Conodonts and Biostratigraphy of the Wisconsin Paleozoic

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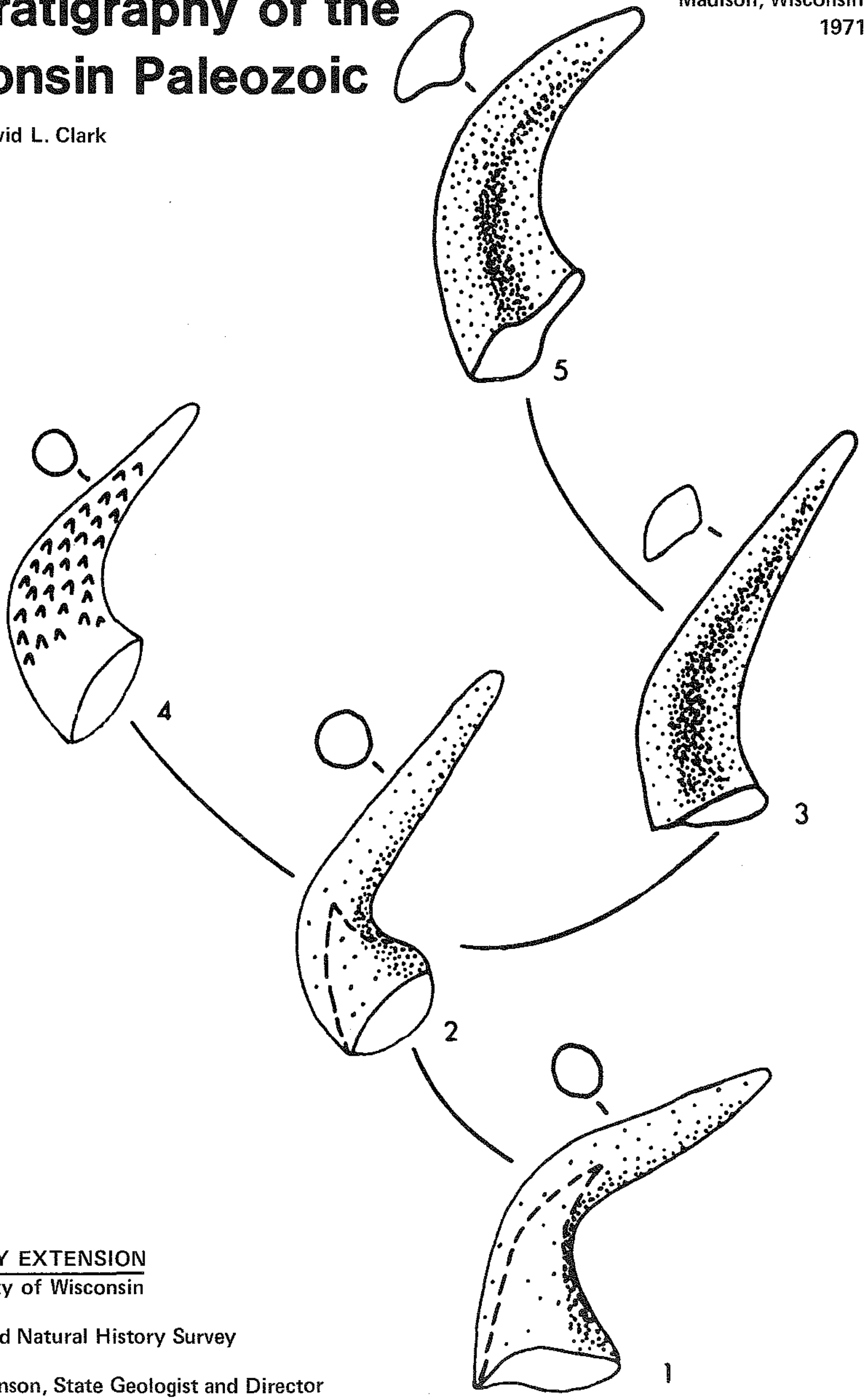
Edited by David L. Clark



UNIVERSITY EXTENSION
The University of Wisconsin

Geological and Natural History Survey

George F. Hanson, State Geologist and Director

Cover shows the evolutionary development of the *Oneotodus* conodont complex in Late Cambrian-Early Ordovician rocks. Figure 1 is *Proconodontus*, the ancestral form that gave rise to 2) *Oneotodus* and its descendents, 3) *Acodus*, 4) *Hirsutodontus* and 5) *Acontiodus*. Important parts of the sequence have been found in the Cambro-Ordovician of Wisconsin. (From Clark and Miller, 1969, Geol. Soc. America Bull., p. 132).

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GEOLOGICAL AND NATURAL HISTORY SURVEY

George F. Hanson, State Geologist & Director

CONODONTS AND BIOSTRATIGRAPHY OF THE WISCONSIN PALEOZOIC

Edited by

David L. Clark

Contributions by

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INTRODUCTION

The Wisconsin Paleozoic consists of a sequence of sedimentary rocks whose study dates back to such classic geologists as Chamberlin, Hall, Ulrich, Twenhofel, and others. More recently, the Wisconsin Geological and Natural History Survey (Ostrom, 1964, 1965, 1966, 1969, 1970) has initiated detailed study of some of the Paleozoic units. Biostratigraphy of the Wisconsin section has been based on the larger invertebrates that are abundant in at least a few of the Paleozoic formations. Few microfossils have been described although conodonts were reported from the Ordovician of Wisconsin more than 30 years ago (Furnish, 1938, p. 319-320). The present study of the Wisconsin Paleozoic was initiated in order to define the microfossils and use these superior stratigraphic tools for a thorough biostratigraphic analysis.

The development of conodonts as a biostratigraphic research tool has been spectacular during the past 10 years. These curious microfossils now are considered the most important group of biostratigraphically significant fossils in terms of their total stratigraphic range (Middle Cambrian through Upper Triassic). An enormous amount of work with conodonts has been accomplished in rocks of Ordovician and Devonian age on a world-wide basis. Rocks of this age in Wisconsin contain relatively large and well preserved faunas. The study of these faunas along with other work in the lithologically less favorable Silurian and Cambrian rocks has been a long term project of students and staff of the Department of Geology and Geophysics at Madison. The refined biostratigraphic interpretations made possible by conodont study is significant. Upper Cambrian and Upper Devonian faunas in particular have clarified long standing uncertainties concerning ages and boundary determinations in Wisconsin. In addition, the value of conodonts in inter-continental correlation and classification is important in our understanding of other parts of the Wisconsin Paleozoic.

ACKNOWLEDGMENTS

This work has been supported by the Wisconsin Geological and Natural History Survey, the Wisconsin Alumni Research Foundation and the National Science Foundation. M. E. Ostrom and G. F. Hanson, Wisconsin Geological and Natural History Survey have been particularly helpful. Help with field work and in preparation of fossils by students of the University of Wisconsin is gratefully acknowledged.

SUMMARY OF RESULTS

General

Different emphasis has been given to various parts of the Wisconsin Paleozoic section. Certain units of the Silurian and Upper Cambrian have been particularly difficult. Dolomite and non-calcareous sandstone are characteristically difficult to disaggregate for microfossils. Our success until now has been limited. New techniques, slightly different facies or more patient investigators could aid in furnishing additional material from several parts of the section. Also, conodonts of the Decorah and

Galena have been studied less thoroughly because good studies and descriptions of these faunas in adjacent states are available (Stauffer, 1930 etc., Ethington, 1959, Webers, 1966). Conversely, the microfauna of the Milwaukee and "Kenwood" Devonian units was unknown prior to the present study.

This different emphasis on the different parts of the Wisconsin Paleozoic results in an uneven treatment for the various formations. Thus, the Trempealeau, Platteville, Maquoketa, and Devonian formations are discussed in detail in the biostratigraphic part of the text and important comments concerning conodonts of these stratigraphic units are presented in the paleontology section. In addition, discussion of each of these sections is followed by a general summary. Only faunal lists are presented for the other Wisconsin Paleozoic units but the occurrences of all conodonts is documented to sections and geographic locality.

Little new paleontological data concerning the nature of conodonts has been determined from these investigations and no new taxa are proposed. More important are the stratigraphic results and they are summarized below.

Cambrian

Rocks traditionally defined as Trempealeauan (Upper Cambrian) and used at least indirectly as a "type" North American time-rock term are now demonstrated to correlate with lower and upper Tremadocian rocks in other parts of North America and Europe. If the Tremadocian is considered Ordovician as it is in the usage of Scandinavia and elsewhere then the time significance of the Wisconsin Trempealeauan is altered. In the British definition, the Tremadocian is considered Upper Cambrian. Because the Wisconsin Prairie du Chien (overlying the Trempealeauan) is also Tremadocian it is important to note that the Cambrian-Ordovician transition as defined in Wisconsin (and therefore in other parts of North America) does not correlate with the Cambrian-Ordovician boundaries of either the British or Scandinavian sequence. Rather, our North American boundary falls within the Tremadocian as defined elsewhere. Miller's investigations have defined the problem in the North American "type" area.

Ordovician

There is good evidence of diachronism of Ordovician units across Wisconsin. Atkinson demonstrates that the Platteville may become younger from east to west across the state. This is based on the vertical ranges of <u>Oistodus venustus</u> and <u>Belodus dispansa</u>. Froming notes a similar diachronism in the distribution of Maquoketa conodonts and concludes that all lithologic divisions of the Maquoketa in the type Iowa section are younger than equivalents in Wisconsin.

Devonian

Schumacher is able to confirm a correlation of the Lake Church to the lowermost Givetian (Middle Devonian) and with the Rogers City Limestone of Michigan. The conodont fauna of the lower Milwaukee Formation supports an uppermost Middle Devonian correlation with the Rapid and Coralville Members of the Iowa Cedar Valley Formation.

Significant conclusions can now be made concerning the "Kenwood" Shale of the Milwaukee area. Conodonts of the "Kenwood" are the most abundant of any noted to date in Wisconsin. They confirm a range of Frasnian and Famennian (Upper Devonian) and a correlation with the middle Antrim Shale of Michigan as well as numerous other well-defined Late Devonian units in Europe, North America and Australia. Because the name "Kenwood" is preoccupied for stratigraphic units elsewhere, Schumacher recommends that the name be dropped and that the name Antrim Shale (from Michigan) be used in Wisconsin.

CAMBRIAN

Biostratigraphy

General

Upper Cambrian sediments lie unconformably on Precambrian rocks and are exposed beneath glacial debris for over more than a third of Wisconsin. Recent studies by Ostrom (1965, 1966, 1970) have lead to recognition of six or seven formations that occur within the Upper Cambrian St. Croixian Series which is subdivided into three stages. To date, studies of the trilobite faunas have been the bases of the time classification for these units which primarily consist of sandstones and orthoquartzites and contain a small variety of marine invertebrates.

Although conodonts are seldom abundant in such sediment types they were sampled. Only formations of the Trempealeauan Stage, youngest of the St. Croixian Series, yielded significant faunas to date. The Trempealeauan stratigraphy is indicated in Figure 1.

Trempealeauan Conodonts

James F. Miller and John H. Melby

Introduction

Cambrian conodonts are more poorly known than conodonts from any other part of the Paleozoic or Triassic. The only reported sequence of faunas from measured sections of Cambrian age is from Utah (Miller, 1969). Work in progress has defined similar sequences from equivalent strata in Texas and Oklahoma. The fauna reported here is based on only 110 specimens. It is important because it is from the type area of the Upper Cambrian in North America.

Most of the specimens were recovered by Melby in conjunction with a graduate thesis that dealt with the stratigraphy of the Sunset Point Member of the Jordan Sandstone. Melby bears the main responsibility for stratigraphic interpretations that deal with this unit. Specimens from the Lodi Siltstone and the Norwalk Sandstone were recovered by Miller, who assumes responsibility for their stratigraphic interpretations and for all faunal identifications.

Acknowledgments

Financial support for Melby's field work was provided by a grant from the University-Industry Research program and by the Wisconsin Geological and Natural History Survey. Lewis M. Cline of the University of Wisconsin directed this study. Special thanks are extended to M. E. Ostrom, Associate State Geologist, for many hours of help in the field and for helpful discussions of stratigraphic problems with the writers. D. L. Clark, University of Wisconsin, advised Miller on identification of the fauna. Harrell L. Strimple and Brian F. Glenister, University of Iowa, arranged for loan of type Ordovician and related specimens.

Stratigraphy and Sample Localities

The stratigraphy of units to which reference will be made is summarized in Figure 1. Conodonts were recovered from the Lodi Siltstone and from all members of the Jordan Sandstone.

Locality 1. -- Section 29, T.28N., R.14W. The locality is in a small quarry on Wisconsin 29, near the junction with Dunn County Highway Q, between Menomonie and Spring Valley, Wisconsin (Figure 2). The Lodi Siltstone is mainly buff to brown dolomitic siltstone with minor fine sand and dolomite beds. Conodonts from the Lodi were found in one sample (69-Rt.29-Lodi) comprised of trimmings from several specimens of the trilobite *Dikelocephalus* sp.

Locality 2. -- Same as above. The Norwalk is the lower member of the Jordan Sandstone and is light brown, fine-grained, relatively pure quartz sandstone and overlies the Lodi Siltstone. A single sample (69-Rt.,29-N10) collected about 31 feet above the base of the quarry (mentioned above) yielded several conodonts.

Locality 3. -- Section 32, T.111N.,R.10W. This section (TW) is located one mile west of Wabasha, Minnesota on Minnesota Road 60 (Figure 2). Next higher is the Van Oser Member of the Jordan Sandstone, a medium grained, light brown, relatively pure quartz sandstone. A single sample (TW-3) yielded conodonts. Sample TW-3, is from 4.5 feet below the top of the top of the Van Oser Member

Localities 4-7. -- The bulk of the conodonts found to date is from the Sunset Point Member of the Jordan Sandstone. This is the youngest member of the Jordan and, in general, the unit is composed of impure sandstone with interbedded minor dolomite, oolite, chert and shale partings.

Four sections of the Sunset Point yielded conodonts. The Wabasha section (TW) (4) is 30 feet thick. TW-11 is 17½ feet above the base of the Sunset Point Member. Another section, (SV), (5), section 16, T.27N., R.15W., is located two miles southeast of Spring Valley, Wisconsin, near the junction of Wisconsin 128 and Pierce County Highway T (Figure 2). This section is 28 feet thick. Sample SV-5 (5a) is 9½ feet above the base and SV-9 (5b) is 23 feet above the base of the Member. A third section (SVD) (6) section 5, T.27N., R.15W., is within the town of Spring Valley, Wisconsin, at the dam across the Eau Galle River. This section is 32 feet thick. SVD-5 (6a) is 19 feet, SVD-8 is 29½ feet (6B), and SVD-9 (6C) is 31 feet above the base of the Sunset Point Member. The fourth section (WN) (7), section 30, T.106N., R.8W., is located three miles west of Winona, Minnesota, on U. S. Highway 14 (Figure 2). This section is 27 feet in thickness; sample WN-12 was collected a few inches above the base.

Age and Correlation

The faunas from the Lodi and Norwalk Members are quite different from those from the younger Van Oser and Sunset Point fauna. The older Lodi-Norwalk specimens are all referred to the genus *Proconodontus*. This occurrence appears to correlate quite well with the upper 53 feet of member 5 and/or the lower 180 feet of member 6 of the Notch Peak Limestone of western Utah (Miller, 1969). The Utah rocks are assigned to the *Saukiella*

<table>
<tr><th colspan="4">NORTH AMERICA</th><th colspan="2">EUROPE</th></tr>
<tr><th>TIME UNIT</th><th>GROUP</th><th>FORMATION</th><th>MEMBER</th><th colspan="2">TIME UNIT</th></tr>
<tr><td>LOWER ORD</td><td>PRAIRIE DU CHIEN</td><td>ONEOTA DOLOMITE</td><td></td><td>UPPER</td><td rowspan="6">TREMADOCIAN</td></tr>
<tr><td rowspan="5">TREMPEALEAUAN STAGE (UPPER UPPER CAMBRIAN)</td><td rowspan="5">TREMPEALEAU</td><td rowspan="3">JORDAN SANDSTONE</td><td>SUNSET POINT SANDSTONE</td><td rowspan="5">LOWER</td></tr>
<tr><td>VAN OSER SANDSTONE</td></tr>
<tr><td>NORWALK SANDSTONE</td></tr>
<tr><td rowspan="2">ST LAWRENCE</td><td>LODI SILTSTONE</td></tr>
<tr><td>BLACK EARTH DOLOMITE</td></tr>
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Figure 1. Trempealeauan stratigraphy and classification of Wisconsin units

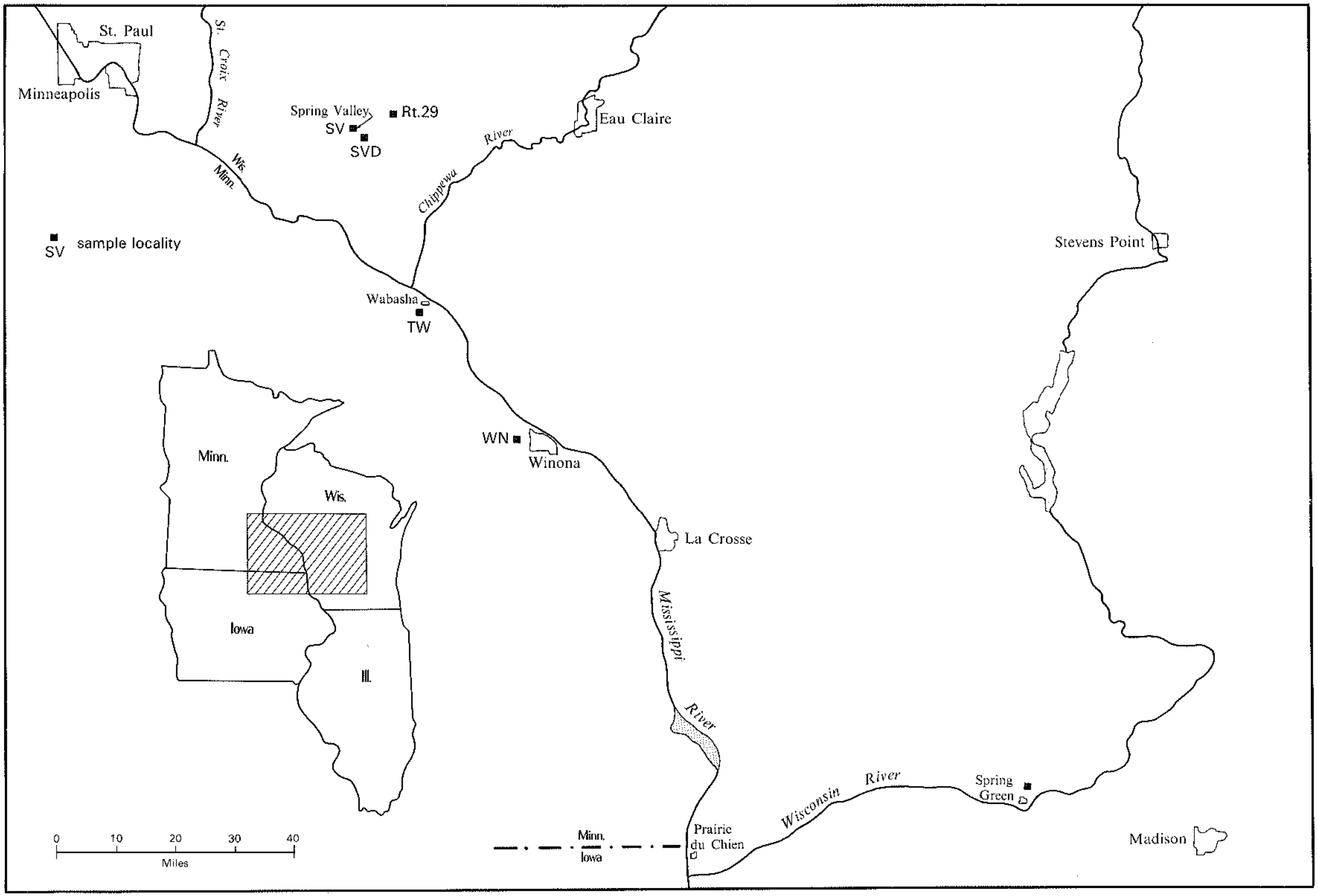

Figure 2. Trempealeauan localities in Wisconsin and Minnesota

junia and *S. serotina* subzones of the *Saukia* Zone (written communication, Dr. Michael Taylor) which are upper Trempealeauan and can be further classified with the Lower Tremadocian of Europe and Southern North America (Robison and Pantoja-Alor, 1968).

The conodonts of the Van Oser and Sunset Point Members comprise a mixed fauna. Some species are conspecific with forms from the upper half of member 6 of the Notch Peak Limestone of Utah (Miller, 1969), and other species are conspecific with forms described from the Prairie du Chien Group of the Upper Mississippi Valley (Furnish, 1938). Species found in the Prairie du Chien are represented by specimens in *Missisquoia* and *Symphysurina* Zone rocks of Oklahoma and Texas and are Lower Ordovician by North American standards. They are further classified as upper Tremadocian by European and South American standards (Robison and Pantoja-Alor, 1968). *Cyrtoniodus prion* is the only species from the Wisconsin Trempealeauan which has been reported from the upper Tremadocian of Sweden (Lindström, 1955).

According to this interpretation, the Cambrian-Ordovician boundary in Wisconsin (Sunset Point-Prairie du Chien) falls somewhere in the Tremadocian. Outside of England, the Tremadocian is considered Ordovician and, therefore, part of the Wisconsin Trempealeauan is Ordovician.

Table 1

Conodonts from the Trempealeauan

	Localities									
	1	2	3	4	5a	5b	6a	6b	6c	7
Acodus housensis Miller									1	
Acontiodus (Acontiodus) staufferi Furnish									1	
Acontiodus sp. aff. A. staufferi Furnish								1		
Acontiodus (Semiacontiodus) nogamii Miller			4							
Acontiodus n. sp. A.			1	2						
Cordylodus proavus Müller ?								1		
Cyrtoniodus prion Lindström			1					2	1	
Drepanodus erectus (Furnish)							3			
Drepanodus n. sp. A			1	1		2	1		3	
Oneotodus simplex (Furnish)			24	6		6		2	8	
Oneotodus sp. aff. O. simplex (Furnish)										1
Oneotodus n. sp. A.			2			1		7	2	
Paltodus bassleri Furnish								6	1	
Paltodus utahensis Miller			1?							
Paltodus variabilis Furnish							1		1	
Proconodontus carinatus Miller		1								
Proconodontus muelleri muelleri Miller	2?	2								
Proconodontus notchpeakensis Miller	1	1	2		1				1	

Number of specimens of each species indicated. Locality description in text.

ORDOVICIAN BIOSTRATIGRAPHY

General

The Ordovician of Wisconsin consists of up to 1500 feet of carbonate and clastic sediment (Ostrom, 1969, p. 675). The lowest (Canadian) part of the Ordovician has been considered to be the dolomitic Prairie du Chien Group (See previous page). This unit together with the overlying St. Peter Sandstone of the Ancell Group have yielded the poorest conodont faunas of the Wisconsin Ordovician.

Prairie du Chien

David L. Clark and Laurel C. Babcock

Conodonts from the Prairie du Chien in Iowa, Wisconsin, and Minnesota were described by Furnish in 1938. More recently, Guldenzopf (1967) has discussed some of the stratigraphic problems and illustrated conodonts from the Prairie du Chien of the Northern Peninsula of Michigan.

The Prairie du Chien, named by Bain (1905) for exposures around the town of the same name in western Wisconsin, consists of two formations. The lower is the Oneota Dolomite, that generally is buff in color and sandy in appearance and has some chert. The upper is the Shakopee Formation. This is separable into two members. The lower member is the New Richmond Sandstone, a whitish somewhat dolomitic unit that has some thin green shale beds. The upper member is the Willow River Dolomite, a unit which is similar to the Oneota below. Both dolomites contain cryptozoans and the Willow River contains other fossils as well. An apparent angular unconformity may be seen between the Oneota and Shakopee in the quarry at Eastman, Wisconsin, and at other exposures in the Upper Mississippi Valley area (Davis, 1968, 1970). The Oneota ranges in thickness from 215 feet at Prairie du Chien to 100 feet in the Madison area. The New Richmond ranges from at least 4 in the outcrop area to over 175 feet thick in the subsurface of the Illinois Basin (Workman & Bell, 1948). The Willow River ranges considerably, from zero to 75 feet locally and up to 300 feet in the Illinois Basin (op. cit.), because of the erosion surface developed at its top. Some channels in this erosion surface may extend below the top of the Oneota even down to the Mt. Simon (Cambrian).

Samples collected from the Prairie du Chien previous to this study have yielded few microfossils. For example, samples at two to five foot intervals have been collected from an excellent section of the Oneota in the Hoyt Park area of Madison. Only fragments of conodonts were secured. For the present study, samples were collected from five exposures that exhibit what was hoped to be the "optimum" facies. Only 5 specimens were found in the Oneota, none was found in the New Richmond and 9 were obtained from the Willow River. They are identified with 9 species whose distribution is listed in Table 2.

This compares with 28 species that Furnish reported in his study of the Prairie du Chien (1938, p. 320). All of the material collected by Furnish came from thin plastic beds within predominantly dolomitic Prairie du Chien (1938, p. 219). Similar shale seams are not commonly present in the well weathered outcrops of the Prairie du Chien in Wisconsin. All of our samples were of the dolomitic parts of the formations.

The Prairie du Chien was sampled at five localities (Fig. 3) as follows:

Locality 7. Section 27, T.11N., R.2W., quarry east of County Highway G. 1 mile north of Bosstown. At this locality, all three members of the Prairie du Chien were sampled.

Locality 8. Section 27, T.11N., R.4W., roadcut on east side of Highway 14-61, 5 miles southeast of Viroqua. Only the Oneota was sampled here.

Locality 15. Section 22, T.7N., R.6W., quarry and roadcut on north side of Highway 27, 2.5 miles east of Prairie du Chien. Oneota and Shakopee were sampled.

Locality 16. Section 9, T.8N., R.5W., quarry on north side of Highway 179, 2 miles east of Eastman. Oneota and New Richmond were sampled.

Locality 19. Section 34, T.5N., R.7E., roadcut on both sides of County Highway G, .2 miles west of Mt. Vernon. New Richmond and Shakopee were sampled.

The biostratigraphic significance of the Wisconsin collections is not great. Perhaps one of the most important species is Loxodus bransoni Furnish. This species was collected from the upper part of the Shakopee in Wisconsin but Furnish found it in the Oneota of Minnesota and Iowa. It is not safe to draw any diachronous boundary conclusions from the meager data at hand, however.

The Prairie du Chien species are part of a large fauna that was widespread in North America during the Early Ordovician. References to this fauna have been documented by Ethington and Clark (1970) in upper Tremadocian rocks in several parts of North America.

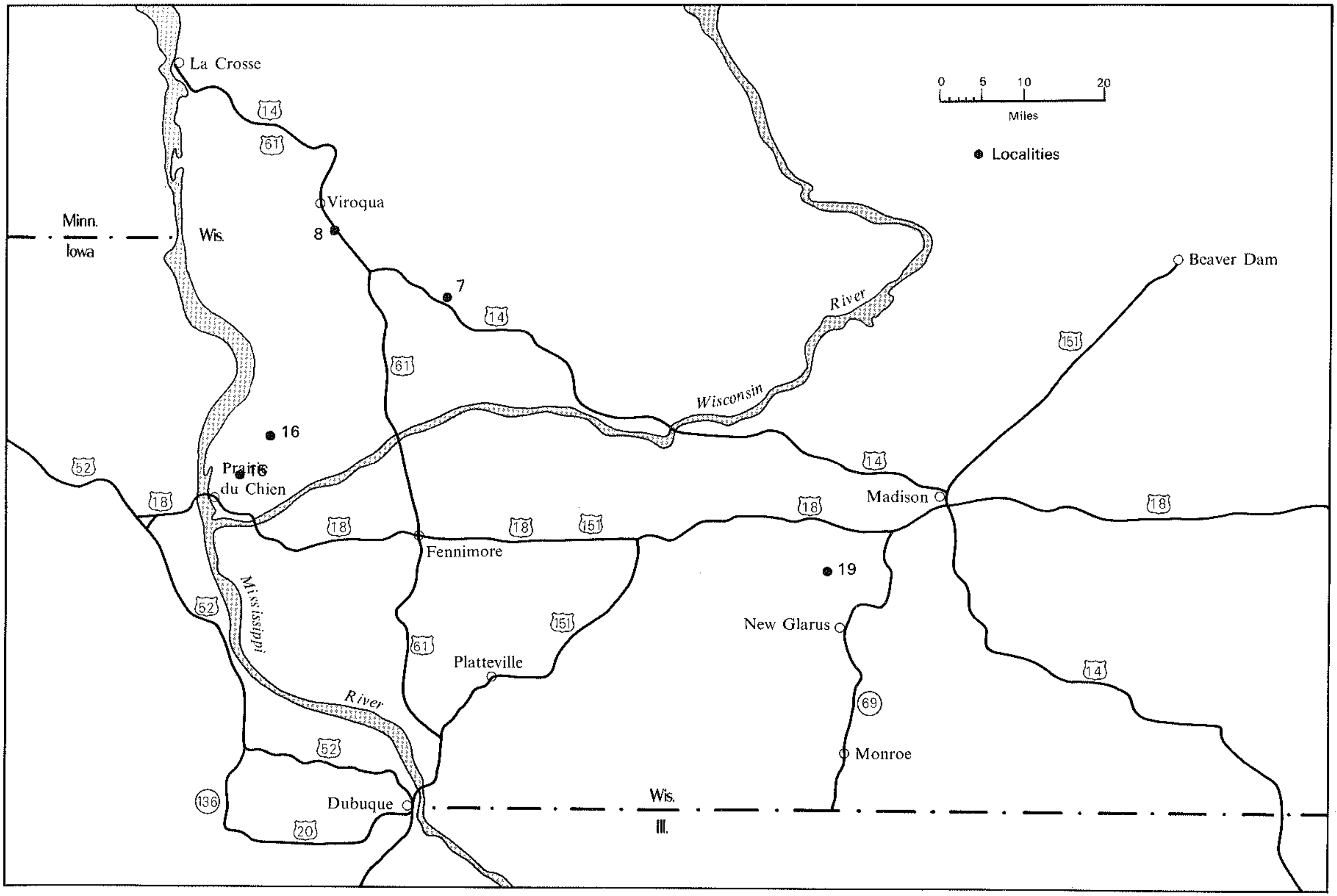

Figure 3. Prairie du Chien localities in Wisconsin

Table 2

Prairie du Chien conodonts

	Oneota	New Richmond	Willow River
Acontiodus sp. aff. A. iowaensis Furnish	1		
Acontiodus sp.	1		
Drepanodus homocurvatus Lindström			1
Drepanodus sp. aff. D. subarcuatus Furnish	1		
Drepanodus sp.			1
Loxodus bransoni Furnish			1
Scandodus furnishi Lindström			3
Scolopodus quadraplicatus Branson and Mehl	1		2
Scolopodus sp.	1		1

St. Peter Sandstone

David L. Clark and James F. Miller

The St. Peter Sandstone is the lower unit of the Ancell Group of Early or Middle Ordovician age in Wisconsin. Owen (1847) generally is credited with first bringing this stratigraphic unit to the attention of geologists and more recently, Dapples (1955) has reviewed sedimentologic and stratigraphic aspects. The formation is unconformable with older rocks and consists of several hundred feet of generally unfossiliferous sandstone that has a shaly to conglomeratic zone in its base. The basal zone is called the Readstown Member and the overlying sandstone is referred to as the Tonti Member (for discussion of these units in Wisconsin see Ostrom, 1967).

The Readstown Member consists of green shale at several localities in Wisconsin and contains an abundant conodont fauna. Specimens have been obtained from a single exposure on the west side of County Highway P, Section 9, T.7N., R.7E., approximately 0.5 miles north of its Junction with U.S. 18-151, south of Klevenville. The fauna consists of species that are the same as those present in the underlying Shakopee Member of the Prairie du Chien in part, but also the same species as those reported from the middle part of the El Paso Formation of west Texas. Some of the diagnostic Upper Tremadocian (Prairie du Chien) species have not been found in the Readstown, e.g. Loxodus, Acanthodus. Similarly, El Paso species referred to Gothodus, Oepikodus, and several other diagnostic forms appear to be absent in the Readstown fauna. In Europe, these latter two genera first occur in early Arenigian rocks. Their absence in the Readstown along with the presence of other El Paso species as well as the abundance of typical Prairie du Chien species suggest that this fauna is uppermost Tremadocian or possibly very early (pre-El Paso) Arengian.

Such age assignments raise two interesting ideas: 1. The unconformity between the Prairie du Chien and the St. Peter does not involve nearly as much time as has been supposed, and, 2. The St. Peter, at least at its base in Wisconsin may be Early Ordovician (Tremadocian, Canadian, etc.).

Additional work in progress may define this problem with a greater degree of resolution.

Table 3

Conodonts of the Readstown Member of the St. Peter Sandstone

Acanthodus sp.
Acontiodus staufferi Furnish
Drepanodus homocurvatus Lindström
Drepanodus subarcuatus Furnish
Oneotodus simplex (Furnish)
Oneotodus sp.
Scandodus furnishi Lindstrom
Scolopodus cornutiformis Branson and Mehl
Scolopodus gracilis Ethington and Clark
Scolopodus quadraplicatus Branson and Mehl
Scolopodus variabilis Ethington and Clark
Ulrichodina deflexus Furnish
Ulrichodina wisconsinensis Furnish
Ulrichodina sp.

Glenwood Formation

David L. Clark

Introduction

The Glenwood Formation, named by Calvin (1906) for exposures in Glenwood, Iowa, consists of one to thirteen feet of shale and sandy dolomite in Wisconsin. Its relationship to older and younger stratigraphic units as well as details of lithology have been documented by Ostrom (1969). It is considered to be the upper formation of the Ancell Group.

For this investigation, the Glenwood was sampled at four localities in southwestern Wisconsin (Figure 4) and specimens were obtained from two of these. Two samples yielded good material (Gl-1 and Gl-2-68). The first, section 36, T.5N., R.7E., from the roadcut approximately 3 miles north of New Glarus on the east side of Highway 69. A second sample (Pl-29-68) yielded a fauna similar to this. This was collected from a roadcut, section 7, T.5N., R.2W., approximately 4 miles south of Fennimore on U.S. Highway 61. In addition, samples of the Glenwood were taken by Atkinson in his study of the Platteville (this volume) at other Wisconsin localities.

Fauna and comments

Species recovered are listed in Table 4. Stauffer (1935a) described an abundant Glenwood conodont fauna from Minnesota. This report included references to 81 species, most of which were thought to be new and undescribed. Although many of Stauffer's species are now considered to be invalid (e.g. Bergström, and Sweet, 1966, p. 373-374), the fauna of the Glenwood is large and commonly well-preserved. Its stratigraphic position (lower Champlainian) is confirmed with conodonts. Webers (1966) described Glenwood conodonts from Minnesota and assigned the upper beds of the unit to the *Chirognathus monodactyla-Bryantodina typicalis* Assemblage Zone. Webers pointed out the uniqueness of the Glenwood and confirmed previous correlations of the Glenwood with the Harding Sandstone of Colorado (1966, p. 19).

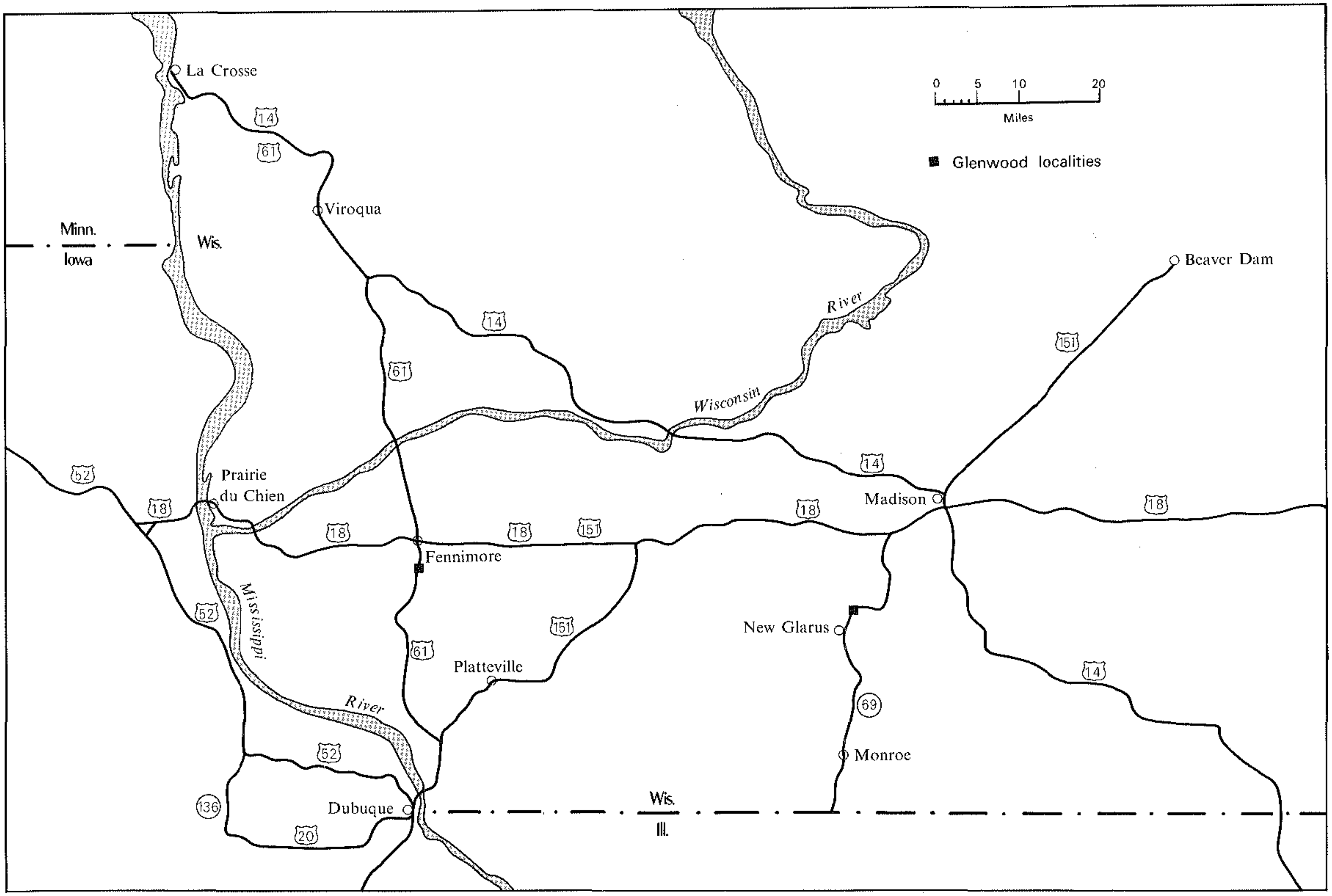

Figure 4. Glenwood localities in Wisconsin

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Table 4

Conodonts from the Glenwood Formation

Gl-1-68

Belodina compressa (Branson and Mehl)+
Distacodus falcatus Stauffer +
Drepandous homocurvatus Lindstrom +
Drepanodus suberectus (Branson and Mehl)+
Oistodus inclinatus Branson and Mehl +
Microcoelodus unicornus ? Branson and Mehl
Microcoelodus sp. +
Panderdous arcuatus (Stauffer)
Polycaulodus bidentatus Branson and Mehl
Polycaulodus sp.
Polyplacognathus sp.
Stereoconus robustus ? Branson and Mehl

Gl-2-68

species indicated above with + plus the following:

Panderodus compressus (Branson and Mehl)
Phragmodus sp.

Pl-29-68

species indicated above with + plus the following:

Phragmodus cognitus ? Stauffer
Phragmodus inversus Webers

Platteville Formation

Robert F. Atkinson

Introduction

This study of the Platteville Formation conodont fauna was undertaken in an attempt to recognize a biostratigraphic zonation of the Platteville using conodont occurrences and to interpret this fauna in relationship with those of the underlying and overlying formations. Two hundred forty-four samples were collected from fifteen localities (Figure 5) in the southwestern and east-central portions of Wisconsin, including a well core from an oil test drilled in Sheboygan County.

Acknowledgments

I want to thank Dr. David L. Clark of the University of Wisconsin for stimulating my interest in micropaleontology and for aid in compiling this manuscript. Dr. Meredith E. Ostrom, associate state geologist for the state of Wisconsin, aided by locating exposures and by procuring the Oostburg drill core. Mr. Perry Olcott, also with the Wisconsin Geological Survey, gave additional information concerning outcrops in eastern central Wisconsin. Dr. Raymond Ethington, University of Missouri, gave invaluable assistance by checking some identifications and providing type specimens for comparison. Finally, I want to thank my wife, Judy, for extensive help in this work.

Procedure

Two hundred to three hundred grams of each sample were disaggregated in 15 percent glacial acetic acid. Shale samples were treated in various ways. Some of the shales completely disaggregated with only one soaking in either kerosene or Stoddard Solvent. For others this procedure had to be repeated several times, along with boiling in sodium bicarbonate. Others responded to hydrogen peroxide treatment and one particularly stubborn shale was finally partially disaggregated by several repetitions of freezing and thawing.

The residues were washed and sieved on a 14 mesh (0.141 mm) and a 120 mesh (0.125 mm) screen. The fine fraction was collected and dried then processed in tetrabromoethane (acetylene tetrabromide) which was slightly diluted with kerosene to ensure more complete separation of the conodonts. The conodont-bearing heavy fraction was drained away and washed with acetone, dried, then spread on a microfossil picking tray.

Platteville Conodont Localities

Fifteen localities were sampled during the summer and fall of 1965. Sampling was restricted to Wisconsin localities. Locality 14 is a drill core. (Stored in the geology building of the University of Wisconsin-Milwaukee). Locality 1, which is described in detail by Agnew and others (1956), was used as a reference section. Locality 15, a sequence of shale and dolomite of unknown affinities, was sampled to determine if it was Platteville age. Conodonts suggest that it must be younger than Platteville. Localities are shown in Figure 5.

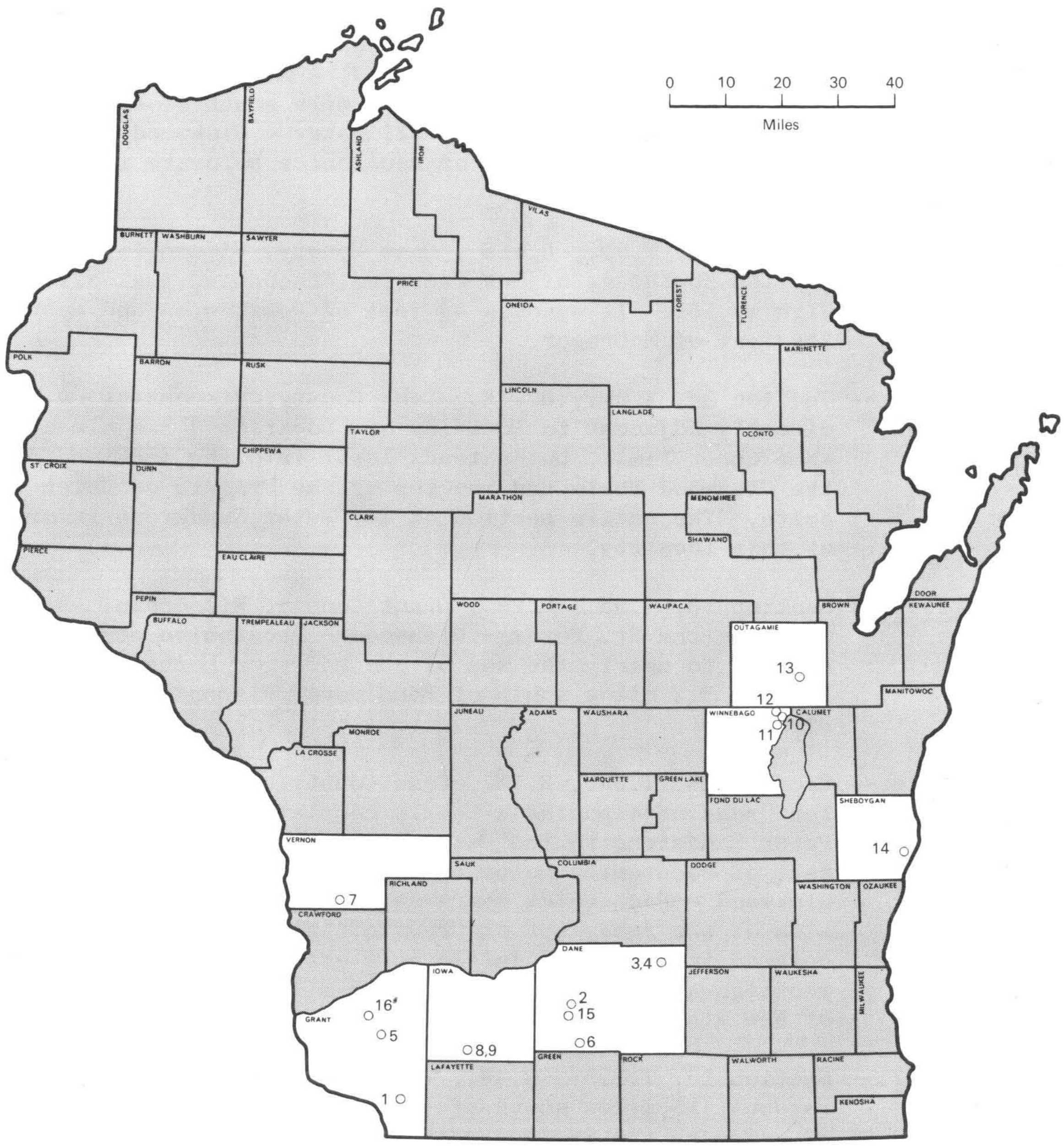


Figure 5. Platteville localities in Wisconsin

Locality 1.-- Section 12, T.2N., R.2W., Grant County, Wisconsin. A roadcut along U.S. Highway 151, 6.2 miles southwest of the intersection of Highway 151 and 81, south of Platteville, Wisconsin, exposes a nearly complete section of Platteville. The section ranges from the St. Peter - Glenwood - Pecatonica contacts at the base to the Quimbys Mill, the uppermost member of the Platteville.

