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Identification and Use of Conodonts from Meramecian Rocks
(Upper Mississippian) Recovered from Well Cores from the
Subsurface of Western Kansas

by

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IDENTIFICATION AND USE OF CONODONTS FROM MERAMECIAN ROCKS (UPPER
MISSISSIPPIAN) RECOVERED FROM WELL CORES FROM THE SUBSURFACE OF
WESTERN KANSAS

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Thomas L. Thompson and Edwin D. Goebel*

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*Paper will be presented by junior author.

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ABSTRACT

Because the usefulness of conodonts as guide fossils has been demonstrated in the type Mississippian section, a pilot study was established by the State Geological Survey of Kansas to determine if rock cores, previously correlated primarily on the basis of lithologic features and assigned to the Meramecian Stage in western Kansas, contained sufficient conodonts to make age determinations possible.

Conodonts of the Meramecian Stage of the Mississippian System (7 species, 6 genera) were collected from the Warsaw, Salem, St. Louis, and Ste. Genevieve Limestones from the subsurface of western Kansas. Specimens studied and collected from 455 samples taken from 376 feet of limestone cores were recovered from 6 wells in Haskell, Scott, Logan, Gove, Lane, and Ness Counties, Kansas. Comparison of the Meramecian strata in western Kansas with the standard section through the use of conodonts as a tool of correlation seems to be feasible and seems to substantiate previously established lithologic correlations. Four conodont species recovered in this pilot study shows sufficient restrictions to have probable stratigraphic significance to the Meramecian.

*Paper will be presented by junior author.

BIOGRAPHICAL SKETCH

Thomas L. Thompson completed the Bachelor of Science and Masters of Science degrees at the University of Kansas in 1960 and 1962, respectively. While a graduate student at the University of Kansas, he was employed part-time in the Oil and Gas Division of the Kansas Geological Survey. Presently, he is a candidate for the PhD and an assistant in the Department of Geology at The State University of Iowa, Iowa City, Iowa.

Edwin D. Goebel graduated from Augustana College in 1949 with an A.B. in Geology. He completed a Masters of Science degree in 1951 from The State University of Iowa, and has been employed at the State Geological Survey of Kansas as Head of the Oil and Gas Division since 1951. He is presently a candidate for the PhD degree in Geology at The University of Kansas.

INTRODUCTION

- A. Story of '61 KGS field trip, and our interest--Bull. 165, Pt. 1
- B. The usage of conodonts as guide fossils within the Mississippian section in the upper Mississippi Valley demonstrated the practicality of these forms as tools of correlation. Because the usefulness of conodonts as guide fossils has been demonstrated, a pilot study was established at the Kansas Geological Survey. Rock cores previously correlated primarily on the basis of lithologic features and assigned to the Meramecian Stage in western Kansas were ~~utiliz~~ utilized. Girty (1940) had previously identified some megafossils from some of these cores.

WHAT ARE CONODONTS? Slide 1. C. V. (discuss)

- A. Conodonts are microscopic toothlike and platelike structures belonging to an extinct, unknown group of marine animals which probably were bilaterally symmetrical, soft bodied, and free swimming. These fossil structures range from a fraction of a millimeter to about three millimeters in length. They are composed chiefly of calcium phosphate, are either amber or grayish black in color, and are translucent to opaque. Conodonts, known to range from the Lower Ordovician into the Upper Triassic, have a world-wide distribution and have

been found to be a useful tool to the stratigraphic paleontologist, despite the fact that there has been little unanimity on the zoological affinity of the animal that bore the conodonts, or on the function that was performed by these structures (Hass, 1962). Conodonts are good index fossils because they are durable, abundant, distinctive, and widespread in their geographic distribution yet restricted in their stratigraphic ranges. Because they are minute, conodonts are well suited for subsurface investigation. They provide a relatively dependable means of correlating different lithologies of biostratigraphic equivalents.

B. Are conodonts lithic features? *(Expand - discuss)*

C. Conodonts are often confused with Scolecodonts (worm-mandibles), but conodonts are morphologically distinct. Scolecodonts are brittle, jet-black in color, and composed of siliceous, chitinous material.

