1.0	1.0

Measured Section No. 11

A road cut on the north side of U. S. Highway 40, 6.9 miles west of the county line in NW$\frac{1}{4}$, SW$\frac{1}{4}$, Sec. 27, T. 11 S., R. 12 E., Wabaunsee Co., Kansas. Modified from M. S. Garber (1962). Intervals 1, 2, 3, 6, 8 and 10 from Garber. Other intervals described by the present author.

Foraker Limestone

Long Creek Limestone Member

31. Limestone, blocky, medium-gray, weathers light-brown	0.4	44.3
30. Shale, laminated, shaly, calcareous, medium-gray, weathers light-gray . . .	0.3	43.9
29. Limestone, blocky, slightly chalky, weathers light-brown	0.6	43.6
28. Shale, platy, very calcareous, medium-gray, weathers yellowish-gray	0.6	43.0
27. Limestone, blocky, slightly chalky, light-gray, weathers light-brown . . .	0.7	42.4
26. Shale, platy, very calcareous, medium-gray, weathers grayish-orange	0.5	41.7
25. Limestone, platy, irregular bedding, very calcareous, bluish-gray, weathers light-gray; fossiliferous, predominatly fusulinids	2.5	41.2
Hughes Creek Shale Member		
24. Mudstone, laminated, shaley, soft, very calcareous, pale yellowish-brown; nonfossiliferous	1.1	38.7
23. Shale, blocky, moderately soft, calcareous, medium light-gray, weathers to light-gray; non-fossiliferous . . .	1.3	37.6
22. Shale, bottom part laminated, shaly, upper part blocky, moderately soft, slightly calcareous, medium dark-gray to dark-gray; sparsely fossiliferous, contains some brachiopods	3.7	36.3
21. Limestone, platy, irregular bedding, very argillaceous, light brownish-gray; fossiliferous, brachiopods, abundant fusulinids	1.4	32.6
20. Shale, laminated, fissile, soft, very calcareous, yellowish-gray; fossiliferous, contains sparse fusulinids in upper part	0.7	31.2
19. Limestone, massive, hard, medium-gray, weathers grayish-orange; fossiliferous, contains brachiopods and bryozoans, fusulinids in upper part	0.8	30.5
18. Shale, bottom and top fissile, moderately soft, very calcareous, moderate yellowish-brown; middle (1 foot) blocky, moderately soft, non-calcareous, black; fossiliferous, abundant <u>Orbiculoidea</u> in the base, moderate amount in the middle and top, moderate amount of <u>Ambocoelia</u> in the top	2.3	29.7

17. Limestone, massive, hard, light brownish-gray, weathers to dark yellowish-orange; fossiliferous, contains fossil fragments and brachiopods	0.6	27.4
16. Shale, mostly covered, fissile, moderately soft, medium-gray; contains thin, straight stringers, of light-gray, very calcareous shale; nonfossiliferous	1.8	26.8
15. Shale, platy, very calcareous, medium light-gray, weathers grayish-orange; fossiliferous, contains brachiopods and abundant fusulinids	3.6	25.0
14. Limestone, massive, hard, dark-gray; fossiliferous, trace of Orbiculoidea and Ambocoelia	0.2	21.4
13. Shale, fissile, brittle, slightly calcareous, black; fossiliferous, moderate amount of Orbiculoidea	0.1	21.2
12. Limestone, massive, hard, dark-gray to black; fossiliferous, contains a trace of Orbiculoidea	0.2	21.1
11. Shale, fissile, brittle, slightly calcareous, black; fossiliferous, contains a moderate amount of Orbiculoidea and Ambocoelia	0.2	20.9
10. Limestone, massive, hard, brownish-gray fresh surface, weathers light-gray; contains limonite and glauconite; fossiliferous, composed largely of fossil debris (brachiopod, algal, fusulinid, and coralline) in a silty microcrystalline matrix	0.5	20.7
9. Shale, clayey, calcareous, middle 0.4 in. medium-gray, top and bottom dusky-yellow; fossiliferous, contains brachiopods, ramase bryozoans, and crinoid fragments	0.8	20.2
8. Limestone, platy, moderately hard, mottled light-gray and tan fresh surface, weathers yellowish-tan; limonitic; fossiliferous, microcrystalline matrix containing brachiopods, fusulinids and phosphatic fragments	0.7	19.4
7. Shale, blocky, soft, calcareous, medium-gray; fossiliferous, contains brachiopods, bryozoans, and fusulinids	5.1	18.7
6. Limestone, platy, irregular surface, tannish-gray with irregular bands of medium-gray on fresh surface, weathers yellowish-gray; fossiliferous, contains		