Locality 2.-- Section 34, T.7N., R.7E, Dane County, Wisconsin. A very small roadcut on County Highway J, $\frac{1}{2}$ mile west of the intersection with County Highway P, $\frac{1}{2}$ mile south of the town of Pine Bluff. It exposes the St. Peter - Glenwood - Pecatonica contacts. Only two feet of Pecatonica Dolomite is present at this location.

Locality 3.-- Section 34, T.9N., R.11E., Dane County, Wisconsin. A quarry 2 miles northeast of Sun Prairie, Wisconsin, just off U. S. Highway 151. It exposes $4\frac{1}{2}$ feet of Pecatonica and approximately $25\frac{1}{2}$ feet of McGregor.

Locality 4.-- Section 34, T.9N., R.11E., Dane County, Wisconsin. A quarry directly adjacent to location 3. Location 4 has almost the same upper limit, but extends lower into the section, exposing the Glenwood Shale and the top of the Prairie du Chien Dolomite. The entire section of St. Peter Sandstone is missing at this locality.

Locality 5.-- Section 18, T.5N., R.2W., Grant County, Wisconsin. A roadcut exposing the St. Peter - Glenwood - Pecatonica contacts, and extends to nearly the top of the McGregor Member. It is located 5.2 miles south of Fennimore, Wisconsin, on U. S. Highway 61.

Locality 6.-- Section 36, T.5N., R.7E., Dane County, Wisconsin. An excellent roadcut exposing a nearly complete section from the St. Peter Sandstone to the Galena Dolomite. Approximately 11 feet of Pecatonica Dolomite is covered. The St. Peter - Glenwood - Pecatonica contacts are exposed only on the south side of the road, but the rest of the section (above the covered interval) is fairly well exposed on both sides of the highway. This section is 3.5 miles north of the town of New Glarus, on Wisconsin Highway 69.

Locality 7.-- Section 16, T.12N., R.4W., Vernon County, Wisconsin. A small roadcut, 15 miles south of Viroqua, on Wisconsin Highway 27-82, exposes the St. Peter - Glenwood - Pecatonica contacts. Only the basal four feet of the Pecatonica Member is present.

Locality 8.-- Section 15, T.4N., R.2E., Iowa County, Wisconsin. The St. Peter - Glenwood - Pecatonica contacts are exposed in a roadcut 3.6 miles southwest of Mineral Point, on U.S. Highway 151. The section ranges upward into the very basal portion of the McGregor Member.

Locality 9.-- Section 15, T.4N., R.2E., Iowa County, Wisconsin. A roadcut across the valley from location 8. It is 2.9 miles southwest of Mineral Point on U.S. Highway 151. The top part of the Pecatonica is exposed at the base of this section, which extends up into the Decorah.

Locality 10.--Section 11, T.20N., R.17E., Winnebago County, Wisconsin. A large quarry exposing upper Platteville and Decorah rocks. It is located on Wisconsin Highway 47 at the northern city limits of the town of Menasha, on property owned by Badger Highways Company, Inc. All measurements were made from the base of the Decorah downward to nearly 29 feet into the Platteville. Since the lithologies are considerably different in this area, the identity of the members is uncertain.

Locality 11.--Section 29, T.20N., R.17E., Winnebago County, Wisconsin. This locality, the Courtney - Plummer Quarry, is west of the town of Neenah. The quarry is located on Tullar Road, .2 mile north of Wisconsin Highway 114. Tullar Road crosses Highway 114, .4 mile west of the U.S. Highway 41 underpass. The upper portion of the Pecatonica and much of the McGregor is exposed in this quarry.

Locality 12.--Section 5, T.20N., R.17E., Winnebago County, Wisconsin. approximately nine feet of the bottom portion of the Pecatonica is exposed in a small quarry. It is located .2 mile south of County Highway BB, 1.3 miles west of the Highway 41 underpass. The quarry is not visible from the road.

Locality 13.--Section 21, T.22N., R.18E., Outagamie County, Wisconsin. Entrance to this quarry is made from County Highway C, .8 mile north of the end of County Highway 9, about 3½ miles east of Wisconsin Highway 47. The quarry is .2 mile east of Highway C. The Prairie du Chien - Glenwood - Pecatonica contacts are exposed here, with slightly over eight feet of Pecatonica present. The entire section of St. Peter Sandstone is missing.

Locality 14.--Section 12, T.13N., R.22E., Sheboygan County, Wisconsin. This is the drill core from the Oostburg area. The entire section of Platteville rock is contained in the core.

Locality 15.--Section 9, T.6N., R.7E., Dane County, Wisconsin. This is a small roadcut .2 mile north of U. S. Highways 18-151, on County Highway P. The exact age of this sequence of shales and dolomites has not been determined. As stated before, it is assumed not to be Platteville age on the basis of conodonts.

Locality 16.--Section 22, T.6N., R.3W., Grant County, Wisconsin. This roadcut exposes the section from the Glenwood to the Decorah. Samples were taken only from the upper part of the McGregor to the base of the Decorah, however. This was to compensate for the missing portion of section which could not be collected at locality 5. Locality 16 is 3.1 miles west of Fennimore on U. S. Highway 18.

Stratigraphy

The Platteville Formation was originally called the "Platteville limestone" by Bain (1905) after the town of Platteville, Wisconsin, near which the "formation is typically exposed." In his report Bain included everything between the top of the St. Peter Sandstone and the base of the Galena Dolomite as belonging to the "Platteville limestone." In his generalized section of the Platteville, Bain listed four main units (p. 19):

4.	Thin beds of limestone and shale	10'-20'
3.	Thin-bedded brittle limestone, breaking with a conchoidal fracture	25'-30'
2.	Buff to blue magnesian limestone, heavy bedded, frequently a dolomite	20'-25'
1.	Shale, blue	1'-5'

Calvin (1906), working in the state of Iowa, renamed two of Bain's units. Bain's number 4 unit was renamed the Decorah Shale. The number 1 unit was called the Glenwood Shale, which is fifteen feet thick at the type locality. Calvin (1906, p. 76) stated that the Glenwood "should probably be divided into two parts, the upper to be classified as Platteville, the lower as Saint Peter." Since that time the Glenwood has been considered to be the basal unit of the Platteville. Most recent workers, however, separate it from the Platteville, and include it with the St. Peter (Swann and Willman, 1961; Ostrom, 1967). Ostrom (1969) has proposed that the Platteville be considered the basal member of the Sinnipee Group.

In Wisconsin, the Platteville currently is divided into three members. They are, in ascending order, the Pecatonica Dolomite Member, the McGregor Limestone Member, and the Quimbys Mill Member. The Pecatonica was named in 1897 by Hershey from exposures in the Pecatonica River Valley in southwestern Green County, Wisconsin; the McGregor, named by Kay in 1935 from exposures near the town of McGregor, Iowa; and the Quimbys Mill, named by Agnew and Heyl in 1946 from exposures in a quarry near Quimbys Mill, 5 miles west of Shullsburg, Wisconsin. A good review of these members and their history in literature is given in Agnew and others (1956, p.269). The section described by Agnew and others (1956) was used as a reference section. It appears as my locality 1.

The Quimbys Mill, as it appears in this described section, differs in color from the other sections of Quimbys Mill collected. At all other locations it is a light-gray limestone. The rest of the described section is fairly representative of the Platteville as it is found in southwestern Wisconsin. The lithology in the Winnebago County area and the lithology of the Oostburg core are similar, but they differ somewhat from the lithology in southwestern Wisconsin. A description of the Oostburg Core is given here for comparison. The descriptions were made by the Texas-Wisconsin Exploration Corporation in an unpublished report.

DECORAH:	Thickness (feet)
Dolomite, with shale, green fossiliferous, shale occurs in stringers up to 0.2 feet thick	8.8

PLATTEVILLE: Thickness (feet)

Description	Thickness (feet)
Dolomite, very light buff, micro to cryptocrystalline, some large vugs and vertical fractures	21.1
Dolomite, as above, the presence of argillaceous material creates a mottling effect on the core	9.0
Dolomite as above, no argillaceous material	3.0
Dolomite as above, with some argillaceous material and a few fossil outlines	4.2
Dolomite as above, no argillaceous material	1.9
Dolomite, very light buff, micro to cryptocrystalline, tight, scattered to numerous dark gray shale streaks up to ½" thick	14.5
Dolomite, brown to dark brown, finely crystalline, tight, argillaceous material occurs as thin contorted bands	3.5
Dolomite, brown to dark brown, crypto to microcrystalline, tight, highly contorted bedding, with mud lumps	1.8
Dolomite as above, appears massive in core	2.1
Dolomite as above, highly contorted bedding with numerous small nodules, some tripolitic chert filled vugs	1.1
Dolomite as above, with numerous large (up to 0.5 mm) well rounded and frosted sand grains. Dolomite appears massive in core	0.9
Dolomite, as above, with increasing sand content finally grading into a sandstone at base. No bedding is apparent; there are, however, numerous nodules and lump structures, also two pyrite filled vugs and two pyrite healed vertical fractures. The contact with underlying sandstone is entirely gradational	1.1
Total, Platteville	64.2

ST PETER:

Description	Thickness (feet)
Sandstone, light buff to white, fine to medium grained, subangular, frosted, poorly sorted grains, friable	2.0

Multielement Species

The first "natural assemblage" of conodonts was described by Schmidt in 1934. Since that time other authors (e.g. Scott, 1942; DuBois, 1943; Rhodes, 1952) have described additional assemblages. These natural assemblages occur on pieces of shale, and are composed of 14 to 22 paired conodonts representing three to five form-species. Most contemporary students of conodonts agree that each assemblage represents a single biologic species, and that ultimately, conodont identification should and will be based on a multielement taxonomy. However, because natural assemblages preserved together are extremely rare, another method of grouping individual form-species into natural, biologic species had to be devised.

Müller (1956) suggested that a statistical study of a large population composed of a small number of form-species could separate natural assemblages from the various form-species. Four authors (Bergström and Sweet, Webers, and Schopf) worked on this method simultaneously, and their results were published in three reports in 1966.

In identifying conodont specimens for this report, I have adopted the multielement taxonomy utilized by Bergström and Sweet (1966) and Webers (1966). In order to properly recognize multielement (biologic) conodont species, large, systematically made faunal collections must be statistically analyzed. This has been done and based on extremely large faunas by others (e.g. Bergström and Sweet, 1966). Because I have a relatively small number of specimens ranging over a narrow interval of geologic time, no statistical analysis was attempted. Therefore, form-species were group into the multielement species recognized in the more detailed previous work.

It should be noted that Bergström and Sweet (1966), Webers (1966), and Schopf (1966) also recognized several biologic species that they considered to be composed of only one morphologic type. These are forms whose stratigraphic ranges are different from all other form-species. These forms, then, are not "multielement" species, but still are considered to be naturally occurring species and are described with the multielement species.

The naming of natural assemblages has been the cause of considerable debate in the past (see Webers, 1966, p. 6 & 7 for a concise review). Previous assemblages have been given a formal generic and specific name, as were each of the included form-species. This created a system of dual nomenclature in conodont taxonomy, which, according to Rhodes (1962), is illegal and unstable. To avoid the problem of having a dual nomenclature, Moore (1962) suggested informally identifying the constituent form-species by relating them to previously described species. The multielement species would then take on the name of the oldest described component. This is essentially what Webers (1966) and Bergström and Sweet (1966) have done.

Thirty-nine species, including seven multielement species, were identified and placed in 24 genera. Fifty-one form-species were recognized. In the table that follows, the correlation of "natural species" and their form-species has been listed.

Table 5

Form-species and assemblages of the Platteville

Form-species Name	Number of Specimens	Assemblage Name
Acontiodus alveolaris	25	Acontiodus alveolaris
Belodina compressa	954	Belodina compressa
Eobelodina fornicala	188	
Belodina dispansa	45	Belodina dispansa
Cyrtoniodus flexuosus	23	Cyrtoniodus flexuosus
Distacodus falcatus	93	Distacodus falcatus
Distacodus variabilis	69	Distacodus variabilis
Drepanodus suberectus	88	Drepanodus suberectus
D. homocurvatus	875	

Natural Species - Continued

Form-species Name	Number of Specimens	Assemblage Name
Oistodus inclinatus	247	
Oistodus venustus	100	Oistodus venustus
Oulodus primus	11	Oulodus serratus
Cordylodus serratus	13	
Ozarkodina concinna	18	Ozarkodina concinna
Panderodus arcuatus	170	Panderodus arcuatus
Panderodus gracilis	33	Panderodus gracilis
P. striatus	136	
P. compressus	223	
Panderodus panderi	146	Panderodus panderi
Phragmodus undatus	54	Phragmodus undatus
Oistodus abundans	80	
Dichognathus typica	97	
Dichognathus brevis		
Cordylodus aculeatus	158	Plectodina aculeata
Trichonodella recurva	96	
Zygognathus illustris	34	
Polyplacognathus ramosa	151	Polyplacognathus ramosa
P. bilobata	28	
Pravognathus idonea	13	Pravognathus idonea
Scyphiodus primus	13	Scyphiodus primus

Additional Form-species	Number of Specimens
Belodina sp. cf. B. inornata	18
Cardiodella tumidus	9
Chirognathus delicatula?	9
C. sp. cf. C. multidens	1
Curtognathus limitaris	2
C. typa	1
Distacodus? aff. D.? trigonius	1
Erismodus asymmetricus	14
E.? expansus	5
E. gracilis	10
E. symmetricus	7
Oistodus parallelus	17
Ozarkodina sp cf. O. typica	1
Polycaulodus bidentatus	27
P. inclinatus	6
Prioniodina polita?	37
Prioniodina? sp.	2
Scandodus sp. cf. S. sinuosus	2
Trucherognathus distorta	4
Zygognathus? sp. cf. Z.? abnormis	6

Biostratigraphy

Nearly 4,300 identifiable conodonts were recovered from 244 Platteville samples. Of these 244 samples, only seventeen contained no conodonts. A total of 59.25 kilograms of rock was completely dissolved by acid which results in a yield of one conodont per 13.9 grams of rock. When the weight of the barren samples is subtracted, a yield of one conodont per 12.9 grams results.

It became apparent after examining the contact between the Platteville and the Decorah that the form-species Phragmodus undatus showed a marked increase in percentage of specimens found in the Decorah samples. This phenomena was observed at every locality where the contact between the two formations was exposed (e.g., localities 6, 9, 10, 14, and 16). These relationships are shown in Table 6 below:

Table 6

Platteville Conodont Occurrences

Locality	Total number of specimens recovered		Total number of the form-species, Phragmodus undatus	
	Upper Platteville	Basal Decorah	Upper Platteville	Basal Decorah
6	100±	60±	4	16
9	12	37	1	9
10	8	50±	1	7
14	0	35	0	2
16	600±	57	9	12

At locality 9, the contact between the Platteville and the Decorah is gradational in the form of a fine to medium grained gray dolomite. It is my opinion that the relative occurrences of the form-species Phragmodus undatus may be used to establish the placement of the contact. It is interesting to note that the five samples of basal Decorah yielded 46 specimens of the form-species P. undatus, whereas all 244 Platteville samples yielded only 54 specimens of that species.

The occurrence of the form-species Phragmodus undatus was used to help solve another stratigraphic problem. Locality 15 is a small roadcut exposing a sequence of dolomite and shales of unknown affinities (see M.E. Ostrom, 1965). It is known to be Middle or Upper Ordovician on the bases of macrofossils, however, the problem lies in placing it in correct sequence in the Ordovician formations. This exposure occurs approximately ¼ mile south and approximately on the same level as a small outcrop of Pecatonica which is resting on top of a large roadcut of St. Peter Sandstone. The sixteen samples collected at this locality yielded approximately 1,500 excellently preserved conodonts of which the form-species Phragmodus undatus was clearly the most abundant individual form. The conodont fauna plus the nature of the outcrop itself are convincing evidence that this sequence is not Platteville and most likely is Decorah.

Another inconsistency in fossil distribution was observed when the results of this study were compared to those of Webers' Minnesota study (1966). He showed the species Oistodus venustus not extending above the top of the McGregor (before reappearing much later in the Galena Formation). In Wisconsin, this form ranges to the top of the Platteville. This could be an indication that the Platteville becomes younger in a westward direction.

Within the state of Wisconsin, this theory is supported by the distribution of Belodina dispansa. This form was not found at any locality in the northeast (i.e., localities 10, 11, 12, 13, and 14) but was abundantly represented at nearly all the southwest localities. Used in conjunction with the distribution of Oistodus venustus, this may indicate that most, if not all, of the Platteville section had been deposited in the northeast before Belodina dispansa made its appearance. Because Webers (1966) lumps B. dispansa with B. compressa, no information is available concerning the range of B. dispansa in Minnesota. Two other forms, Cyrtoniodus flexuosus and Soyphiodus primus were also missing from every northeast locality, but were sparingly represented (23 specimens and 13 specimens, respectively) in the southwest. Ecological differences could provide an explanation for these differences. However, other writers (Clark and Stearn, 1960, p. 68) have suggested that deposition during Platteville time was from the north--the Canadian Shield--and from the east--the Appalachian geosyncline which, if true, confirms the younger-to-the-west theory.

Summary

Nearly 4,300 identifiable conodonts were recovered from 244 samples at fifteen localities of the Middle Ordovician Platteville Formation in southwestern and east-central Wisconsin. The samples yielded 51 form-species which were grouped into 39 simgle or multielement species of 24 genera. The genera represented include Acontiodus, Amorphognathus?, Belodina, Cardiodella, Chirognathus, Curtognathus, Cyrtoniodus, Distacodus, Drepanodus, Erismodus, Oistodus, Oulodus, Ozarkodina, Panderodus, Phragmodus, Plectodina, Polycaulodus, Polyplacognathus, Pravognathus, Prioniodina, Scandodus, Scyphiodus, Trucherognathus, and Zygognathus(?).

The abundance of the form-species Phragmodus undatus in the Decorah was useful in differentiating that formation from the Platteville. An unidentified sequence of dolomite and shale at one locality suspected to belong with the Platteville Formation contained a P. undatus abundance and is assigned to the Decorah.

Four species (i.e., Scyphiodus primus, Oistodus venustus, Belodina dispansa, and Cyrtoniodus flexuosus) were either absent in eastern Wisconsin, or found to occur higher in the section to the east indicating that the Platteville is younger in the western part of the state.

Faunal lists for the Platteville

A faunal list of form-species recovered at each locality and recorded by member is given here. The names of the members have been abbreviated as follows: Pecatonica = Pec; McGregor = McG; Quimbys Mill = QM. Multi-element species are listed as being present, even though all the elements may not have been recovered. Numbers of specimens are given in descriptions.

Locality 1	Pec	McG	QM
Acontiodus alveolaris	X	X	
Belodina compressa	X	X	X
B. dispansa	X	X	X
B. sp. cf B. inornata		X	

Locality 1, continued	Pec	McG	QM
Cardiodella tumidus	X		
Curtognathus limitaris	X		
Cyrtoniodus flexuosus	X		
Distacodus falcatus	X	X	
D. variabilis	X	X	X
Drepanodus suberectus	X	X	X
Erismodus asymmetricus	X		
E. gracilis	X		
E. symmetricus	X		
Oistodus parallelus	X		
Ozarkodina concinna	X		
Panderodus arcuatus	X	X	X
P. gracilis	X	X	X
P. panderi	X	X	X
Phragmodus undatus	X	X	X
Plectodina aculeata	X	X	X
Polycaulodus bidentatus	X		
P. inclinatus	X	X	
Polyplacognathus ramosa	X	X	X
Pravognathus idonea		X	
Prioniodina polita?	X		
Prioniodina? sp.	X		
Scandodus sp cf. S. sinuosus	X	X	
Trucherognathus distorta	X		
Zygognathus? sp. cf. Z.? abnormis	X		

Locality 2 - Pecatonica Member only

Belodina compressa
B. dispansa
Cyrtoniodus flexuosus
Distacodus falcatus
D. variabilis
Drepanodus suberectus
Oistodus venustus
Panderodus arcuatus
P. gracilis
P. panderi
Phragmodus undatus
Plectodina aculeata

Locality 3	Pec	McG
Acontiodus alveolaris		X
Belodina compresa	X	X
B. dispansa	X	X
B. sp. cf. B. inornata		X
Distacodus falcatus		X
D. variabilis	X	X
Drepanodus suberectus	X	X
Erismodus asymmetricus		X
E.? expansus		X
E. symmetricus		X

Locality 3, continued	Pec	McG
Panderodus arcuatus	X	X
P. gracilis		X
P. panderi		X
Phragmodus undatus	X	X
Plectodina aculeata		X
Polycaulodus bidentatus	X	X
P. inclinatus		X
Polyplacognathus ramosa		X
Prioniodina polita?	X	X
Scandodus sp. cf. S. sinuosus	X	X

Locality 4 - Pecatonica Member only

Drepanodus suberectus
Erismodus symmetricus
Phragmodus undatus

Locality 5	Pec	McG
Acontiodus alveolaris	X	X
Belodina compressa	X	X
B. dispansa	X	X
B. sp. cf. B. inornata	X	X
Cardiodella tumidus	X	
Cyrtoniodus flexuosus	X	
Distacodus falcatus	X	X
D.? aff. D.? trigonius		X
D. variabilis	X	X
Drepanodus suberectus	X	X
Erismodus? expansus	X	
Oistodus parallelus	X	X
O. venustus	X	X
Panderodus arcuatus	X	X
P. gracilis	X	X
P. panderi	X	X
Phragmodus undatus	X	X
Plectodina aculeata	X	X
Polyplacognathus ramosa	X	X
Prioniodina polita?	X	X
Scandodus sp. cf. S. sinuosus	X	X
Scyphiodus primus		X
Zygognathus? sp. cf. Z.? abnormis	X	

Locality 6	Pec	McG	QM
Acontiodus alveolaris		X	
Belodina compressa	X	X	X
B. dispansa		X	
B. sp. cf. B. inornata		X	
Cardiodella tumidus	X		
Cyrtoniodus flexuosus	X		
Distacodus falcatus	X	X	
D. variabilis	X	X	
Drepanodus suberectus	X	X	X

Locality 6, continued	Pec	McG	QM
Erismodus? expansus	X	X	
E. gracilis	X	X	
E. symmetricus		X	
Oistodus parallelus	X		
O. venustus	X	X	
Oulodus serratus			X
Panderodus arcuatus	X	X	X
P. gracilis	X	X	X
P. panderi	X	X	
Phragmodus undatus	X	X	X
Plectodina aculeata	X	X	X
Polycaulodus bidentatus	X		X
Polyplacognathus ramosa		X	
Prioniodina polita?	X	X	
Scandodus sp. cf. S. sinuosus		X	
Zygognathus? sp. cf. Z.? abnormis			X

Locality 7 - Pecatonica Member only

Belodina compressa
B. dispansa
Drepanodus suberectus
Oistodus parallelus
Panderodus gracilis
P. panderi
Phragmodus undatus
Plectodina aculeata
Polyplacognathus ramosa
Prioniodina polita?

Locality 8	Pec	McG
Acontiodus alveolaris	X	
Amorphognathus? sp.	X	
Belodina compressa	X	X
Cardiodella tumidus	X	
Chirognathus delicatula?	X	
C. sp. cf. C. multidens	X	
Cyrtoniodus flexuosus	X	X
Distacodus falcatus	X	X
D.? aff. D.? trigonius	X	
D. variabilis	X	X
Drepanodus suberectus	X	X
Oistodus parallelus	X	
O. venustus	X	X
Oulodus serratus	X	
Ozarkodina concinna	X	
O. sp. cf. O. typica	X	
Panderodus arcuatus	X	X
P. gracilis	X	X
P. panderi	X	X
Phragmodus undatus	X	
Plectodina aculeata	X	

Locality 8, continued	Pec	McG
Polycaulodus bidentatus	X	
Polyplacognathus ramosa		X
Pravognathus idonea		X
Prioniodina polita?	X	
Prioniodina? sp.	X	
Scandodus sp. cf. S. sinuosus	X	
Scyphiodus primus	X	X

Locality 9	McG	QM
Acontiodus alveolaris	X	
Belodina compressa	X	X
B. dispansa	X	
B. sp. cf. B. inornata	X	
Cardiodella tumidus		X
Cyrtoniodus flexuosus		X
Distacodus falcatus	X	
D. variabilis	X	
Drepanodus suberectus	X	X
Erismodus asymmetricus	X	
E. gracilis		X
Oistodus parallelus		X
O. venustus	X	
Oulodus serratus	X	
Panderodus arcuatus	X	X
P. gracilis	X	X
P. panderi	X	
Phragmodus undatus	X	X
Plectodina aculeata	X	X
Polyplacognathus ramosa	X	X
Pravognathus idonea	X	X
Prioniodina polita?	X	X
Scyphiodus primus	X	X

Locality 10

No sharp lithologic break was observed at this locality. However, because 28 feet 9 inches of Platteville rock was sampled, the Quimbys Mill - McGregor contact must be present. At a point 8 feet 2 inches down from the Decorah contact there seems to be a faunal increase. This could be indicative of a short hiatus or a slight change of conditions. This level has been chosen arbitrarily as the Quimbys Mill - McGregor contact for the purpose of this faunal distribution chart.

	McG	QM
Belodina compressa	X	X
Drepanodus suberectus	X	X
Erismodus gracilis		X
Ozarkodina concinna		X
Panderodus gracilis		X
Phragmodus undatus	X	X
Plectodina aculeata	X	X

Locality 10, continued		McG	QM
Polycaulodus bidentatus		X	X
P. inclinatus		X	
Prioniodina polita?			X
Zygognathus? sp. cf. Z.? abnormis			X

Locality 11	Pec	McG
Belodina compressa	X	X
B. sp. cf.B. inornata		X
Curtognathus limitaris		X
Distacodus falcatus		X
Drepanodus suberectus	X	X
Erismodus asymmetricus		X
E. gracilis		X
E. symmetricus		X
Oistodus venustus		X
Ozarkodina concinna		X
Panderodus arcuatus		X
P. gracilis	X	X
P. panderi	X	X
Phragmodus undatus	X	X
Plectodina aculeata	X	X
Polycaulodus bidentatus		X
Prioniodina polita?	X	
Zygognathus? sp. cf. Z.? abnormis		X

Locality 12 - Pecatonica Member only

Belodina compressa
B. sp. cf. B. inornata
Cardiodella tumidus
Curtognathus typa
Distacodus variabilis
Drepanodus suberectus
Erismodus asymmetricus
E. gracilis
Ozarkodina concinna
Panderodus arcuatus
P. gracilis
Phragmodus undatus
Plectodina aculeata
Polycaulodus inclinatus
Prioniodina polita?
Trucherognathus distorta

Locality 13 - Pecatonica Member only

Belodina compressa
Drepanodus suberectus
Erismodus asymmetricus
Ozarkodina concinna
Plectodina aculeata
Prioniodina polita?
Scandodus sp. cf. S. sinuosus

Locality 14	Pec	McG	QM
Acontiodus alveolaris		X	
Belodina compressa	X	X	
B. sp. cf. B. inornata		X	
Distacodus falcatus		X	
Drepanodus suberectus	X	X	
Erismodus asymmetricus		X	
E.? expansus	X		
E. gracilis	X		
E. symmetricus		X	
Oistodus parallelus		X	
Panderodus arcuatus	X		
P. gracilis	X	X	
Phragmodus undatus	X	X	
Plectodina aculeata	X	X	
Polycaulodus bidentatus	X		
Polyplacognathus ramosa		X	
Prioniodina polita?		X	X
Trucherognathus distorta		X	

Locality 16	McG	QM
Acontiodus alveolaris	X	X
Belodina compressa	X	X
B. dispansa	X	X
B. sp. cf. B. inornata		X
Cyrtoniodus flexuosus		X
Distacodus falcatus	X	X
D. variabilis		X
Drepanodus suberectus	X	X
Oistodus venustus		X
Oulodus serratus		X
Panderodus arcuatus	X	X
P. gracilis	X	X
P. panderi		X
Phragmodus undatus	X	X
Plectodina aculeata	X	X
Polyplacognathus ramosa	X	X
Pravognathus idonea		X
Scandodus sp. cf. S. sinuosus		X
Scyphiodus primus		X
Trucherognathus distorta		X

Decorah Formation

David L. Clark and Laurel C. Babcock

Above the Platteville is the Decorah Formation, named for exposures around Decorah, Iowa, by Calvin (1906). The Decorah is divided into three members. The lowest is the Spechts Ferry, ranging from 6.5 feet along the Mississippi River to only 1 foot at a site south of Madison on the Wisconsin Arch. It is composed of alternating thin beds of green shale and gray shelly limestone, highly fossiliferous. There are occasional thin (1 inch) bentonite beds. Above the Spechts Ferry is the Guttenberg Member, ranging from 16 feet to 9 feet between the Mississippi River and Madison, It consist of wavy thin-bedded light gray limestone, with a few green shale beds, and is quite fossiliferous. The topmost member is the Ion, a thick-bedded gray limestone, fossiliferous, though less so than the Spechts Ferry. Its thickness ranges from 20 feet to 16 feet, west to east. Although the carbonates in the Decorah are generally calcareous, they are dolomitic at Darlington and New Glarus, the two eastern-most exposures for this study.

The Decorah contains some of the earliest conodonts described and, consequently, some of the best known species. Stauffer (1930) first described Decorah conodonts from Minnesota and later (1932; 1935b) elaborated on details of the fauna. His descriptions included 70 species.

A total of 32 samples were taken from 6 exposures, 9 from the Spechts Ferry, 11 from the Guttenberg, and 12 from the Ion. The exposures cover a north-south range of 25 miles and an east-west range of 80 miles.

Localities at which Decorah material was collected (Figure 6) include the following:

Locality 1. Section 36, T.5N., R.7E., Roadcut on both sides of Highway 69, 3 miles north of New Glarus, all three members.

Locality 2. Section 29, T.4N., R.3W., Roadcut on east side of County Highway N, approximately 4 miles southwest of Lancaster. Here the Guttenburg and Ion Members were collected.

Locality 13. Section 7, T.5N., R.2W., Roadcut on both sides of Highway 61, 4 miles south of Fennimore. All members were sampled.

Locality 28. Section 34, T.3N., R.3E., Natural exposure behind trucking garage, east of Highway 23, in Darlington. The Guttenburg was sampled.

Locality 35 b. T.6N., R.3W., Roadcut on east side of Highway 340, 1 mile south of McGregor, Iowa. Spechts Ferry was sampled.

Locality 36. Section 6, T.92N., R.2W., Roadcut on west side of Highway 52, 1 mile north of Guttenberg, Iowa. All members sampled.

Samples were taken from highly fossiliferous beds. Most numerous conodonts were obtained from Guttenberg, Iowa, exposures. The Wisconsin section is more dolomitic and has fewer specimens. The most abundant species are Drepanodus homocurvatus Lindström and Ozarkodina concinna

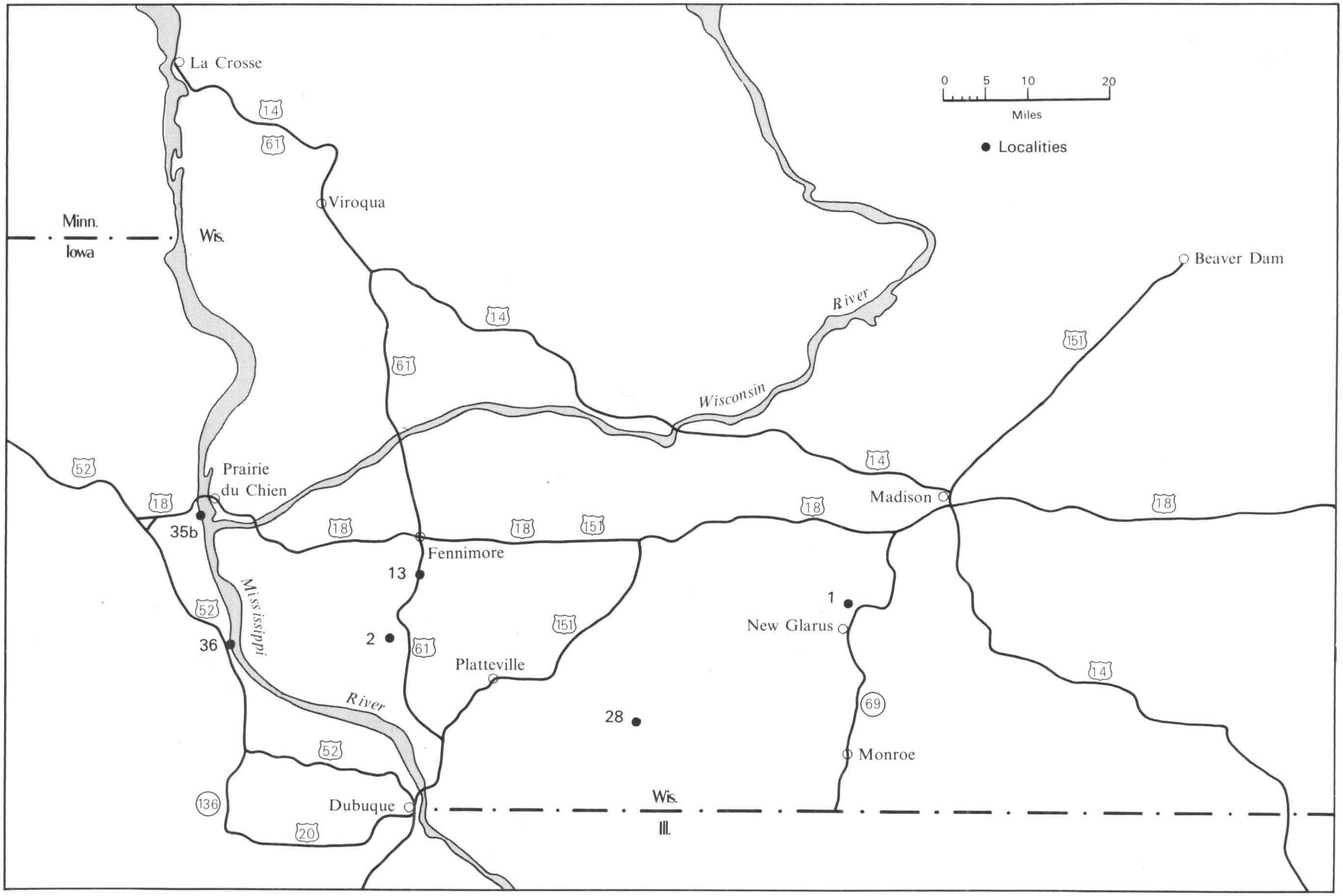


Figure 6. Decorah localities in Wisconsin

Stauffer in the Spechts Ferry; Phragmodus undatus Branson and Mehl in the Guttenburg; and Phragmodus undatus Branson and Mehl and Oistodus abundans Branson and Mehl in the Ion. A total of 17 genera were identified. Other microfossils noted include sponge spicules, crinoid fragments, brachiopods, gastropods, bivalves, ostracodes, and conularid fragments.

Webers (1966, p. 19) commented that "the Platteville and the Decorah Formations contain conodont faunas which are so similar in gross aspects that they might be considered a single fauna differing primarily in abundance of the separate species." Atkinson (this report) has confirmed this but has emphasized that abundance of certain species can lead to identification of partial sections whose identity may be in doubt.

Webers also indicated that three assemblage zones characterize the Decorah (Pravognathus idonea, Phragmodus undatus-Ozarkodina obliqua, Trichonodella recurva-Zygognathus illustris) and that all of these assemblages are present in the underlying Platteville, as well. Evidently, the most profound conodont change in the Glenwood, Platteville, Decorah, Galena sequence, occurs in the basal beds of the Galena.

The Decorah is the second member of the Sinnipee Group of Ostrom (1969) and is middle Champlainian (Trentonian) by North American standards.

Table 7

Conodonts of the Decorah

In the table that follows, the "natural species" name is followed in parenthesis by the form species that have been assigned to the natural taxon. Numbers indicate individual form species distribution.

	SF	Gut	Ion
Acodus mutatus (Branson and Mehl)			
(Distacodus procerus Ethington)	1		
Belodina compressa (Branson and Mehl)			
(Belodina compressa	5	22	56
Eobelodina fornicala)		1	7
Chirognathus invictus Stauffer?			1
Chirognathus sp.	2		4
Curtognathus chatfieldensis (Stauffer)			1
Cyrtoniodus flexuosus (Branson and Mehl)	39		
Cyrtoniodus serratus	2	3	1
Dichognathus variabilis Stauffer?		2	
Dichognathus sp.	9	17	5
Distacodus falcatus Stauffer		1	
Drepanodus suberectus (Branson and Mehl)			
(Drepanodus suberectus (Branson and Mehl)	7	1	12
Drepanodus homocurvatus Lindström	62	55	85
Oistodus inclinatus Branson and Mehl)	13	13	23
Oistodus venustus Stauffer			2
Oulodus primus (Stauffer)?	32	25	
Ozarkodina concinna Stauffer	67		10
Panderodus feulneri (Glenister)			1

Panderodus gracilis (Branson and Mehl)			
(Panderodus gracilis (Branson and Mehl)		1	22
Panderodus compressus (Branson and Mehl)	39	4	5
Panderodus intermedius (Branson and Mehl)		1	7
Panderodus panderi (Stauffer)	3		
Phragmodus undatus Branson and Mehl			
(Phragmodus undatus Branson and Mehl	38	251	173
Dichognathus brevis Branson and Mehl	15	48	12
Dichognathus typica Branson and Mehl		123	76
Oistodus abundans Branson and Mehl)		132	117
Plectodina aculeata (Stauffer)			
Cordylodus aculeatus (Stauffer)	39	28	15
Trichonodella recurva (Branson and Mehl)	45	15	1
Plectodina furcata (Hinde)			
(Cordylodus delicatus Branson and Mehl	45		19
Prioniodina delecta (Stauffer)	7	1	8
Trichonodella angulata Sweet and others)	1		3
Polyplacognathus ramosa Stauffer			
(Polyplacognathus ramosa Stauffer	3		67
(Polyplacognathus bilobata Schopf)	2		43
Prioniodina polita Stauffer ?	7	1	3
Prioniodina sp.			5
Tetraprioniodus breviconus Webers ?			2
Trichonodella sp.		1	
Zygognathus sp.			1

Galena Dolomite

David L. Clark and Laurel C. Babcock

The name Galena, taken from the city of Galena in northwestern Illinois, was used as a formation name by Hall (1851). Considerable paleontologic work has been accomplished on the Galena (e.g. Agnew and others, 1956) and a comprehensive study of Galena conodonts in Iowa has been published (Ethington, 1959).

The Galena Dolomite lies directly above the Decorah and the contact between the formations is gradational. The Galena has been subdivided in two ways; faunally into the Prosser, Stewartville and Dubuque, and lithologically into the Lower Cherty (including the lower two thirds of the Prosser) and the Upper Noncherty. Further subdivision on the basis of chert and Receptaculites is possible and the Lower Cherty has been divided into zones D, C, B and A.

The Galena has a fairly consistent thickness of approximately 225 feet in southwest Wisconsin. It is quite uniform in appearance, buff-colored, vuggy, thick-bedded dolomite. Exceptions to the uniformity are the thinner shaly beds in the upper 35 feet (comprising the Dubuque Member) and the cherts that occur only in the lowest 95 to 100 feet. The Lower Cherty unit is divided (in ascending order) into the D zone with no chert, and C zone with abundant chert, the B zone with little chert and abundant Receptaculites, and the A zone with both abundant chert and abundant Receptaculites (Agnew and others, 1956). These zones are about 10, 10, 15, and 70 feet thick, respectively. The Prosser averages approximately 140 feet, the Stewartville approximately 80 feet and the Dubuque, 35 to 45 feet.

Localities at which the Galena was sampled (Figure 7) are the following:

Locality 2. Same as locality 2 of Decorah section. Zone D was sampled.

Locality 3. Section 12, T.2N., R.2W., Roadcut on both sides of Highway 151 (Hoadley Hill), approximately 6 miles southwest of Platteville. Zones D and C were sampled.

Locality 23. Section 1, T.4N., R.1E., Roadcut on Highway 151, approximately 2 miles north of Belmont. Zone D was sampled.

Locality 24. T.29N., R.1E., Quarry on campus of Loras College, Dubuque, Iowa. The upper part of the Galena was sampled.

Locality 28. Same as locality 28 of Decorah section. Zone D was sampled.

Locality 30. Section 27, T.1N., R.1W., Roadcut on both sides of Highway 11, approximately 2 miles west of Hazel Green. Zones D and A were sampled.

Locality 31. Section 11, T.7N., R.5E., Quarry north of Highway 18-151, 1 mile east of Barneveld. Zones D and C were sampled.

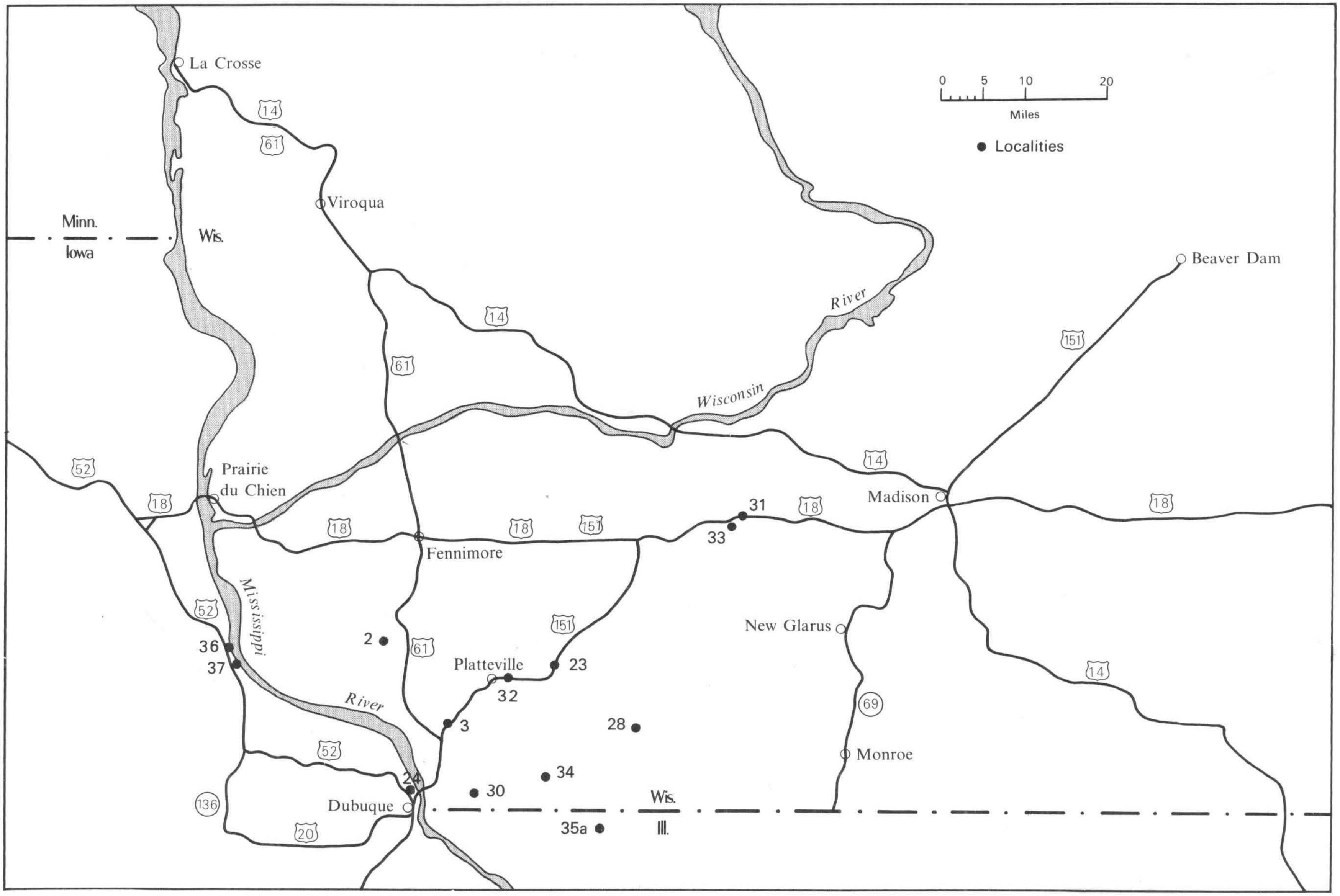


Figure 7. Galena localities in Wisconsin

Locality 32. Section 13, T.3N., R.1W., Quarry north of Highway 151, 1 mile east of Platteville. Zone B was sampled.