Conodonts are dissolved in hydrochloric acid, scolecodonts are insoluble in HCL. *(Conodonts in 10% HCL - careful test!)* (We are destroying!). The specific gravity of conodonts is greater than that of quartz, calcite, and dolomite making it possible to separate them from most sediments by the use of heavy liquids such as tetrabromaine. Early workers thought that conodonts

occurred in greater abundance in shales rich in organic matter. Conodonts were thought to be abundant in black fissile shales which generally lack association of other marine invertebrates. Generally in such detrital units as sandstones and shales, the conodonts are found to be concentrated near the top or bottom of lithologic units. In this respect they seem to represent "lag" concentrates. The wide stratigraphic and geographic distribution, coupled with the mode of occurrence and different types of sedimentary deposits (they transgress facies) strongly suggests that the conodonts are remains of pelagic organisms. Because they are highly resistant to chemical weathering, conodonts are commonly concentrated in the residuum from rocks that originally contained them and may be found reworked in the younger sediments and admixed with younger faunas. Conodont-bearing organisms evolved rapidly during much of the paleozoic era and new forms were dispersed so swiftly that most marine formations contain at least several distinctive faunas that are restricted to relatively short intervals of geologic time (Collinson, 1963). In addition the fossil remains are so abundant and widely distributed that regional and stratigraphic variability of species can be determined precisely

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on faunal sequences reconstructed to form the basis for unusually accurate bio-stratigraphic zonations.

The stratigraphic distribution of conodonts and the relation of occurrence to lithology indicates that the conodont-bearing animal (whatever the beast was) was almost continuously present and uniformly abundant in Paleozoic and early Mesozoic seas. The rate of sediment deposition was apparently the most important factor governing the present day occurrence of conodonts. Sea bottom environment seems to have been a negligible factor.

Conodonts tend to be abundant in cephalopod-bearing limestones. Often they are associated with fish remains and ostracodes. Biohermes and biostromes apparently contain few conodonts. Fusulinid-bearing limestones almost nowhere yield conodonts.

The orientation of conodonts is a problem because the zoological position is not known. Arbitrary orientation now used by most students is as follows: (1) the points of the dentacles are upward or oral, (2) the attachment scar is downward or ab-oral, (3) the blade end of the platform is forward or anterior, and (4) the dentacles of both the bars and blades in the simple cones are inclined backward or posterior.

Conodont viewing.--A magnification of between 10 and 24 times is suggested for examination by microscope of rotary sample cuttings. We have found that a magnification of 27 enables us to easily pick out the complete ~~eender~~ conodont, the fragments of conodonts, and arenaceous foraminifers^{W/A} from the insoluble residue portion of core samples processed.

KANSAS MERAMECIAN ROCKS Slide 2.

Ax ~~TKK~~ (Slide shows Rock Chart--Jewett). Meramecian featured--Say why chosen--most complete cores.

A. The Mississippian sequence of rocks in western Kansas is confined to the subsurface. In ascending order, Kinderhookian (not shown), ^{discuss} "Cowley", Osagian, Meramecian, and Chesteran rocks are present. Chesteran rocks are confined to the deeper parts of the Hugoton Embayment and unconformably overlies Meramecian rocks. Elsewhere in western Kansas, the Meramecian rocks are overlain unconformably by Pennsylvanian rocks.

The sequence of formations of the Meramecian Stage in western Kansas, in ascending order the Warsaw, ^(discuss "Cowley") Salem, St. Louis, and Ste. Genevieve Limestones, is a dominantly carbonate lithologic section.

Presently, subdivision of Meramecian rocks in western Kansas is based wholly on lithologic characteristics. The partial or complete removal of the upper Meramecian formations by ~~post-~~ ~~post-~~ post-Mississippian erosion renders lithologic comparisons difficult. In some cases, even thorough lithologic comparisons cannot produce positive formational identification. This problem is compounded as the eastern, truncated edge of the eroded Mississippian rocks in the Hugoton Embayment is approached (against the Central Kansas Uplift). The known thickness of the Meramecian rocks ranges from a feathered edge on the western flank of the Central Kansas Uplift to more than 867 feet in the center of the Hugoton Embayment.

Establishment of Mississippian carbonate rock equivalents in western Kansas by electric log characteristics and sample logs prepared from rotary cuttings has been found by ~~me~~^{us} to be difficult and generally unreliable.

Most Mississippian megafossils recovered from well cores consist of fragments of large shells and an occasional small shell large enough to allow tentative generic identification. Mega-~~f~~ossils have been found to be abundant in certain parts of the Meramecian rocks of western Kansas, but because many Mississippian genera have long ranges, a list

of genera would have slight value as evidence for age determination (Girty, 1940). For this reason, researchers recently have looked toward microfossils as a feasible tool for subdivision of the Mississippian rock section, especially the standard surface sections of Mississippian rocks.