abundant arenaceous foraminifera; brachiopod, and crinoid fragments, algae, and numerous small fossil fragments in a microcrystalline matrix	2.6	13.6
5. Shale, blocky, moderately soft, calcareous, dark-gray; fossiliferous, contains brachiopods and sparse fusulinids	7.4	11.1
4. Shale, clayey, soft, very calcareous, dark-gray with some grayish-orange; fossiliferous, contains <u>Ambocoelia</u>	0.3	3.7
Americus Limestone Member		
3. Limestone, massive, hard, light tannish-gray fresh surface, weathers yellowish-gray; contains abundant small fossil fragments, and glauconite in a finely crystalline matrix	1.2	3.4
2. Shale, fissile, soft, argillaceous, slightly calcareous, light-brown; fossiliferous, contains brachiopods and crinoid fragments	0.4	2.2
1. Limestone, platy, silty, yellowish-tan fresh surface, weathers grayish-yellow; composed largely of silt in a microcrystalline matrix; contains styolites	1.8	1.8

CONODONT FAUNAS IN THE HUGHES CREEK SHALE AND BENNETT SHALE OF RILEY AND WABAUNSEE COUNTIES, KANSAS

by

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ABSTRACT

An investigation was made of conodonts in the Hughes Creek Shale Member of the Foraker Limestone and the Bennett Shale Member of the Red Eagle Limestone in the Lower Council Grove Group of the Lower Permian of Riley and Wabaunsee Counties, Kansas. A stratigraphic inventory was compiled and a lithologic and paleontologic relationship was established for the conodonts in these shale members.

Samples were taken from 11 measured sections in Riley and Wabaunsee Counties. Each shale bed within the Hughes Creek Shale Member and Bennett Shale Member was carefully sampled. These samples were broken down in the laboratory by freezing and thawing, acetic acid, and hydrogen peroxide. Conodonts were concentrated by use of a Frantz Isodynamic Magnetic Separator.

Nine genera and 12 species of conodonts were identified from the Hughes Creek Shale Member of the Foraker Limestone and the Bennett Shale Member of the Red Eagle Limestone. This conodont fauna was dominated by specimens of *Streptognathodus elongatus*. Other species were present in rare and common occurrences. This fauna correlates well with the conodont fauna described by Rhodes (1963) from the topmost Tensleep Sandstone at Mayoworth, Wyoming.

Conodonts in this investigation had a characteristic association with dark-gray to black shales. They occurred abundantly at the base of black shales which overlie

limestones. Few conodonts were present within the remainder of the black shale units.

The conodonts had typical occurrence with Orbiculoidea and fish teeth. They occurred to a lesser extent with Ambocoelia.

Conodont zones which could be traced over a distance were established in the two shale members. The Hughes Creek Shale Member of the Foraker Limestone contained three well defined conodont zones. The top zone was the most prolific and averaged 217 specimens of Streptognathodus elongatus in each sample. The other two Hughes Creek zones contained conodonts in lesser amounts. The Bennett Shale Member of the Red Eagle Limestone contained only one conodont zone; this was at the base of the shale. Conodonts were not as abundant in the basal Bennett zone as in the upper Hughes Creek zone. Other occurrences in the Bennett Shale Member were of local extent.