Locality 33. Section 11, T.7N., R.5E., Roadcut on north side of Highway 18-151, just west of locality 31. Zone B was sampled.

Locality 34. Section 10, T.1N., R.1E., Roadcut on north side of Highway 11, just east of Galena River, .5 miles west of Leadmine. Zone A was sampled.

Locality 35a. Section 26, T.29N., R.2E., Both sides of railroad cut; just west of Scales Mound, Illinois. Upper Galena sampled.

Locality 36. Same as locality 36 of Decorah section. Zones D, C, B and A sampled.

Locality 37. Section 20, T.92N., R.2W., Roadcut on west side of Highway 52, 1 mile south of Guttenberg, Iowa. Zone A and upper Galena sampled.

A total of 28 samples were collected from 13 sites as follows: 6 samples from the D zone, 4 from C, 4 from B, 5 from A, and 9 from the upper Noncherty (6 of these from the Dubuque Member).

The Galena is the upper formation of the Sinnipee Group of Ostrom (1969) and is upper Champlainian.

Ethington (1959) reported 48 species of 26 conodont genera from the Galena outcrops, primarily in Iowa. The Wisconsin Galena also provided a satisfactory number of conodonts in spite of the extreme dolomitization of most exposures. The fauna of 41 species is very similar to that reported in Iowa by Ethington. Those species present in Iowa (Ethington, 1959) and missing in Wisconsin are primarily from the topmost Dubuque Member. This member is not well exposed at the exposures sampled in Wisconsin. Two species are present in Wisconsin but not reported in Iowa from the lowermost D zone. Drepanodus suberectus (Branson and Mehl) and Polyplacognathus are common in the D zone, the former in C zone, Panderodus gracilis (Branson and Mehl) in the B and Z zones and Ozarkodina concinna Stauffer in the upper Noncherty. Another interesting note is that Polyplacognathus ramosa Stauffer, abundant in the Decorah and lowermost D zone, is sometimes confused with Amorphognathus ordovicica Branson and Mehl which is present only in the upper part of the Galena. Sweet and Bergström (1966) have suggested that Amorphognathus is a good Upper Ordovician index fossil. In Wisconsin, the Middle-Upper Ordovician boundary might be drawn at the base of the first occurrence of Amorphoganthus in the upper Galena.

Table 8

Conodonts of the Galena

In the listing that follows, the "natural species" name is followed in parenthesis by form species that have been assigned to the natural taxon. Numbers indicate individual form-species distribution.

	D	C	B	A	Upper
Acodus mutatus (Branson and Mehl)					
(Distacodus procerus Ethington)	3	1	1		8

	D	C	B	A	Upper
Acontiodus alveolaris Stauffer			1		1
Amorphognathus ordovicica Branson and Mehl					
(Amorphognathus ordovicica Branson and Mehl					23
Ambalodus triangularis Branson and Mehl)					8
Belodina compressa (Branson and Mehl)					
(Belodina compressa (Branson and Mehl)	27	1	1	3	10
Eobelodina fornicala (Stauffer)	2				
Chirognathus sp.	1				
Cyrtoniodus flexuosus (Branson and Mehl)	2	1	2	1	10
Distacodus falcatus Stauffer		2			1
Drepanodus suberectus (Branson and Mehl)					
(Drepanodus suberectus (Branson and Mehl)	7	2	2	1	4
Drepanodus homocurvatus Lindström	75	25	40	4	24
Oistodus inclinatus Branson and Mehl)	17	4	12	1	6
Falodus prodentatus (Gravel and Ellison)			2	1	
Icriodella superba Rhodes					
(Icriodella superba Rhodes					3
Sagittodontus dentatus Ethington					1
Sagittodontus robustus Rhodes)					2
Oistodus venustus Stauffer	1			1	1
Ozarkodina concinna Stauffer	5	1	11	9	35
Panderodus gracilis (Branson and Mehl)					
(Panderodus gracilis (Branson and Mehl)	32	11	30	4	26
Panderodus compressus (Branson and Mehl))	12	14	33	12	11
Panderodus feulneri (Glenister)	9			1	3
Panderodus intermedius (Branson and Mehl)	12	4	6	6	14
Panderodus panderi (Stauffer)	2				1
Periodon grandis (Ethington)	5				
Phragmodus undatus Branson and Mehl					
(Phragmodus undatus Branson and Mehl	34	21	1	1	
Dichognathus brevis Branson and Mehl	13	3	1		
Dichognathus typica Branson and Mehl	15	14			
Oistodus abundans Branson and Mehl)	29	19	8	3	1
Plectodina furcata (Hinde)					
(Prioniodina furcata (Hinde)		1	8	4	11
Triconodella angulata Sweet and others)				4	3
Scolopodus insculptus (Branson and Mehl)	3				5

Maquoketa Shale

George T. Froming

Introduction

The purpose of this study was twofold: to study the conodonts of the Maquoketa Formation from outcrops and drill core in Wisconsin, and to determine whether or not the Maquoketa Formation is time transgressive in an east-west direction. A complete Maquoketa section was collected in Iowa for comparative purposes with the various sections collected in Wisconsin.

Acknowledgments

This study was aided by a grant from the Wisconsin Alumni Research Foundation. Dr. Meredith E. Ostrom, associate state geologist for the state of Wisconsin, was instrumental in procuring the Oostburg drill core. Dr. David L. Clark of the University of Wisconsin verified the identifications and offered valuable advice. Figured specimens are in the Paleontology Repository, University of Wisconsin (UW).

Maquoketa Conodont Localities

During June of 1964, the writer sampled fifteen outcrops at localities in Iowa, Illinois and Wisconsin. Three localities were in Iowa, one locality in Illinois (six miles south of Shullsburg, Wisconsin), and eleven localities were in Wisconsin (Figure 8). Locality number four of Wisconsin is actually a drill core. Whenever possible, sections were chosen that had been previously described. Localities two and three were described and zoned in 1958 by Parker, Dorheim, and Campbell. Locality one was listed by the above authors in their 1959 publication, but the section was not described. The Wisconsin drill core of locality four was briefly described by the Texas-Wisconsin Exploration Corporation (unpublished report). All the remaining localities were tersely described in a publication by Cole, Hanson, and Westbrook (1961).

Locality 1.-- Section 16, T.96N., R.6W., The Cooney Quarry exposes the contact between the Dubuque Member of the Galena Formation and the overlying Elgin Member of the Maquoketa Formation. The quarry is located approximately three miles north of Postville, Iowa, on Highway 51.

Locality 2.-- Sections 8 and 9, T.95N., R.7W., The Elgin, Clermont, and Fort Atkinson Members are exposed at the Fitzgerald Creek section on the Lee Palmer farm. The farm is situated approximately four miles northwest of Clermont, Iowa.

Locality 3.-- Section 18, T.95N., R.8W., A continuous section of the Maquoketa beds from the upper portion of the Elgin to the overlying Silurian can be seen in a roadcut southwest of Eldorado, Iowa, along Highway 150. Samples were collected from all four members of the Maquoketa.

Locality 4.-- Section 12, T.13N., R.22E., The only complete section of the Maquoketa Formation in Wisconsin was obtained from a drill core taken in the Oostburg, Wisconsin area.

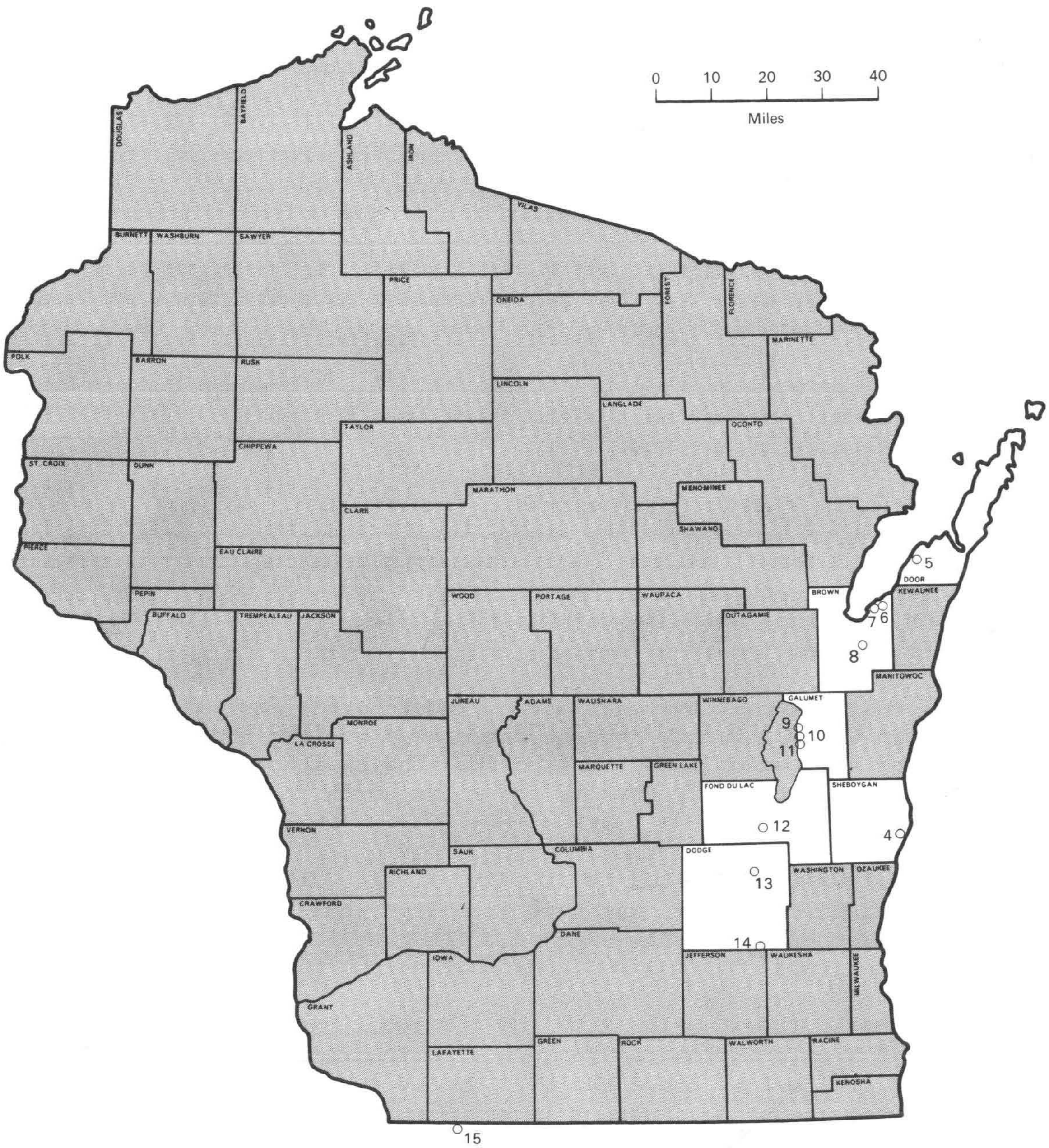


Figure 8. Maquoketa localities in Wisconsin

Locality 5.-- Section 26, T.27N., R.23E. Little Sturgeon--An outcrop of the Maquoketa can be seen at the water level of Green Bay and at a nearby roadcut in the Little Sturgeon Quadrangle. The twenty feet of shale that is exposed at this roadcut is 350 feet east of the Sugar Creek Park entrance on County Trunk N. The exposure cannot be correlated with the Oostburg core lithology.

Locality 6.-- Section 7, T.24N., R.22E., Wequiock Cascade--The contact between the Niagara Dolomite and the Brainard Member is exposed at Wequiock Cascade. This nineteen feet of Brainard Shale is at the Wayside Park along Highway 57, east of Wequiock.

Locality 7.-- Niagara Excarpment--Another exposure of the Brainard Member occurs downstream from the Wequiock Cascade locality (locality six). Thirty-six feet of dolomitic shales and dolomite are present.

Locality 8.-- Section 32, T.23N., R.21E., Kolb--Eight feet of the Brainard Member underlies the Neda Formation in a sink hole on County Trunk G, one-half mile west of the junction of the county roads V-G-M.

Locality 9.-- Section 11, T.10N., R.13E., Winnebago Quarry--In an abandoned shale quarry on the shores of Lake Winnebago, forty-five feet of Scales shale is exposed.

Locality 10.--Gulley Road--This locality is in the same section, township and range as is locality nine. Locality ten is several hundred feet southeast of locality nine. This outcrop is just below a house on a gully road leading to the beach. Assigning this exposure to a member in the Wisconsin section would be questionable. Ten feet of interbedded shales and dirty dolomites is present.

Locality 11.--T.19N., R.18E., Calumet County Park--Behind the boat launch in Calumet County Park on the shores of Lake Winnebago, a twenty-five foot section of shale is exposed. The shales belong to the Scales Member. Calumet County Park is two miles north, one and a quarter miles west of Stockbridge.

Locality 12.--Section 14, T.14N., R.16E., Oakfield--The Oakfield Shale, Brick, and Tile Company, operates an active shale pit. Forty feet of the Brainard Member is freshly exposed. The quarry is a mile southwest of the town of Oakfield.

Locality 13.--Section 8, T.13N., R.16E., Horicon--This outcrop is an eighth of a mile inside the Horicon Wildlife Refuge on the east-west marsh road. Eight feet of brown shale is poorly exposed in a drainage ditch. The outcrop cannot be assigned to any member of the Maquoketa Formation.

Locality 14.--Section 27, T.9N., R.16E., Sugar Island--Eight feet of brownish shale is exposed in a roadside cut. Access to this exposure is gained by traveling west through Sugar Island until one meets the first "left-hand" road. One turns left and then proceeds south for a seventh of a mile. The roadside cut is on the left. I was not able to determine the stratigraphic position of this exposure.

Locality 15.--Section 26, T.29N., R.2E., Scales Mound--Half a mile west of the railroad station at Scales Mound is a railroad cut which exposed the type section of the Scales Formation. Scales Mound is in Jo Daviess County, Illinois. Thirty feet of shale is present. In this report, I consider the Scales Formation to be synonymous with the Elgin and Clermont Members in Iowa. Hence, the name Scales Member is used for the Elgin and Claremont Members in Wisconsin. Therefore in Wisconsin the Maquoketa Formation consists of the Scales Member, the Fort Atkinson Member and the Brainard Member.

Stratigraphy

The first reference to rock now known as the Maquoketa Shale was in 1840 by John Locke in his report to David Dale Owen, who was in charge of exploring the mineral lands of the United States. The name "Maquoketa Shales" was proposed by C. A. White in 1870 for the shales which lie between the Galena dolomites and the Niagara "limestones" in the vicinity of Maquoketa, Iowa. The Maquoketa Formation is Late Ordovician.

The greatest amount of detailed work with the Maquoketa has been done in Iowa. Exposures of the formation in northeast Iowa have been studied by Savage (1964), Calvin (1906), Ladd (1926), Huffman (1941), Feulner (1953), Agnew (1955), Parker, Dorheim and Campbell (1959), among others. Calvin (1905) divided the Maquoketa Formation into distinct members which are in ascending order - the Elgin, the Clermont, the Fort Atkinson, and the Brainard. The type sections of these members are located in northeast Fayette County and southwest Winneshiek County, Iowa. Sections studied for this report are located in Figure 9.

A composite section of the Maquoketa Formation for northeast Iowa (Figure 10), i.e. a complete section comprised of partial sections from various localities, was described and zoned by Parker, Dorheim, and Campbell (1959).

In Wisconsin the Maquoketa Formation strikes north-south and dips to the southwest. The formation forms a long, narrow sinuous outcrop pattern which extends from the northeastern part of Wisconsin in the vicinity of Green Bay into Illinois. Isolated outcrops are present in southwestern Wisconsin.

In Wisconsin the only complete section of the Maquoketa Formation known is that obtained in a drill core which was taken at Oostburg, Wisconsin. This core is unique in that it represents the farthest eastward extent of the Maquoketa Formation. The core is described as follows:

BRAINARD MEMBER

7.	Shale, green, dolomitic, with numerous sand grains and dolomite partings, bedding massive sometimes contorted.	17.8'
6.	Dolomite, gray to pink, finely to very coarsely crystalline, appears in contorted layers with green dolomitic shale.	5.2'

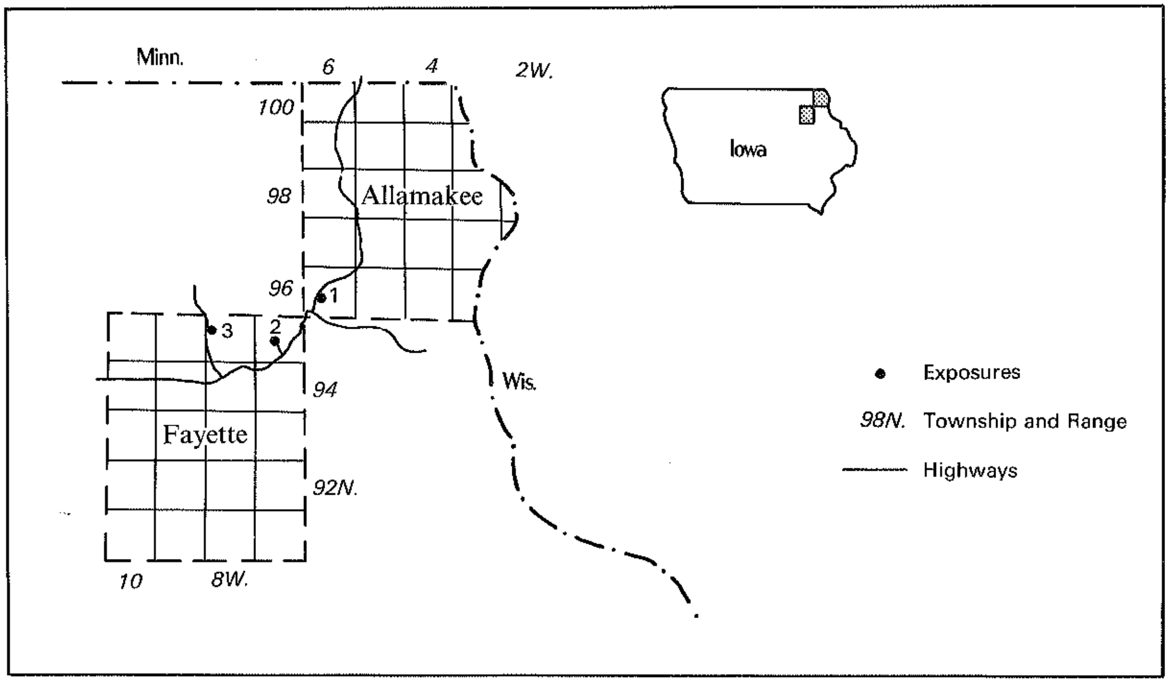


Figure 9. Maquoketa localities in Iowa

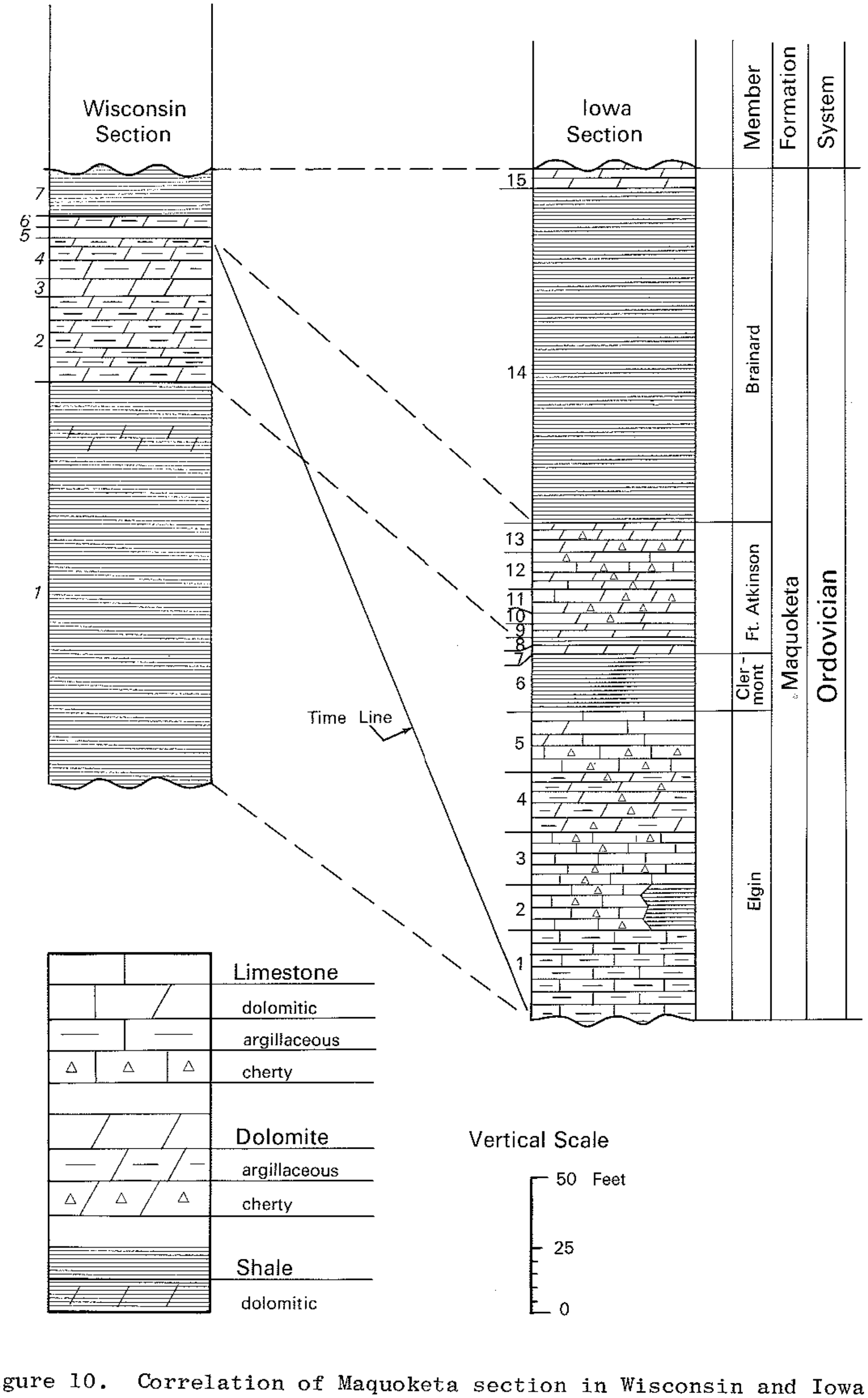


Figure 10. Correlation of Maquoketa section in Wisconsin and Iowa

5. Shale, green dolomitic, with brown dolomitic laminations, percentage of brown shale increases toward base. 2.8'

Total thickness Brainard Member 25.8'

FORT ATKINSON MEMBER

4. Dolomite, brown to dark brown, Finely to coarsely crystalline, argillaceous. 14.7'

3. Dolomite, gray to gray-brown, finely to coarsely crystalline, no argillaceous material. 5.9'

2. Dolomite, gray to brown, microcrystalline to coarsely crystalline, argillaceous, bryozoan fragments and thin algal banks noted. 31.2'

Total thickness Fort Atkinson Member 51.8'

SCALES MEMBER

1. Shale, ranging in color from a blue gray to a gray to a light green, fossiliferous dolomitic streaks present, blocky fracture. 150.9'

Total thickness Scales Member 150.9'

Total thickness Maquoketa Formation 228.5'

A well marked-erosional disconformity separates the Maquoketa Formation from the underlying Galena Formation. This disconformity is regional and it is more strongly developed to the south. Another erosional disconformity separates the Maquoketa from the overlying Silurian dolomite. DuBois (1945, p. 14) stated that the "wide-spread nature of this unconformity is further apparent from the isopach map of the Maquoketa Formation which shows what is interpreted as the irregular eroded upper surface of the formation, from the considerable variations in thickness, and from the fact that Silurian strata rest upon different zones in the Maquoketa within relatively limited areas."

The lithology of the Maquoketa is variable throughout Wisconsin but generally consists of shales and dolomites. In the mining district of southwestern Wisconsin, the Maquoketa is chiefly a blue or gray dolomitic silty shale with some grayish-buff, medium grained, sugary, argillaceous, thin-bedded dolomite. A "depauperate" fauna is present at some localities in the outcrop area. The fauna consists of forty-four species, none of which exceed a quarter of an inch in diameter. Pelecypods are the most abundant forms present. Pyrite and phosphatic pebbles are also present with the fauna. The two inch "depauperate" zone is overlain by thirty to forty feet of brown basal shale.

Agnew (1956, p. 300) reported that in the western, southern, and eastern portion of Wisconsin, dolomite is more abundant than the shale. This does not appear to be the situation, at least in the eastern Wisconsin core where seventy-five percent of the section is shale, and only twenty-five percent dolomite.

The lateral changes from dolomitic facies to argillaceous facies are prominent. Law (1941, pp. 9, 12) mentioned that in a north-south direction there is southward thinning of the Maquoketa due to loss of units at both the base and the top of the formation. The thickness is more or less consistent in an east-west direction. The thickness of the Iowa section is 311 feet; the total thickness of the Wisconsin core was 228.5 feet. These thicknesses do not correspond to Law's (1941) ideas that the Maquoketa thins to the south. The Iowa section is geographically situated 200 miles southwest of the Oostburg drill core.

Obviously, the relationship visualized by Law (1941) was over-simplified and new information (i.e., Oostburg core) indicates that the Maquoketa thins towards the northeast as well.

Exposures in the eastern section of the state are poor and sparse, and are generally found in quarries, fresh road-cuts, and drainage ditches. The exposures in the southwestern mining district are found on the high ground. The Maquoketa weathers rapidly to form covered slopes.

Table 9

Conodonts of the Maquoketa

	Total specimens
Amorphognathus ordovicica Branson and Mehl	
(Amorphognathus ordovicica Branson and Mehl	40
Ambalodus triangularis Branson and Mehl)	12
Belodina compressa (Branson and Mehl)	25
Belodus ornatus Branson and Mehl	25
Coelocerodontus trigonius Ethington	1
Drepanodus arcuatus Pander	3
Drepanodus concavus (Branson and Mehl)	50
Drepanodus suberectus (Branson and Mehl)	
(Drepanododus suberectus (Branson and Mehl)	25
Drepanodus homocurvatus Lindström	125
Oistodus inclinatus Branson and Mehl)	25
Ligonodina valma Rhodes	3
Oistodus parallelus Pander	4
Ozarkodina concinna Stauffer	35
Panderodus acostatus (Branson and Branson)	10
Panderodus feulneri (Glenister)	13
Panderodus gracilis (Branson and Mehl)	
(Panderodus gracilis (Branson and Mehl)	59
Panderodus compressus (Branson and Mehl))	2?
Panderodus intermedius (Branson, Mehl and Branson)	25
Panderodus panderi (Stauffer)	1
Phragmodus undatus Branson and Mehl	
(Phragmodus undatus Branson and Mehl	726
Dichognathus brevis Branson and Mehl	24
Dichognathus typica Branson and Mehl	75
Oistodus abundans Branson and Mehl)	5
Plectodina furcata (Hinde)	
(Cordylodus delicatus Branson and Mehl	35

Prioniodina furcata (Hinde)	9
Zygognathus mira (Branson and Mehl)	40
Trichonodella angulara Sweet and Others)	70
Tetraprioniodus delicatus (Branson and Mehl)	4

To determine whether or not the Maquoketa Formation is time transgressive in an east-west direction the precise stratigraphic position of the conodont species were studied in both the Iowa section and the Wisconsin section. Glenister's (1957) report was used to compliment the conodont ranges determined in this study.

Ten form-species (Figure 11) indicate that the Maquoketa Formation becomes younger in the west. In Iowa these ten species first occur at the base of the Elgin Member while in Wisconsin these same ten species first occur in the upper Scales, Fort Atkinson and Brainard Members. Ambalodus sp. aff. A. triangularis has been reported to exist only in the basal phosphatic member of the Maquoketa (Glenister, 1957). In the Wisconsin core, Ambalodus triangularis first occurs in the upper Scales Member. An Amorphognathus was found in the upper Fort Atkinson of Wisconsin but in Iowa it occurs only in the basal phosphatic member of the formation (Glenister, 1957). Triconodella angulara is restricted to the Elgin of Iowa. In Wisconsin it makes its first appearance in uppermost Scales time and continues through the rest of the Maquoketa period. Two drepanodids, Drepanodus concavus and D. suberectus, are present only in Elgin and Clermont strata in Iowa. In Wisconsin, D. concavas first occurs in the Fort Atkinson Member and D. suberectus occurs in the Scales Member but the latter persists even in the upper part of the Fort Atkinson, while the former is present in the Brainard. Belodus ornatus, Drepanodus homocurvatus, and Ozarkodina concinna - all of Iowa, have identical ranges. They range from the base of the Elgin to the top of the Fort Atkinson. In Wisconsin, B. ornatus ranges from upper Fort Atkinson to upper Brainard; D. homocurvatus from middle Scales to upper Brainard and; O. concinna from lower Fort Atkinson to upper Brainard. Two panderodids conclude the list of stratigraphically important conodonts. They are Panderodus gracills and P. intermedius. In Iowa they both occur in all the members of the Maquoketa Formation. In Wisconsin, P. gracilis first occurs in upper Fort Atkinson strata and exists through Brainard time while P. intermedius is only present in the upper Brainard.

It may be concluded from this evidence that any given lithologic unit of the Maquoketa Formation in Wisconsin is older than is the equivalent lithologic unit in the Maquoketa Formation in Iowa. The Maquoketa seas, therefore, are believed to have invaded Iowa from the northeast. This belief is substantiated by Ladd's work (1928).

Summary

Well preserved conodonts are present in the Maquoketa Formation in Iowa and Wisconsin. 1,471 specimens were recovered from 23 kg of crushed rock. The Maquoketa Formation in Wisconsin consists of three members which are in ascending order - Scales, Fort Atkinson, and Brainard. Fifteen localities were sampled and studied. The fauna consists of 28 form-species of 12 genera.

The occurrence of several species (e.g. Ambolodus sp. aff. A. tri-

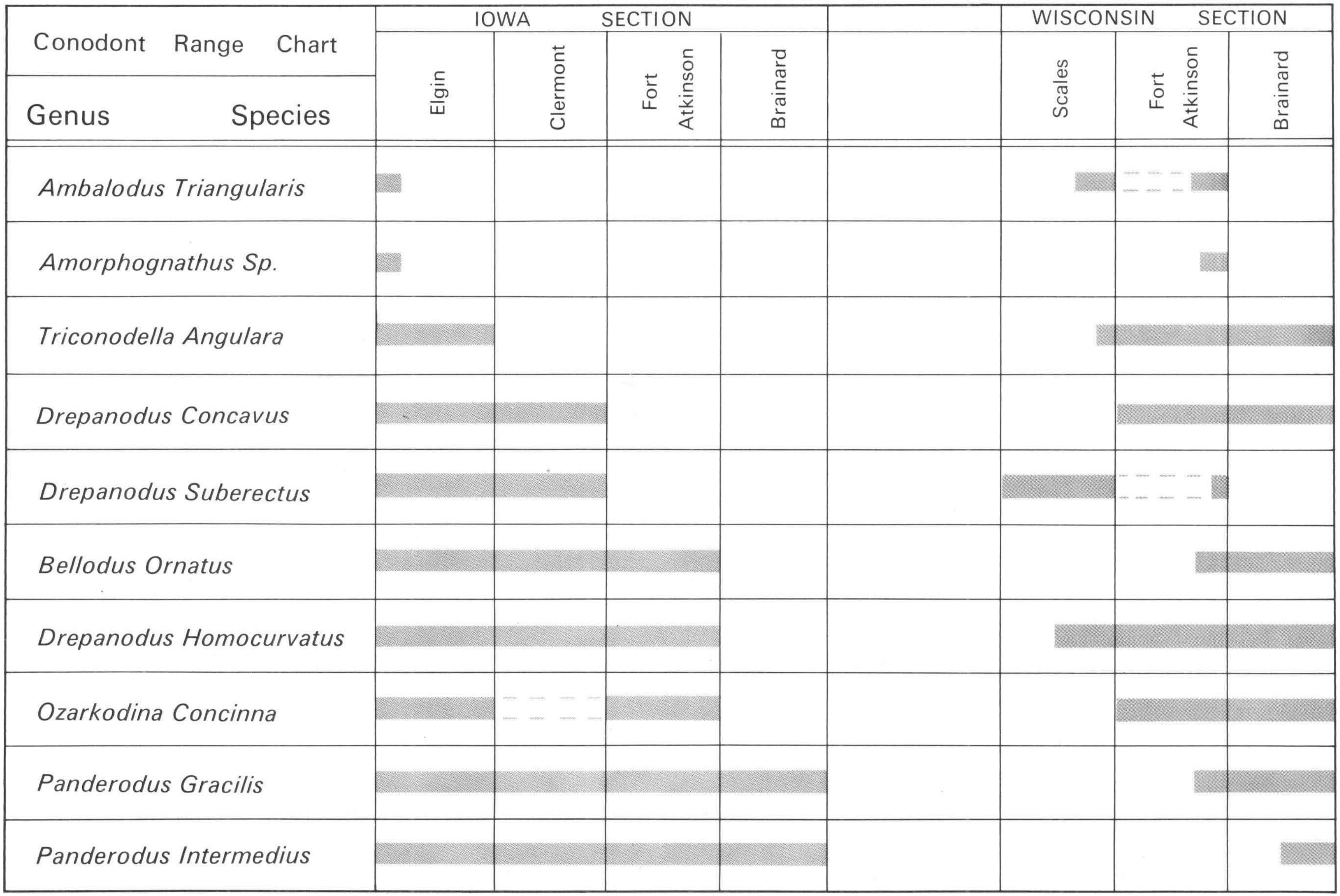


Figure 11. Range of conodont form-species in the Maquoketa of Wisconsin and Iowa

angularis and *Amorphognathus* sp.) which occur at the base of the Maquoketa in Iowa but in the Fort Atkinson Member in Wisconsin indicate that the Maquoketa seas moved into this part of the mid-continent from the northeast. Thus the lithologic units of the Maquoketa have different ages across Wisconsin and each member is younger in the western part of the state than in the eastern part.

SILURIAN FORMATIONS

David L. Clark

Most of the Silurian in Wisconsin occurs in a strip along the eastern border of the state from northern Illinois north through the Door Peninsula. The oldest formation is the Mayville which consists of dolomite and is Early Silurian (Shrock, 1939, p. 535-540). The overlying Burnt Bluff, Manistique, Racine and Waubakee Formations are dolomitic as well, and, in part, reefoid. Chamberlin (1877, p. 372-377) studied the reefoid parts of the Silurian and Shrock (1939) published important interpretations of these rocks.

The dolomitic lithology appears very unfavorable as a matrix for preservations of microfossils but samples were collected from five localities as follows:

Locality 1. Section 1, T.12N., R.16E., Quarry on Highway 33, one half mile east of intersection with Highway 67, east of Horicon. Samples taken from 1 to 54 feet above lowest exposure of Byron Member of the Burnt Bluff Formation.

Locality 2. Section 9, T.14N., R.17E., Fond du Lac Stone Company quarry, 1 mile west of Highway 41 on County Trunk B, 5 miles south of Fond du Lac. Samples taken from the Mayville-Byron contact through the quarry.

Locality 3. Section 5, T.20N., R.22E., Quarry 1/4 mile southwest of Grimms, Highway 10, 3 miles east of Reedsville. Manistique Formation, Cordell Member sampled here from bottom to top of quarry and in various ecologic settings of reef.

Locality 4. Section 23, T.11N., R.21E., Private road that crosses river on right side of Highway 57, 1/4 mile before Highway 57 and railroad track separation, Northeast of Saukville. 25 feet of Waubakee was sampled.

Locality 5. T.7N., R.21E., Schoonmaker Quarry, State and 68th Street, Wauwatosa. Racine Formation sampled through 25 feet.

Samples were collected from those parts of the different formations that appeared most likely to contain microfossils. Less than a dozen fragments of distacodontids were recovered. The best specimens were recovered from the Manistique Formation at Locality 3. An interesting ecologic note is that these specimens were obtained from an upright and in place <u>Halysites</u> head on the flank of the reef mass exposed in this quarry. Samples from shale pockets in the reef and from non-reef parts of the exposure did not yield specimens. Too few specimens were obtained to conclude little other than the association of <u>in situ</u> corals and conodonts is confirmed.

Less has been learned concerning the Silurian dolomites and their conodont biostratigraphy than has been learned concerning any other part of the Wisconsin Paleozoic. The problems are formidable but the detail known concerning Silurian conodonts in Europe (Walliser, 1964) and in North America (e. g. Rexroad, 1967) is impressive and would support the suggestion that the Wisconsin Silurian may yield significant faunas with biostratigraphic value to the patient investigator.

All specimens recovered appear to be referrable to the distacodontid *Panderodus*. Specific determination has not been possible.

DEVONIAN BIOSTRATIGRAPHY

The Wisconsin Devonian is restricted to isolated outcrops along Lake Michigan just in and north of Milwaukee. The Devonian section consists of several formations of varied lithology. No Lower Devonian has been identified.

Conodonts from the Middle Devonian Lake Church and Milwaukee Formations

Dietmar Schumacher

Introduction

Devonian strata were first recognized in Wisconsin in 1860 when Lapham reported rocks near Milwaukee containing the remains of fishes. Hall (1861; 1862) verified the Devonian age of these strata and correlated them with the Hamilton of New York. Whitfield (1882) first described a fauna from beds now assigned to the Milwaukee Formation. Monroe (1900) was the first to recognize a Devonian fauna in strata now referred to the Lake Church Formation. Alden (1906) formally named the Milwaukee Formation and designated the section along the Milwaukee River in Estabrook Park as its type locality. Raasch (1935) re-examined the Devonian rocks of Wisconsin and divided the section into three formations (Figure 12). These are in ascending order the Lake Church, Thiensville, and Milwaukee Formations. Their outcrop area is confined to a narrow band along Lake Michigan between Milwaukee and Sheboygan. Owing to a thick covering of glacial drift, there are few natural exposures.

Some uncertainty presently exists regarding the placement of the Lake Church, Thiensville, and Milwaukee Formations within the Middle Devonian. The megafauna of these units is still inadequately known because only a few detailed paleontologic investigations have been conducted (Cleland, 1911; Pohl, 1929; Griesemer, 1965). Because conodonts previously have not been described or reported from these strata, it was hoped that this study would permit improved correlation of Wisconsin's Middle Devonian with that of nearby states.

I am indebted to Dr. David L. Clark of the University of Wisconsin for serving as my thesis advisor and offering many helpful suggestions. Thanks are also extended to Dr. Gilbert Klapper, University of Iowa, and Dr. Raymond Ethington, University of Missouri, for their helpful discussions with the writer concerning taxonomic and stratigraphic matters. This study was supported in part by the Research Committee of the Graduate School at the University of Wisconsin from funds supplied by the Wisconsin Alumni Research Foundation.

Previous Work

Although Upper Devonian conodont faunas have been studied in considerable detail, comparatively little serious attention has been given to Middle Devonian faunas until recently. Stauffer (1938) described Middle Devonian conodonts from the Olentangy Shale of Ohio. Branson and Mehl, in the same year, investigated the conodont genus *Icriodus* and discussed its stratigraphic distribution in the Middle Devonian. Stauffer (1940) and

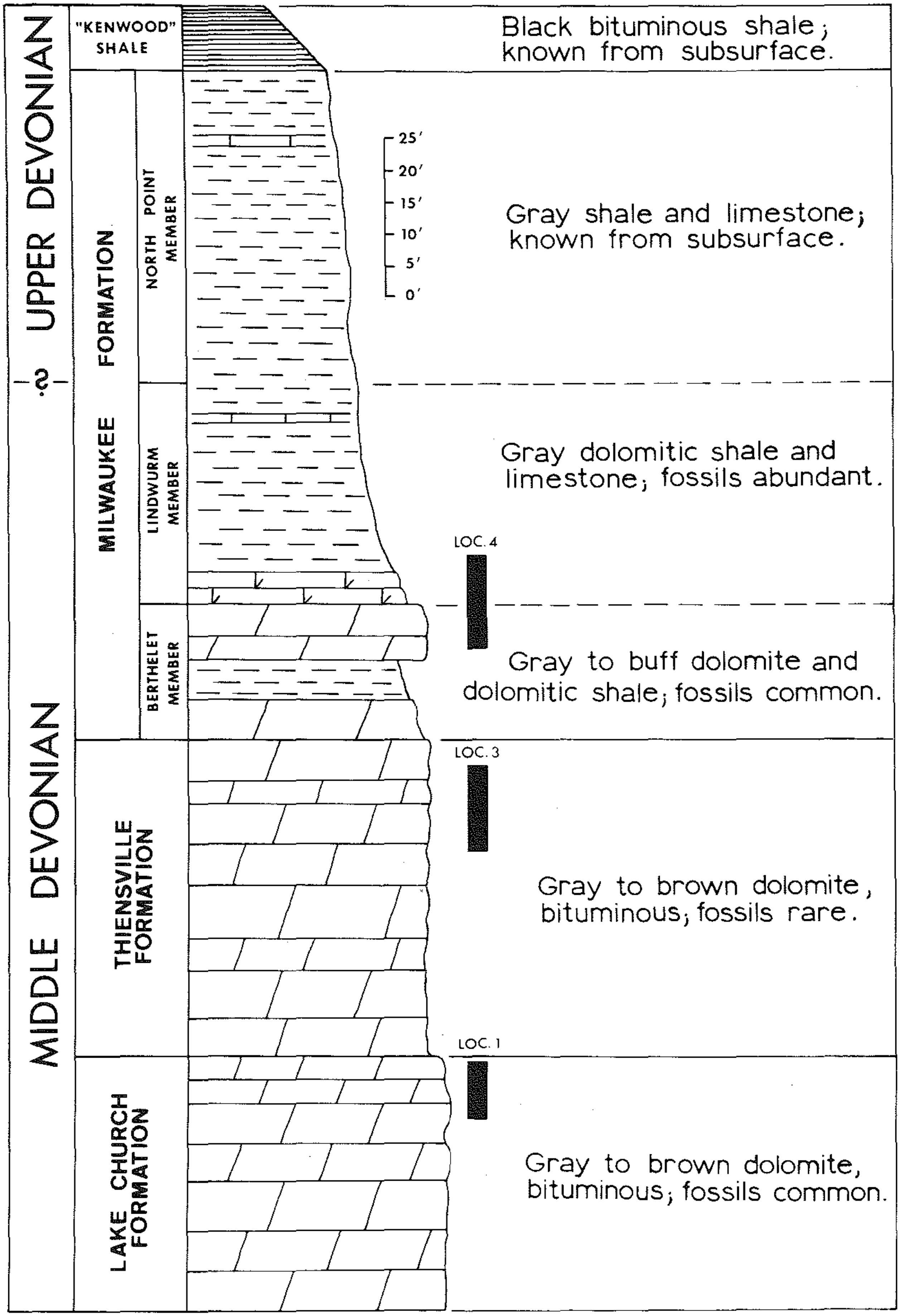


Figure 12. Columnar section of the Devonian of Wisconsin

Downs and Youngquist (1950) described conodonts from the Cedar Valley Limestone of Minnesota and Iowa, respectively. Stewart and Sweet (1956) described a small conodont fauna from several Middle Devonian "bone-beds" in Ohio. Most of these early investigations were purely descriptive in nature and placed little emphasis on the possible biostratigraphic significance of these faunas. It is only with the research of the last dozen years that the biostratigraphic value of conodonts has become recognized and utilized.

Much of the renewed interest in Middle Devonian conodont faunas is attributable to the efforts of Bischoff and Ziegler (1957) who described the succession of conodonts from the Middle Devonian of West Germany and established a preliminary zonation. Orr (1964) described conodonts from the Lingle and Alto Formations of southern Illinois and discussed their correlation with the succession described by Bischoff and Ziegler. Wittekindt (1965) established a more detailed zonation for the German Middle Devonian and recognized seven conodont assemblage zones. Ziegler (1958, 1965) Krebs (1959), and Orr and Klapper (1968) discussed the conodont faunas of the Middle Devonian-Upper Devonian boundary beds in greater detail and refined the pre-existing zonation. Most recently, Klapper and others (1970) have summarized the existing knowledge of Devonian conodont biostratigraphy in North America and discussed similarities and discrepancies with the established conodont zonation of Europe.