The well cores used for study ^{Bull. 165 pt 1} (in T&G-63) represent a sequence of Meramecian rocks ranging from an almost complete section from the center of the Kansas part of the Hugoton Embayment to a section containing only the lowermost Meramecian formations, situated near the truncated edge of the Mississippian rocks as they presently outline the Central Kansas Uplift.

Erroneous beliefs about occurrence.--Collinson, ^{put up his paper} 1963, points out that two erroneous beliefs about the occurrence of conodonts are widely held--first, that they occur most commonly in shale and secondly that they occur most abundantly in black shale. He cites that of all the rock types processed in a mass production study, limestones were the most reliable and productive. For example, he cites that more than 85 percent of all of his limestone samples of late Mississippian age yielded at least 10 conodonts per kilograms and several

beds yielded more than 100 conodonts per kilogram. It is true that shales are generally excellent sources for faunas and frequently produce spectacular abundances, but Collinson reports shales do not yield as consistently as limestones nor is the average yield as high. Because of ease of processing and because shales have for many years been considered the primary source of conodonts, enormous quantities have been processed with the result that more conodonts have been collected from gray, green, buff, or brown shales than any other kind of rock. Actually according to Collinson, black shales are among the poorest rather than the best sources of conodonts. The low productivity is probably due to the lack of a satisfactory mass technique for separating conodonts from them. The best known faunas from black shales are found on bedding planes. Conodonts are common in dolomites also, and frequently are found in abundance greater than 50 specimens per kilogram (Collinson, 1963).

(Don't know about dry dolomites?)

It was his conclusion that limestone represents the most favorable rock type for collection of conodonts. (We agree.) He found the distribution more regular than in other rock types and the average number of specimens contained as higher. Faunas from limestones are,

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in general, superior because of better preservation, less breakage, and cleaner specimens. Most shales are more easily disaggregated than limestones using standard insoluble techniques, and in some beds, produce prodigious collections. However, distribution is uneven and the overall average of specimens per kilogram is lower than the limestones. Sandstones and siltstones produce faunas but sporadically and relatively in low numbers.

RECOVERY TECHNIQUES

In acidizing calcareous samples generally 2 gallons of glacial acetic acid, 10 percent, will dissolve 450 grams of relatively pure limestone. Concentrations up to 14 percent can be used without serious etching of specimens, however, 10 percent will dissolve 400 grams of sample in a 12 to 24 hour period with no etching of specimens.

Most conodonts will pass through a 16 mesh sieve and will be retained on a 150 mesh screen. Their specific gravity ranges from 2.84 to 3.10 (Ellison). Quartz (specific gravity 2.65 to 2.66),
~~Quartz~~ can be separated by a solution of Bromoform and acetone.

Acetic acid is the most inexpensive common method of dissolving calcareous rocks to recover conodonts. However, the rate at which

the reaction proceeds is governed to some degree by the amount of calcium acetate present in the solution. This salt is but slightly soluble in water and by coating the undigested part of sample, it retards the reaction so that the solute must be replaced frequently. Some investigators utilize a monochloroacetic acid because its calcium salt, being quite soluble in water, does not impede the chemical reaction. But this acid has a handicap of being quite caustic.

Experience in collecting samples from surface outcrops for conodonts, showed Collinson that a 2-kilogram sample was satisfactory for both biostratigraphic and taxonomic studies. A 7 by 12 inch cloth sample bag will hold slightly more than 2 kilograms. Collecting from middle Paleozoic rocks demonstrated to him that this size of sample will contain on the average, ten to twenty conodonts in more than half of all samples. Sometimes, however, it is necessary to collect and process 400 to 500 pounds of material from a single bed in order to attempt to resolve a stratigraphic problem.

Well Samples.--The normal size of sample ~~cuttings~~ cuttings saved for microscopic study is too small for conodont studies and it is necessary for the worker to make special collections at the well site.

Because well cuttings are generally finer than samples crushed for
~~XXXXXXXXXX~~

processing of conodonts, approximately twice as much material must be collected per stratigraphic unit as would be used for a smaller outcrop study. Approximately 4,000 grams per sample should represent the practical minimum to be collected at the well. (Mention Anderson Co. well)

Cores.---Core represent irreplaceable material and should therefore be ~~XXXXXX~~ subdivided into the smallest practical sample intervals. In the pilot study by Tom and myself from each core 200 gram samples were selected at approximately 1-foot intervals. Out selection of samples from the cores was not influenced by any lithologic change. The amount of material available was controlled by the diameter of the cores, which ranged from 3 to 4 inches. No more than one quadrant of each piece of core was used.