Biostratigraphy

Klapper and others (1970) recognized and described eight informal Middle Devonian conodont assemblage zones, five from the lower Middle Devonian (Eifelian) and three from the upper Middle Devonian (Givetian). A ninth distinctive fauna was reported from a problematical interval between the Middle and Upper Devonian.

The oldest of the Givetian faunas described overlies the upper Eifelian *Icriodus angustus* Zone and is characterized by the presence of *Icriodus latericrescens latericrescens*, in association with *I. nodosus*, *I. obliquimarginatus*, and *Polygnathus linguiformis linguiformis*, before the first occurrence of *P. varcus*. The common occurrence of *P. varcus* with the aforementioned species characterizes the fauna of the *P. varcus* Zone. The *Schmidtognathus hermanni-Polygnathus cristatus* Zone was described in Germany from beds that could not be assigned on the basis of ammonoids to either the Middle or the Upper Devonian (Ziegler, 1965). Independent megafaunal evidence from North America now supports a Middle Devonian (uppermost Givetian) assignment for this zone (Klapper and other, 1970). The fauna of the *S. hermanni-P. cristatus* Zone includes the name species as well as *S. wittekindti*, *Polygnathus pennatus*, *P. caelatus*, *P. ordinatus*, and *Elsonella rhenana*. The *Spathognathodus insitus* Zone overlies the *S. hermanni-P. cristatus* Zone and has been defined as that interval between the first appearance of the name species and the first appearance of *Ancyrodella rotundiloba* (Klapper and others, 1970). This zone represents a problematical interval between the Middle and Upper Devonian and may include the Middle-Upper Devonian boundary within it.

Collecting Localities

Samples studied for this investigation were collected by the writer during the summer of 1964. The collection plan was similar to that outlined by Collinson (1963) in which the initial sampling was designed to locate productive and barren horizons. Recollection and more closely spaced sampling of productive intervals followed. Initially, one kilogram samples were collected. As much as 5-6 kilograms have been processed for some samples. Less than half of the samples processed yielded conodonts. Preservation was generally good but relative abundances, with one or two exceptions, were low.

Table 10

Occurrence of conodonts in the Middle Devonian of Wisconsin

FORMATION	LOC.	NUMBER OF SAMPLES TOTAL	CONODONTS	RELATIVE ABUNDANCE
Milwaukee	4	25	21	0-65/kg
Thiensville	3	14	0	None
Lake Church	2	8	0	None
Lake Church	1	10	4	0-40/kg

Locality 1.--Section 19, T.12N., R.23E., Old Lake Shore Stone Quarry, now flooded, 1½ miles southeast of the village of Lake Church, Ozaukee County. Type locality for Lake Church Formation; uppermost 7½ feet accessible at southwest side of quarry.

Locality 2.--Section 10, T.9N., R.21E., Flooded quarry two miles north of Thiensville, one-fourth mile west of Locality 3; Ozaukee County. Lake Church Formation, stratigraphic position uncertain; rock very badly weathered; 5½ feet accessible.

Locality 3.--Section 10, T.9N., R.21E., Roadcut two miles north of Thiensville, extending about 550 feet along Wisconsin Highway 57; Ozaukee County. Type locality for Thiensville Formation; rock badly weathered; approximately fourteen feet exposed.

Locality 4.--Section 4, T.7N., R.22E., Exposure on both banks of the Milwaukee River in Estabrook Park, Milwaukee: Milwaukee County. Type locality of Milwaukee Formation; 11½ feet exposed at waterfall (Lindwurm Member, upper Berthelet Member); additional four feet (Berthelet Member) exposed on river's east bank at times of low water, approximately one-third mile north of waterfall.

Figure 13 illustrates the area of Devonian outcrop in eastern Wisconsin and the localities from which conodonts were collected. The lithologic sequence of the sections sampled is shown in Figure 14.

Stratigraphy and Correlation

Lake Church Formation.--The Lake Church Formation crops out in a narrow band bordering Lake Michigan in parts of Sheboygan, Washington, and Ozaukee Counties. Raasch (1935) designated the exposures in and around the old Lake Shore Stone Quarry near the village of Lake Church, Ozaukee County, as the type locality. This quarry is now flooded and only the uppermost 7½ feet of section are accessible.

The rock is dark gray to brown, generally thick-bedded, in places bituminous dolomite. Fossils, abundant at certain horizons, are commonly

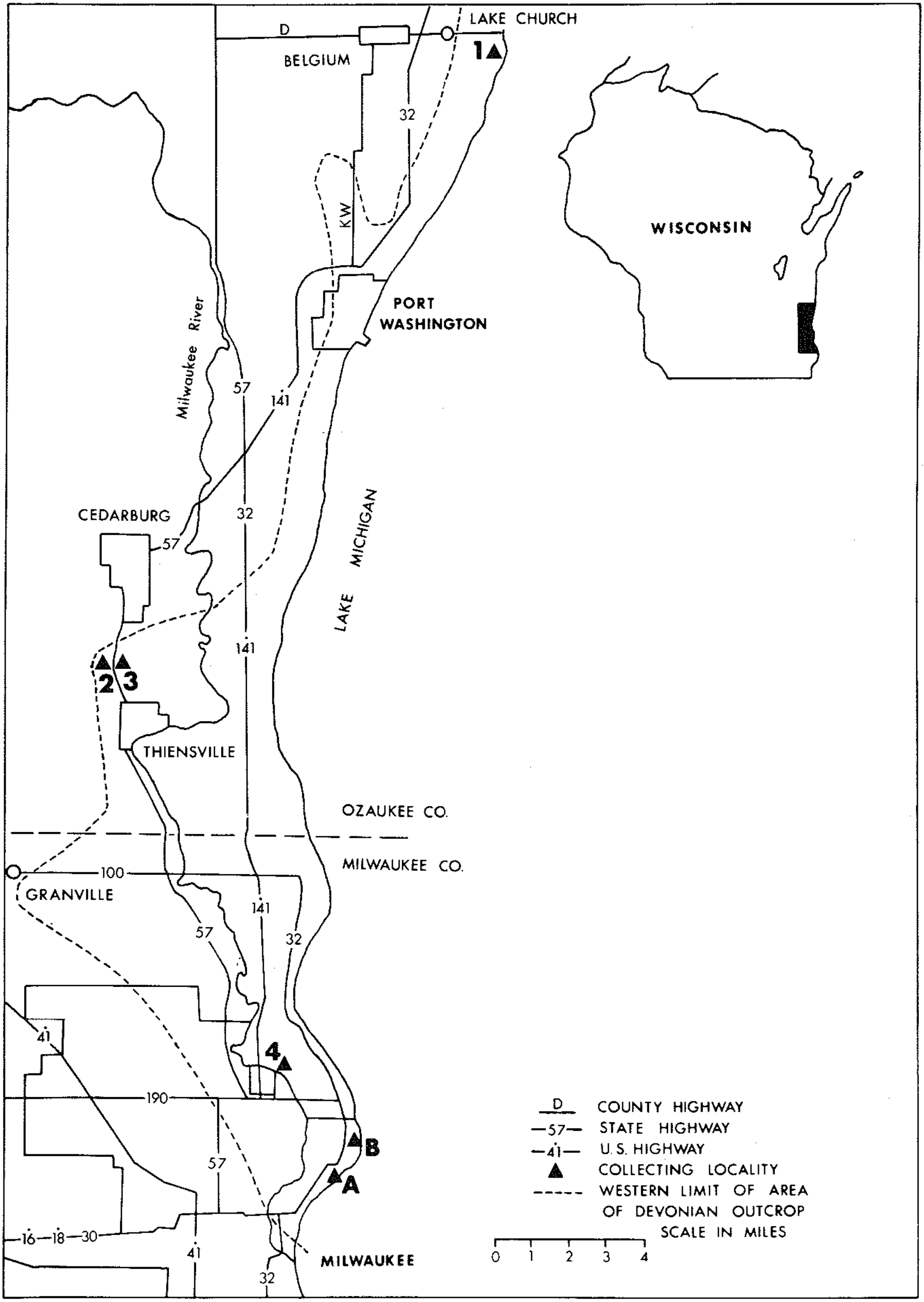


Figure 13. Map of Devonian outcrop area and collecting localities in eastern Wisconsin

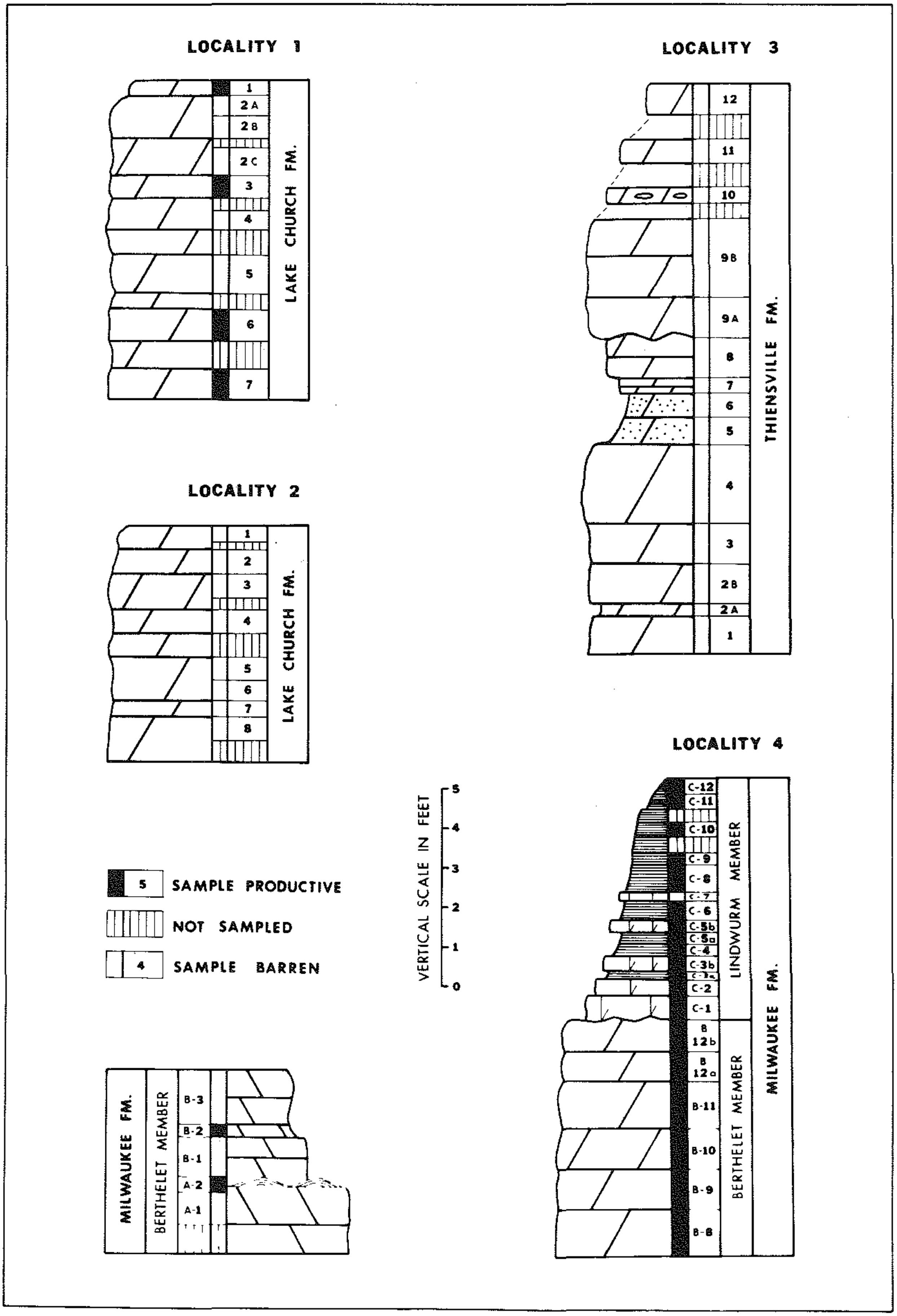


Figure 14. Generalized columnar sections of Lake Church, Thiensville and Milwaukee formations and sampling data

in the form of casts. Brachiopods, pelecypods, gastropods, and corals comprise the bulk of the fauna. Raasch (1935) estimated that the maximum thickness of this unit in the subsurface is 45 feet. The Lake Church thins southward and is absent south of the Milwaukee-Ozaukee County line. Eighteen samples were collected from exposures at localities 1 and 2. Four samples yielded 250 conodonts; fourteen samples were barren.

Cooper and others (1942) stated that the Lake Church Formation stratigraphically lies low in the Givetian because of its faunal similarities with the lower *Stringocephalus* Zone of Manitoba. *Stringocephalus*, a large and easily identified brachiopod, was formerly thought to range from the upper portion of the Eifelian through the Givetian Stage, but is now considered to be restricted to the Givetian Stage (Struve, 1961; Boucot and Struve, 1966). Many of the same species associated with the *Stringocephalus* fauna in Manitoba have also been found in the Rogers City Limestone of Michigan, the Cedar Valley Limestone of Iowa, and the Nevada Limestone of Nevada. Although Cooper and others (1942) state that it is not yet possible to place the Lake Church accurately in the Devonian column, they suggest that it should be correlated with the Dundee and Rogers City Formations of Presque Isle County, Michigan, and the Devonian at Spring Valley, Minnesota.

The uppermost Lake Church Formation has yielded a small but distinctive conodont fauna of 11 genera and 17 species, and is characterized by *Icriodus nodosus* s.l., *Polygnathus linguiformis linguiformis*, *P. webbi*, and *Panderodus*.

Table 11

Distribution of conodont species in the Lake Church Formation. (Sample numbers refer to Figure 14).

	LC 7	LC 6	LC 3	LC 1	Number of Specimens
Acodina curvata				X	2
Belodella triangularis				X	1
Hibbardella sp. A				X	2
Hindeodella adunca				X	1
H. priscilla			X	X	7
Icriodus nodosus	X	X		X	250
Ligonodina sp.			X	X	5
Neoprioniodus pronus				X	7
Ozarkodina spp.				X	4
Panderodus cf. P. simplex				X	3
P. sp. A				X	2
P. sp. B				X	2
Polygnathus decorosus			X		1
P. linguiformis linguiformis				X	40
P. webbi			X	X	13
P. sp. A			X	X	3
Synprioniodina forsenta				X	1

A fauna very similar to that of the Lake Church has been found by the writer in the Dundee Formation and Rogers City Limestone of northeastern Michigan. The overlying Bell Shale, basal unit of the Traverse Group, has also yielded a *P. linguiformis linguiformis*-*I. nodosus* dominated fauna, but in addition contains *I. obliquimarginatus* and is thus younger than the Lake Church. The Lake Church fauna also very closely resembles one described by Orr (1964) from the lower Lingle Formation of southern Illinois. The absence of key late Eifelian species such as Icriodus angustus and/or Polygnathus kockelianus, as well the absence of the younger Givetian species I. latericrescens latericrescens and I. obliquimarginatus, present in higher strata in Michigan and Illinois, suggests assignment of this fauna to the lowermost Givetian. Assignment of this fauna to the Eifelian cannot yet be ruled out, because one species, tentatively identified as Polygnathus sp. A, closely resembles the Late Eifelian species Polygnathus angustipennatus.

The conodont fauna described by Steward & Sweet (1956) from the Delaware and Columbus Limestone of Ohio also contains the dominant species of the Lake Church fauna, however, the added presence of I. angustus and I. latericrescens n. subsp. A indicates that these beds are older and should be assigned to the late Eifelian I. angustus Zone (Klapper and others, 1969). Another fauna assignable to the I. angustus Zone has been reported by Klapper and Ziegler (1967) from the Dundee Limestone of northern Ohio. I have not yet found I. angustus in the Dundee of northeastern Michigan, but it should be noted that my Dundee collection at present numbers less than 100 specimens. Clark and Ethington (1966) have described the conodont fauna of the Nevada Formation but the sparseness of conodonts in the Middle Devonian portion of this unit does not permit direct comparison with the Lake Church fauna. It is probable, however, that a Lake Church equivalent is present somewhere within their "P. linguiformis Zone." The conodonts of the Cedar Valley have most recently been discussed by Klapper (1968) and Collinson & James (1968). There is no Lake Church equivalent in the Cedar Valley. The presence of I. nodosus and P. linguiformis linguiformis in the Solon Member of the Cedar Valley is accompanied by Polygnathus varcus, Icriodus obliquimarginatus, and I. latericrescens latericrescens and is therefore indicative of the P. varcus Zone (middle-upper Givetian).

The conodont evidence supports the assignment of the Lake Church by Cooper and others (1942) to the lowermost Givetian and its correlation with the Rogers City Limestone and Dundee Formation of Michigan. It does not, however, support their suggested correlation with the Cedar Valley of Iowa.

Thiensville Formation.-- The areal distribution of the Thiensville Formation is identical to that of the Lake Church except that the Thiensville extends southward into Milwaukee County. A roadcut about two miles north of Thiensville on Wisconsin Highway 57 was designated the type locality by Raasch (1935).

The Thiensville Formation consists of thick-bedded, gray-brown to dark chocolate-brown bituminous dolomite. The rock at the type locality is badly weathered and some layers are now very soft and crumbly. Fossils are rare and poorly preserved. Raasch has recorded the presence of Favosites, Atrypa, Athyris, Cranaea, and Stropheodonta. He estimated the maximum thickness of the Thiensville to be fifty feet. The Thiensville Formation overlies the Lake Church Formation in Ozaukee County but farther south, in Milwaukee County, it rests directly on the Upper Silurian Waubakee Dolomite.

Cooper and others (1942) and Cooper (1967) indicated that the Thiensville is of late Middle Devonian age and suggested a correlation with the

Solon Member of the Cedar Valley Formation of Iowa.

Conodonts were not found in the Thiensville Formation although 14 samples with a combined weight of more than 18 kilograms were processed. Because conodonts from the lower part of the overlying Milwaukee Formation are younger than those from the Solon Member of the Cedar Valley, Cooper's (1967) correlation of the Thiensville with the Solon appears sound.

Milwaukee Formation.-- Outcrops of the Milwaukee Formation are confined to the northern portion of Milwaukee County. Alden (1906) designated as the type locality the exposures along the Milwaukee River in Lincoln and Estabrook Parks, including those in the Milwaukee Cement Company quarries along the river. These quarries are now largely inaccessible due to flooding and infilling. Approximately fifteen feet of section are accessible in the exposures along the Milwaukee River.

In redefining the Milwaukee Formation in 1935, Raasch proposed that it be divided into three members. The lowermost of these, the Berthelet, includes Zones A and B of Cleland (1911). It consists of medium- to thick-bedded gray, dolomitic shales and dolomite in its lower portion and six feet of massive, very dense, buff-weathering dolomite at its top. Calcite, pyrite, marcasite, sphalerite, millerite, and asphaltum are found in the numerous cavities that occur throughout this upper dolomite layer. Fossils, particularly the remains of fish and cephalopods, are abundant in this member. Of a total thickness of 21 feet, only the upper eight feet are presently accessible.

The Lindwurm Member, Zone C of Cleland, is the most fossiliferous member of the Milwaukee Formation. It consists of moderately thick-bedded dolomitic shales and limestones which readily weather to a sticky gray, fossil-rich mud. Crinoid fragments, brachiopods, bryozoa, trilobites, and ostracodes occur in abundance. Raasch estimated the thickness of the Lindwurm to be between 30 and 45 feet. Only the lowermost $5\frac{1}{2}$ feet are exposed at the type locality.

The North Point Member, the uppermost unit of the Milwaukee Formation, is known only from subsurface data, namely tunnel excavations and well data. Raasch (1935) described it as consisting of gray shales and shaly limestones, attaining a maximum thickness of approximately fifty feet. Fossils are abundant in some layers, and Tentaculites, Chonetes, and Paleoneilo are among the most common.

Cleland (1911) and Pohl (1929) correlated the Milwaukee Formation with the Hamilton of New York and the Cedar Valley of Iowa on the basis of faunal similarity. Cooper and others (1952) and Cooper (1967) assigned the Milwaukee Formation to the uppermost Middle Devonian and correlated it with the Rapid and Coralville Members of the Cedar Valley Formation of Iowa, the Potter Farm and Thunder Bay Formations of the upper Traverse Group of Michigan, and the Tully Formation of New York. Griesemer's (1965) study of the Milwaukee brachiopods supported the previous correlations with the Cedar Valley, but did not help to establish the age of the Milwaukee Formation because the ages of the Rapid and Coralville Members are not firmly established.

Twenty-five samples were collected from exposures of the Milwaukee

Formation at its type locality. Of these, eleven are from the Berthelet Member and fourteen from the overlying Lindwurm Member. Twenty-one samples yielded more than 1000 conodonts; four samples were barren. Samples of the North Point Member could not be obtained for study.

The Milwaukee Formation has yielded a moderately large and diverse fauna consisting of 21 species referable to 14 genera. The fauna is dominated by Polygnathus decorosus and Icriodus nodosus s.l.; P. pennatus and Icriodus n. sp. A aff. I. symmetricus are common. Uncommon, but of considerable biostratigraphic importance are P. cristatus, P. ordinatus, and Elsonella rhenana. Conodont faunas assigned to the S. hermanni-P. cristatus Zone have been described and discussed by Ziegler (1965), Orr and Klapper (1968), and Klapper and others (1970). The informally recognized higher portion of the S. hermanni-P. cristatus Zone, above the first appearance of P. cristatus, occurs in that portion of the Milwaukee Formation exposed at its type locality and is also known from the upper part of the Alto Formation of southern Illinois (Orr, 1964). Klapper (1968) has recognized the fauna of the lower portion of the S. hermanni-P. cristatus Zone, that part below P. cristatus, in the uppermost Solon and lower Rapid Members of the Cedar Valley Formation of Iowa. Schumacher and Ethington (1968) and Schumacher (1969) have reported this same fauna from the middle part of the Callaway Formation of central Missouri.

The samples from which the Milwaukee fauna was obtained are from an interval approximately 12-27 feet above the base of the formation (Figure 12). Because the formation is between 100 and 120 feet thick and the lower portion of the formation is assignable to the uppermost Middle Devonian, it appears likely that the higher portions of the Lindwurm Member and the overlying North Point Member are of early Late Devonian age. It has not been possible to obtain samples from these units for study.

In conclusion, the conodont fauna of the lower Milwaukee Formation is assignable to the S. hermanni-P. cristatus Zone and thus occupies a post-Tully, uppermost Middle Devonian position. Earlier correlations of the Milwaukee Formation with the Rapid and Coralville Members of the Cedar Valley Formation of Iowa are fully supported by the conodont evidence, but correlations of the Milwaukee with the Potter Farm and Thunder Bay Formations of Michigan and the Tully of New York are rejected.

Summary

Conodonts, referable to 16 genera and 29 species, are described for the first time from the Middle Devonian of Wisconsin. These rocks, primarily carbonates and shales, have been referred to the Lake Church, Thiensville, and Milwaukee Formations. Figure 15 summarizes the correlation of the Wisconsin Middle Devonian with that of nearby states.

Icriodus nodosus, Polygnathus linguiformis linguiformis, P. webbi, and species of Panderodus characterize the fauna of the Lake Church Formation. The absence of key late Eifelian species such as I. angustus and of younger Givetian species such as I. latericrescens latericrescens suggests assignment of this fauna to the earliest Givetian.

Conodonts were not found in the Thiensville Formation and correlation of it with other formations is based on its meager megafauna and its

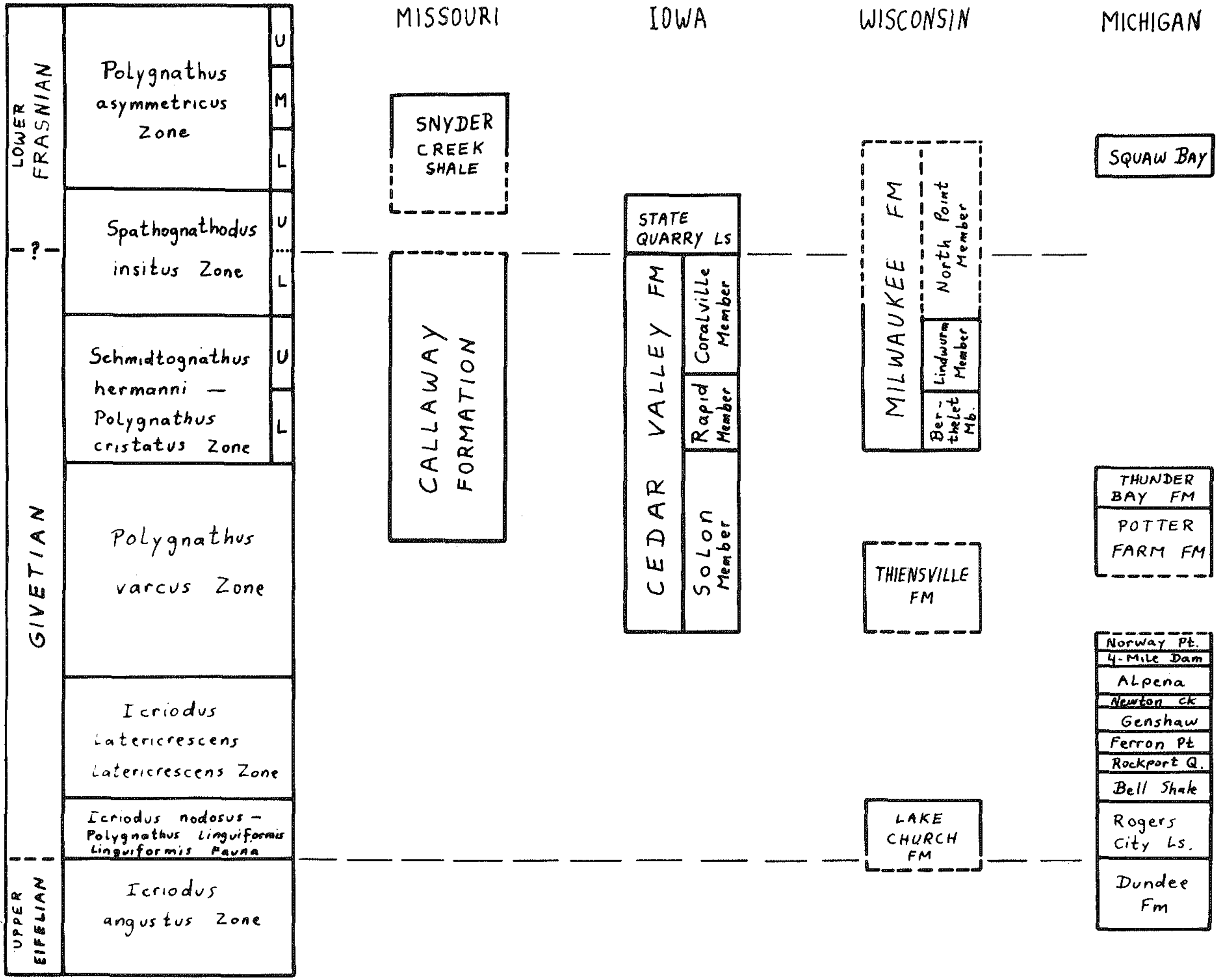


Figure 15. Correlation of Wisconsin Devonian units with that of nearby states. Conodont zonation is after Klapper and others (1970)

Table 12

Distribution of conodont species in the Milwaukee Formation. (Sample numbers refer to Figure 14).

	Berthelet Member					Lindwurm Member													Number of
	8	9	10	11	12	1	2	3a	3b	4	5a	5b	6	8	9	10	11	12	Specimens
Acodina curvata						X													2
A. spp.						X	X					X							8
Angulodus cf. A. demissus					X		X												2
Bryantodus cf. B. colligatus					X														2
Elsonella rhenana																			3
Falcodus-Element					X	X													
Roundya-Element						X													
Hibbardella sp. B								X				X					X		5
Hindeodella austinensis					X	X						X						X	22
H. priscilla		X			X												X		7
Icriodus nodosus	X				X	X	X	X	X	X	X	X		X	X		X		250
I. n. sp. A					X	X			X			X	X	X	X				75
Ligonodina panderi			X		X	X		X	X			X		X	X		X		66
Lonchodina cf. L. arcuata				X	X	X	X		X		X	X		X					10
Neoprioniodus pronus					X				X			X							8
Ozarkodina spp.	X				X	X		X	X			X							4
Polygnathus cristatus									X										2
P. decorosus	X	X	X		X	X	X	X	X	X		X		X	X			X	300
P. linguiformis linguiformis	X																		1
P. ordinatus					X														2
P. pennatus			X		X	X		X	X			X		X	X		X		75
Prioniodina aversa									X	X		X							14
Synprioniodina forsenta					X	X	X		X	X	X	X							6

stratigraphic position between the Lake Church and Milwaukee Formations.

The conodont fauna of the Milwaukee Formation is dominated by *Icriodus nodosus* and *Polygnathus pennatus* with rare but biostratigraphically significant *P. cristatus*, *P. ordinatus*, and *Elsonella rhenana*. In terms of the standard Devonian conodont zonation it is assignable to the *S. hermanni-P. cristatus* Zone and thus occupies an uppermost Middle Devonian, post-Tully position.

Conodonts and biostratigraphy of the "Kenwood" Shale
(Upper Devonian)

Dietmar Schumacher

Introduction

The "Kenwood" Shale of eastern Wisconsin was originally described by Edwards & Raasch (1921). They named it from the section of Milwaukee in which it occurred, assigned it to the Upper Devonian, and correlated it with the Antrim Shale of Michigan. Subsequently, these beds were not only assigned to the Mississippian (Raasch, 1935), but even the origin of the name "Kenwood", as it was applied in Wisconsin, became confused (Keroher, 1966).

The name Kenwood was first used by Norton (1894) to refer to the middle member of the Wapsipinicon Formation (Middle Devonian) of Iowa. Later, Butts (1915) applied the name to a sandstone member of the New Providence Formation (Lower Mississippian) of Kentucky. In 1935, Raasch formally proposed the name Kenwood Formation for the black shales of eastern Wisconsin and assigned them to the Lower Mississippian. Cooper and others (1942) regarded these black shales to be either Late Devonian or Early Mississippian. Weller and others (1948) assigned Wisconsin's Kenwood to the Lower Mississippian and, because the name was preoccupied, suggested that quotation marks be placed around the name. The present study confirms the Late Devonian age of the Wisconsin "Kenwood" and establishes its equivalence to the lower and middle Antrim Shale of Michigan.

I am grateful to the Milwaukee Public Museum for providing samples of "Kenwood" Shale for study. Thanks are extended to Mr. Elmer Nelson, Curator of Geology (now retired), and Mr. Joseph Emielity, Assistant Curator, for their helpful cooperation and assistance. I am indebted to Dr. David L. Clark, University of Wisconsin, for suggesting and directing this study. I have benefited greatly from discussions with Dr. Willi Ziegler, Philipps Universität-Marburg, concerning taxonomic matters and owe him a special note of thanks. This study was supported in part by the Research Committee of the Graduate School of the University of Wisconsin from funds supplied by the Wisconsin Alumni Research Foundation.

THE "KENWOOD" SHALE

The "Kenwood" Shale, like the North Point Member of the Milwaukee Formation is known only from subsurface data. Well borings and tunnel excavations near the shore of Lake Michigan at the foot of North Avenue in Milwaukee (Fig. 16, Loc. A), and later at the foot of Linwood Avenue one mile to the north (Fig. 16, Loc. B), encountered fifteen feet of black shale above the gray shales and limestones of the Milwaukee Formation (late Middle Devonian). The Linwood Avenue Intake Tunnel was designated as the type locality by Raasch (1935).

Although the "Kenwood" consists predominantly of fissile black shales, Raasch (1935) recorded the presence of brown, green, and blue-gray clay shales as well as several thin seams of coal. Fossils, abundant in certain layers, are primarily those of conodonts, fish bones, pelecypods, gastropods, and inarticulate brachiopods. The "Kenwood" attains a maximum

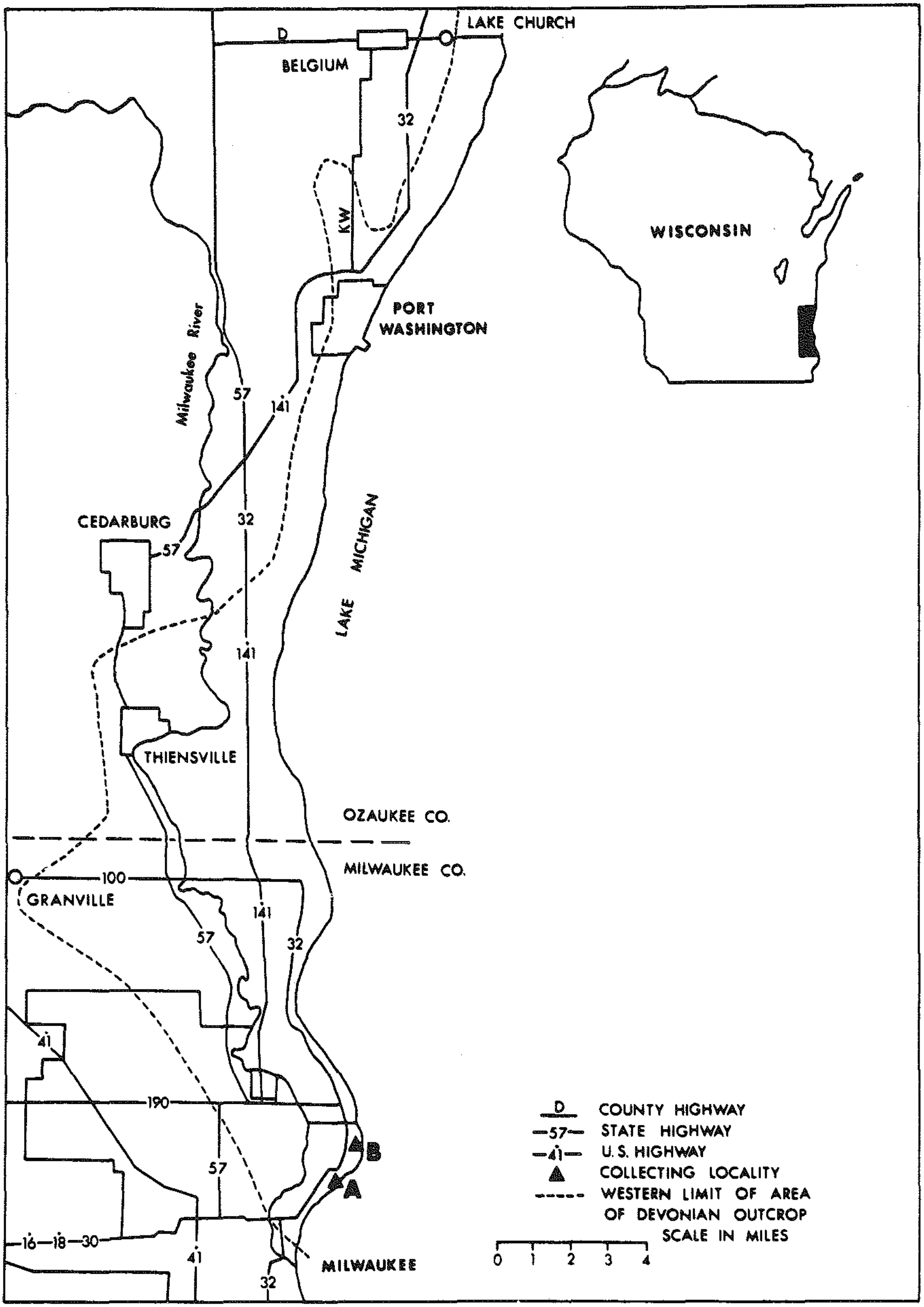


Figure 16. Map of Devonian outcrop area and localities at which tunnel excavations encountered the "Kenwood" Shale

thickness of 55 feet (Raasch, 1935).

The material studied consisted of shale chips and larger fragments originally collected during the excavation of the Linwood Avenue Intake Tunnel, but with no record of their original stratigraphic position within the "Kenwood." Each individual chip or fragment was treated as a single sample so as to avoid any mixing of faunas that might result from combining two or more chips, each possibly from a different stratigraphic level.

The "Kenwood" Shale, like most black shales, did not respond satisfactorily to normal shale disaggregation techniques, such as those employing kerosene or Stoddard Solvent. I found that a 15% solution of hydrogen peroxide (H_2O_2) proved to be highly successful in freeing conodonts from the shale matrix. The reaction between the hydrogen peroxide and the shale fragments was vigorous but short lived, generally ten to fifteen minutes in duration. On the average, 13% of the shale was reduced to sludge during this time. Conodont elements were not adversely affected by the hydrogen peroxide treatment of a 15% concentration was used, a 30% concentration, however, resulted in severe etching and bleaching of specimens. The high relative abundance of conodonts in the "Kenwood" Shale made processing of large samples unnecessary. Samples weighing from 5 to 25 grams yielded a good, representative conodont fauna when the hydrogen peroxide treatment was employed.

The Conodont Fauna

Two distinctive conodont faunas, referred to as "Kenwood" I and "Kenwood" II, have been recognized in the "Kenwood" Shale. These faunas contain elements of four of the standard Upper Devonian conodont assemblage zones and can be correlated precisely with the sequence established by Ziegler (1962a). Two of these zones are assignable to the Frasnian and two to the Famennian. The 60 species of conodonts found can be assigned to 15 genera. Table 13 lists the distribution of conodonts within the "Kenwood."

Conodonts were extremely abundant and very well preserved in the "Kenwood" Shale. They were recovered from all samples processed and frequently were sufficiently abundant so as to be readily visible on the surface of the shale. The 35 samples processed yielded an average of more than 130 conodonts per gram; values for individual samples ranged from 2-600 per gram.

The fact that conodonts occur in such great numbers in some deposits is generally attributed to a very slow rate of sedimentation (Lindström, 1964, p. 68-70). Conodonts, because of their higher specific gravity and relatively resistant nature, would also tend to be concentrated by normal sedimentary processes, much like the manner in which heavy mineral concentrates are formed. In samples of "Kenwood" I, one frequently sees "scour and fill" -type microstructures in which the conodonts have been concentrated in thin lens-like bodies within the shale. These lenses are veritable conodont coquinas consisting almost solely of conodonts with some phosphatic pellets, pyrite, and occasional fish teeth and/or bone.

As might be expected in a deposit of this type some intermixing of conodont faunas has occurred. Species not normally found together but occurring in adjacent conodont assemblage zones were found in the same sample. Palmatolepis linguiformis for example, is stratigraphically

Table 13

Distribution of Conodont Species in the "Kenwood" Shale of Wisconsin

	"Kenwood" II								"Kenwood" I																	
	C	D	K	T	X	G	H	U	I	J	L	A	B	M	Z	Q	P	F	R	O	W	Y	E	V	?	Number of Specimens
Acodina lanceolata															X											4
A. lirata																	X					X				4
A. sp. A																	X					X				6
A. sp. B																X	X									2
Ancyrodella buckeyensis									X	X		X	X	X	X	X	X	X			X					42
A. curvata													X												X	3
A. lobata																									X	2
Ancyrognathus asymmetricus									X			X	X	X												7
A. bifurcatus	X		X	X	X		X																			11
A. sinelaminus				X										X												2
A. symmetricus			X	X	X																					7
A. triangularis												X														1
Bryantodus conjunctus																									X	2
B. multidens				X									X				?									2
B. nitidus				X																					X	15
B. simplex																									X	1
B. typicus	X			X	X																					6
B. spp. (fragments)				X			X						X		X		X	X	X			X				
Diplododella sp. A																	X									1
Hibbardella spp. (fragments)			X														X									
Hindeodella sp. A.																									X	1
H. spp. (fragments)	X		X	X	X	X	X	X		X			X	X	X	X	X	X	X	X	X	X	X	X		
Icriodus alternatus									X	X		X	X	X	X	X	X	X		X	X		X			150
I. cymbiformis														X		X	X	X								13
I. symmetricus																								X	X	3
Ligonodina panderi (fragments)													X		X		X									
L. spp. (fragments)	X			X	X	X		X					X	X	X	X	X	X	X	X		X				
Lonchodina cf. L. arcuata					X												X									6
L. spp. (fragments)				X									X				X				X	X				
Neoprioniodus alatus								X																		3
N. armatus				X	X		X					X					X	X								20
N. pronus													?				X		X							10
Nothognathella sublaevis				X																						1
N. typicalis			X				X					X	X		X	X	X						X			30

Table 13, continued

	C	D	K	T	X	G	H	U	I	J	L	A	B	M	Z	Q	P	F	R	O	W	Y	E	V	?	Number of Specimens
	"Kenwood" II								"Kenwood" I																	
N. spp. (fragments)	X			X			X			X		X	X	X	X		X				X					
Ozarkodina immersa															X	X	X									15
O. regularis																	X					X				30
O. spp. (fragments)		X	X	X					X		X	X	X	X	X	X	X		X	X		X		X		
Palmatolepis glabra glabra	X	X	X	X	X	X	X	X																		65
P. glabra elongata	X		X	X			X																			
P. cf. P. regularis	X	X	X	X		X		X																		28
P. quadrantinodosalobata				X	X																					25
P. minuta minuta	X	X	X	X	X	X	X	X																		180
P. termini				X																						1
P. tenuipunctata	X			X																						12
P. subperlobata	X		X	X	X										X	X	X									60
P. triangularis									X	X	X	X	X	X	X	X	X	X				X				180
P. sp. aff. triangularis												X			X											5
P. delicatula delicatula									X	X	X	X	X	X	X	X	X	X	X			X				225
P. subrecta									X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		300
P. linguiformis												X	X	X	X	X	X	X		X		X				35
P. gigas														X		X				X					X	22
P. perlobata perlobata															X		X					X				5
P. unicornis																X										5
P. foliacea																							X		X	3
P. cf. P. punctata																	X								X	3
Polygnathus glaber glaber	X		X	X																						40
P. nodocostatus nodocostatus	X			X																						12
P. nodocostatus ovatus			X	X	X																					6
P. normalis				X												X	X									17
P. foliatus									X	X	X		X	X	X	X	X	X		X	X				X	100
P. brevilaminus													X													7
P. granulosus															X	X	X				?					3
P. sp. A																									X	1
Spathognathodus sp.																									X	2

confined to the upper portion of the Upper *Palmatolepis gigas* Zone (Ziegler, 1962a; Klapper and others, 1970), yet in several "Kenwood" samples (A, B, M, P, Q, Z) it occurs together with *P. delicatula* and *P. triangularis* of the overlying *P. triangularis* Zone. Mixed conodont faunas are not new, having been reported by Branson and Mehl (1941), Cloud and others (1957), Hass (1959a), Krebs (1964), and others. Recognition that intermixing has occurred rests primarily on a thorough familiarity with the conodont succession for the stratigraphic interval in question. Upper Devonian faunas, fortunately, are among the best known.

Mixed conodont faunas arise primarily in one of two ways: 1) stratigraphic admixture, and 2) stratigraphic condensation (Lindström, 1964, p. 71-73). In the first instance, old conodonts have been washed clean of their original embedding sediment and have become redeposited with younger species; in the case of stratigraphic condensation, one finds that the net result of a long period of sedimentation is only a thin layer that contains materials representing a significant portion of geologic time. The conodont faunas in the latter case may occur in an orderly succession or be completely intermixed depending on the tranquility or turbulance of bottom conditions. Buchholz (1963) has described an Upper Devonian limestone section less than one meter thick which, due to condensation, contains almost the entire Upper Devonian conodont sequence.

The "scour and fill" structures observed in samples of "Kenwood" I suggest that at least some reworking and redeposition has occurred. Some conodont specimens, particularly polygnathids, show considerable surface wear. Most, however, including those known to have been redeposited (*Palmatolepis linguiformis*), are very well preserved and show no signs of abrasion, an observation similar to one previously made by Krebs (1963, 1964). It appears that a very slow rate of sedimentation together with periodic but slight agitation of bottom sediment to intermix previously deposited conodont elements with those that were currently being deposited offers a satisfactory explanation for the admixture of *Palmatolepis gigas* and *Palmatolepis triangularis* Zone faunas in "Kenwood" I samples.

BIOSTRATIGRAPHY

Although Upper Devonian conodont faunas have received considerable attention during the last several decades, most of the early studies were purely descriptive in nature and placed little emphasis on the possible biostratigraphic significance of these faunas. It is only with the research of the last ten years that the biostratigraphic value of conodonts has become recognized and utilized.

Ziegler (1962a) described in detail the Upper Devonian conodont succession in the Rhenisch Schiefergebirge of West Germany and established ten major Upper Devonian conodont assemblage zones and recognized 24 subdivisions. These zones were related to the previously established ammonoid Stufen and like the ammonoid zones, the conodont zones are recognizable on a world wide basis. In the United States, Collinson and others (1962) recognized this multiple sequence in Upper Devonian rocks of the Upper Mississippi Valley. Klapper and Furnish (1963) recognized four of Ziegler's subdivisions in the Sweetland Creek Shale of Iowa. Ethington (1965) described a fauna from the Late Devonian of Arizona and New Mexico and noted its relationship to the West German section. Late Devonian faunas from several biostratigraphic horizons have been described by Anderson (1966) from north-central Iowa. Glenister and Klapper (1966) described the Upper Devonian conodont zonation in Western Australia and demonstrated that it was essentially identical to that in Germany. Clark and Ethington (1967) have recognized and described conodont faunas from nine of Ziegler's ten major zones in Upper Devonian rocks of Utah and Nevada. Most recently, Klapper and others (1970) have re-examined the conodont succession in Upper Devonian strata of North America and have refined the zonation initially proposed by Ziegler (1962a).

Table 13 lists the distribution of conodonts within the "Kenwood." The known ranges of some of the more important species which also occur in the "Kenwood" are indicated in Table 14.

The oldest conodont fauna identified with certainty in the "Kenwood" is that of the uppermost *Ancyrognathus triangularis* or Lower *Palmatolepis gigas* Zone. It is characterized by the presence of *P. foliacea*, *P. unicornis* and *P.* cf. *P. punctata*. Whenever any of the above species occurred together with either *A. triangularis* or *P. gigas* it was invariably accompanied by species such as *P. linguiformis* or *P. triangularis*, species not normally found occurring together. The ranges of the species in question are well enough known, however, so that an approximate age determination is possible (Table 14). *P. foliacea* occurs with *P. subrecta* in sample E. The ranges of these two species overlap only in the upper *Ancyrognathus triangularis* Zone and the Lower *P. gigas* Zone. *P. unicornis* ranges through both the *A. triangularis* and *P. gigas* Zones according to Ziegler (1962a); Clark and Ethington (1967), however, found it only in the Lower *P. gigas* Zone. A middle Frasnian age, *to* Iγ or *to* Iγ/Iδ , seems to be established for this fauna.

The next youngest fauna, as exemplified by sample O, is comprised primarily of *P. gigas*, *P. subrecta*, and *P. linguiformis*. The zone in the interval between the last occurrence of *P. foliacea* and the first occurrence of *P. triangularis*, an interval characterized by *P. linguiformis* in its upper portion, has been named the Upper *P. gigas* Zone (*to* Iδ). Common species whose ranges continue through this zone include *Icriodus alternatus*, *Polygnathus foliatus*, *P. xylus*, *Ancyrodella buckeyensis*, and *Ancyrognathus asymmetricus*. *P. linguiformis* was also found in six other samples, with or without *P. gigas*, in which elements of the overlying *P. triangularis* Zone were also present.

A third distinctive conodont fauna, secured from samples I, J, and L, is dominated by *P. triangularis*, *P. delicatula delicatula*, and *P. subrecta*, together with *I. alternatus* and *Polygnathus foliatus/xylus*. The only zone of overlap for the three species of *Palmatolepis* is the Middle *P. triangularis* Zone (*to* Iδ?). *P. delicatula delicatula* does not range below it and *P. subrecta* does not occur above it. As mentioned earlier, elements of this zone are commonly intermixed with those of the underlying *P. gigas* Zone.

The youngest Upper Devonian fauna yet recognized in the "Kenwood" Shale, the "Kenwood" II fauna, is characterized by *Palmatolepis minuta minuta*, *P. glabra glabra*, *Polygnathus glaber glaber*, and *P. nodocostatus*. Also present are the palmatolepids *subperlobata*, *termini*, *tenuipunctata*, *quadrantinodosalobata*, and cf. *regularis*. Ranges of these forms, as indicated on Table 14, suggest an Upper *P. crepida* Zone assignment

Table 14

Ranges of some key late Devonian Conodonts which occur in the "Kenwood" Shale of eastern Wisconsin. (Conodont ranges compiled from Ziegler (1958, 1962a), Helms (1961), and Clark and Ethington (1967).

	Frasnian							?	Famennian															
	POLYGNATHUS ASYMMETRICUS			ANCYROGNATHUS TRIANGULARIS	PALMATOLEPIS GIGAS		PALMATOLEPIS TRIANGULARIS			PALMATOLEPIS CREPIDA			PALMATOLEPIS RHOMBOIDEA	PALMATOLEPIS QUADRANTINODOSA		SCAPHIGNATHUS VELIFER			POLYGNATHUS STYRIACUS			SPATHOGNATHODUS COSTATUS		
	L	M	U		L	U	L	M	U	L	M	U		L	U	L	M	U	L	M	U	L	M	U
Palm. glabra glabra												x	x	x	x									
Palm. termini											x	x												
Pol. glaber glaber										x	x	x	x	x	x									
Palm. tenuipunctata									x	x	x	x												
Palm. cf. P. regularis									x	x	x	x												
Pol. nodocostatus								x	x	x	x	x	x	x	x	x	x	x	x	x				
Palm. minuta minuta								x	x	x	x	x	x	x	x	x	x	x						
Ancyrognathus sinelaminus								x	x	x	x	x												
Palm. delicatula delicatula								x	x	x														
Palm. subperlobata							x	x	x	x	x	x												
Palm. quadrantinodosalobata							x	x	x	x	x	x												
Palm. triangularis							x	x	x	x														
Palm. linguiformis						x																		
Ancyrognathus asymmetricus						x																		
Palm. gigas					x	x	x	x																
Palm. foliacea				x	x	x																		
Palm. unicornia				x	x	x	x																	
Palm. subrecta			x	x	x	x	x	x	x															
Palm. punctata		x	x	x	x																			

for this fauna. Four of the six palmatolepids do not range higher than the upper P. crepida Zone and one does not occur below it. P. termini, represented by only a single specimen, is not known to range higher than the lower portion of the Upper P. crepida Zone. Both polygnathids range through the P. crepida Zone and into younger zones. Despite the absence of the name species, it would be difficult to assign this fauna to a position other than within the Upper P. crepida Zone (to IIα). This fauna was secured from "Kenwood" samples C, D, G, H, K, T, U, and X.

CONCLUSIONS AND CORRELATIONS

In summary, the "Kenwood" Shale of Wisconsin ranges in age from middle Frasnian (to Iγ) to early Famennian (to IIα) and includes elements of the Lower and Upper Palmatolepis gigas Zones, the Middle P. triangularis Zone, and the Upper P. crepida Zone. These faunas clearly establish an early to middle Late Devonian age for the "Kenwood" Shale, disproving the previous designation of this unit as Early Mississippian.

On the basis of its conodont fauna, the "Kenwood" Shale correlated with formations of the Cohocton and Cassadaga Stages of New York (Angola Shale Member of the West Falls Formation to Gowanda Shale Member of the Perrysburg Formation) (Hass, 1959B; Oliver and others, 1967; Huddle, 1969), the lower Kettle Point Shale of southwestern Ontario (Winder, 1966a), the upper Olentangy Shale (Stauffer, 1938) and the lower Huron Shale (lower Ohio Shale) of Ohio (Hass, 1947), the upper Doewlltown Member and the lower Gassaway Member of the Chattanooga Shale of Tennessee (Hass, 1956; Huddle, 1968), the middle New Albany Shale (Blackiston Formation) of Indiana (Huddle, 1934; Campbell, 1946), the lower and middle Antrim Shale of Michigan (Morse, 1938), the Grassy Creek of Illinois (Collinson and others, 1962), the Sweetland Creek Shale of Iowa (Klapper & Furnish, 1963), the lower Maple Mill Shale and the Lime Creek and Sheffield Formations of the same state (Anderson, 1964, 1966), the Grassy Creek of Missouri (Branson and Mehl, 1934a; Mehl, 1960), the Chattanooga of southwest Missouri (Brown, 1959; Mehl, 1960), the Sylamore Sandstone and Chattanooga Shale of northern Arkansas (Freeman and Schumacher, 1969), the upper portion of the lower Arkansas (Freeman and Schumacher, 1969), the upper portion of the lower member of the Arkansas Novaculite at Caddo Gap (Hass, 1951), zones II and III of the Huoy Formation of Texas (Cloud and others, 1957), the Martin Limestone of Arizona (Ethington, 1965), and the Pilot Shale and Devils Gate Limestone of Nevada and Utah (Clark and Ethington, 1967).

The Wisconsin "Kenwood" is not related or equivalent to either the Kenwood Member of the Wapsipinicon Formation (Middle Devonian) of Iowa or the Kenwood Member of the New Providence Formation (Lower Mississippian) of Kentucky. The Wisconsin black shale is, however, equivalent to the lower and middle Antrim Shale of Michigan and represents the most westerly extent of that unit. Because the name "Kenwood" is preoccupied, I recommend that name be dropped in Wisconsin and that Antrim Shale be substituted.

Summary

The "Kenwood Shale of eastern Wisconsin is one of several "Devonian-Mississippian" black shales whose age and correlation have long been in doubt. A large conodont fauna has been recovered from the "Kenwood" and contains elements of four of the standard Upper Devonian conodont assemblage zones: the Lower and Upper Palmatolepis gigas Zones (middle-upper Frasnian),

the Middle *Palmatolepis triangularis* Zone (lowest Famennian) and the Upper *Palmatolepis crepida* Zone (lower Famennian). These faunas clearly establish the early and middle Late Devonian age for the "Kenwood" Shale, previously considered to be Early Mississippian.

The "Kenwood" Shale of Wisconsin is not to be confused with the Kenwood Member of the Wapsipinicon Formation (Middle Devonian) of Iowa or the Kenwood Member of the New Providence Formation (Lower Mississippian) of Indiana and Kentucky. The Wisconsin black shale is, however, equivalent to the lower and middle Antrim Shale of Michigan and represents the most westerly extent of that unit. Since the name "Kenwood" is preoccupied, I recommend that name be dropped in Wisconsin and that Antrim Shale be substituted.

COMMENTS ON THE CONODONT FAUNAS

Complete faunal lists for each formation including number of specimens are given under the biostratigraphic discussions. All of the Wisconsin conodonts have been identified with existing taxa and a systematic description of each species appears unnecessary. Certain elements of the Wisconsin faunas are worthy of special comment because of unique stratigraphic occurrences or because of special biologic features, however. Such data is included in this section.

Specimens have been deposited in the University of Wisconsin, Madison, Repository (UW) or as indicated.

Trempealeauan Conodonts

James F. Miller

ACONTIODUS sp. aff. A. (ACONTIODUS) STAUFFERI

Furnish, 1938

Pl. 1, fig. 9-10

Acontiodus sp. aff. *A.* (*Acontiodus*) *staufferi* MILLER, 1969, p. 420, p. 64, figs. 66, 67, text-fig. 3E.

Remarks.--A single specimen from SVD-8 appears conspecific with the one cited in the synonomy (above) from the Notch Peak Limestone of Utah. Two narrow lateral costae flank a wide central costa which has a faint, central posterior groove. This ornamentation is characteristic of *A.* (*Acontiodus*) *staufferi*. The Sunset Point and Notch Peak specimens, however, are nearly round at the basal margin, whereas Furnish's specimens of *A. staufferi* are distinctly compressed anterio-posteriorly. If additional similar specimens are found, it may prove to be a new species.

Repository.--UW1531-5.

ACONTIODUS n. sp. A

Pl. 1, fig. 11-13

Description.--Short, fat simple cones, proclined, bilaterally symmetrical. Basal cavity very shallow. Faint lateral costa present on either side; central posterior costa present on some specimens. White matter present only on tip and upper part of anterior side (pl. 1, figs. 11-13).

Remarks.--The three specimens from TW-3 resemble *Acontiodus propinquus* Furnish in overall plan, but do not have the deep posterior sulcus. One specimen of *A. propinquus* mentioned by Furnish which lacks this sulcus is similar to the specimens at hand and appears to be intermediate between them and Furnish's other type material. The morphologic series is completed by *Oneotodus* n. sp. A (this paper) which is nearly identical to *Acontiodus* sp. A but lacks any trace of costae. Possibly two or more of these forms were part of a single multi-element species.

Assignment of this species to subgenus Acontiodus or Semiacontiodus is ignored until more material is available. Specimens included in A. propinquus by Furnish could be assigned to both subgenera, as some have and some lack a posterior costa, the presence of which distinguishes subgenus Acontiodus from Semiacontiodus. The same is true for the form under discussion here. The close similarity of these forms in all other respects casts doubt on the significance of this posterior costa, and thus on the concept of these subgenera. If an evolutionary sequence from those lacking a costa to those possessing one can be demonstrated, the concept of the two subgenera could be confirmed.

Repository.--UW1531-6.

CRYTONIODUS PRION (Lindstrom), 1955

Pl. 1, fig. 14-16, 17 ?

Cordylodus prion LINDSTRÖM, 1955, p. 552-53, pl. 5, figs. 14-16.

Remarks.--One specimen from SVD-8 (pl. 1, fig. 17) is only questionably placed here because of the unusual projection of the basal cavity into the denticle. This species differs from Crytoniodus oklahomensis, from which it apparently evolved, in having a shorter basal cavity.

CORDYLODUS PROAVUS Müller, 1959

Pl. 1, fig. 18-19

Cordylodus proavus MÜLLER, 1959, p. 448-49, pl. 15, figs. 11, 12, 18 text-fig. 3B; MILLER, 1969, p. 424, pl. 65, figs. 37-45, text-fig. 3D.

Remarks.--Two specimens are placed in this species, one from SVD-8, and one from an unknown sample.

Repository.--UW1531-10, 1531-11.

DREPANODUS n. sp. A.

Pl. 1, fig. 6, 21-22

Drepanodus subarcuatus FURNISH, 1938, pl. 41, figs. 31, 32; non pl. 41, figs. 25-30, pl. 42, figs. 2, 3, text-fig. 1F, 1G (=Drepanodus subarcuatus FURNISH).

Remarks.--Furnish's collection contains two slightly different forms which are referred to this species. The holotype and all other specimens from the Shakopee Dolomite are faintly striated over the entire surface of the lower part of the cusp, and the white matter is confined to a narrow, central growth axis. The tip of the basal cavity is very near the anterior margin. Specimens from the underlying Oneota Dolomite are generally more robust, not striated, and the entire cusp above the basal cavity is composed of white matter. The tip of the basal cavity is more nearly central in these older forms. My specimens resemble the Oneota type (pl. 1, figs. 6, 21, 22); none resemble the Shakopee type. This should be described as a new species, but the present material is not adequate to do so.

Repository.--UW1531-13, 1531-14, 1531-15.

ONEOTODUS SIMPLEX (Furnish), 1938

Pl. 2, fig. 1-5

Distacodus? simplex FURNISH, 1938, p. 328, pl. 42, figs. 24, 25, text-fig. 1 0.

Oneotodus nakamurai NOGAMII, 1967, p. 216-217, pl. 1, figs. 9, 12, text-fig. 3A, 3B; MILLER, 1969, pl. 435-436, pl. 63, figs. 1-9, 10 (?), text-fig. 5 E.

Remarks.--This is the most abundant species of the fauna. The present material as well as additional specimens from Oklahoma and Texas suggest that *Oneotodus nakamurai* and *O. simplex* cannot be consistently distinguished, and they are here considered synonomous.

Repository.--UW1531-17.

Cross-section diagrams of critical species are shown in Figure 17.

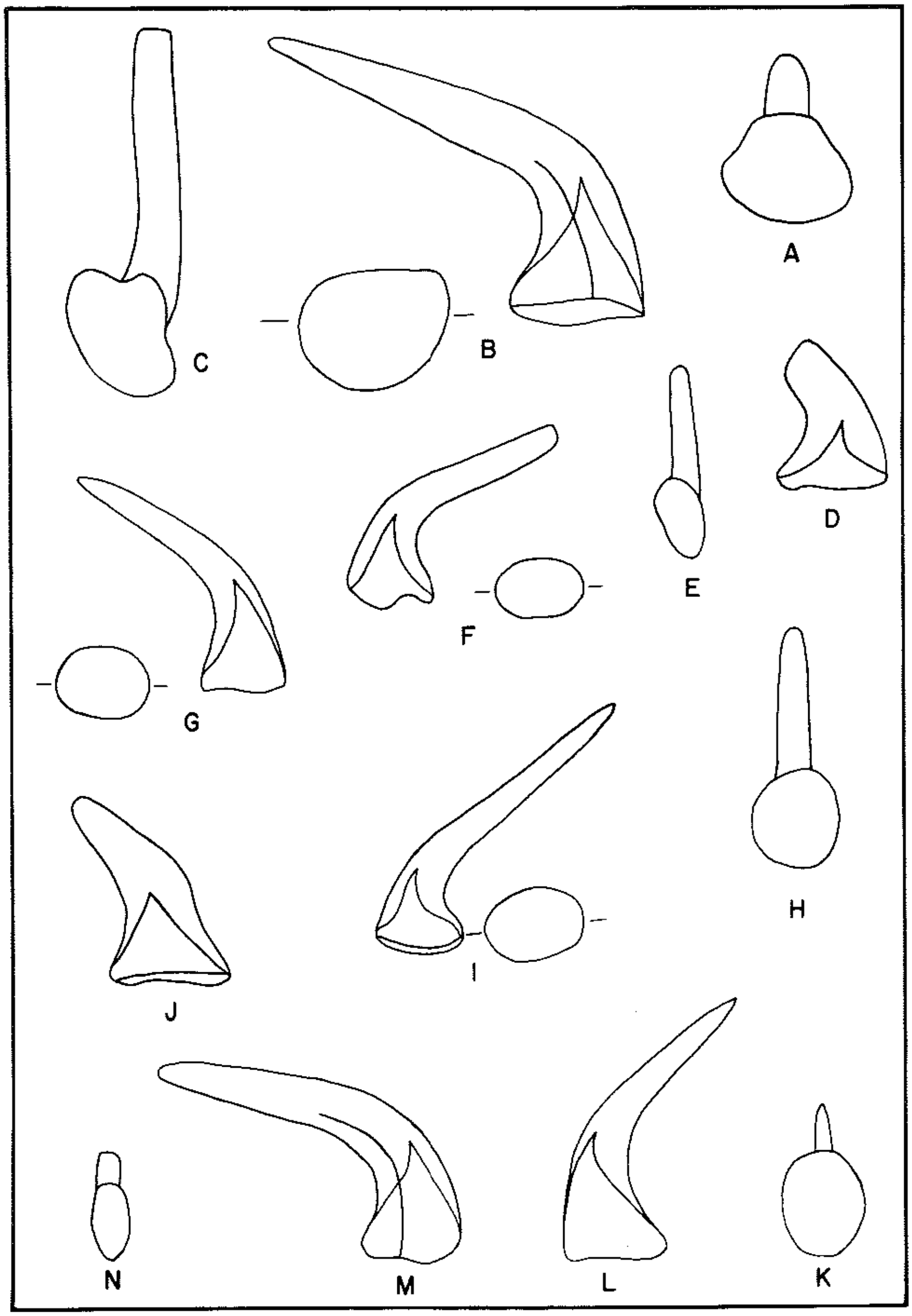


Figure 17. Basal views, cross-sections, and views of basal cavities of Trempealeauan conodonts, X100. A, Acontiodus (Semiacontiodus) nogamii Miller (Pl. 1, figs. 1-2); B, Acodus housensis Miller (Pl. 1, fig. 5); C, Drepanodus n. sp. A (Pl. 1, fig. 6); D(?), Drepanodus n. sp. A; E, Drepanodus n. sp. A (Pl. 1, fig. 22); F, Oneotodus simplex (Furnish)(Pl. 1, fig. 23); G, O. simplex (Furnish)(Pl. 2, fig. 1); H, O. simplex (Furnish) (Pl. 2, fig. 5); I, O. simplex (Furnish)(Pl. 2, fig. 3); J, Oneotodus n. sp. A (Pl. 2, fig. 8); K, Oneotodus sp. aff. O. simplex (Furnish)(Pl. 2, fig. 9); L, Paltodus bassleri Furnish (Pl. 2, fig. 11); M, Paltodus variabilis Furnish (Pl. 2, fig. 13); N, Proconodontus notchpeakensis Miller (Pl. 2, fig. 20).

Platteville Conodonts

Robert F. Atkinson

BELODINA COMPRESSA (Branson and Mehl)

Pl. 5, fig. 13, 15-16

Belodus compressus BRANSON and MEHL, 1933b, p. 114, pl. 9, figs. 15, 16.

Belodina compressa BERGSTRÖM & SWEET, 1966, p. 312-315, pl. 31, figs. 12-19 (includes synonomy to 1966).

Belodina grandis WINDER, 1966b, v. 40, pl. 10, fig. 1 (plate only).

Eobelodina fornicala WINDER, 1966, v. 40, pl. 10, fig. 3 (plate only).

Remarks.--This multielement species is composed of several previously well known and well described conodonts, namely Belodina compressa, B. grandis, B. wykoffensis, and Eobelodina fornicala. B. compressa, B. grandis and B. wykoffensis probably represent a single, variant form. However, complete specimens can be readily separated into the two form groups of B. grandis and B. wykoffensis. The degree of curvature of the lower surface appears to be quite consistent with B. grandis being more elongate (having less curvature) than B. wykoffensis.

Both Bergström and Sweet (1966) and Webers (1966) consider Belodina dispansa to be a juvenile form of B. compressa and therefore include it with their multielement B. compressa. Webers (1966, p. 24) states "B. dispansa Glenister is considered to be a juvenile form of this / B. compressa / variable form-species. Very well preserved mature specimens of the more elongate variety of 'B. compressa' show that the earliest growth stages bore small denticles inclined exactly like those of B. dispansa." Although this is true in some cases, not all of the mature, elongate forms exhibit this phenomenon. The Platteville material has several very young juveniles of both the B. grandis and B. wykoffensis forms which are considerably smaller than most of my B. dispansa forms and the denticles of the juveniles are not inclined at all. Therefore, B. dispansa is considered to be a distinct form which can be readily distinguished from the B. compressa forms.

Stratigraphic distribution supports this observation. B. dispansa occurs with B. compressa at all of the southwest localities but is not found in any sample from either the Lake Winnebago area or the Oostburg core, where B. compressa was found in every member of the Platteville.

It is quite likely that the form that contained Belodina dispansa was closely related to B. compressa, and even possible that B. dispansa was a later evolutionary development of B. compressa, but until more is known about the relationships of these two forms, they could be listed independently.

Occurrence.--This abundant species, which comprises nearly 27% of my collection, is found in virtually every member at every location, with the exception of locality 4, where no forms were found. Nine hundred fifty-four belodinid forms and 188 eobelodinid forms were recovered.

Repository.--UW 803, 804, 805.

CURTOGNATHUS TYPA (Branson and Mehl)

Pl. 4, fig. 8

Curtognathus typa BRANSON and MEHL, 1933b, p.87, pl. 5, fig. 28; ANDREWS, 1967, p. 887, 888, pl. 113, figs. 4, 21, pl. 114, fig. 22 (includes synonomy to 1966).

Curtognathus chatfieldensis WEBERS, 1966, p. 63, pl. 4, fig. 4.

These are symmetrical, neurodontiform units possessing divergent, pointed denticles mounted on the upper surface of an arched bar which terminates in thin to spatulate ends. The crest of the arch may support an apical denticle which bisects the unit. The denticles, which are confined to the plane of the bar, are circular at the arch, becoming smaller and slightly compressed laterally.

Remarks.--This specimen has two rejuvenated denticles and appears to have a small portion of one end broken. This species closely resembles Polycaulodus inclinatus but differs from the latter in having an arched base.

Occurrence.--One specimen was recovered from the Pecatonica Member at locality 12.

Repository.--UW 815.

DREPANODUS SUBERECTUS (Branson and Mehl)

Pl. 3, fig. 7, 9-10, 13-14

Oistodus suberectus BRANSON and MEHL, 1933b, no. 2, p. 111, pl. 9, fig. 7.

Drepanodus suberectus BERGSTRÖM and SWEET, 1966, p. 330, pl. 35, figs. 22-27 (includes synonomy to 1966); OBERG, 1966, p. 137-138, pl. 16, fig. 1; WINDER, 1966b, pl. 9, fig. 6 (plate only).

Drepanodus homocurvatus OBERG, 1966, p. 137, pl. 16, fig. 13; WINDER, 1966 pl. 9, fig. 11 (plate only); ANDREWS, 1967, p. 889, pl. 113, fig. 16, pl. 114, figs. 8, 15.

Oistodus inclinatus OBERG, 1966, p. 139, pl. 15, fig. 3; ANDREWS, 1967, p. 895, pl. 114, fig. 19.

Oistodus excelsus OBERG, 1966, p. 139, pl. 15, fig. 2; WINDER, 1966b, pl. 9, fig. 13 (plate only).

Remarks.--This multielement species is composed of three well known and well described form-species, namely Drepanodus homocurvatus, D. suberectus, and Oistodus inclinatus. D. homocurvatus and D. suberectus are quite variable with respect to degree of curvature of the cusp and of basal configuration. Bergström and Sweet (1966, p. 332) stated: "We have been unable to divide either form-species into subordinate groups that maintain stability in any combination of these characters." Bergström and Sweet (1966) also compared the type specimens of both Oistodus inclinatus Branson and Mehl and Oistodus excelsus Stauffer and found them to be conspecific.

The form-species Drepanodus homocurvatus is nearly three times as abundant as the combined totals of the form-species D. suberectus and Oistodus inclinatus. Webers' (1966) tabulations suggested a similar relationship. However, the totals of Bergström and Sweet's (1966) fauna indicate a 4 to 1 relationship. This is probably due to the greater number of specimens in their collection. (Bergström and Sweet recovered nearly 250,000 conodonts, Webers nearly 50,000.)

Occurrence.--This abundant species, which comprises slightly over 28% of my collection, is found in every Platteville Member at every locality. I recovered 875 of the form-species Drepanodus homocurvatus, 247 oistodid forms, and 88 of the form-species Drepanodus suberectus.

Repository.--UW 822, 823, 824, 825, 826.

PANDERODUS GRACILIS (Branson and Mehl)

Pl. 6, fig. 4, 5, 9,

Paltodus gracilis BRANSON and MEHL, 1933b, p. 108, pl. 8, figs. 20, 21.

Panderodus gracilis BERGSTRÖM and SWEET, 1966, p. 355, pl. 35, figs. 1-6 (includes synonomy to 1966); OBERG, 1966, p. 140, pl. 16, fig. 3; WINDER, 1966, pl. 9, fig. 25 (plate only); ANDREWS, 1967, p. 896, pl. 113, fig. 9.

Panderodus compressus OBERG, 1966, p. 140, pl. 15, fig. 8; WINDER, 1966b, pl. 9, fig. 26 (plate only); ANDREWS, 1967, p. 895, pl. 113, fig. 3.

Panderodus striatus WINDER, 1966b, pl. 9, fig. 24 (plate only).

This multielement species is composed of several form-species which have been lumped traditionally into two distinct forms, namely Panderodus gracilis (Branson and Mehl) and Panderodus compressus (Branson and Mehl). (See Bergström and Sweet, 1966, p. 355-357 for complete synonomy.) The forms included in P. gracilis are relatively slender, gently recurved units with broadly rounded anterior faces. They all have a distinct costa near the anterior margin on the inside, and a conspicuous groove near the posterior margin on the outside. They all have a deeply excavated basal cavity, extending half the length of the cusp.

The forms included in Panderodus compressus are laterally compressed recurved units having more or less keeled anterior and posterior margins. One side is completely free of ornamentation. Near the posterior margin of the other side a faint groove extends the length of the cusp. Similar to other Panderodus forms, these have the deeply excavated basal cavity.

Remarks.--The Panderodus gracilis forms are quite variable with respect to degree of curvature of the cusp, placement and degree of lateral ornamentation, and depth of basal excavation. The Panderodus compressus forms do not exhibit such wide variation, and are readily identified by their compressed nature.

Recovery of 223 Panderodus compressus forms and 169 P. gracilis forms gives a ratio of 1.0:0.77, whereas Bergström and Sweet (1966) tallied a ratio of about 1:2. This difference can probably be attributed to the unequal size of the two collections. Webers (1966) did not recognize this multielement species in Minnesota.

Occurrence.--Panderodus gracilis (including P. compressus was found in all three members in the Lake Winnebago area, in the Pecatonica and McGregor Members of the Oostburg core, and in virtually every member at every locality in the southwest, except locality 4. Two hundred twenty-three P. compressus forms, 136 P. striatus forms, and 33 P. gracilis forms were recovered.

Repository.--UW 838, 839, 840.

PHRAGMODUS UNDATUS (Branson and Mehl)

Pl. 4, fig. 6; Pl. 5, fig. 8; Pl. 6, fig. 6

Phragmodus undatus BRANSON and MEHL, 1933b, no. 2, p. 115, 116, pl. 8, figs. 22-26; BERGSTRÖM AND SWEET, 1966, p. 369, pl. 28, figs. 13-20 (includes synonomy to 1966); WINDER, 1966b, pl. 10, fig. 11 (plate only); ANDREWS, 1967, p. 896, pl. 114, fig. 10.

Oistodus abundans WINDER, 1966b, pl. 9, fig. 16 (plate only); ANDREWS, 1967, p. 895, pl. 114, fig. 14.

Dichognathus typica ANDREWS, 1967, p. 889, pl. 114, fig. 12.

Dichognathus brevis OBERG, 1966, p. 137, pl. 15, fig. 16; WINDER, 1966b, p. 55, pl. 10, fig. 23.

This multielement species is composed of our well known form-species. They are: Phragmodus undatus, Dichognathus typica, D. brevis, and Oistodus abundans, all described by Branson and Mehl. The phragmodid forms are laterally compressed, arched, bar-like units having a posterior process which bears denticles on the upper surface. The main cusp is slightly recurved. Posterior to the main cusp, at the point of greatest flexure of the bar, a second, large cusp is present, generally larger than the anterior one. The space between the large denticles is usually occupied by several smaller denticles. The lower surface of the bar is excavated and enclosed in a sheath beneath the anterior denticle.

Dichognathid forms are arched, blade-like units having a laterally compressed, sharply keeled, reclined cusp. Lateral processes bear laterally compressed denticles which may be fused or discrete. The apical denticle is conspicuously off-set laterally on the anterior face. The basal cavity is deep beneath the apical denticle, then tapers to the tips of the processes. In the form-species Dichognathus brevis, the lateral processes are more strongly arched and directed more posteriorly than in the form-species D. typica.

The oistodid forms have a laterally compressed, sharply keeled, strongly reclined cusp with an elongate, excavated base which is sharply pointed at both ends. The basal cavity comes to a small point which is directed anteriorly beneath the cusp. The base is markedly flared on one side, the other side being just slightly convex.

Remarks.--Most specimens of Dichognathus are quite fragmentary, and very few could be separated into the form-species D. brevis and D. typica.

It should be noted that some of the specimens of the form-species Oistodus abundans closely resemble Oistodus linguatus var. extenuatus Lindström (1955) in that the anterior end of the specimen is extenuate. Indeed, O. abundans closely resembles the forms described and illustrated by Lindström (1955) as O. linguatus and it may be that they are closely related, if not identical, forms.

The oistodid, dichognathid, and phragmodid forms occur in Wisconsin in a ratio of 1:1.2:0.68 respectively. Webers' (1966) specimens were found together in a 1:1.14:1.83 ratio, and Bergström and Sweet's (1966) tabulations showed a 1:1.5:3.1 relationship. The disparity of the ratios is probably the result of the significant differences in the size of the three collections.

Occurrence.--Phragmodus undatus (including form-taxa Dichognathus typica, D. brevis, and Oistodus abundans) was recovered from all members at all localities in the southwest and the Lake Winnebago area (except locality 13), and from the Pecatonica and McGregor Members of the Oostburg core. Ninety-seven dichognathids, 80 oistodids, and 54 phragmodids were found.

Repository.--UW 842, 843, 844.

PLECTODINA ACULEATA (Stauffer)

Pl. 3, fig. 4-6, 8

Prioniodus aculeatus STAUFFER, 1930, p. 126, pl. 10, fig. 12.

Plectodina aculeata BERGSTRÖM and SWEET, 1966, p. 373-377, pl. 32, figs. 15, 16; pl. 33, figs. 22, 23; pl. 34, figs. 5, 6; text-figs. 9 A-F (includes synonomy to 1966).

Subcordylodus plattinensis OBERG, 1966, p. 142, pl. 16, fig. 12

Trichonodella recurva OBERG, 1966, p. 143, pl. 15; figs. 5, 26.

This is a multielement species composed of the three form-species Cordylodus aculcatus, Trichonodella recurva, and Zygognathus illustris. The cordylodid elements are bowed, laterally compressed, asymmetric units consisting of an erect to distally recurved, sharply keeled cusp and a long posterior process which bears a row of low, reclined denticles on its upper surface. The denticles tend to be fused throughout most of their height. The cusp is twisted laterally so that the plane containing its keeled edges nearly forms a right angle to the plane of the posterior process. The anterior edge of the cusp is extended downward in a posterior direction forming a distinct anticusp which may bear one or two short, sharp denticles on the distal portion. The basal cavity, which extends as a shallow excavation along the lower surface of the process, is enclosed within a sheath beneath the main cusp.

The trichonodellid elements are symmetric to subsymmetric units consisting of a stout, recurved cusp. The posterobasal portion is extended posteriorly as a short process. The upper surface bears one to two or more short denticles which tend to be discrete but may become fused if several denticles are present. Two straight lateral processes are directed sharply downward and bear from two to six erect, antero-posteriorly compressed denticles in early growth stages. The denticles become circular and peg-like in late growth stages. The basal cavity exists as a relatively deep, subconical cavity beneath the main cusp, and as shallow excavations which extend to the tips of all three processes.

The zygognathid elements are highly asymmetric units possessing a stout, recurved cusp which is slightly laterally deflected, and two lateral processes which are directed sharply downward, One process is extended posteriorly and slightly flexed in an inward direction, the other extends generally straight down with a slightly convex lower surface. The upper surface of the processes are set with antero-posteriorly compressed denticles. The denticles on the posteriorly extended bar are directed laterally due to the flexure of the bar; those on the other bar are erect. These denticles tend to become peg-like in later growth stages. The basal cavity is a subconical excavation beneath the main cusp, which extends as a shallow groove to the tips of the processes.

Remarks.--In Wisconsin the zygognathid-trichonodellid-cordylodid ratio of this multielement species is 1:2.8:4.6. Bergström and Sweet (1966) tallied a ratio of 1:3.1:3.4. Webers (1966) did not recognize this multielement species in Minnesota.

Occurrence.--Plectodina aculeata was recovered from all the Platteville Members from nearly every locality. One hundred fifty-eight cordylodids, 96 trichonodellids, and 34 zygognathids were found.

Repository.--UW 845, 846, 847, 848.

POLYPLACOGNATHUS RAMOSA Stauffer

Pl. 5, fig. 5, 9

Polyplacognathus ramosa STAUFFER, 1935b, p. 615, pl. 75, figs. 23, 28-31, 37; BERGSTRÖM and SWEET, 1966, p. 386, pl. 28, figs. 9-12 (includes synonomy to 1966).

This is a multielement species composed of Polyplacognathus ramosa Stauffer and a new form recently described by Schopf (1966), P. bilobata. The P. ramosa form is a long, straight platform which is rounded on the posterior end and comes to a sharp point anteriorly. Four lateral lobes are developed near the posterior end and are arched downward. The three larger lobes are spatulate; the fourth and smallest is somewhat broader. On the upper surface, the lobes bear nodular carinas which meet at a central node on the platform. The upper surface of the broad posterior portion of the platform has a median, nodular carina which is surrounded on both sides by small nodes which may develop into lateral carinas. The anterior extension also has a median nodular carina which may have smaller lateral carinas paralleling it part of the way. The lower surface is keeled, sharply beneath the lateral lobes and anterior extension, and indistinctly beneath the broad, posterior end.

The P. bilobata form is an elongate platform having a long anterior process and a bifid posterior process. The anterior process bears discrete, median, ridge-like denticles. The posterior lobes have low, median, nodular carinas. A large, postero-laterally deflected ridge-like cusp occurs at the junction of the posterior and anterior processes. The lower surface is keeled and a small pit may be formed at the junction of the keels beneath the main denticle.

Remarks.--The nodular carinas of both forms may occur as discrete, low nodes on some of the processes during early growth stages. With the exception of the figured form, all specimens of Polyplacognathus bilobata are broken.

Recovery of 28 bilobatid forms and 151 ramosid forms gives a ratio of 1:5.4. Bergström and Sweet's (1966) ratio for this species was 1:9.4 whereas Webers (1966) reported ratio of 1:1.1. The variation in the ratios may be the result of a combination of the collection size differences and the fragile nature of the specimens. Both forms of this multielement species are easily broken into many fragments making accurate counts difficult.

Occurrence.--Polyplacognathus ramosa (including P. bilobata) was recovered from the McGregor Member at locality 14, and from all the members in the southwest.

Repository.--UW 852, 853.

PRIONIODINA POLITA? (Stauffer)

Pl. 6, fig. 16

Tortoniodus politus STAUFFER, 1935a, p. 155, pl. 10, figs. 38, 42.

Prioniodina polita WEBERS, 1966, p. 53, pl. 7, figs. 8, 10, 17 (includes synonomy to 1966).

Laterally compressed forms having a large, erect to slightly postero-laterally reclined main cusp, with anterior and posterior processes which bear denticles. The anterior process is shortest, and directed slightly downward. The denticles are erect and fused, tending to be discrete only distally. The longer, posterior process is directed more sharply downward causing the denticles to be strongly inclined posteriorly. These denticles tend to be much more discrete than the anterior denticles. The denticles on each process tend to become larger away from the main cusp, then smaller near the extremities. The basal cavity is subconical and somewhat flared beneath the main cusp, and extends as a shallow groove to near the tips of the processes.

Remarks.--This form resembles the ozarkodinid element of *Ozarkodina obliqua* (Stauffer), a multielement species figured by Webers (1966) and illustrations and description of *Prioniodina polita*, they were questionably assigned to that species.

Occurrence.--*Prioniodina polita*? was recovered from the Pecatonica Member at localities 11, 12, and 13; from the McGregor and Quimbys Mill Members at locality 14; from the upper Platteville at locality 10; and from all three members in the southwest. 37 specimens.

Repository.--UW 855.

Lake Church and Milwaukee Conodonts

Dietmar Schumacher

Genus ACODINA Stauffer, 1940

Type species.--Acodina lanceolata Stauffer, 1940

A number of investigators, among them Hass (1962) and Lindström (1964), have questioned the validity of this genus. Hass regards Acodina to be a junior synonym of Acontiodus. Lindström, on the other hand, regards it to be synonymous with Drepanodus. The writer considers the genus Acodina to be distinct from both these genera and, in this respect, is in agreement with Sannemann (1955a) and Clark and Ethington (1966, 1967).

Specimens of Acodina are not uncommon in Middle and Upper Devonian faunas from Europe and North America. The highly variable nature of the cusp outline makes specific identification difficult and often impractical, particularily when only a few specimens are available for study.

ACODINA CURVATA Stauffer

Pl. 7, fig. 1-2

Acodina curvata STAUFFER, 1940, p. 418, pl. 60, figs. 3, 14, 16; ORR, 1964 p. 6, pl. 1, fig. 11; CLARK and ETHINGTON, 1967, p. 28, pl. 2, fig. 3.

A species of Acodina characterized by a pronounced longitudinal curvature and plano-convex cross-section. The Wisconsin specimens compare favorably with those described and illustrated by Stauffer (1940) and others. A. curvata has been recorded from the upper Middle Devonian and lower Upper Devonian of Europe and North America.

Occurrence.--Lake Church Formation, Milwaukee Formation; four specimens.

Repository.--Figured hypotype, UW-626-A.

Genus BRYANTODUS Bassler, 1925

Type species.--Bryantodus typicus Bassler, 1925.

Bryantodus is distinguished from other arched blades, such as Ozarkodina, by the presence of a lateral flange, or apical lips, at the base of the denticles on one or both sides of the bar. Numerous species of Bryantodus have been proposed, but many are based on broken specimens and/or come from small collections. The highly variable nature of the denticulation, degree of arching, and development of the lateral platform ledges makes specific identification of broken specimens of questionable merit. A thorough review of this genus and related genera will be necessary to establish significant criteria for sound recognition of its species.

BRYANTODUS cf. B. COLLIGATUS (Bryant)

Pl. 8, fig. 6, 8

Prioniodus colligatus BRYANT, 1921, p. 17, pl. 3, figs. 1, 2, 4, pl. 5, figs. 6, 10, pl. 6, fig. 8, pl. 7, figs. 2, 6.

Bryantodus colligatus MÜLLER and CLARK, 1967, p. 910, pl. 117, figs. 2, 9.

A species of Bryantodus characterized by smooth, well-developed platform ledges on both sides of a robust, slightly arched bar. The ledge on the inner (concave) side of the blade is widest. Denticles are closely spaced and fused except for their tips. The cusp is distinct on the specimens found. The lateral faces of the aboral surface slope upward and are marked by growth lines and a narrow crimp; the keel is distinct. Grooves extend in both directions from the small, centrally located pit.

Remarks.--Huddle (1968) redefined Polygnathellus Bassler and distinguished it from Bryantodus on the basis of its well-developed lateral flanges and relatively indistinct cusp. Bryantodus, according to Huddle, is easily distinguishable from Polygnathellus by the bosslike aboral extension of the cusp and the lack of flanges on the bar. Bryantodid species with well-developed flanges, such as B. typicus and B. colligatus, can be distinguished by their large cusps and smooth flanges. Bischoff and Ziegler (1957) have recorded this species from the uppermost Middle Devonian; Bryant's specimens are from the lowermost Upper Devonian.

Occurrence.--Milwaukee Formation; two specimens.

Repository.--Figured specimens, UW-659 and UW-659 A.

Genus ELSONELLA Youngquist, 1945

Type species.-Elsonella prima Youngquist, 1945

ELSONELLA RHENANA Lindström and Ziegler

Pl. 7, fig. 4-5

Elsonella rhenana LINDSTRÖM and ZIEGLER, 1965, p. 212-215, pl. 1, figs. 1-8, pl. 2, figs. 1-10.

Falcodus-Element ORR, 1964, p. 8, pl. 1, figs. 8, 13, 14; LINDSTRÖM and ZIEGLER, 1965, p. 212-213, pl. 1, figs. 1-8.

Roundya-Element LINDSTRÖM and ZIEGLER, 1965, p. 214, pl. 2, figs. 7, 8.

This multi-element species has been discussed at some length by Lindström and Ziegler. The specimens from the Milwaukee Formation compare favorably with descriptions and illustrations of the Falcodus- and Roundya-Elements of Elsonella rhenana. Orr (1964) illustrated what appears to be an identical Falcodus-Element from the upper Alto Formation of southern Illinois. The other elements of the E. rhenana assemblage, Oulodus and

Angulodus, were not found in the Milwaukee collection, but it should be noted that bar and blade types as a whole are only a minor constituent of the Milwaukee fauna.

Lindström and Ziegler (1965) state that E. rhenana is most abundant in faunas of the S. hermanni-P. cristatus Zone, but it has also been recorded from the highest P. varcus Zone and the Lower P. asymmetricus Zone.

Occurrence.--Milwaukee Formation; three specimens.

Repository.--Figured hypotypes, UW-659 C and UW-659 D.

HINDEODELLA AUSTINENSIS Stauffer

Pl. 8, fig. 1-2

Hindeodella austinensis STAUFFER, 1940, p. 424, pl. 58, figs. 3-7, 9; BISCHOFF and ZIEGLER, 1957, p. 58-59, pl. 7, figs. 8, 11, pl. 20, figs. 34, 35; ORR, 1964, p. 8, pl. 2, fig. 1.

Several complete specimens of Hindeodella from the Milwaukee Formation possess an anterior bar that is deflected sharply downward immediately anterior to the cusp, thus forming an angle of almost 90° with the remainder of the bar. The posterior bar is long and only slightly bowed. One to three small denticles alternate with the large denticles of the posterior bar. These specimens conform closely with H. austinensis as described and illustrated by Stauffer (1940) and Bischoff and Ziegler (1957). The latter authors have recorded this species from Middle Devonian (Eifelian, Givetian) and lower Upper Devonian (to I) strata.

Occurrence.--Milwaukee Formation; 22 specimens.

Repository.--Figured hypotypes, UW-664- and UW-664 A.

Genus ICRIODUS Branson and Mehl, 1938

Type species.--Icriodus expansus Branson and Mehl, 1938.

Since Branson and Mehl discussed the stratigraphic distribution of the genus Icriodus, many new species and/or subspecies have been described. The validity of many of these species is open to question because they frequently are known from only a single locality or based on a very small number of specimens. The relationship of the various icriodid species to each other is also a matter worthy of further investigation. Specimens have been described, for example, which are morphologically intermediate between I. expansus and many other icriodid species (I. nodosus, I. symmetricus, I. alternatus, I. curvatus, etc.). The genus Icriodus is in need of monographic revision if present specific designations are to be meaningful and biostratigraphically useful.