SOME PROBLEMS IN WORKING WITH CONODONTS

1. Mixed faunas consisting of (a) Stratigraphic Leaks, and (b) Stratigraphic admixures (Branson and Mehl, 1941).
2. Minimum specimens needed for correlation:

A stratigraphic leak involving conodonts has been defined as the introduction of conodonts of one age into association with beds

of an earlier time (Branson and Mehl, 1941). This kind of mixed fauna resulted through filling of cavities in a formation with materials of younger stratigraphic units; the filling occurred either at the time of the deposition of the younger unit, or later, through the action of geologic agents. A stratigraphic admixture of conodonts has been defined as the inclusion of an earlier assemblage of conodonts in the sediments and faunas of a later age. This kind of mixed fauna is common because conodonts are resistant to many kinds of chemical weathering. Acetic and similar acids do not affect conodonts and because these acids are stronger than those that usually have been active in the weathering of rocks throughout geologic time, conodonts, generally have remained unchanged in the resulting residuum. Later such conodonts were reworked into the sediments of the younger formation. Hence, it is possible for specimens from different sources and different ages to be found together, especially in the basal beds of the formation. Differences in the physical appearance (color, preservation, luster) or associated specimens are indicators of a mixed fauna; but the recognition of a mixed fauna is chiefly dependent upon one's knowledge of the true stratigraphic

range of each kind of distinct conodont.

3. Minimum Specimens needed for Correlation

In biostratigraphy a great fund of information must be accumulated before any group of fossils can be considered reliable indices for detailed stratigraphic correlation.

Conodont taxa should be considered deficient unless related in time to ancestor, descendant, and contemporary variance; biostratigraphic zones, correlations, and age determinations should be considered less than certain unless sequences of faunas above and below the unit in question are known. Elements comprising the fauna from any particular horizon represent only increments of numerous phylogenetic lineages and must be related to major portions of these lineages to be useful biostratigraphically. Many a fauna described as representing a specific stratigraphic unit actually represents only one of many integrating faunas and may be quite unlike faunas from other stratigraphic horizons in the same unit. (Collinson & Rexroad).

Although very long ranges for many conodont genera have been widely accepted, few long-range species have been recognized. Some species are limited to a single formation, or even a part of a formation, many have much more extensive ranges and some occur in more

than one geologic system. Thus the overall nature of the fauna rather than the presence of one or two species common to the units must be the basis for the correlation.

Slide 3. I would like now to exhibit to you some of the conodonts recovered from the Pilot Study (KGS Bull. 165, pt. 1) and described in detail in Thompson (Unpublished MS thesis, 1961, K. U.). The 83 specimens (average yield 7-10/2 kilograms per 200 gms) represent 7 species and 6 genera. Conodonts are identified primarily on form. I will try to point out the important, distinguishing characteristics of each. Some ranges of the species are indicated.

The first slide ^{shows} ~~here is~~ Apatognathus geminus and it is indicative generally of the St. Louis formation. The picture on the left is an inter-lateral view and the other one is an outer-lateral view. We had only one of these specimens collected and that was from a well in Scott County. You may notice the one prominent denticle which destroys the bilateral symmetry of the specimen.

Next slide. Cavusgnathus unicornis which is known from the mid-St. Louis to Chesteran up through Desmoinesian-Pennsylvanian time. Three views of it and we have five specimens. You'll notice the size of the specimen is less than a millimeter. We have three speci-

mens from Logan and two from Gove County in Kansas. There is a horn-like appearance--the posterior most dentacle and the straight to concave ~~and XXXXXX~~ outline of the blade.s

Slide. Here is Gnathodus texanus which is known from the Keokuk-
Warsaw. You will notice one pillar-like dentacle compressed laterally and lying parallel to the carina which is the central ~~xxx~~ blade on the top. Number A is the lateral view and B is an oral looking down from above and C is aboral looking up from the bottom of the specimen. We have 22 of these specimens, quite common, 5 from Logan County and 17 from Ness County.

Next Slide. This is Ligonodina levis. This is known from West
Wasaw Warsaw Chesteran
~~Chesteran~~ through ~~Warsaw~~ rocks. We have 2 specimens. One from Lane
and one from Ness County. You might notice the ^{one} long discreet dentacle
and four small ones curved ^{and} in the curved terminal fang. A is an inter-
lateral and B is an outer-lateral view.

Slide 6 is Neoprioniodus loxus from St. Louis to Chesteran and
this is an inter-lateral view A and we have 2 from Scott County. Notice
the small unequal dentacles on the posterior bar.

Slide 7 is Neoprioniodus scitulus. There are 2 specimens of this. One from Ness County. It is known from the Warsaw through Chesteran. You will notice it is larger than the previous Neoprioniodus which we viewed and you will notice the broad aboral projection of the terminal fang.

Next slide. Synprioniodina is from the upper Devonian through the Lower Permian. We can see that this is ~~an~~ extremely long-ranging ^{fauna} and-here-is

Slide 9. Taphrognathus which is known from Osagian through St. Louis. We have 14 of these specimens. A is a lateral view, B. is an oral, and C is an aboral. ~~In~~ Incidentally, this one formed during St. Louis time, ~~and~~ changed into the Taphrognathus varians.

Slide 10 is Taphrognathus, new species, which is described, but not published yet by Tom Thompson. We have two of these and it is limited to the St. Louis. It is one of the transitional forms between the Taphrognathus ^{ids} and the Cavusgnathus ^{ids}.

ABUNDANT OF FAUNA

The most abundant Meramecian species are Gnathodus texanus and Taphrognathus varians, which together make up over half the total fauna. The genera Cavusgnathus and Apatognathus are represented by much smaller populations but are stratigraphically important to the

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fauna. Species of the genera Ligonodina, Neoprioniodus, and Synprioniodina are present.

There are important stratigraphic implications of the fauna, and ~~these are the~~ most important ~~to the~~ conodont genera to the stratigraphy of the Meramecian Stage are Cavusgnathus, Gnathodus, and Taphrognathus. Of these three genera, Taphrognathus is the most important stratigraphic indicator, ranging from the Keokuk Limestone (Osagian Stage) to the St. Louis Limestone. During St. Louis time, Taphrognathus evolved into Cavusgnathus (Rextoad, 1959), the latter replacing Taphrognathus in stratigraphic importance from late St. Louis time at least through Chesteran time. T. Sp. is the transitional form for Taphrognathus to Cavusgnathus, and it is restricted to the St. Louis Limestone. G. texanus ranges from the Keokuk Limestone through the Warsaw Limestone; the upper limit of the range possibly approximates the Warsaw-Salem formational boundary.

Apatognathus geminus appears to be restricted to the St. Louis Limestone, and it represents the youngest known species of the genus. None of the other forms found is stratigraphically important in this study, but the occurrences are included in the belief that future studies may increase their value as stratigraphic indicators.

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IDENTIFICATION OF MERAMECIAN FORMATIONS BY FAUNA

Formations of the Meramecian Stage in western Kansas appear to be distinguishable by their conodont fauna. The following discussion lists these formations and their characteristic conodont faunas based upon preliminary observations.

The Warsaw Limestone is generally characterized by the presence of Gnathodus texanus and abundant specimens of Taphrognathus varians. The abundance of the latter possibly distinguishes the Warsaw conodont fauna from that of the Osagian Stage; T. varians is much less abundant in the Osagian Stage.

The Salem Limestone appears to be characterized by the presence of abundant specimens of Taphrognathus varians and the seeming absence of Gnathodus texanus, T. sp., Apatognathus geminus, and species of Cavusgnathus.

The St. Louis Limestone is characterized by the presence of Taphrognathus sp., T. varians, Apatognathus geminus, and species of Cavusgnathus.

The Ste. Genevieve Limestone is characterized by the presence of species of Taphrognathus and possibly Apatognathus. Presently,

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this unit must be distinguished from Chesteran strata by lithologic criteria; the conodont fauna is insufficiently known for positive identification.

Obviously, additional study is needed to validate the usefulness of conodonts as guide fossils. Undoubtedly, additional investigations is also needed in evaluation of conodonts from other sections of Mississippian rocks in the Midcontinent region.

SUMMARY

In Summary I would like to make 3 points.

- 1.) From our pilot study, Tom and I concluded that conodonts *are* ^{*probably*} present and in the quantity needed to use them safely as time markers in the Meramecian of western Kansas.
- 2.) Geologists in using HCl to differentiate limestone from dolomite in sample cuttings are probably destroying conodonts.
- 3.) Whether or not, one considers conodonts useful as guide fossils, the physical occurrence of them in the rocks may be useful as lithic features of the rocks. Conodonts are as much a lithic feature as color of chert or shape of

oolites.

Thank you for allowing me to share ^{our} ~~my~~ enthusiasm for conodonts

in correlation problems.