ICRIODUS NODOSUS (Huddle)

Pl. 9, fig. 1-29

Gondolella ? nodosa HUDDLE, 1934, p. 94, pl. 8, figs. 24, 25.

Icriodus nodosus BRANSON and MEHL, 1938, p. 160, pl. 26, figs. 14-17, 22; DOWNS and YOUNGQUIST, 1950, p. 670, pl. 87, figs. 17, 18, 21, 22; FAY, 1952, p. 110; STEWART and SWEET, 1956, p. 269, pl. 33, figs. 8, 10; ZIEGLER, 1956, p. 102, pl. 6, figs. 18-21; BISCHOFF and ZIEGLER, 1957, p. 62, pl. 6, figs. 2, 3, 5, pl. 19, figs. 1-4, ?5; MÜLLER and CLARK, 1967, p. 914.

Icriodus expansas BRANSON and MEHL, 1938, p. 160, pl. 26, figs. 18-21. STAUFFER, 1938, p. 430, pl. 52, figs. 12, 14, 16, 19, 20, 25, 33, 35; STAUFFER, 1940, p. 425, pl. 60, figs. 40, 47, 48, 59-64, 70-71; GROHSKOPF, CLARK, and ELLISON, 1943, p. 15-16, pl. 2, figs. 1, 2, 5, 8, 11, 13; DOWNS and YOUNGQUIST, 1950, p. 669, pl. 87, figs. 5-7, 13, 14; FAY, 1952, p. 110; STEWART and SWEET, 1956, p. 267, pl. 33, figs. 1, 3, 9, 12-14; MÜLLER and MÜLLER, 1957, p. 1106, pl. 142, fig. 4; CLARK and ETHINGTON, 1966, p. 680, pl. 83, fig. 9; CLARK and ETHINGTON, 1967, p. 39, pl. 3, figs. ?1, ?2.

Icriodus postiflexus BRANSON and MEHL, 1938, p. 163-164, pl. 26, figs. 10-13.

Icriodus alternatus DOWNS and YOUNGQUIST, 1950, p. 669, pl. 87, figs. 8, 11, 12; ORR, 1964, p. 9, pl. 2, fig. 12 (not pl. 2, fig. 11 = n. sp. A aff. I. symmetricus).

Icriodus curvatus BISCHOFF and ZIEGLER, 1957, p. 61, pl. 6, figs. 6a, 6b; CLARK and ETHINGTON, 1966, p. 680. pl. 83, fig. 8.

Icriodus symmetricus BISCHOFF and ZIEGLER, 1957, p. 64, pl. 6, figs. 1, 4; ORR, 1964, p. 10-11, pl. 2, figs. 13, ?14, 15.

Not Icriodus nodosus ZIMMERMANN, 1960, p. 188, pl. 4, figs. 3a, 3b (= I. alternatus?); WOLSKA, 1967, p. 380-381, pl. 2, figs. 1-3 (=I. alternatus?); MOUND, 1968, p. 488, pl. 66, figs. 38, 39 (= icriodid of curvatus/symmetricus type).

Not Icriodus expansus YOUNGQUIST and PETERSON, 1947, p. 246-247, pl. 37, figs. 5-7, 10, 20, (= icriodid of "I. alternatus-Group").

Diagnosis.--A species of Icriodus characterized by non-alternating denticulation, a biconvex oral outline, and a broadly expanded basal excavation.

Description.--An icriodid in which the lateral margins of the oral surface are more or less biconvex. Sides curve gently to form a pointed anterior terminus and a pointed to broadly rounded posterior terminus. The axis is straight or slightly bowed with maximum curvature occurring near the anterior tip. Three rows of denticles ornament the oral surface. Denticles of median row are of uniform size and circular cross section except for the posteriormost one or two which tend to be larger and laterally compressed. They may be joined by a thin longitudinal (medial) ridge and are 8-10 in number. Denticles of the lateral rows are generally more conspicuous, 7-9 in number, rounded or transversely compressed and bar-like in cross section, and may be fused with the corresponding denticle of the median series. Denticles of the median row are located just opposite or slightly anterior to those of the lateral rows. The aboral excavation is deep, lachrymiform; posterior half of excavation is of circular to subcircular outline. A triangular, antero-laterally directed spur-like offset is developed to a greater or less degree on the inner margin of most specimens. The outline of the basal excavation is highly variable and all gradations between forms with a well developed offset and those lacking it can be seen. The specimens studied ranged from 0.5 mm. to slightly more than 1.0 mm. in length.

Remarks.--Previous workers have been reluctant to place *I. expansus* into synonomy with *I. nodosus* because the holotype of the latter species was broken and is now missing. Branson and Mehl (1938) proposed the name *I. expansus* for an icriodid similar to *I. nodosus* except that it lacked the well-developed spur-like offset of that species. It is evident from large collections, however, that the outline of the basal excavation is a highly variable character and all gradations appear to exist between the two species. If this is so, then the two species must be conspecific and the older name, *I. nodosus*, has priority. This same range in variation in basal cavity outline can be observed in the Upper Devonian icriodid *I. alternatus*.

Icriodus postiflexus Branson and Mehl (1938) falls well within the range of variation for icriodids of the *nodosus-expansus* group and is here considered a junior synonym of *I. nodosus* s.l..

Specimens of *I. nodosus* s.l. from the Milwaukee Formation differ from those of the Lake Church in several respects. The outline of the basal excavation is more nearly circular and the spur-like offset, if present, is less sharply delineated. Denticles of the lateral rows are more frequently transversely compressed and bar-like or wedge-shaped. In the Lake Church specimens, the lateral row denticles are frequently wedge-shaped but specimens in which they are of circular cross section are not uncommon. Denticles of the median row are less frequently joined by a longitudinal ridge and, in a number of Lake Church specimens, 3-4 denticles in the posterior portion of the median row are greatly reduced in size or absent altogether. Aborally, many of the Lake Church specimens show a pronounced anteriorly and slightly laterally directed spur-like offset in the posterior half of the aboral excavation.

The Lake Church specimens resemble specimens from the Dundee Formation (upper Eifelian) and Rogers City Limestone (lowermost Givetian) more closely than those from the overlying Silica Shale and/or Traverse Group (lower-upper Givetian) or Milwaukee Formation (uppermost Givetian). Accordingly, it may be desirable at a later time to differentiate *I. nodosus* s.l. into at least two subspecies, an older one, characterized by a well-developed spur-like offset and an incomplete or reduced median denticle row, known from upper Eifelian and lowermost Givetian strata, and a younger one possessing normal denticulation and a less well-defined spur-like offset and occurring in younger Givetian strata.

Specimens transitional in character between I. nodosus s.l. and I. symmetricus occur in the Milwaukee Formation and are here assigned to a new but unnamed species of Icriodus. Specimens are also present in the Milwaukee which appear to be transitional in character between I. nodosus s.l. and I. alternatus. A single specimen from the Lake Church is unique in possessing a very large, broadly expanded basal cavity (see pl. 9, figs. 15, 16) and resembles specimens illustrated by Bischoff and Ziegler (1957, pl. 19, fig. 5) and by Orr (1964, pl. 2, fig. 14). These specimens appear to represent an extreme variant of I. nodosus s.l., but may merit separate subspecies status if they can be shown to be stratigraphically useful.

Occurrence.--Abundant in Lake Church and Milwaukee Formations; more than 500 specimens.

Repository.--Figured hypotypes, UW-678 to UW-686, UW-691.

ICRIODUS n.sp. A aff. I. SYMMETRICUS Branson and Mehl

Pl. 9, fig. 30-40

? Icriodus alternatus GROHSKOPF, CLARK, and ELLISON, 1943, p. 15, pl. 2, figs. 3, 6; ORR, 1964, p. 9, pl. 2, fig. 11, ?12.

Description.--A slender icriodid, about four times as long as wide, with parallel to subparallel sides which gradually taper anteriorly and posteriorly. Three rows of discrete, regularly rounded denticles ornament the oral surface. Denticles of the median row are of uniform size, 7-10 in number, and circular or slightly laterally compressed in cross-section except for the posteriormost 2-3; these tend to be larger and more laterally compressed and are frequently fused into a blade-like crest. A thin, longitudinal ridge may join the denticles of the median row. Denticles of the lateral rows, 3-6 in number, are circular in cross-section and tend to end abruptly at a point 3-4 denticles anterior of the posteriormost denticle of the median row. Denticles of the median row tend to be higher and are located just opposite or, more frequently, slightly anterior of those in the lateral rows. The axis is most frequently straight but may be very slightly bowed. The aboral excavation is lachrymiform and its posterior third subcircular in outline.

Remarks.--Specimens assigned to this species most closely resemble I. symmetricus Branson and Mehl but can be distinguished from that species because the axis of the element is straight rather than curved, the base somewhat more expanded posteriorly, and the conodont element itself is slightly less slender than in "typical" I. symmetricus. The slender nature of this new species, its parallel sides, and the less broadly expanded basal excavation serve to distinguish it from I. nodosus s.l. Specimens transitional in character between the new species and I. nodosus are present, however, in large collections from the Milwaukee (Figure 18 , pl. 9, figs.

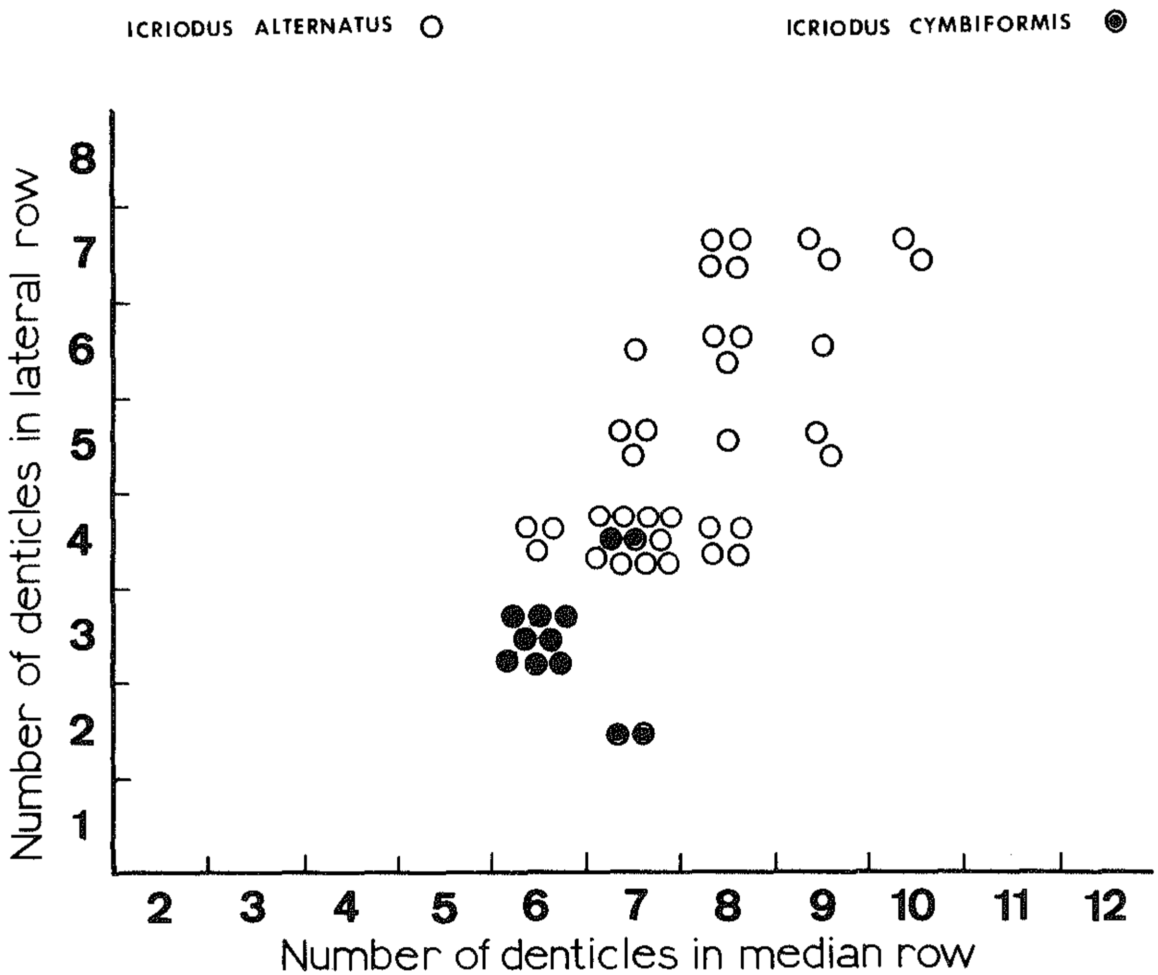


Figure 18. Scatter diagram of number of denticles in median and lateral rows of Icriodus alternatus and Icriodus cymbiformis

29, 40). I. alternatus is distinguishable from the new species by its alternating denticulation and shorter and less conspicuous median denticle row.

Icriodus symmetricus Branson and Mehl has not yet been recorded from rocks older than earliest Late Devonian (middle Polygnathus asymmetricus Zone, to I∝). Representatives of this new species have been found by the writer in the lower Milwaukee Formation, the Rapid Member of the Cedar Valley Formation of Illinois and Iowa, the middle and upper Callaway Formation of central Missouri, all of latest Middle Devonian age, and from the earliest Late Devonian State Quarry Limestone of Iowa and Snyder Creek Shale of Missouri. Some of the specimens illustrated by Grohskopf, Clark, and Ellison (1943) from the Fortune Formation of Missouri and by Orr (1964) from the Alto Formation of Illinois seem to be referable to this species.

Occurrence.--Common in Milwaukee Formation; 75 specimens.

Repository.--Figured specimens UW-687, UW-688, UW-692, UW-692 A, and UW-692 B.

Genus PANDERODUS Ethington, 1959

Type species.--Paltodus unicostatus Branson and Mehl, 1933

Ethington (1959) proposed the name Panderodus for asymmetrical conodonts fitting the general description of Paltodus but possessing a basal cavity which extends at least half the length of the cusp. Hass (1962) questioned the validity of the genus Panderodus and regarded it to be synonymous with Paltodus. Lindström (1964), on the other hand, considered Panderodus to be valid and distinct from Paltodus. Clark and Ethington (1966) have recently emended the description of Panderodus and have clearly shown it to be distinct from Paltodus.

The presence of representatives of Panderodus in the Lake Church Formation of Wisconsin and in the lower Traverse Group (Bell Shale) of Michigan represents the highest occurrence of this genus in the Devonian.

PANDERODUS cf. P. SIMPLEX (Branson and Mehl)

Pl. 8, fig. 11

Paltodus simplex BRANSON and MEHL, 1933a, p. 42-43, pl. 3, fig. 4.

Panderodus simplex CLARK and ETHINGTON, 1966, p. 682-683, pl. 82, figs. 10, 14.

Specimens herein referred to P. cf. P. simplex most closely resemble that species and P. compressus in that both species possess blunt anterior and posterior edges and a lenticular transverse section. The more strongly curved cusp of P. compressus serves to distinguish it from P. simplex. Clark and Ethington have recorded this species from the Lower Devonian of Nevada.

Occurrence.--Lake Church Formation: three specimens.

Repository.--Figured specimen, UW-765.

Genus POLYGNATHUS Hinde, 1879

Type species.--Polygnathus dubius Hinde, 1879.

Next to icriodids, polygnathids are the most abundant elements in the Lake Church and Milwaukee conodont faunas. Although eight species of Polygnathus have been recognized, 95% of the specimens found are referable to only three of these.

POLYGNATHUS CRISTATUS Hinde

Pl. 10, fig. 1-2

Polygnathus cristatus HINDE, 1879, p. 366, pl. 17, fig. 11; ZIEGLER, 1965 p. 670-671, pl. 4, figs. 17-23, pl. 5, figs. 1-5; CLARK and ETHINGTON, 1967, p. 59-60, pl. 7, figs. 16, 17.

A species of Polygnathus characterized by a short, high free blade and a strongly arched, oval platform which tapers to a pointed posterior tip and is ornamented by large, rounded nodes and/or tubercles. Aborally, a small rounded pit is located just anterior of the plate's midpoint; the keel is low; the crimp, broad.

The Milwaukee specimens conform very closely to those illustrated by Orr (1964) and Ziegler (1965). The occurrence of P. cristatus in the lower part of the Lindwurm Member of the Milwaukee represents the informally recognized higher part of the S. hermanni-P. cristatus Zone, above the first appearance of P. cristatus. P. cristatus ranges from within the S. hermanni-P. cristatus Zone into the overlying Polygnathus asymmetricus Zone.

Occurrence.--Milwaukee Formation; two specimens.

Repository.--Figured hypotype, UW-790 A.

POLYGNATHUS DECOROSUS Stauffer

Pl. 10, fig. 12; Pl. 11, fig. 1-10

Polygnathus decorosus STAUFFER, 1938, p. 438, pl. 53, figs. 1, 5, 6, 10, 11, 15, 16, 20, 30; ORR, 1964, p. 14, pl. 1, fig. 2.

Remarks.--P. decorosus is the single most abundant polygnathid in the Milwaukee Formation. Specimens are well preserved and show a complete gradation in size and morphology from the smallest specimens, identical to P. juvensis Stauffer, to slightly larger specimens which compare favorably with Stauffer's P. hulkus and P. zylus, and finally to typical P. decorosus. This sequence is demonstrated by the specimens illustrated on Pl. 11, figs. 1-10. These specimens are from a single sample (B-12) and range in size from less than 0.4 mm. to more than 1.0 mm. Ornamentation on the platform ranges from smooth or indistinctly nodose on the smaller specimens to elongate nodes and/or ridges on larger specimens. Specimens transitional in character between P. decorosus and P. pennatus and P. foliatus are not uncommon in the Milwaukee fauna and closely resemble variants of P. decorosus illustrated by Ziegler (1965, Pl. 3, figs. 1-4, pl. 4, figs. 1-4, pl. 6, figs. 7-11, 13-17).

Occurrence.--?Lake Church Formation, one specimen; Milwaukee Formation, more than 300 specimens.

Repository.--Figured hypotypes, UW-770 A to UW-770 J, UW-774 B.

POLYGNATHUS PENNATUS Hinde

Pl. 10, fig. 3, 4, 13

Polygnathus pennatus HINDE, 1879, p. 366, pl. 17, fig. 8; MÜLLER and CLARK, 1967, p. 917, pl. 115, figs. 1, 2; HUDDLE, 1968, p. 39-40, pl. 14, figs. 18, 19, 21, 31.

Description.--A species of Polygnathus with a lancet-shaped platform as long as, or longer than, the free blade. The posterior terminus is pointed and somewhat laterally deflected. Elongate nodes and short ridges oriented normal to the platform margin ornament the upper surface of the platform. The ridges do not meet the carina and commonly degenerate into discrete nodes as they approach the carina. Nodes are more frequent on the posterior half of the platform. The carina is composed of strong fused nodes which are most robust near the platform's mid-portion. Aborally, a small, elongate pit is located in the anterior third of the platform; the keel is distinct.

Remarks.--This species resembles P. foliatus in general outline, but can be distinguished from it by the ribbed ornamentation on the oral surface in contrast to the predominantly nodose ornamentation of P. foliatus. Also, the pit of P. foliatus is located further anteriorly than on P. pennatus. P. pennatus differs from P. decorosus in having a somewhat shorter free blade and a smaller, more centrally located pit; P. decorosus also tends to have a more slender platform. Specimens transitional in character between P. pennatus and P. decorosus and/or P. foliatus have been figured and discussed by Ziegler (1965) and can be recognized in the Milwaukee collection. P. pennatus has been recorded from the base of the S. hermanni-P. cristatus Zone (uppermost Givetian) into the overlying Lower P. asymmetricus Zone (lowermost Upper Devonian).

Occurrence.--Milwaukee Formation; 75 specimens.

Repository.-- Figured hypotypes, UW-791 A and UW-793 A; unfigured hypotypes UW-791, UW-792 and UW-793.

"Kenwood" Conodonts

Dietmar Schumacher

Genus ANCYRODELLA Ulrich and Bassler, 1926

Type species.--*Ancyrodella nodosa* Ulrich and Bassler, 1926.

The range of *Ancyrodella* is restricted to the Frasnian Stage of the Upper Devonian. Ziegler (1962b) outlined the course of evolution of species within this genus and demonstrated their biostratigraphic usefulness. The most important characteristics for specific identification are considered by him to be the general outline of the platform and the development of the secondary keels.

Representatives of *Ancyrodella* are common in the "Kenwood" I fauna. Almost all of the Wisconsin specimens are referable to one species, *A. buckeyensis*. The absence of earliest Late Devonian species such as *A. rotundiloba* and *A. rugosa* from the "Kenwood" is significant and may suggest that the earliest Late Devonian is not represented in the "Kenwood" but rather in the underlying Milwaukee Formation.

ANCYRODELLA BUCKEYENSIS Stauffer

Pl. 12, fig. 1-3

Ancyrodella buckeyensis STAUFFER, 1938, p. 418, pl. 52, figs. 17, 18, 23, 24; CLARK and ETHINGTON, 1967, p. 29.

A species of *Ancyrodella* with a nearly symmetrical, slightly arched triangular platform ornamented with elongated nodes or ridges set normal to the platform margin. Lateral margins straight or slightly convex; posterior tip pointed.

Remarks.--*A. gigas* may have a platform outline similar to *A. buckeyensis*, but differs in possessing ornamentation of discrete nodes rather than nodose ridges on its upper surface. In general, the upper surface of *A. buckeyensis* is weakly ornamented in comparison to *A. gigas*. Secondary lobes, as found in *A. curvata* and *A. lobata*, are not present in *A. buckeyensis*. Ziegler (1958) recorded this species from the Middle *P. asymmetricus* Zone (to $I\alpha$) into the Middle *P. triangularis* Zone (to $I\delta$?).

Occurrence.--Common in "Kenwood" I; 42 specimens.

Repository.--Figured hypotypes, UW-630 to UW-632.

ANCYRODELLA CURVATA (Branson and Mehl)

Pl. 12, fig. 4-6

Ancyrognathus curvata BRANSON and MEHL, 1934a, p. 241, pl. 19, figs. 6, 11.

Ancyrodella curvata GLENISTER and KLAPPER, 1966, p. 708, pl. 86, figs. 13-15.

A species of Ancyrodella which, in addition to the normal number of lobes, has developed a strongly pronounced posterolateral lobe which bears a distinct secondary carina and keel. The upper surface of the platform is ornamented with nodes which have become distinctly aligned.

Remarks.--A. curvata has a more prominent secondary lobe and stronger secondary carinae and keels than A. lobata. The latter species also lacks the distinctive row-like arrangement of nodes so typical of A. curvata. Ziegler (1962a) recorded A. curvata from the base of the Upper P. asymmetricus Zone (to I$\beta\gamma$) to the top of the Lower P. triangularis Zone (to Iδ).

Occurrence.--"Kenwood" I; three specimens.

Repository.--Figured hypotypes, UW-634 and UW-634 A.

ANCYROGNATHUS SINELAMINUS (Branson and Mehl)

Pl. 12, fig. 18-21

Polygnathus sinelamina BRANSON and MEHL, 1934a, p. 248, pl. 20, figs. 20, 22.

Ancyrognathus sinelamina ZIEGLER, 1962a, p. 50-51, pl. 9, figs. 7-12.

A species of Ancyrognathus with a slender, slightly arched canoe-shaped platform. The carina is low, irregular in height and composed of fused nodes in anterior half, but degenerates into low, discrete nodes posteriorly. Carina does not continue as a free blade. Upper surface of platform is ornamented with low, rounded nodes distributed in a more or less irregular manner.

Remarks.--Specimens here referred to A. sinelaminus compare favorably with specimens described and illustrated by both Branson and Mehl (1934a) and Zeigler (1962a). The Wisconsin specimens differ from the holotype in that they possess a larger pit than in the specimens described by Branson and Mehl. Ziegler (1962a) recorded A. sinelaminus from the Middle P. triangularis Zone (to Iδ ?) into the Upper P. crepids Zone (to IIα), with specimens occasionally found as high as the P. rhomboidea Zone (to IIβ).

Occurrence.--"Kenwood" I, "Kenwood" II; two specimens.

Repository.--Figured hypotypes, UW-641 and UW-642.

Genus ICRIODUS Branson and Mehl, 1938

Type species.--Icriodus expansus Branson and Mehl, 1938.

Many new icriodid species have been described since the genus was first discussed by Branson and Mehl (1938). Many of these are known only from a single locality or based on very few specimens. As a result, the range of variation for these species is frequently inadequately known and the validity of some of these proposed species is questionable.

Icriodus has been recorded from rocks as young as to V in Europe (Freyer, 1961). In North America however, Collinson and others (1962) indicated that the upper limit of the range of Icriodus coincides with that of the Manticoceras-Stufe (to I). In Wisconsin, icriodids are abundant in the "Kenwood" I fauna (to I) but have not yet been recorded from the "Kenwood" II fauna (upper to IIα).

ICRIODUS ALTERNATUS Branson and Mehl

Pl. 13, fig. 1-7

Icriodus alternatus BRANSON and MEHL, 1934 a, p. 225, pl. 13, figs. 4-6; ETHINGTON, 1965, p. 573, pl. 67, fig. 8; ANDERSON, 1966, p. 405. pl. 52, figs. 11, 12; GLENISTER and KLAPPER, 1966, p. 804.

Remarks.--Icriodid of medium to large size in which denticles of the median and lateral series fail to align. Denticles of the median series, 6 to 10 in number, are generally considerably smaller and less conspicuous than those of the lateral series, of which there are 4 to 7. In Branson and Mehl's holotype the median row of denticles continues posteriorly beyond the lateral row for the space of one denticle. The Wisconsin material shows considerable variation in this respect. The denticles of some specimens continue posteriorly for the space of one denticle, as in the holotype, but many continue posteriorly for the space of three denticles. Ethington (1965) made similar observations on specimens from the Martin Limestone of Arizona and New Mexico.

The larger size and more robust appearance of I. alternatus serve to distinguish it from the smaller and more slender I. cymbiformis. A scatter diagram plot of the number of denticles in the median and lateral rows of these two species (Figure 18) strongly suggests that I. cymbiformis and I. alternatus represent different stages of development of the same form. I. alternatus is abundant in "Kenwood" I fauna, comprising about ninety percent of its icriodid fauna.

Ziegler (1958, 1962a) recorded I. alternatus from the Ancyrognathus triangularis Zone (to Iγ) to the Upper P. quadrantinodosa Zone (to IIIα). In Wisconsin, this species does not appear to range as high as the Upper P. crepida Zone (to IIα).

Occurrence.--Abundant in "Kenwood" I; more than 150 specimens.

Repository.--Figured hypotypes, UW-670 to UW-673.

ICRIODUS CYMBIFORMIS Branson and Mehl

Pl. 13, fig. 8-13

Icriodus cymbiformis BRANSON and MEHL, 1938, p. 164, pl. 26, figs. 27-29; ANDERSON, 1966, p. 406.

This is a small, slender icriodid with a median row of 6-7 distinct, somewhat laterally compressed denticles and lateral rows consisting of 2-3 denticles each. The position of denticles in lateral rows alternates with that of the median series. The basal excavation is deep, lachyrmiform; greatest width occurs at about one-third of the total length from posterior end; element tapers gradually to a pointed anterior terminus and a more broadly rounded posterior terminus.

Remarks.--The relatively few denticles in the lateral series of I. cymbiformis, as well as the small size of this conodont element (0.4 - 0.6 mm.) compared with I. alternatus (0.5 - 0.9 mm.), suggests that crymbiformis represents immature elements of the alternatus-form (Figure 18). In Wisconsin, I. cymbiformis is restricted to the "Kenwood" Shale and comprises about five percent of its icriodid fauna. Bischoff and Ziegler (1956) and Freyer (1961) have recorded I. cymbiformis from strata as young as to IIα.

Occurrence.--"Kenwood" I; 13 specimens.

Repository.--Figured hypotypes, UW-675 to UW-677.

Genus NEOPRIONIODUS Rhodes and Müller, 1956

Type species.--Prioniodus conjunctus Gunnell, 1931.

Rhodes and Müller (1956) created the genus Neoprioniodus for those conodonts with a large, generally slender cusp at the anterior end of a denticulated bar; denticles may be fused or discrete; the anterior process is absent or greatly reduced.

Several authors have questioned the validity of the genus Neoprioniodus. Lindström (1959) considered it to be an assembly of species belonging to the genera Prioniodina, Cordylodus, and Paracordylodus. Bischoff and Ziegler (1957) regard Neoprioniodus and Synprioniodina to be synonymous with Prioniodina, stating that the absence of denticles on the anterior process is not a rigid criterion in this group and should therefore not be the sole characteristic for distinguishing Neoprioniodus from other genera. Lindström (1964) considers Neoprioniodus and Synprioniodina valid genera, distinct from Prioniodina, although he recognized that some specimens will remain borderline cases. At present, almost all North American conodont investigators consider Neoprioniodus a valid genus. Representatives of this genus are not abundant in the "Kenwood" and their fragmentary nature makes specific identification difficult.

Genus NOTHOGNATHELLA Branson and Mehl, 1934

Type species.--*Nothognathella typicalis* Branson and Mehl, 1934.

Nothognathella, according to Branson and Mehl (1934a) can be distinguished from *Bryantodus* because it lacks a well differentiated cusp and possesses distinct platform ledges. Lindström (1964) questioned the validity of the genus *Nothognathella* stating that not everyone may agree that specimens of *Nothognathella* lack a distinct cusp, or that *Bryantodus* lacks platform ledges. The type species of these genera, *B. typicus* and *N. typicalis*, appear distinct from each other, but many of the species which have subsequently been assigned to these genera vary considerably from the original definition. In the present study, *Nothognathella* and *Bryantodus* are considered valid form genera.

Although nothognathellids are common in the "Kenwood", the highly variable nature of the denticulation, degree of arching, and development of platform ledges frequently make specific identification difficult. Because many of the described species of *Nothognathella* are based on fragmentary material or known from a single locality only, the range of morphologic variation for these species is inadequately known. A thorough review of this genus will be necessary before significant criteria for sound recognition of its species can be established.

Genus PALMATOLEPIS Ulrich and Bassler, 1926

Type species.--*Palmatolepis perlobata* Ulrich and Bassler, 1926.

The biostratigraphic succession of the many distinctive, short ranging species of *Palmatolepis*, as established and validated in Europe by Ziegler (1958, 1962a, b), has been tested and confirmed for various parts of the Upper Devonian in Australia by Glenister and Klapper (1966) and in North America by Klapper and Furnish (1963), Ethington (1965), Anderson (1966), Clark and Ethington (1967), and Klapper and others (1969). Representatives of this genus are by far the single most abundant element of the "Kenwood" fauna.

PALMATOLEPIS GIGAS Miller and Youngquist

Pl. 14, fig. 17-20

Palmatolepis gigas MILLER and YOUNGQUIST, 1947, p. 512-513, pl. 75, fig. 1; CLARK and ETHINGTON, 1967, p. 51, pl. 4, fig. 19.

This is a species of *Palmatolepis* with a prominent, strongly extended inner lateral lobe. The upper surface of the platform is sculptured with coarse nodes which in some specimens have become elongate and radially arranged. The blade-carina is slightly sigmoidal; a secondary carina is often present. The posterior portion of the platform is flexed downward.

Remarks.--Some specimens referred to *P. gigas* compare favorably with material described and illustrated by Müller and Müller (1957) as *P. flabellifromis* Stauffer. The lectotype of this species has been lost and the specimens figured by Müller and Müller fall within the range of variation of *P. gigas* and should be considered representatives of that species rather than *P. flabelliformis* (Ethington, 1965; Glenister and Klapper, 1966). Ziegler (1962a) recorded *P. gigas* ranging from the base of the *P. gigas* Zone (*to* Iγ) into the Lower *P. triangularis* Zone (to Iδ).

Occurrence.--"Kenwood" I; 22 specimens.

Repository.--Figured hypotypes, UW-715 to UW-718.

PALMATOLEPIS GLABRA GLABRA Ulrich and Bassler

Pl. 16, fig. 7-8

Palmatolepis glabra ULRICH and BASSLER, 1926, p. 51, pl. 9, figs. 18-20; HUDDLE, 1968, p. 29-31, pl. 14, figs. 2-16.

Palmatolepis glabra glabra GLENISTER and KLAPPER, 1966, p. 811, pl. 89, figs. 6, 7, pl. 90, fig. 3; CLARK and ETHINGTON, 1967, p. 51, pl. 9, fig. 8.

A subspecies of *Palmatolepis* characterized by a long, slender sigmoidal platform with a smooth, shagreen-like upper surface. An inner lobe is not developed. The blade-carina is moderately sigmoidal. A parapet may be weakly developed.

Remarks.--*Palmatolepis glabra* has been differentiated into subspecies by Ziegler (1962a). He recorded *P. glabra glabra* from the base of the Upper *P. crepida* Zone (*to* IIα) into the Upper *P. quadrantinodosa* Zone (*to* IIIα). Although *P. glabra glabra* is a major element in the "Kenwood" II fauna, comprising about one-fourth of the total number of palmatolepids found, few specimens are unbroken.

Occurrence.--Common in "Kenwood" II; 65 specimens.

Repository.--Figured hypotypes, UW-720 and UW-721.

PALMATOLEPIS GLABRA ELONGATA Holmes

Pl. 16, fig. 5-6

Palmatolepis elongata HOLMES, 1928, p. 33, pl. 11, fig. 33.

Palmatolepis glabra elongata GLENISTER and KLAPPER, 1966, p. 811, pl. 95, fig. 1; CLARK and ETHINGTON, 1967, p. 52.

Palmatolepis glabra HUDDLE, 1968, p. 29-31, pl. 14, figs. 2-16.

Remarks.--A small number of specimens from the "Kenwood" are provisionally assigned to this subspecies of P. glabra because they compare favorably with those described and illustrated by Helms (1959, 1963), Ziegler (1962a), Glenister and Klapper (1966), and Huddle (1968).

In the Wisconsin material there seems to be a gradation between forms typical of P. glabra glabra and those more like P. glabra elongata. Scott and Collinson (1959) described the intraspecific variation in P. glabra based on a study of more than 300 specimens from a single sample of Saverton Shale. They recognized and described six morphotypes, including forms here assigned to P. glabra glabra and P. glabra elongata, and illustrated complete morphologic gradation between the different morphotypes.

Ziegler (1962a) recorded P. glabra elongata from the Lower P. quadrantinodosa Zone (to IIβ) into the Upper S. velifer Zone (to IIIβ-IV). Clark and Ethington (1967) reported it from strata they assigned to the P. rhomboidea Zone (to IIβ). Conodonts associated with this subspecies in the "Kenwood" Shale suggest assignment of the Wisconsin occurrence to the Upper P. crepida Zone (to IIα).

Occurrence.-"Kenwood" II; 12 specimens.

Repository.--Figured hypotypes, UW-719 and UW-719 A.

PALMATOLEPIS QUADRANTINODOSALOBATA Sannemann

Pl. 15, fig. 22-24

Palmatolepis quadrantinodosalobata SANNEMANN, 1955b, p. 328, pl. 24, fig. 6; CLARK and ETHINGTON, 1967, p. 54, pl. 9, figs. 1, 4.

This species is characterized by a large triangular platform with a well-developed inner lateral lobe, ornamented with a cluster of coarse nodes on the anterior part of the outer platform. The remainder of the platform surface is shagreen-like. The inner lobe may be pointed or bluntly rounded. The blade-carina is nearly straight or weakly sigmoidal; a secondary carina may be present.

Remarks.--P. quadrantinodosalobata may possess coarse nodes on the anterior inner platform. Ziegler (1962a) described forms transitional between P. triangularis and P. quadrantinodosalobata which are characterized by coarse ornamentation over the entire platform, with a concentration of the coarsest nodes anteriorly. Sculpture on the remaining platform is not as coarse as in P. triangularis. The Wisconsin specimens fit well within the limits of typical P. quadrantinodosalobata and not the transitional group. In numbers, this species comprises about five percent of the "Kenwood" II palmatolepid fauna. Ziegler (1962a) reported this species restricted to the P. crepida Zone (to IIα), however forms transitional with P. triangularis occur as low as the Lower P. triangularis Zone (to Iδ).

Occurrence.--"Kenwood" II; 25 specimens.

Repository.--Figured hypotypes, UW-735 A and UW-736.

Other Conodonts Present

Conodont genera and species other than those presented in this report are present in the "Kenwood" Shale of Wisconsin. The "Kenwood" I fauna, in particular, is a large and varied fauna containing represetatives of additional genera and species. I have not included in this report those forms whose presence is known or strongly suggested by very fragmentary material. A list of these would include *Enantiognathus* cf. *lipperti*, species of *Palmatodella*, *Falcodus*, *Scutula*, *Prioniodella*, plus possible additional species of *Ozarkodina*, *Bryantodus*, *Hindeodella*, *Lonchodina*, and perhaps several others.

REFERENCES CITED

Agnew, A., 1955, Facies of Middle and Upper Ordovician rocks in Iowa: Amer. Assoc. Petrol. Geol., Bull., v. 39, pp. 1703-1752.

__________, 1956, Facies of Platteville, Decorah, and Galena rocks of the upper Mississippi valley region: Guidebook for Field Trips, Minneapolis, Geol. Soc. Amer., pp. 41-54.

__________, and Heyl, A. V., Jr., 1946, Quimbys Mill, new member of Platteville Formation, upper Mississippi valley: Am. Assoc. Petroleum Geologists, Bull., v. 50, p. 1585-1587.

__________, Heyl, A. V., Jr., Behre, O. H., Jr. and Lyons, E. J., 1956, Stratigraphy of Middle Ordovician rocks in the lead-zinc district of Wisconsin, Illinois and Iowa: U.S. Geol. Survey Prof. Paper 274-K, p. iv, 251-312, illus.

Alden, W. C., 1906, Geologic Atlas of the United States: Milwaukee Special Folio, No. 140, Wisconsin: U. S. Geol. Survey, 17 p., 15 text-figs.

Anderson,W.I.,1964, Upper Devonian and Lower Mississippian conodont faunas, north-central Iowa: Iowa Acad. Sci., v. 71, pp. 320-334, text-figs.

__________, 1966, Upper Devonian conodonts and the Devonian-Mississippian boundary of north-central Iowa: Jour. Paleontology, v. 40, p. 395-415, pls. 48-52, 3 text-figs.

Andrews, H. E., 1967, Middle Ordovician conodonts from the Joachim Dolomite of eastern Missouri: Jour. Paleontology, v. 41, p. 881-901, pls. 112-114.

Bain, H. F., 1905, Zinc and lead deposits of northwestern Illinois: U. S. Geol. Survey Bull. 246, 51 p.

Bassler, R. S. 1925, Classification and stratigraphic use of conodonts: Geol. Soc. America, Bull., v. 36, p. 218-220.

Bays, C. A., 1938, Stratigraphy of the Platteville Formation: Geol. Soc. Amer. Proc., 1937, p. 269 (abstract).

__________, and Raasch, G. O., 1935, Mohawkian relations in Wisconsin: Kans. Geol. Soc. 9th Ann. Fld. Conf. - Upper Mississippi Valley, p. 296-301.

Bergström, S. M., and Sweet, W. C., 1966, Conodonts from the Lexington Limestone (Middle Ordovician) of Kentucky and its lateral equivalents in Ohio and Indiana: Bulls. Am. Paleontology, v. 50, no. 229, p. 267-441, pls. 28-35.

Bischoff, Gunther, and Ziegler, Willi, 1957, Die Conodontenchronologie des Mitteldevons und des tiefsten Oberdevons: Hess. Landesamt Boden., Notizbl., Abh., H. 22, 136 p., 21 pls., 16 text-figs., 5 tables.

Boucot, A. J., Johnson, J. G., and Wolfgang Struve, 1966, Stringocephalus, ontogeny and distribution: Jour. Paleontology, v. 40, p. 1349-1364, pls. 169-171, 2 text-figs.

Branson, E. B., and Mehl, M. G., 1933a, Conodonts from the Bainbridge (Silurian) of Missouri: Missouri Univ. Studies, v. 8, no. 1, p. 39-52, pl. 3, 1 text fig.

__________, 1933b, Conodonts from the Plattin (Middle Ordovician) of Missouri: Ibid., pp. 101-120, pls. 8-10.

________ and _______, 1934, Conodonts from the Grassy Creek Shale of Missouri: Ibid., no. 3, p. 171-259, pls. 13-21, 3 text-figs.

________ and _______, 1938, The conodont genus Icriodus and its stratigraphic distribution: Jour. Paleontology, v. 12, p. 156-166, pl. 126, 1 text-fig.

________ and _______, 1941, The recognition and interpretation of mixed conodont faunas: Dennison Univ. Bull., v. 40, p. 195-209.

Brown, W. L., 1959, Conodonts from the basal sandstone of the Noel Shale, southwestern Missouri: Univ. of Missouri, unpublished Master's thesis, Columbia, Missouri.

Bryant, W. L., 1921, The Genesee conodonts: Buffalo Soc. Nat. Sci., Bull., v. 13, no. 2, 59 p., 16 pls., 7 text-figs.

Butts, Charles, 1915, Geology and mineral resources of Jefferson County, Kentucky: Kentucky Geol. Survey, 4th ser., v. 3, pt. 2, p. 148.

Calvin, Samuel, 1905, Geology of Winneshiek County: Iowa Geol. Survey, v. 16, pp. 215-307.

__________, 1906, Geology of Winneshiek County: Iowa Geol. Survey Ann. Repts., v. 16, p. 37-146.

Campbell, Guy, 1946, New Albany Shale: Geol. Soc. America, Bull., v. 57, p. 829-908, pls. 1-3.

Chamberlin, T. C., 1877, Geology of Wisconsin: v. 1-III (1873-1877), 768 p.

Clark, D. L., and Ethington, R. L., 1966, Conodonts and biostratigraphy of the Lower and Middle Devonian of Nevada and Utah: Jour. Paleontology, v. 40, p. 659-689, pls. 82-84, 10 text-figs.

______________ and _____________, 1967, Conodonts and zonation of the Upper Devonian in the Great Basin: Geol. Soc. America, Memoir 103, 94 p., 9 pls., 11 text-figs, 2 tables.

Clark, T. H., and Stearn, C. W., 1960, The Geological evolution of North America: New York, The Ronald Press Company, vi+434 p.

Cleland, H. F., 1911, The fossils and stratigraphy of the Middle Devonic of Wisconsin: Wisc. Geol. and Nat. Hist. Survey, Bull, 21, 222 p. 53 pls, tables.

Cloud, P. E.,Jr., Barnes, V. E., and Hass, W. H., 1957, Devonian-Mississippian transition in central Texas: Geol. Soc. America, Bull., v. 68, p. 807-816, pls. 1-6.

Cole, W. A. Hanson, G. F., and Westbrook, W. T., 1961, Lightweight aggregates: Expansion properties of clays, shales, and Precambrian rocks of Wisconsin: U. S. Dept. of Interior - Bureau of Mines, no. 5906, pp. 1-26.

Collinson, C. W., 1963, Collection and preparation of conodonts through mass production techniques: Ill. Geol. Survey, Circ. 343, 16 p., 6 text-figs.

________________, Scott, A. J., and Rexroad, C. B., 1962, Six charts showing biostratigraphic zones, and correlations based on conodonts from the Devonian and Mississippian rocks of the upper Mississippi valley: Ill. Geol. Survey, Circ. 328, 32 p., 6 charts.

________________, and James, Alan, 1968, Conodont zonation of the Devonian Cedar Valley Formation and the paleogeography of the Cedar Valley and Wapsipinicon Formations (Abstract): Geol. Soc. America, North-Central Section Meeting (1968), p. 42.

Cooper, G. A., 1967, Age and correlation of the Tully and Cedar Valley Formations in the United States: <u>in</u> International Symposium on the Devonian System, Calgary, Alberta, Sept. 1967, Alberta Soc. Petrol. Geologists, v. 2, p. 701-709, 1 text-fig.

____________, and others, 1942, Correlation of the Devonian sedimentary formations of North America: Geol. Soc. America, Bull., v. 53, p. 1729-1794, 1 text-fig., Chart No. 4.

Dapples, E. C., 1955, General lithofacies relationship of St. Peter Sandstone and Simpson Group: Amer. Assoc. Petrol. Geol. Bull. v. 39, p. 444-467.

Davis, Richard A., Jr., 1968, "Canadian-Ozarkian" unconformity in the Upper Mississippi Valley: abstract <u>in</u> Am. Assoc. Petroleum Geologists Bull., v. 52, p. 524.

____________________, 1970, Lithostratigraphy of the Prairie du Chien Group: Wisconsin Geological and Natural Hist. Survey Info. Circ. 11, pp. 35-44.

Downs, H. R., and Youngquist, W. L., 1950, Conodonts from the Cedar Valley Limestone of Iowa: Jour. Paleontology, v. 24, p. 667-672, pl. 87.

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

_____________, 1945, Subsurface relations of the Maquoketa and "Trenton" Formations in Illinois. Ill. Geol. Survey, Reports, No. 105, pp. 7-34.

Edwards, I. and Raasch, G., 1921, Notes on the occurrence of Upper Devonian strata in Wisconsin: Yearbook, Milwaukee Public Museum, vol. 1, p. 88-93.

Ethington, R. L., 1959, Conodonts of the Ordovician Galena Formation: Jour. Paleontology, v. 33, p. 257-292, pls. 39-41.

________________, 1965, Late Devonian and Early Mississippian conodonts from Arizona and New Mexico: Jour. Paleontology, p. 566-589, pls. 67-68, 1 text-fig.

________________, and Clark, D. L., 1970, Lower Ordovician conodonts in North America: in, Conodont biostratigraphy, Sweet and Bergström, eds., Geol. Soc. America Memoir 127, in press.

Fay, R. O., 1952, Catalogue of conodonts: Univ. Kansas Paleont. Contrib., Vertebrata, art. 3, 206 p.

Feulner, A. F., 1953, Geology of Clatoa County: Unpublished master's thesis, State University of Iowa.

Freeman, Tom & Schumacher, Dietmar, 1969, Qualitative pre-Sylamore physiography delineated by onlapping conodont zones, northern Arkansas: Geol. Soc. America, Bull., v. 80, p. 2327-2334.

Freyer, Gunter, 1961, Zur Taxionomie und Biostratigraphie der Conodonten aus dem Oberdevon des Vogtlandes unter besonderer Berucksichtigung des to V/VI: Freiberger Forschungshefte, C 95, 96 p., 6 pls., 151 text-figs.

Furnish W. M., 1938, Conodonts from the Prairie du Chien beds of the upper Mississippi valley: Jour. Paleontology, v. 12, p. 318-340, pls. 41-42.

Glenister, B. F., and Klapper, Gilbert, 1966, Upper Devonian conodonts from the Canning Basin, Western Australia: Jour. Paleontology, v. 40, p. 777-842, pls. 85-96, 3 text-figs, 9 tables.

Glenister, A. T., 1957, The conodonts of the Ordovician Maquoketa Formation in Iowa: Jour, Paleontology, v. 31, p. 715-736, pls. 85-88.

Griesemer, A. D., 1965, Middle Devonian brachiopods of southeastern Wisconsin: Ohio Jour. Sci., v. 65, no. 5, p. 241-295.

Grohskopf, J. G., Clark, E. L., and Ellison, S. P., Jr., 1943, The Fortune, a new Devonian formation in southwestern Missouri: Missouri Geol. Survey and Water Res., 62nd Ann. Rept., App. 4, p. 5-17, pl. 2.

Guldenzopf, E. C., 1967, Conodonts from the Prairie du Chien of Northern Peninsula of Michigan - preliminary report: Michigan Basin Geol. Soc. Ann. Field Excursion, p. 58-64, 1 pl.

Hall, James, 1851, Lower Silurian System: in Foster, J. W. and others, Geology of Lake Superior land district: Congressional Documents, 32nd Cong., Special Session, Senate Exec. Doc. 4, p. 140-166.

___________, 1861, Organic remains of the Niagran Group and associated limestones: Geol. Survey of the State of Wisconsin, Paleontology, Part 3, 94 p.

___________, 1862, Paleontology of Wisconsin: Report of the Geological Survey of the State of Wisconsin, v. 1, p. 425-442.

Hass, W. H., 1947, Conodont zones in Upper Devonian and Lower Mississippian formations of Ohio: Jour. Paleontology, v. 21, p. 131-141, 1 text-fig., 6 tables.

___________, 1951, Age of the Arkansas novaculite: Amer. Assoc. Petrol. Geol., Bull., v. 35, p. 2526-2541.

___________, 1959a, Conodonts from the Chappel Limestone of Texas: U.S. Geol. Survey Prof. Paper 294-J, p. 365-399, pls. 46-50, 1 text-fig., 1 table.

___________, 1959b, Conodont faunas from the Devonian of New York and Pennsylvania (abst.): Geol. Soc. America, Bull., v. 70, p. 1615.

___________, 1962, Conodonts, in Treatise on invertebrate paleontology, Pt. W, Miscellanea: Lawrence, Kansas, Geol. Soc. America and Kansas Univ. Press, p. 3-69, text-figs. 1-42, 1 table.

Helms, Jochen, 1959, Conodonten aus dem Saalfelder Oberdevon (Thüringen): Geologie, Jahrg. 8, H. 6, p. 634-677, 6 pls.

___________, 1961, Die "nodocostata-Gruppe" der Gattung Polygnathus, Oberdevonische Conodonten: Ibid., Jahrg. 10, H. 6, p. 674-711, 4 pls., 17 text-figs.

___________, 1963, Zur "Phylogenese" und Taxionomie von Palmatolepis (Conodontida, Oberdevon): Ibid., Jahrg. 12, H. 4, p. 449-485, 4 pls., 3 text-figs.

Hershey, O. H., 1897, The term Pecatonica Limestone: Am. Geologist, v. 20, p. 66-67.

Hinde, G. J., 1879, On Conodonts from the Chazy and Cincinnati Group of the Cambro-Silurian, and from the Hamilton and Genesee-Shale divisions of the Devonian, in Canada and the United States: Geol. Soc. London, Quart. Jour., v. 35, p. 351-369, pls. 15-17.

Holmes, G. B., 1928, A bibliography of the conodonts with descriptions of Early Mississippian species: U. S. Natl. Mus., Proc., v. 72, art. 5, 38 p., 11 pls.

Huddle, J. W., 1934, Conodonts from the New Albany Shale of Indiana: Bull. Amer. Paleontology, v. 21, no. 72, 137 p., 12 pls., 3 text-figs.

__________, 1968, Redescription of Upper Devonian conodont genera and species proposed by Ulrich and Bassler in 1926: U. S. Geol. Survey, Prof. Paper 578, 55 p., 17 pls., 2 text-figs.

__________, 1969, Upper Devonian conodont zones in western New York and Pennsylvania (abst.): Geol. Soc. America, Northeast Section Meeting (1969), p. 29.

Huffman, G. G., 1941, Geology of Winneshiek County: Unpublished master's thesis, State University of Iowa.

Kay, G. M., 1935, Ordovician system in the upper Mississippi valley: Kans. Geol. Soc. 9th Ann. Fld. Conf. - Upper Mississippi Valley, p. 281-295.

Keroher, G. C., 1966, Lexicon of geologic names of the United States for 1936-1960: U. S. Geol. Survey, Bull. 1200, p. 1993.

Klapper, Gilbert, 1968, Preliminary outline of the conodont sequence within the Cedar Valley and State Quarry Limestones (Middle and Upper Devonian) of southeastern Iowa and northwestern Illinois; an Appendix, in Glenister, B. F., and Rexroad, C. B., Conodont successions: Geol. Soc. America North-Central Section Meeting (1968), Guidebook, Field Trip no. 6, p. 11-15.

__________, and Furnish, W. M., 1963, Conodont zonation of the Early Upper Devonian in eastern Iowa: Iowa Acad. Sci., Proc. 1962, v. 69, p. 400-410, 2 text-figs.

__________, Charles Collinson, J. W. Huddle, R. W. Orr, L. V. Rickard, C. A. Sandberg, Dietmar Schumacher, George Seddon, and T. T. Uyeno, 1970, North American Devonian conodont biostratigraphy: in conodont biostratigraphy, Sweet and Bergström, eds., Geol. Soc. America, Memoir 127 in press.

__________, and Ziegler, Willi, 1967, Evolutionary development of the *Icriodus latericrescens* group (Conodonta) in the Devonian of Europe and North America: Palaeontographica, Bd. 127, Abt. A, Liefg. 1-3, p. 68-83, pls. 8-11, 2 text-figs.

Krebs, Wolfgang, 1959, Zur Grenze Mittel-/Ober-Devon und zur Gliederung des obersten Mittel-Devons und der tieferen Adorf-Stufe nach Conodonten: Senckenbergiana Lethaea, Bd. 40, p. 367-387, 2 pls., 1 text-fig.

Krebs, Wolfgang, 1963, Oberdevonische Conodonten im Unterkarbon des Rheinischen Schiefergebirges und des Harzes: Deutsche Geol. Gesell. Zs., Bd. 114, p. 57-84.

______________, 1964, Zur faziellen Deutung von Conodonten-Mischfaunen: Senckenbergiana Lethaea, Bd. 45, p. 245-284.

Ladd, H. S., 1928, The stratigraphy and paleontology of the Maquoketa Shale of Iowa: Iowa Geol. Survey, v. 34, pp. 306-440.

Lapham, I. A., 1860, Devonian of Milwaukee and Wisconsin: Am. Jour. Sci., 2nd ser., v. 29, p. 145.

Law, M.A., 1941, Subdivision of Richmond Shale in Wisconsin: Unpublished bachelor's thesis, Univ. of Wisconsin, pp. 1-17.

Lindström, M., 1955, Conodonts from the lowermost Ordovician strata of South-Central Sweden: Geol. Fören., (Stockholm), Förhandl, v. 76, p. 517-614, pls. 1-10.

______________, 1959, Conodonts from the Crûg Limestone (Ordovician, Wales): Micropaleontology, v. 5, p. 427-452, 4 pls.

______________, 1964, Conodonts: Amsterdam, Elsevier Publishing Company, 196 p., 64 text-figs.

______________, and Ziegler, Willi, 1965, Ein Conodontentaxon aus vier morphologisch verschiedenen Typen (Grenze Mittel-/Oberdevon, Rheinisches Schiefergebirge): Fortschr. Geol. Rheinld. u. Westf., v. 9, p. 209-218, 2 pls.

Locke, John, 1939, Contribution to David Dale Owen's report geological exploration of part of Iowa, Wisconsin, and Illinois: 28th Congress, 1st Session, Senate Document 407, p. 407.

Mehl, M. G., 1960, The relationships of the base of the Mississippian System in Missouri: Denison Univ., Jour. Sci. Lab., v. 45, art. 5, p. 57-107, 8 figs.

Miller, A. K., and Youngquist, W. L., 1947, Conodonts from the type section of the Sweetland Creek Shale in Iowa: Jour. Paleontology, v. 21, p. 501-517, pls. 72-75.

Miller, J. F., 1969, Conodont fauna of the Notch Peak Limestone (Cambro-Ordovician), House Range, Utah: Jour. Paleontology, v. 43, p. 413-439, pls. 63-66.

Monroe, C. B., 1900, A notice of a new area of Devonian rocks in Wisconsin: Jour. Geol., v. 8, p. 313-314.

Moore, R. C., 1962, Conodont classification and nomenclature: in Treatise on Invertebrate Paleontology, pt. W., Misc., p. 92-98, Geol. Soc. America and Univ. Kansas Press.

Morse, M. L., 1938, Conodonts from the (Devonian) Norwood and Antrim shales of Michigan: University of Michigan, unpublished Ph.D. dissertation, Ann Arbor, Michigan.

Mound, M. C., 1968, Upper Devonian conodonts from southern Alberta: Jour, Paleontology, v. 42, p. 444-524, pls. 65-71, 14 test-figs.

Müller, K. J., 1956, Taxonomy, nomenclature, orientation, and stragigraphic evaluation of conodonts: Jour. Paleontology, v. 30, p. 1324-1340, pl. 145.

____________, 1959, Kambrische Conodonten: Zeit. Deutsch. Geol. Ges., v. 111, p. 434-485.

____________, and Clark, D. L., 1967, Late Devonian conodonts from the Squaw Bay Formation in Michigan: Jour. Paleontology, v. 41, p. 902-919, ls. 115-118, 7 text-figs.

____________, and Müller, E. M., 1957, Early Upper Devonian (Independence) conodonts from Iowa, part 1: Ibid., v. 31, p. 1069-1108, pls. 135-142, 8 text-figs., 2 tables.

Nogami, Yasuo, 1967, Kambrische Conodonten von China: Kyoto Univ. College Sci., Mem. Ser. B. v. 33, p. 211-218.

Norton, W. H., 1894, Notes on the lower strata of the Devonian series in Iowa: Iowa Acad. Sci., Proc., v. 1, pt. 4, p. 22-24.

Oberg, R., 1966, Winnipeg conodonts from Manitoba: Jour. Paleontology, v. 40, p. 130-147, pls. 15-16.

Oliver, W.A., Jr., Wallace De Witt, Jr., J. M. Dennison, D. M. Hoskins, and J. W. Huddle, 1967, Devonian of the Appalachian Basin, United States, in International Symposium on the Devonian System, Calgary, Alberta, Sept. 1967: Alberta Soc. Petrol. Geologists, v. 1, p. 1001-1040, 18 text-figs.

Orr, R. W., 1964, Conodonts from the Devonian Lingle and Alto Formations of southern Illinois: Ill. Geol. Survey, Circ. 361, 28 p., 4 pls., 4 text-figs., 2 tables.

__________, and Klapper, Gilbert, 1968, Two new conodont species from Middle-Upper Devonian boundary beds of Indiana and New York: Jour. Paleontology, v. 42, p. 1066-1075, pls. 139-140, 2 text-figs.

Ostrom, M.E., 1964, Pre-Cincinnatian Paleozoic cyclic sediments in the upper Mississippi valley: a discussion: in, Symposium on Cyclic Sedimentation, Kansas Geol. Survey Bull. 169, v. 2, p. 381-398.

________________, 1965, Cambro-Ordovician stratigraphy of southwest Wisconsin; Wis. Geol. and Nat. Hist. Survey Info. Circ. 6, 29th Ann. Field Conf. Tri-State Field Trip, Guidebook, 57 p.

________________, 1966, Cambrian stratigraphy in western Wisconsin: Wis. Geol. and Nat. Hist. Survey Info. Circ. 7, Guidebook for Ann. Field Conf., Michigan Basin Geol. Soc., 79 p.

________________, 1967, Paleozoic stratigraphic nomenclature for Wisconsin; Wis. Geol. and Nat. Hist. Survey Info. Circ. 8, chart.

________________, 1969, Champlainian Series (Middle Ordovician) in Wisconsin: Amer. Assoc. Petro. Geol. Bull., v. 53, p. 672-678.

________________, 1970, Sedimentation cycles in the Lower Paleozoic rocks of western Wisconsin: in Wis. Geol. and Nat. Hist. Survey Info. Circ. 11, pp. 10-34.

Owen, D.D., 1847, Preliminary report on progress of the geological Survey of Wisconsin and Iowa: U.S. Gen. Land Office Report, p. 169-170.

__________, 1848, Report of a geological reconnaissance of the Chippewa land district of Wisconsin and the northern part of Iowa: U. S. Third Congress, 1st Session, Sen. Exec. Doc. 57, p. 27-31.

Parker, M. C., Dorheim, F. H., and Campbell, R. B., 1959, Resolving discrepancies between surface and subsurface studies of the Maquoketa Formation of northeast Iowa: Iowa Acad. Science, v. 66, pp. 248-256.

Pohl, E. R., 1929, Devonian of Wisconsin, Part 1, Lamellibranchiata: Milwaukee Public Museum, Bull. 11, no. 1, 100 p. 14 pls., 5 text-figs.

Raasch, G. O., 1935, Devonian of Wisconsin: Kansas Geol. Soc. Guidebook, 9th Ann. Field Conf., p. 261-267, 1 text-fig.

Rexroad, C. B., 1967, Stratigraphy and conodont paleontology of the Brassfield (Silurian) in the Cincinnati Arch area: Indiana Dept. Nat. Res. Geol. Survey Bull. 36, 64 p., 4 pls.

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

________________, 1962, Recognition, interpretation, and taxonomic position of conodont assemblages: in Treatise on Invertebrate Paleontology, Geol. Soc. America and Univ. of Kansas Press pt. W. Miscellanea, p. 70-73, fig. 43.

________________, and Dineley, D. L., 1957, Devonian conodont faunas from southwest England: Jour. Paleontology, v. 31, p. 353-369, pls. 37-38.

________________, and Müller, K. J., 1956, The conodont genus Prioniodus and related forms: Ibid., v. 30, p. 695-699, 1 table.

Robison, R. A., and Pantoja-Alor, Jerjes, 1968, Tremadocian trilobites from the Nochixtlan Region, Oaxaca, Mexico: Jour. Paleontology, v. 42, p. 767-800, pls. 97-104.

Ruchholz, Kurtvon, 1963, Ein oberdevonisches Kalkvorkommen am Stollborn sudöstlich Benneckenstein (Harz) als Beispiel einer estremen stratigraphischen Kondensation: Geologie, Jahrg. 12, H. 9, p. 1039-1047, 1 pl.

Sannemann, Dietrich, 1955a, Beitrag zur Untergliederung des Oberdevons nach Conodonten: Neues Jahrb. Geologie u. Paläontologie, Abh., Bd. 100, p. 324-331, pl. 24, 1 text-fig., 1 table.

____________________, 1955b, Oberdevonische Conodonten (to II): Senckenbergiana Lethaea, Bd. 36, p. 123-156, 6 pls., 2 text-figs.

Savage, T. E., 1894, The geology of Fayette County: Iowa Geol. Survey, v. 15, pp. 432-546.

Schmidt, H., 1934, Conodonten-Funde in ursprunglichen Zusammenhang: Paläont. Zeitschr., v. 16, p. 67-85, pls. 58-59.

Schopf, T. J. M., 1966, Conodonts of the Trenton Group (Ordovician) in New York, southern Ontario, and Quebec: New York State Mus., Bull. 405, 105 pp., 6 pls.

Schumacher, Dietmar, 1969, Conodonts and their bearing on the Middle-Upper Devonian boundary in central Missouri (Abstract): in 1969 Transactions of the Missouri Academy of Science, (in press).

____________________, and Ethington, R. L., 1968, Conodonts from the late Middle Devonian and early Late Devonian of central Missouri (Abstract): Geol. Soc. America North-Central Section Meeting (1968), p. 49-50.

Scott, A. J., and Collinson, Charles, 1959, Intraspecific variability in conodonts: Palmatolepis glabra Ulrich and Bassler: Jour. Paleontology, v. 33, p. 550-565, pls. 75-76, 4 text-figs.

Scott, H. W., 1942, Conodont assemblages from the Heath Formation, Montana: Jour. Paleontology, v. 16, p. 293-300.

Shrock, R. R., 1939, Wisconsin Silurian bioherms (organic reefs): Geol. Soc. America Bull., v. 50, p. 529-562.

Stauffer, C. R., 1930, Conodonts from the Decorah shale: Jour. Paelontology, v. 4, p. 121-128, pl. 10.

____________________, 1932, Decorah Shale conodonts from Kansas: Jour. Paleontology, v. 6, p. 257-264.

_____________, 1935a, Conodonts of the Glenwood beds: Geol. Soc. America, Bull., vol. 46, p. 125-168, pls. 9-12.

_____________, 1935b, The conodont fauna of the Decorah Shale (Ordovician): Jour. Paleontology, v. 9, p. 596-620, pls. 71-75.

_____________, 1938, Conodonts from the Oletangy Shale, Jour. Paleontology, v. 12, p. 411-443, pls. 48-53.

_____________, 1940, Conodonts from the Devonian and associated clays of Minnesota: Ibid., v. 14, p. 417-435, pls. 58-60.

Stewart, G. A., and Sweet, W. C., 1956, Conodonts from the Middle Devonian bone beds of central and west-central Ohio: Ibid., v. 30, p. 261-273, pl. 33-34.

Struve, Wolfgang, 1961, Zur Stratigraphie der südlichen Eifler Kalkmulden (Devon: Emsium, Eifelium Givetium): Senckenbergiana Lethaea, v. 42, no. 3/4, p. 291-345, 3 pls., 1 text-fig.

Swann, D. H., and Willman, H. B., 1961, Megagroups in Illinois: Am. Assoc. Petroleum Geologists, Bull., v. 45, no. 4, p. 471-483.

Ulrich, E. C., and Bassler, R. S., 1936, A classification of the toothlike fossils, conodonts, with descriptions of American Devonian and Mississippian species: U. S. Nat. Mus. Proc., v. 68, art. 12, no. 2613, pp. 1-63, pls. 1-11.

Walliser, O. H., 1964, Conodonten des Silurs: Abh. Hess. Landes amt. Boden., v. 41, 106 p., 10 pls.

Webers, G. F., 1966, The Middle and Upper Ordovician conodont faunas of Minnesota: Minnesota Geol. Survey, Spec. Pub. SP-4, 123 p., 15 pls.

Weller, J. M. and others, 1948, Correlations of the Mississippian formations of North America: Geol. Soc. America Bull., v. 59, p. 91-126, 2 pls.

White, C. A., 1870, Report on the Geological Survey of Iowa, presented to the 13th general assembly of Iowa.

Whitfield, R. P., 1882, Paleontology, in Geology of Wisconsin: Geol. Survey of the State of Wisconsin, v. 4, pt. 3, p. 161-363, text-figs.

Winder, C. G., 1966a, Conodont zones and stratigraphic variability in Upper Devonian rocks, Ontario: Jour. Paleontology, v. 40, p. 1275-1293, pl. 156, 9 text-figs.

_____________, 1966b, Conodonts from the upper Cobourg Formation (late Middle Ordovician) at Colborne, Ontario: Jour. Paleontology, v. 40, p. 46-63, pls. 9-10.

Wittekindt, Hanspeter, 1965, Zur Conodontenchronologie des Mitteldevons: Fortschr. Geol. Rheinld. u. Westf., v. 9, p. 621-646, 3 pls., 1 text-fig., 1 table.

Wolska, Zdzislawa, 1967, Upper Devonian conodonts from the southwest region of the Holy Cross Mountains, Poland: Acta Palaeontologica Polonica, v. 12, no. 4, p. 363-456, 19 pls., 17 text-figs., 5 tables.

Workman, L. E., and Bell, A. H., 1948, Deep drilling oil possibilities in Illinois: Am. Assoc. Petroleum Geologists Bull., v. 32, no. 11, pp. 2041-2062.

Youngquist, W. L., 1945, Upper Devonian conodonts from the Independence Shale (?) of Iowa: Jour. Paleontology, v. 19, p. 355-367, pls. 54-56.

_______________, and Peterson, R. F., 1947, Conodonts from the Sheffield Formation of north-central Iowa: Ibid., v. 21, p. 242-253, pls. 36-38.

Ziegler, Willi, 1956, Unterdevonische Conodonten insbesondere aus dem Schonauer und dem Zorgensis-kalk: Hess. Landesamt. Bodenf., Notizbl., Bd. 84, p. 93-106, pls., 6, 7.

_____________, 1958, Conodontenfeinstratigraphische Untersuchungen an der Grenze Mitteldevon/Oberdevon und in der Adorfstufe: Ibid., Notizbl., Bd. 87, p. 7-77, pls. 1-12, 7 text-figs, 10 tables.

_____________, 1962a, Taxionomie and Phylogenie Oberdevonischer Conodonten und ihre stratigraphische Bedutung: Ibid., Abh., H. 38, 166 p. 14 pls., 18 text-figs., 11 tables.

_____________, 1962b, Phylogenetische Entwicklung stratigraphisch wichtiger Conodonten-Gattungen in der Manticoceras-Stufe (Oberdevon, Deutschland): Neues Jahrb. Geologie u. Palaontologie, Abh., Bd. 114, H. 2, p. 142-168, 9 text-figs.

_____________, 1965, Eine Verfeinerung der Conodontengliederung an der Grenze Mittel-/Oberdevon: Fortschr. Geol. Rheinld. u. Westf., v. 9, p. 647-676, 5 pls., 4 text-figs., 6 tables.

Zimmermann, E., 1960, Conodonten aus dem Oberdevon von Wildenfels (Sachsen): Freiberger Forschungshefte, C89, Paläontologie, p. 178-229, 2 text-figs., 5 tables.

EXPLANATION OF PLATE 1

Trempealeauan Conodonts

All illustrations X100

Figs. 1-4 -- Acontiodus (Semiacontiodus) nogammi Miller from TW-3, 1-2, Posterior and left views of UW 1531-1, showing central posterior groove flanked by two poorly defined costae. 3-4, UW1531-2.

5 -- Acodus housenis Miller from SVD-9, right view of UW 1531-3, showing lateral costa.

6, 21-22 -- Drepanodus n. sp. A, from SVD-9, 6, right view of UW 1531-13, showing basal cavity, distribution of white matter on cusp, and carina on right side; 21, left view of UW 1531-14, from TW-11, a very large specimen; 22, left view of UW 1531-15, from TW-3.

7-8 -- Acontiodus (Acontiodus) staufferi Furnish, from SVD-9, right and posterior views of UW 1531-4, 8, shows faint central posterior groove.

9-10 -- Acontiodus sp. aff. A. (Acontiodus) staufferi Furnish, right and oblique posterior view of UW 1531-5, from SVD-8. 10, shows very faint central posterior groove, though this specimen is much narrower than that in 8.

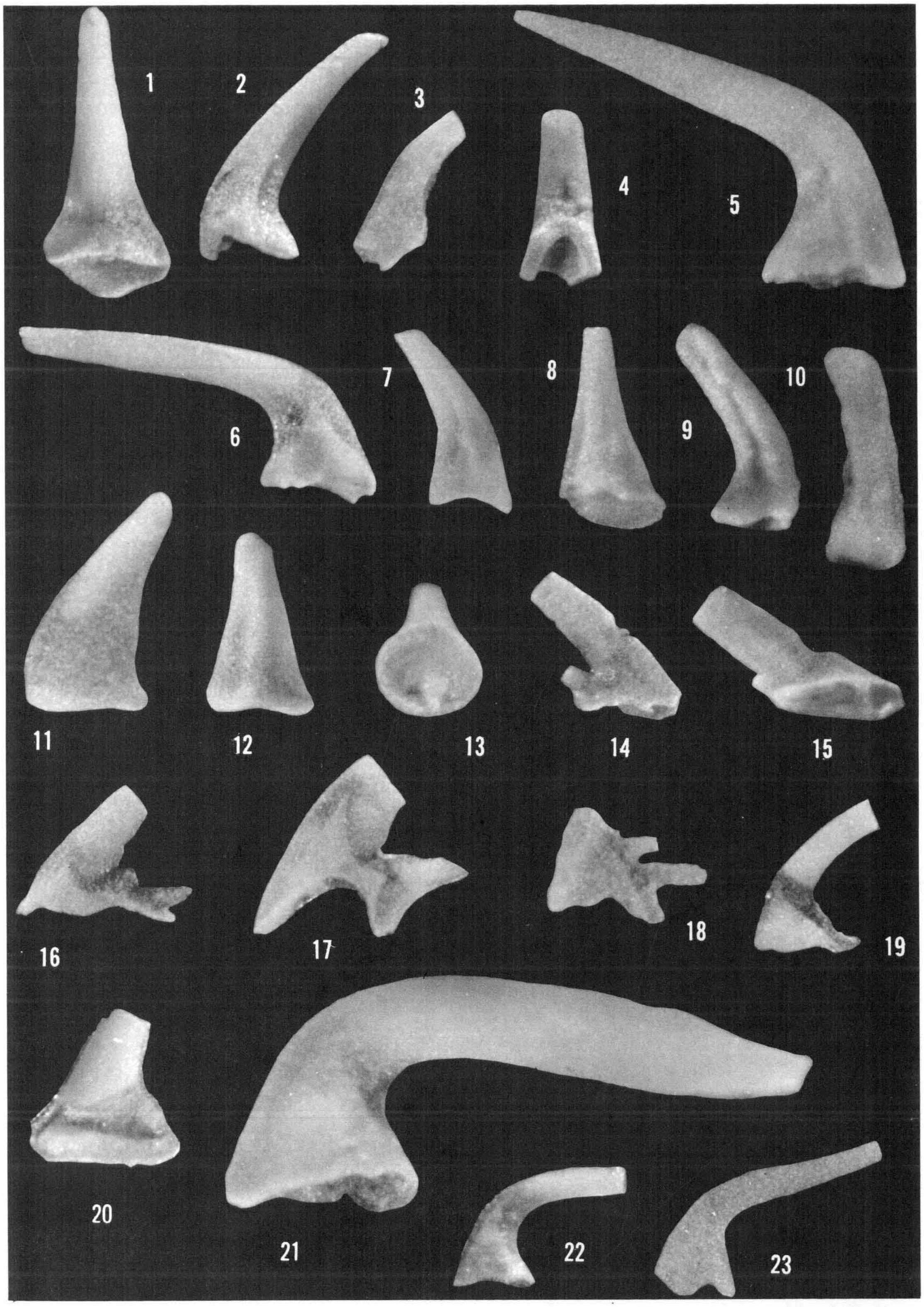
11-13 -- Acontiodus n. sp. A, from TW-11, left, posterior, and basal views of UW 1531-6, showing distribution of white matter in cusp, and prominent central posterior costa.

14-16, 17? -- Cyrtoniodus prion (Lindström), 14-15, right and oblique views of UW 1531-7, from TW-3. Latter view shows lack of carina at basal margin. 16, left view of UW 1531-8, from SVD-8; 17, left view of specimen questionably referred to this species because of extension of basal cavity into denticle (UW 1531-9, from SVD-8).

18-19 -- Cordylodus proavus Müller, 18, left view of UW 1531-10, sample unknown; 19, left view of UW 1531-11, from SVD-8.

20 -- Drepanodus erectus (Furnish), from SVD-5, UW 1531-12.

23 -- Oneotodus simplex (Furnish), from TW-3, right view of UW-1531-17.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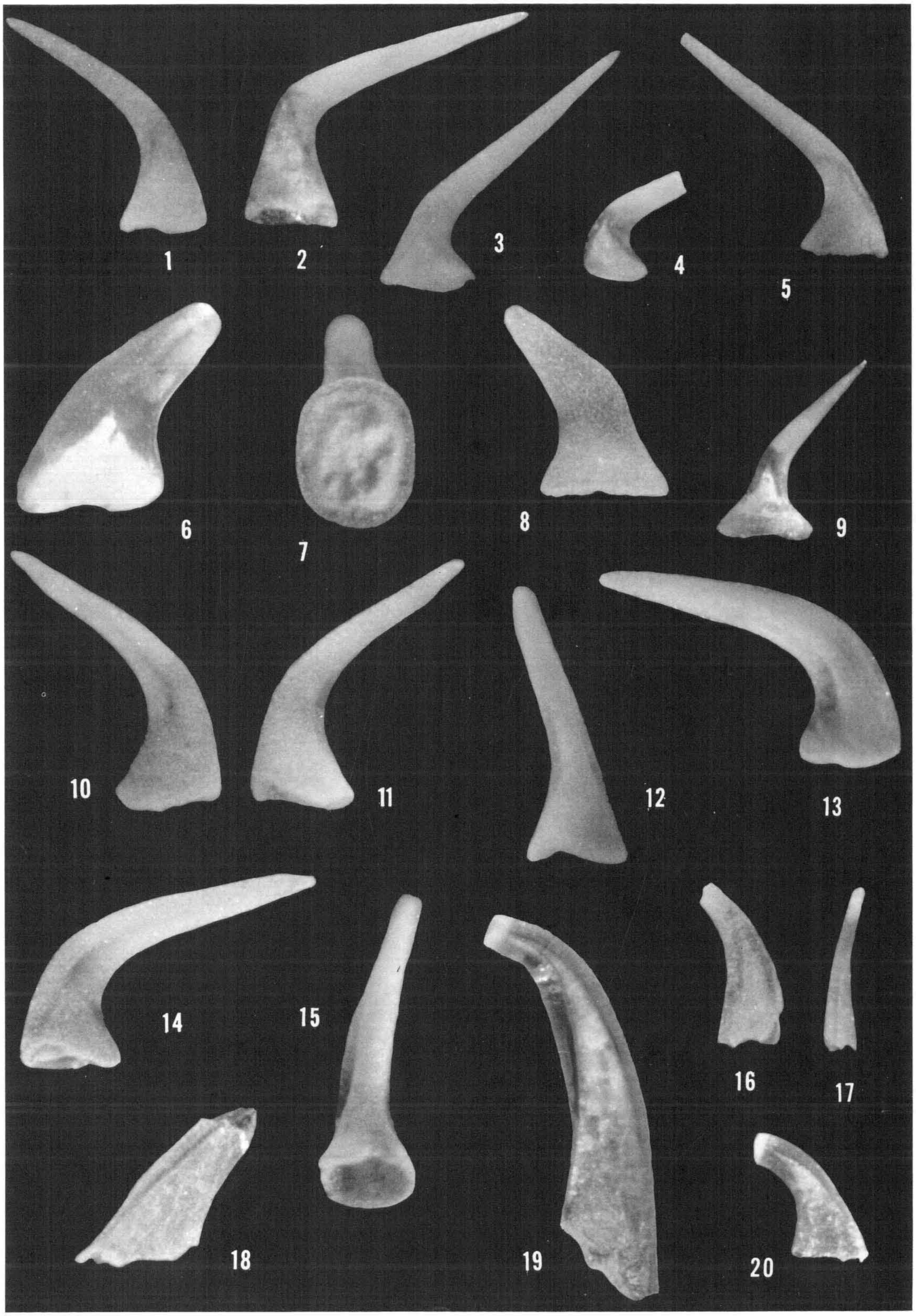
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EXPLANATION OF PLATE 2

Trempealeauan Conodonts

All illustrations are X100

Figs. 1-5 -- Oneotodus simplex (Furnish), 1, right view of UW 1531-18, from SVD-9; 2 left view of UW 1531-19, from SV-9, deep basal cavity with tip near anterior edge; 3, left view of UW 1531-20, from SVD-9, very short basal cavity; 4, left view of UW 1531-21, from TW-11, short basal cavity; 5, right view of UW-1531-22, from SVD-9, basal cavity with tip near anterior edge and intermediate in depth between Figs. 2 and 3.

6-8 -- Oneotodus n. sp. A, 6, left view (in transmitted light) of UW 1531-23, from SVD-8, with short basal cavity, showing distribution of white matter in cusp; 7, basal view of above; 8, right view of UW 1531-24, from SVD-9. Compare Figs. 6-8 with pl. 1, Figs. 11-13.

9 -- Oneotodus sp. aff. O. simplex (Furnish), from WN-12, left view of UW 1531-24, basal cavity fairly deep, with widely flaring basal apron.

10-12 -- Paltodus bassleri Furnish, from SVD-9, right, left, and posterior views of UW 1531-26, with lateral costal and asymmetrical shape.

13-15 -- Paltodus variabilis Furnish, from SVD-5, right, left, and posterior views of UW 1531-27, lateral costa more strongly developed on left side.

16-17 -- Proconodontus carinatus Miller, from 68 Rt. 29-N 10, right and posterior views of UW 1531-28, deep basal cavity, sideward bend of cusp, and poorly developed carina are characteristic of this species.

18 -- Proconodontus muelleri muelleri Miller, from 68 Rt. 29-N 10, left view of broken specimen, UW 1531-29, basal cavity extends to broken end of specimen, posterior sharp edge lacking on preserved portion.

19-20 -- Proconodontus notchpeakensis Miller, 19, right view of UW 1531-30, a primitive specimen with extremely deep basal cavity from Lodi Siltstone float at Rt. 29 section; 20, right view of UW 1531-31, from SV-5, basal cavity shorter than previous specimen.

EXPLANATION OF PLATE 3

Platteville Conodonts

All figures approximately X56 unless otherwise noted.

Figs. 1 -- *Acontiodus alveolaris* Stauffer, posterior view, McGregor Member, loc. 14, UW 801.

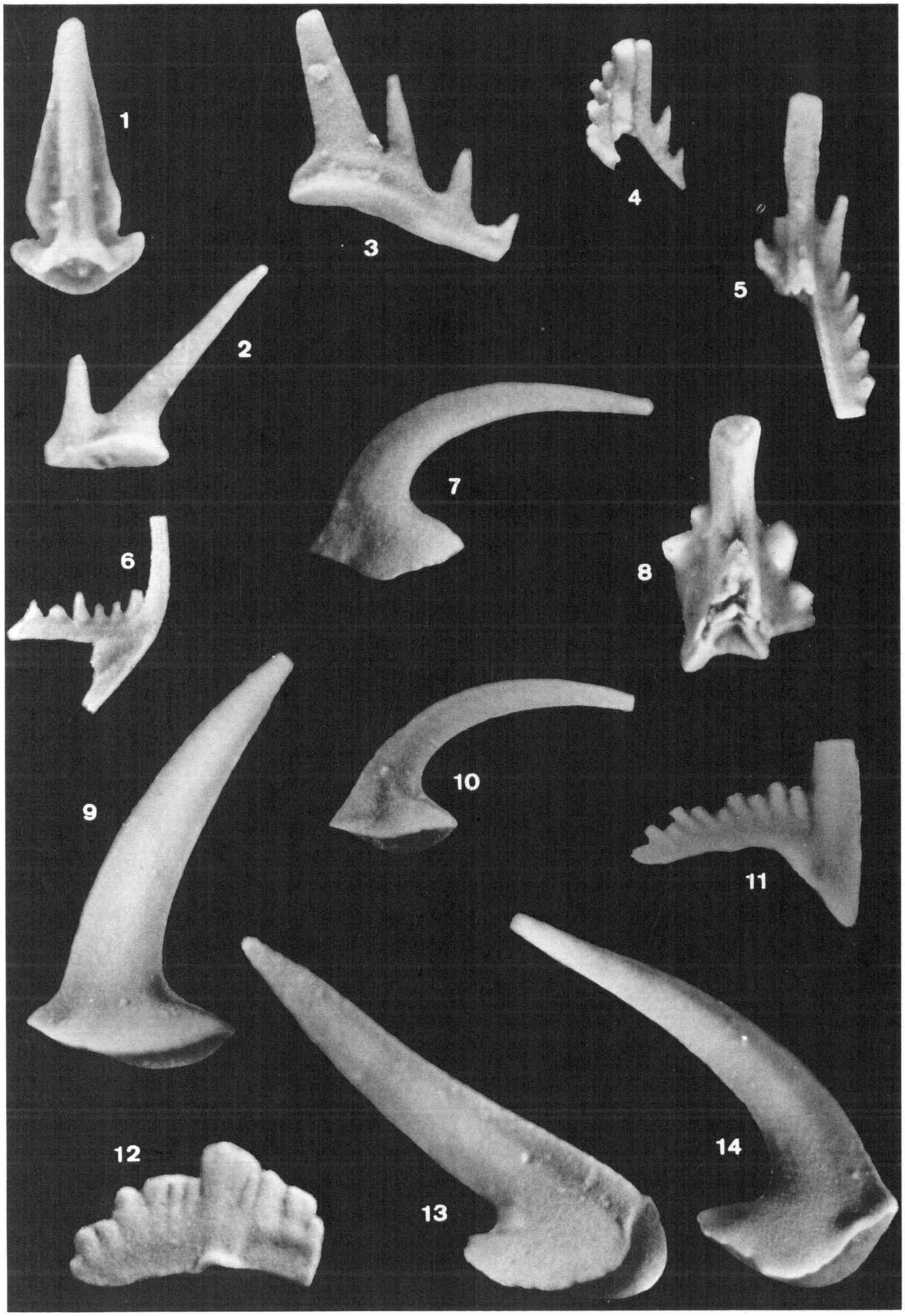
2-3 -- *Polycaulodus bidentatus* Branson and Mehl, lateral views. 2, Pecatonica Member, loc. 13, UW 849; 3, McGregor Member, loc. 6, UW 850.

4-6, 8 -- *Plectodina aculeata* (Stauffer). 4, posterior view of zygognathid element, Quimbys Mill Member, loc. 1, UW 845; 5, 8, posterior views of two trichonodellid elements, Pecatonica Member, locs. 6 and 1, UW 846, UW 848; 6, lateral view of cordylodid element, Pecatonica Member, loc. 8, UW 847.

7, 9, 10, 13, 14 -- *Drepanodus suberectus* (Branson and Mehl). 7, 10, 14, lateral views of the form-species *Drepanodus homocurvatus*; 7, McGregor Member, loc. 9, UW 822; 10, Pecatonica Member, loc. 12, UW 824; 14, McGregor Member, loc. 9, UW 826, 9, lateral view of the form-species *Drepanodus suberectus*, McGregor Member, loc. 5, UW 823. 13, lateral view of the form-species *Oistodus inclinatus*, Pecatonica Member, loc. 2, UW 825.

11 -- *Cyrtoniodus flexuosus* (Branson and Mehl), lateral view, Quimbys Mill Member, loc. 16, X65, UW 816.

12 -- *Ozarkodina* sp. cf. *O. typica* Branson and Mehl, lateral view, Pecatonica Member, loc. 8, UW 836.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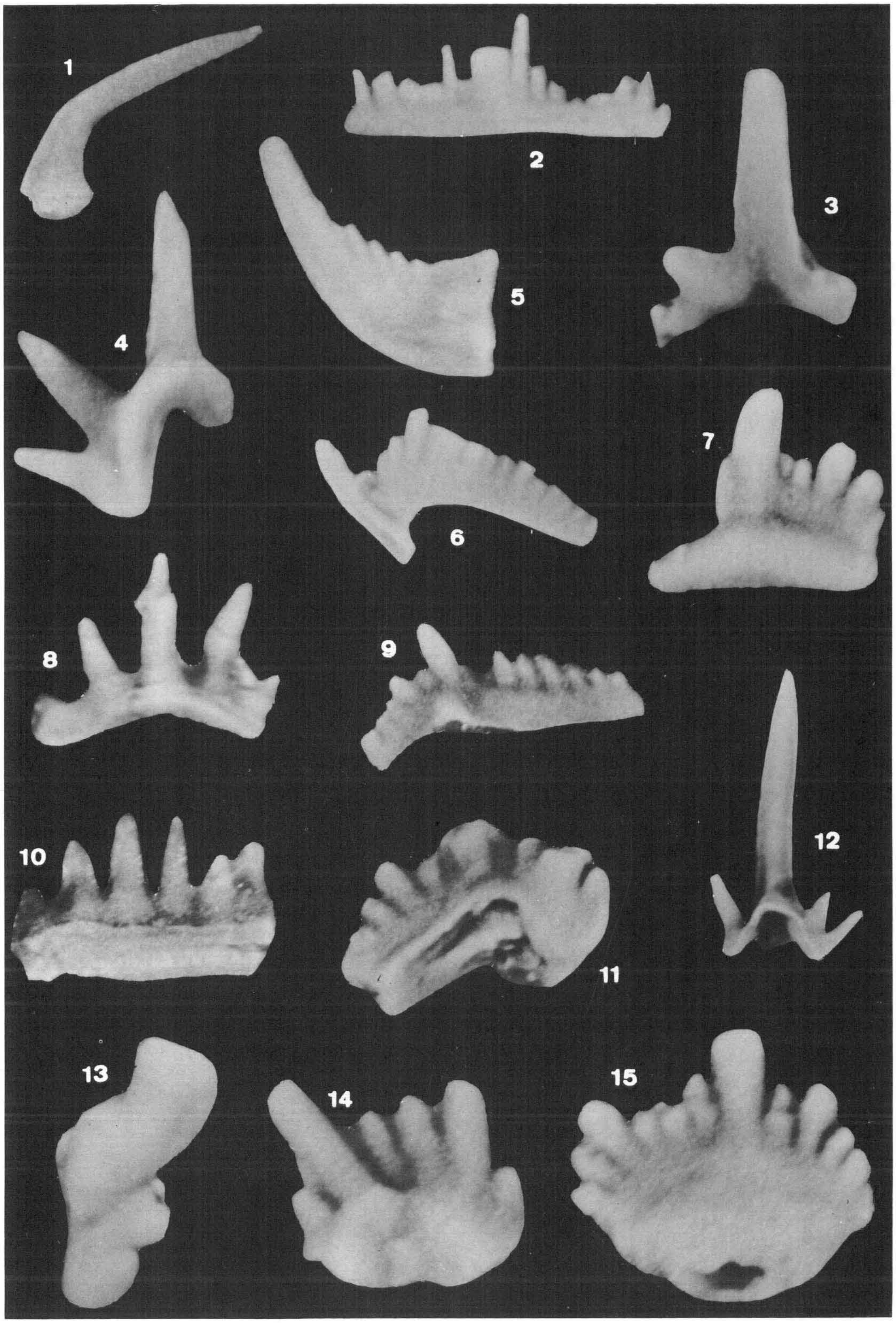
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EXPLANATION OF PLATE 4

Platteville Conodonts

Figs. 1 -- Scandodus sp. of. S. sinuosus Mound, lateral view, McGregor Member, loc. 5, X56, UW 857.

2 -- Pravognathus idonea (Stauffer), posterior view, Quimbys Mill Member, loc. 9, X88, UW 854.

3 -- Cardiodella tumidus (Branson and Mehl), view of upper surface, Pecatonica Member, loc. 1, X56, UW 809.

4 -- Curtognathus limitaris Branson and Mehl, posterior view, Pecatonica Member, loc. 1, X56, UW 814.

5 -- Belodina dispansa (Glenister), lateral view, McGregor Member, loc. 5, X88, UW 806.

6 -- Phragmodus undatus Branson and Mehl, lateral view of the form-species Phragmodus undatus, Quimbys Mill Member, loc. 16, X60, UW 842.

7 -- Chirognathus sp. cf. C. multidens Branson and Mehl, posterior view, Pecatonica Member, loc. 8, X78, UW 813.

8 -- Curtognathus typa Branson and Mehl, posterior view, Pecatonica Member, loc. 12, X80, UW 815.

9 -- Ozarkodina concinna Stauffer, lateral view, Pecatonica Member, loc. 8, X56, UW 835.

10 -- Trucherognathus distorta Branson and Mehl, lateral view, Pecatonica Member, loc. 1, X71, UW 859.

11, 14, 15 -- Chirognathus delicatula? Stauffer, posterior views, all from the Pecatonica Member, loc. 8. 11, X65, UW 810; 14, X100, UW 811; 15, X71, UW 812.

12 -- Erismodus symmetricus Branson and Mehl, posterior view, Pecatonica Member, loc. 6, X23, UW 830.

13 -- Prioniodina? sp., lateral view, Pecatonica Member, loc. 1, X56, UW 856.

EXPLANATION OF PLATE 5

Platteville Conodonts

All figures approximately X56 unless otherwise noted.

Figs.

1, 2, 6 -- Distacodus variabilis Webers, lateral views. 1, 2, Quimbys Mill Member, loc. 16, UW 819, UW 820; 6, Quimbys Mill Member, loc. 1, UW 821.

3 -- Oistodus parallelus Pander, lateral view, McGregor Member, loc. 14, UW 831.

4 -- Distacodus falcatus Stauffer, lateral view, Pecatonica Member, loc. 14, UW 817.

5, 9 -- Polyplacognathus ramosa Stauffer. 5, lateral view of the form-species Polyplacognathus bilobata, Quimbys Mill Member, loc. 16, UW 852; 9, view of lower surface of the form-species Polyplacognathus ramosa, Pecatonica Member, loc. 14, UW 853.

7 -- Belodina dispansa (Glenister), lateral view, Quimbys Mill Member, loc. 16, UW 807.

8 -- Phragmodus undatus Branson and Mehl, lateral view of the form-species Oistodus abundans, Pecatonica Member, loc. 12, UW 843.

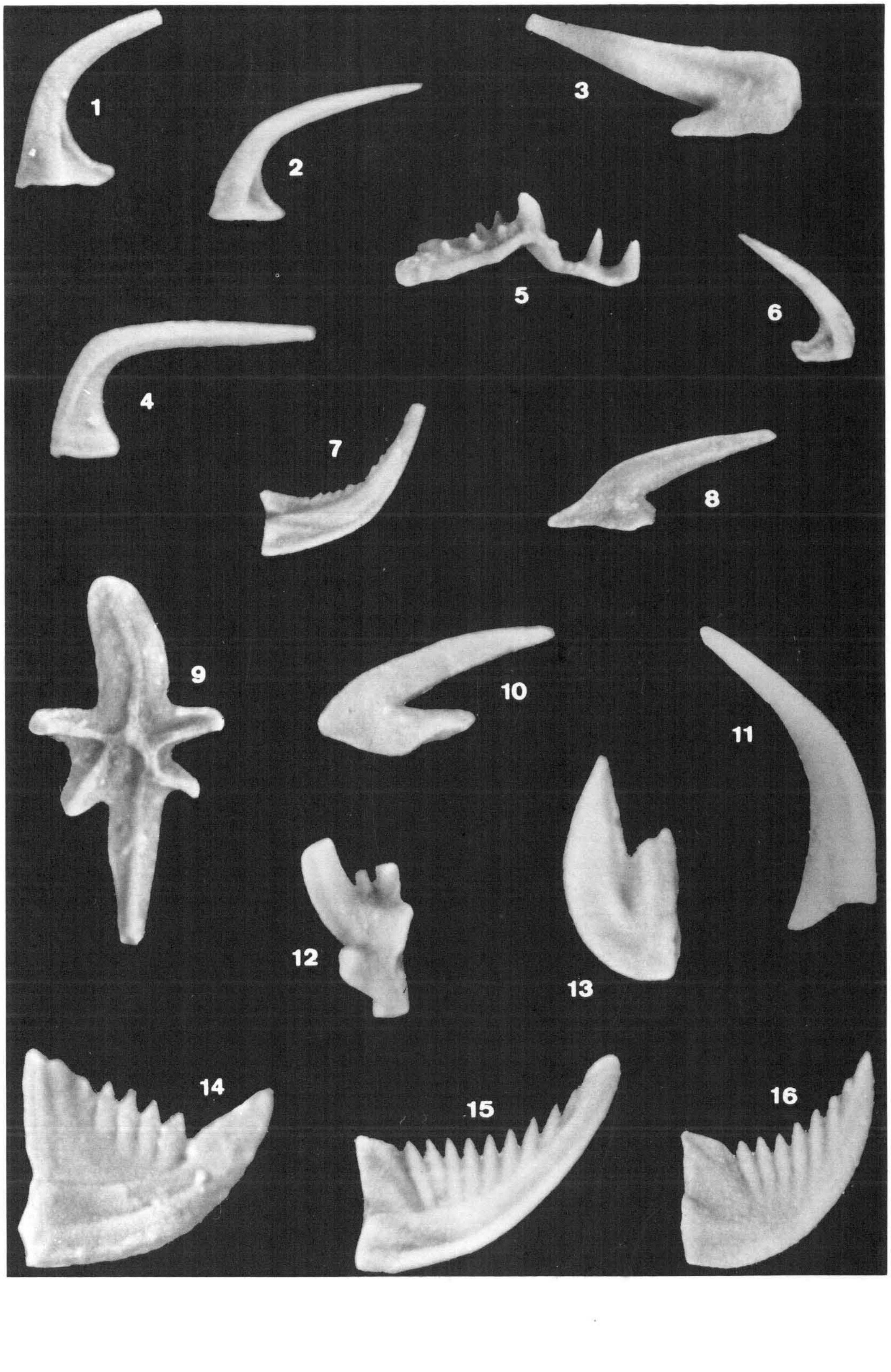
10 -- Oistodus venustus Stauffer, lateral view, Quimbys Mill Member, loc. 1, UW 832.

11 -- Panderodus arcuatus (Stauffer), lateral view, Quimbys Mill Member, loc. 16, X75, UW 837.

12 -- Zygognathus? sp. of. Z.? abnormis Branson, Mehl, and Branson, lateral view, Pecatonica Member, loc. 1, UW 860.

13, 15, 16 -- Belodina compressa (Branson and Mehl). 13, lateral view of the form-species Eobelodina fornicala, Quimbys Mill Member, loc. 16, UW 803; 15, lateral view of the form-species Belodina grandis, McGregor Member, loc. 5, UW 804; 16, lateral view of the form-species Belodina wykoffensis, Pecatonica Member, loc. 14, UW 805.

14 -- Belodina sp. cf. B. inornata (Branson and Mehl), lateral view of a mature specimen, McGregor Member, loc. 6, UW 808.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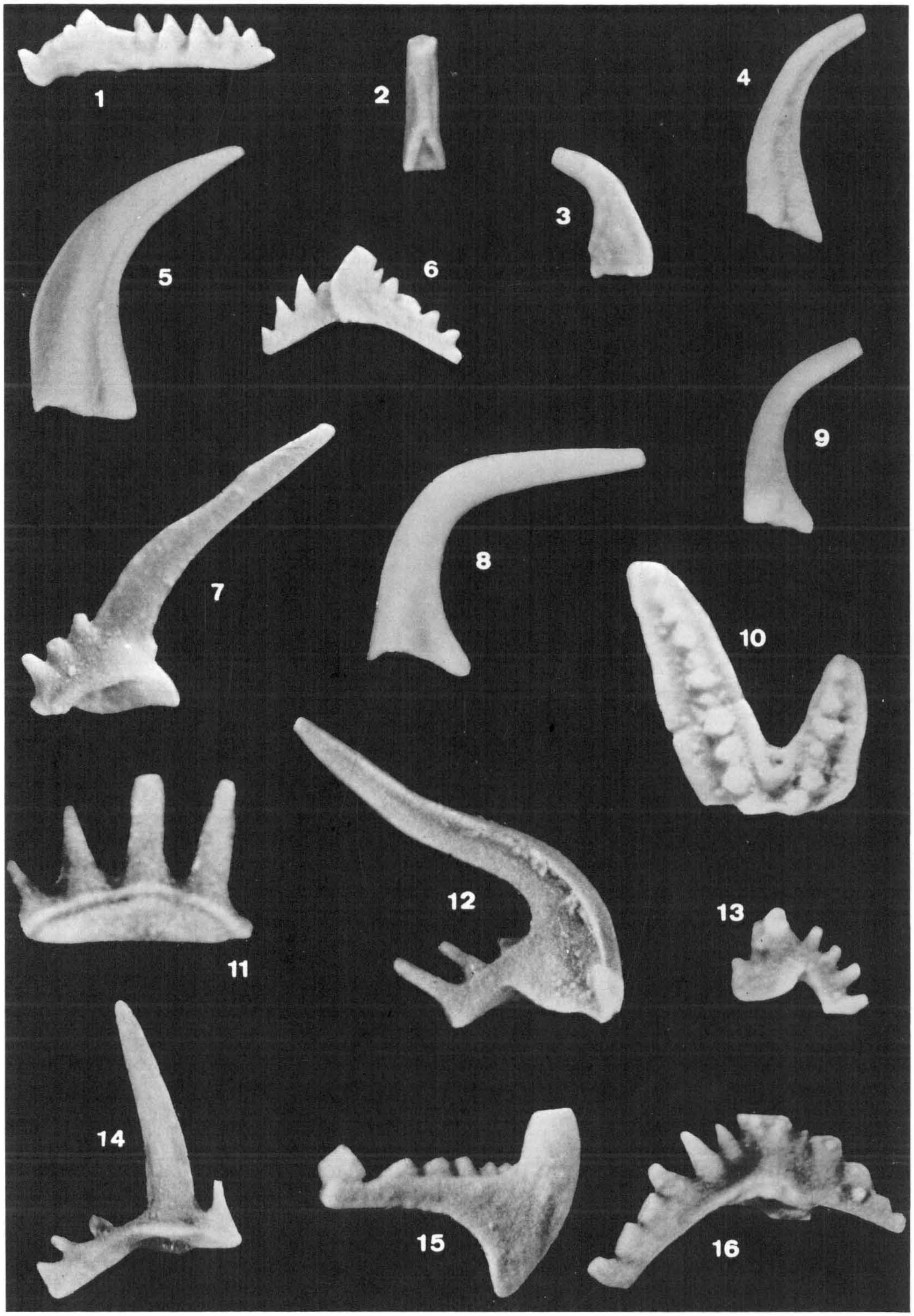
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EXPLANATION OF PLATE 6

Platteville Conodonts

All figures approximately X56 unless otherwise noted

Figs. 1 -- Scyphiodus primus Stauffer, lateral view, Quimbys Mill Member, loc. 16, UW 858.

2, 3 -- Distacodus? aff. D.? trigonius Schopf, posterior and lateral views, Pecatonica Member, loc. 8, UW 818.

4, 5, 9 -- Panderodus gracilis (Branson and Mehl). 4, lateral view of the form-species Panderodus gracilis, Quimbys Mill Member, loc. 6, UW 838; 5, lateral view of the form-species Panderodus compressus, Pecatonica Member, loc. 5, UW 839; 9, lateral view of the form-species Panderodus striatus, McGregor Member, loc. 9, UW 840.

6 -- Phragmodus undatus Branson and Mehl, anterior view of dichognathid element, Quimbys Mill Member, loc. 6, UW 844.

7 -- Erismodus gracilis (Branson and Mehl), postero-lateral view, McGregor Member, loc. 9, UW 829.

8 -- Panderodus panderi (Stauffer), lateral view, Quimbys Mill Member, loc. 16, UW 841.

10 -- Amorphognathus? sp., view of upper surface, Pecatonica Member, loc. 8, X83, UW 802.

11 -- Polycaulodus inclinatus Branson and Mehl, lateral view, McGregor Member, loc. 18, X97, UW 851.

12 -- Erismodus asymmetricus (Branson and Mehl), postero-lateral view, Pecatonica Member, loc. 1, UW 827.

13, 15 -- Oulodus serratus (Stauffer). 13, posterior view of the form-species Oulodus primus, McGregor Member, loc. 9, X56, UW 833; 15, lateral view of the form-species Cordylodus serratus, Quimbys Mill Member, loc. 16, X56, UW 834.

14 -- Erismodus? expansus (Branson and Mehl), posterior view, McGregor Member, loc. 6, X37, UW 828.

16 -- Prioniodina polita? (Stauffer), posterior view, McGregor Member, loc. 5, X65, UW 855.

EXPLANATION OF PLATE 7

Lake Church and Milwaukee Conodonts

All photographs are X54; sample numbers in parentheses.

Figs. 1, 2 -- *Acodina curvata* Stauffer, Lake Church Formation (LC-1), posterior and lateral views of UW-626 A.

3 -- *Acodina* sp., Milwaukee Formation (C-2), posterior view of UW-628.

4, 5 -- *Elsonella rhenana* Lindström and Ziegler, Milwaukee Formation; 4, lateral view of *Falcodus*-Element, UW-659 C (B-12); 5, postero-lateral view of *Roundya*-Element, UW-659 D (C-1).

6, 7 -- *Synprioniodina forsenta* Stauffer, lateral view of two specimens; 6, UW-800, Milwaukee Formation (B-10); 7, UW-800 A, Lake Church Formation (LC-1).

8-10 -- *Neoprioniodus pronus* (Huddle), lateral views of three specimens; 8, UW-706 B, Milwaukee Formation (C-3b); 9, 10, UW-706 and UW-706 A, Lake Church Formation (LC-1).

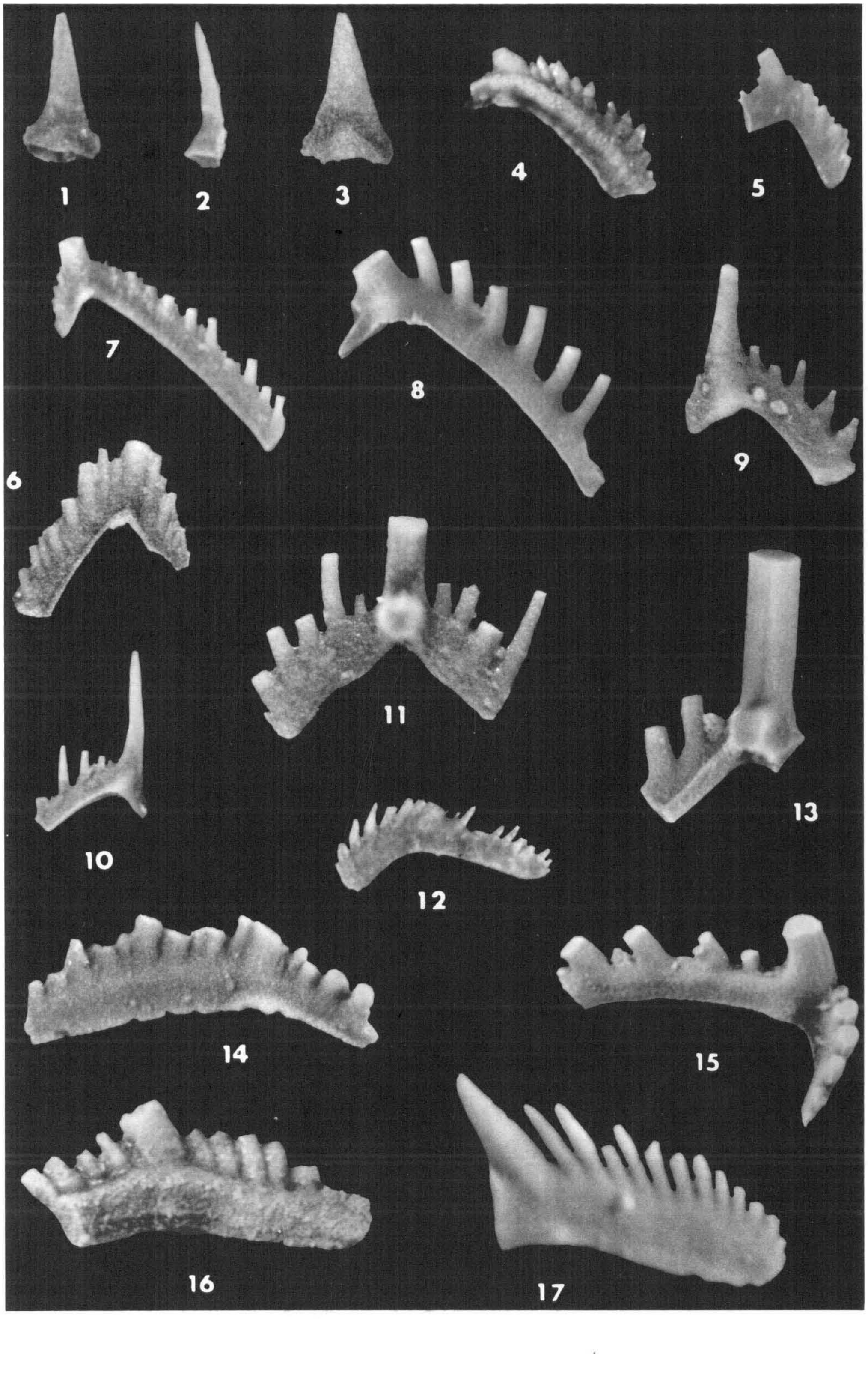
11 -- *Hibbardella* sp. A, Lake Church Formation (LC-1), posterior view of UW-660.

12, 16, 17 -- *Ozarkodina* spp., lateral views of three specimens; 12, 16, UW-709 A and UW-709 B, Lake Church Formation (LC-1); 17, UW-709, Milwaukee Formation (B-12).

13 -- *Hibbardella* sp. B, Milwaukee Formation (C-3b), posterior view of UW-661.

14 -- *Prioniodina aversa* Stauffer, Milwaukee Formation (C-3b), lateral view of UW-798.

15 -- *Ligonodina panderi* (Hinde), Milwaukee Formation (C-5b), inner lateral view of UW-693 A.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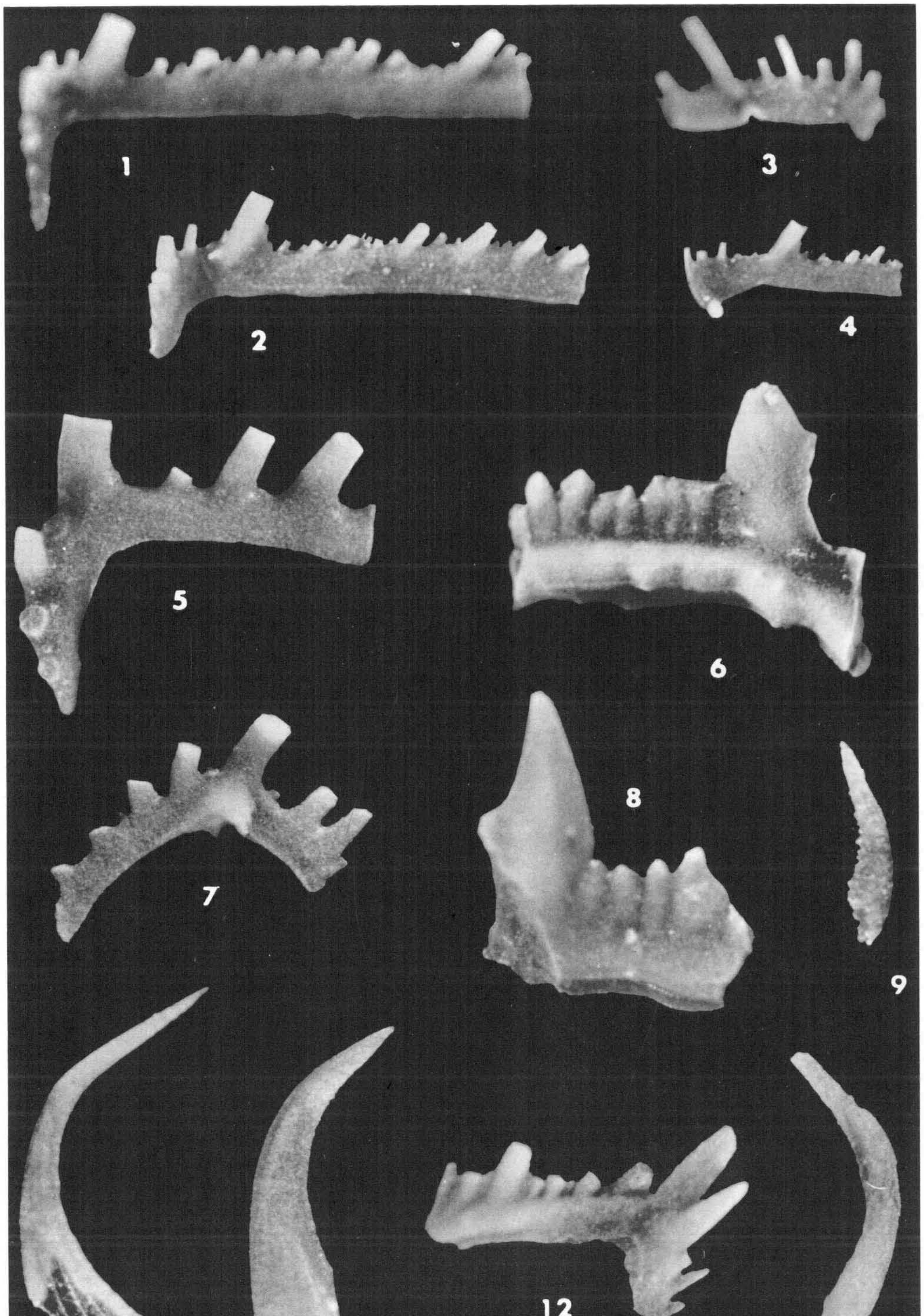
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EXPLANATION OF PLATE 8

Lake Church and Milwaukee Conodonts

All photographs are X54; sample numbers in parentheses

Figs. 1, 2 -- *Hindeodella austinensis* Stauffer, Milwaukee Formation (B-12), inner lateral views of UW-664 and UW-664 A.

3 -- *Hindeodella* cf. *H. adunca* Bischoff and Ziegler, Lake Church Formation (LC-1), inner lateral view of UW-663.

4 -- *Hindeodella priscilla* Stauffer, Milwaukee Formation (B-12), inner lateral view of UW-665 A.

5 -- *Ligonodina panderi* (Hinde), Milwaukee Formation (B-12), inner lateral view of UW-693.

6, 8 -- *Bryantodus* cf. *B. colligatus* (Bryant), Milwaukee Formation (B-12), lateral views of UW-659 A and UW-659.

7 -- *Lonchodina* cf. *L. arcuata* Ulrich and Bassler, Milwaukee Formation (C-5b), inner lateral view of UW-699.

9 -- *Belodella triangularis* Stauffer, Lake Church Formation (LC-1), lateral view of UW-646 A.

10 -- *Panderodus* sp. B, Lake Church Formation (LC-1), lateral view of UW-767; note longitudenal striae.

11 -- *Panderodus* cf. *P. simplex* (Branson and Mehl), Lake Church Formation (LC-3), lateral view of UW-765.

12 -- *Angulodus* cf. *A. demissus* Huddle, Milwaukee Formation (C-2), inner lateral view of UW-646.

13 -- *Panderodus* sp. A, Lake Church Formation (LC-1), lateral view of UW-766.

EXPLANATION OF PLATE 9

Lake Church and Milwaukee Conodonts

All photographs are X27 except figures 30-34, 38, 39 which are X36; sample numbers in parentheses.

Figs. 1-18 -- _Icriodus nodosus_ (Huddle), Lake Church Formation (LC-1).

1-9 -- Lower, upper, and lateral views of three specimens possessing a well-developed spur-like offset in the outline of the basal excavation; note the reduced median denticle row in figs. 2, 5; specimens UW-683, UW-683, and UW-686 respectively.

10-13 -- Lower and upper views of UW-685, and UW-684.

14, 17, 18 -- 14, upper view of UW-681; 17, 18, lower and upper views of UW-679.

15, 16 -- Upper and lower views of a specimen with an extremely large basal excavation, UW-682 A.

19-29 -- _Icriodus nodosus_ (Huddle), Milwaukee Formation.

19-20, 27-28 -- Lower and upper views of UW-691 (C-2) and UW-680 (C-8).

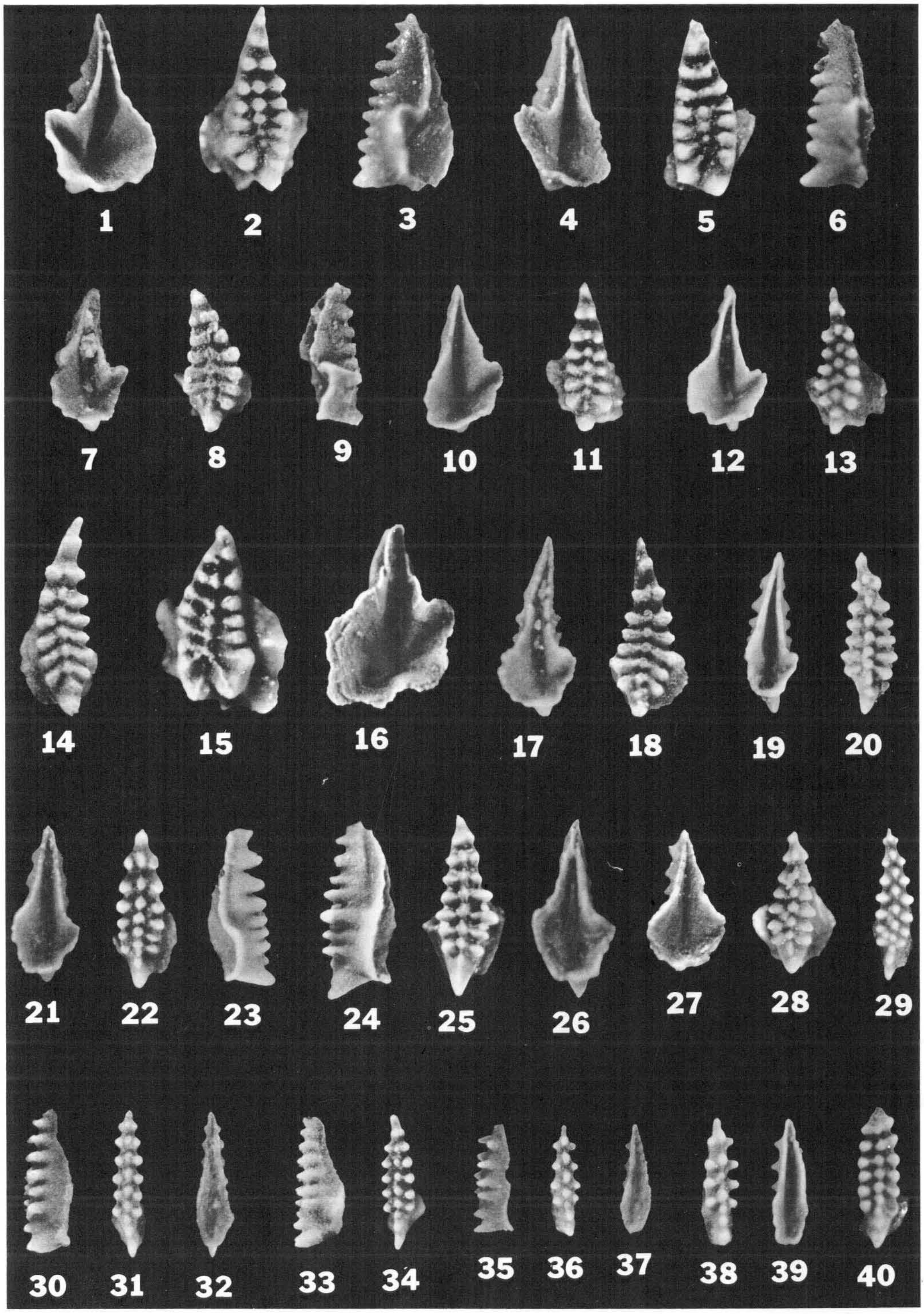
21-26 -- 21-23, lower, upper, and lateral views of UW-680 A (C-1); 24-26, lateral, upper, and lower views of UW-678 (B-8).

29 -- Upper view of a specimen showing tendency toward alternating denticulation, UW-680 B (B-8).

30-40 -- _Icriodus_ n. sp. A, aff. _I. symmetricus_ Branson and Mehl, Milwaukee Formation.

30-32, 35-37 -- Lateral, upper, and lower views of UW-688 (C-5a) and UW-692 A (C-5b).

33-34, 38-40 -- 33, 34, lateral and upper views of UW-692 (B-12); 38, 39, upper and lower views of UW-692 B (C-2); 40, upper view of UW-687 (C-5b).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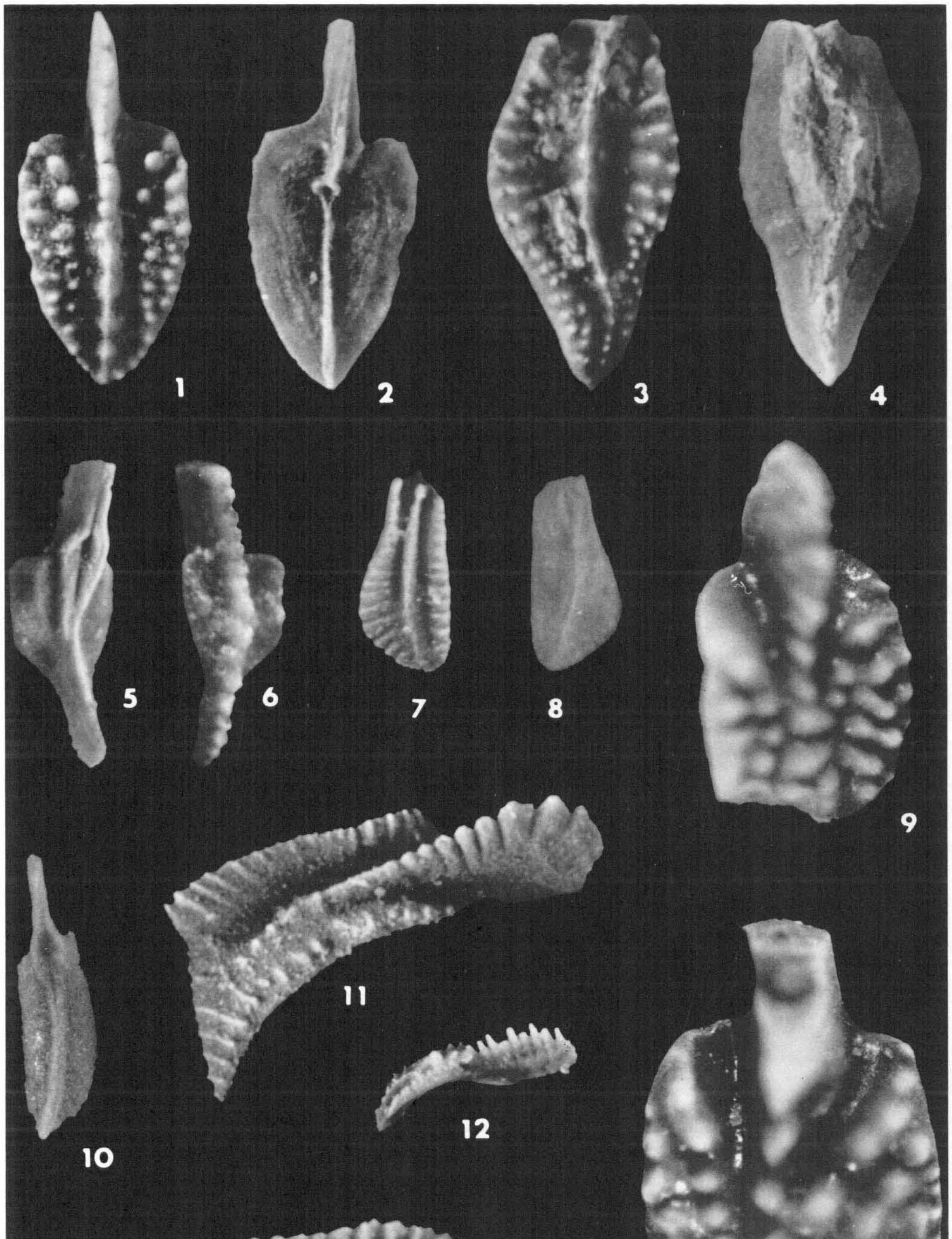
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EXPLANATION OF PLATE 10

Lake Church and Milwaukee Conodonts

All photographs are X54; sample numbers in parentheses

Figs. 1, 2 -- Polygnathus cristatus Hinde, Milwaukee Formation (C-3b), upper and lower views of UW-790 A.

3, 4, 13 -- Polygnathus pennatus Hinde, Milwaukee Formation; 3, 4, upper and lower views of UW-791 A (C-5B); 13, upper lateral view of UW-793 A (B-12).

5, 6 -- Polygnathus sp. A, Lake Church Formation (LC-1), lower and upper views of UW-778 A.

7, 8, 10 -- Polygnathus webbi Stauffer, Lake Church Formation (LC-3); 7, 8, upper and lower views of UW-794 A; 10, lower view of UW-794.

9, 14 -- Polygnathus ordinatus Bryant, Milwaukee Formation (B-12), upper views of UW-790 and UW-789.

11 -- Polygnathus linguiformis linguiformis Hinde, Lake Church Formation (LC-1), upper lateral view of UW-780 A.

12 -- Polygnathus decorosus Stauffer, Lake Church Formation (LC-3), lateral view of UW-794 B.

EXPLANATION OF PLATE 11

Lake Church and Milwaukee Conodonts

All photographs are X54.

Figs. 1-10 -- *Polygnathus decorosus* Stauffer; all specimens are from sample B-12, Milwaukee Formation.

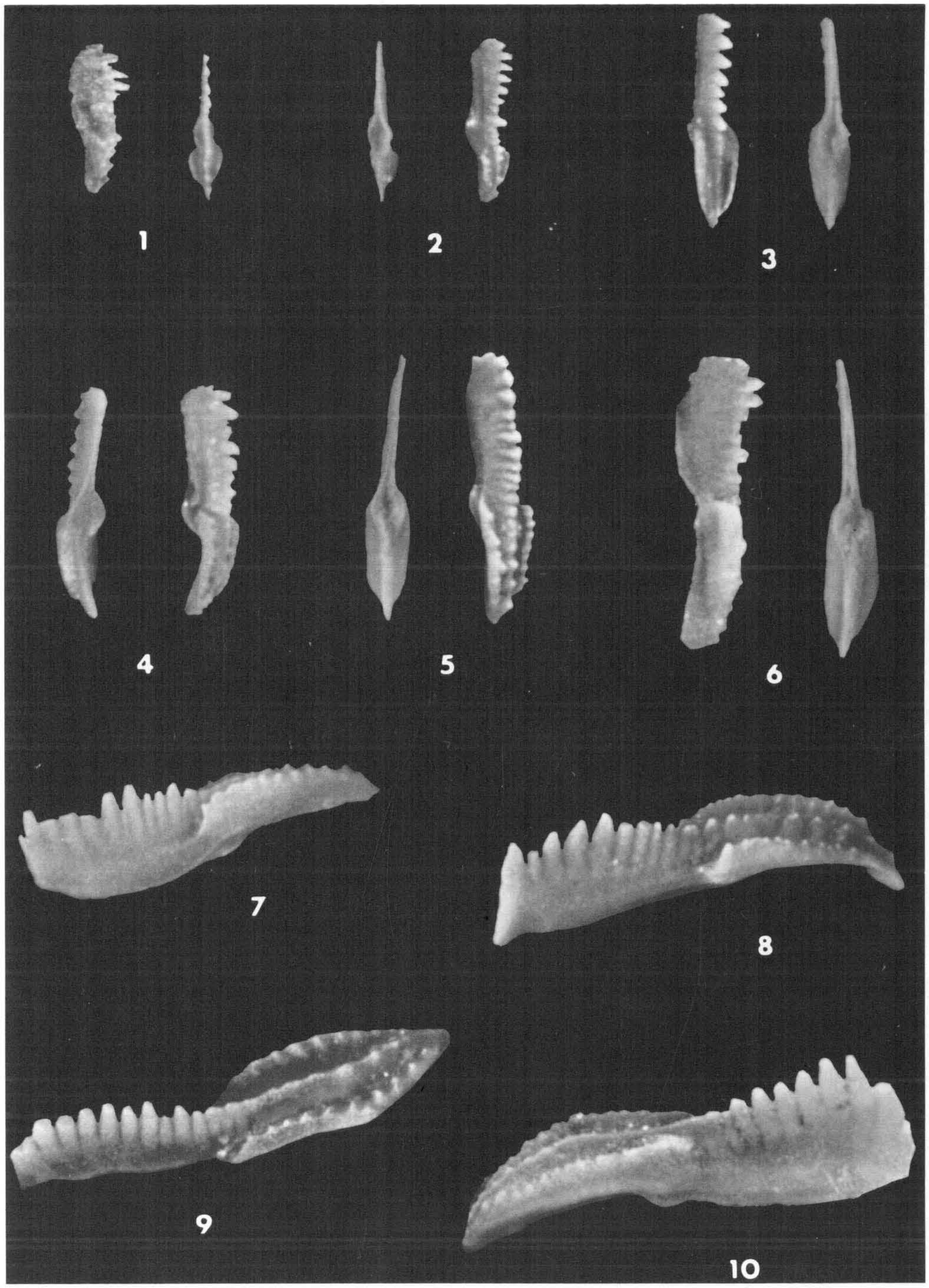
1 -- Lateral and upper views of an immature specimen identical to *P. juvensis* Stauffer, UW-770 A.

2 -- Lower and upper lateral views of an immature specimen, slightly larger than the first, identical to *P. hulkus* Stauffer, UW-770 B.

3-5 -- Upper and lower views of three progressively larger specimens identical to *P. xylus* Stauffer; UW-770 C, UW-770 D, and UW-770 E respectively.

6, 7 -- 6, lateral and lower view of UW-770 F; 7, lower lateral view of UW-770 G; these specimens are transitional in character between *P. xylus* and *P. decorosus*.

8-10 -- Upper lateral, upper, and upper lateral views of three "typical" representatives of *P. decorosus* Stauffer; UW-770 H, UW-770 I, and UW-770 J respectively.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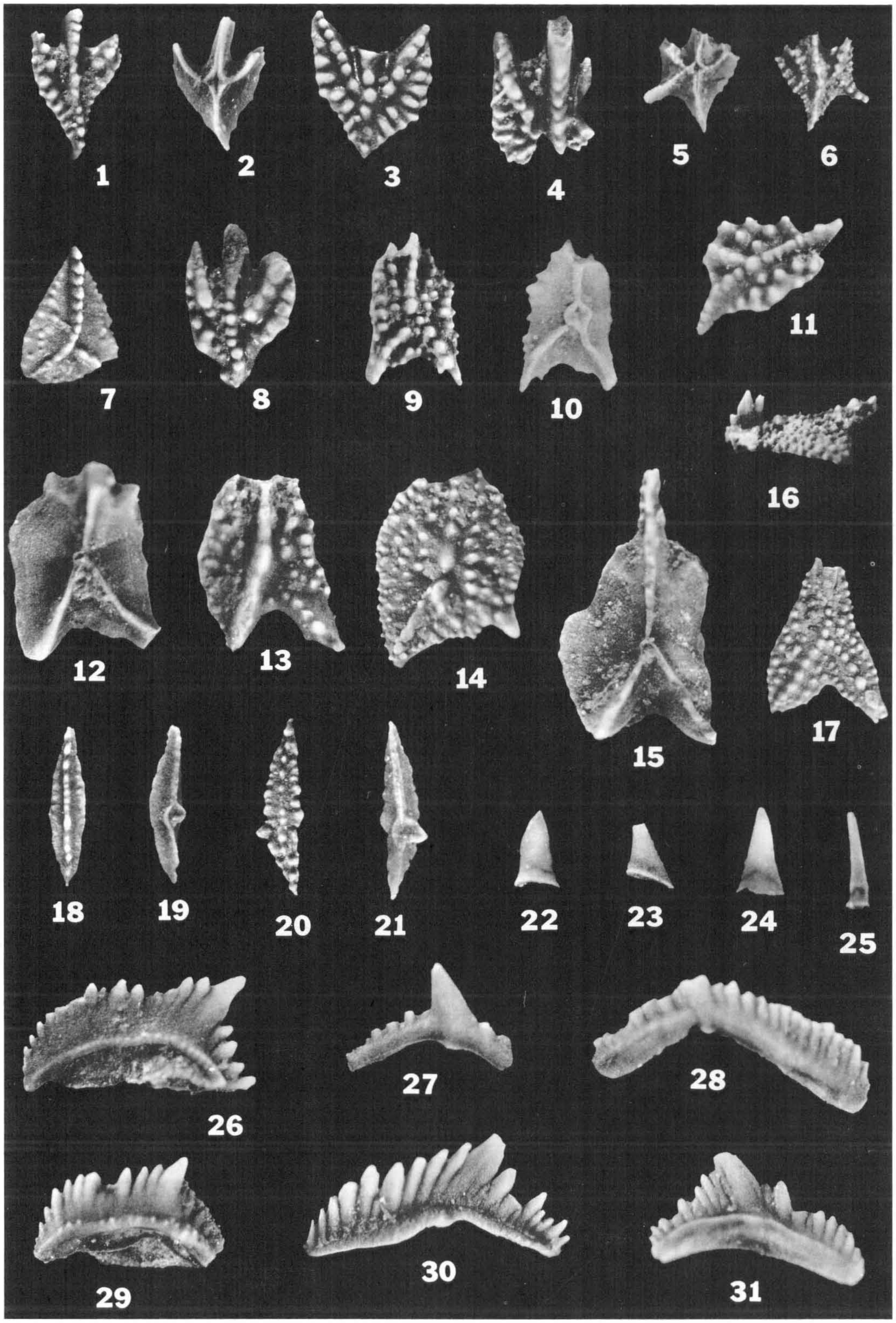
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EXPLANATION OF PLATE 12

"Kenwood" Conodonts

All photographs are X27; sample numbers in parentheses.

Figs. 1-3 -- Ancyrodella buckeyensis Stauffer, "Kenwood" I; upper, lower, and upper views of three specimens, respectively UW-632 (P), UW-631 (B), and UW-630 (P).

4-6 -- Ancyrodella curvata (Branson and Mehl), "Kenwood" I; 4, upper view of UW-634 (B); 5, 6, lower and upper views of UW-634 A (P).

7 -- Ancyrognathus triangularis Youngquist, "Kenwood" I; upper view of "juvenile" specimen, UW-645 (A).

8 -- Ancyrodella lobata Branson and Mehl, "Kenwood" I (?); upper view of UW-635.

9-11 -- Ancyrognathus symmetricus Branson and Mehl, "Kenwood" II; 9, 10, upper and lower views of UW-644 (T); 11, upper view of UW-643 (X).

12-15 -- Ancyrognathus bifurcatus (Ulrich and Bassler), "Kenwood" II; lower, upper, upper, and lower views of four specimens, respectively UW-638 (H), UW-638 A (T), UW-640 (C), and UW-639 (K).

16, 17 -- Ancyrognathus asymmetricus (Ulrich and Bassler), "Kenwood" I; 16, upper lateral view of UW-637 (A); 17, upper view of UW-636 (M).

18-21 -- Ancyrognathus sinelaminus (Branson and Mehl); 18, 19, upper and lower views of UW-641, "Kenwood" II (T); 20, 21, upper and lower views of UW-642, "Kenwood" I (M).

22 -- Acodina lanceolata Stauffer, "Kenwood" I (Z); lateral view of UW-625.

23 -- Acodina lirata Stauffer, "Kenwood" I (P); lateral view of UW-626.

24 -- Acodina sp. A, "Kenwood" I (P); lateral view of UW-628.

25 -- Acodina sp. B, "Kenwood" I (Q); posterior view of UW-629.

26, 29 -- Bryantodus conjunctus Ulrich and Bassler, "Kenwood" I (Q); lateral views of UW-647 and UW-648.

27 -- Bryantodus simplex Branson and Mehl, "Kenwood" I (?); lateral view of UW-652.

28 -- Bryantodus multidens Ulrich and Bassler, "Kenwood" II (T); lateral view of UW-649.

30 -- Bryantodus nitidus Ulrich and Bassler, "Kenwood" II (T); lateral view of UW-651.

31 -- Bryantodus typicus Bassler, "Kenwood" II (T); lower lateral view of UW-659 B.

EXPLANATION OF PLATE 13

"Kenwood" Conodonts

All photographs are X27, except Figures 8-13 which are X36; sample numbers in parentheses.

Figs. 1-7 -- Icriodus alternatus Branson and Mehl, "Kenwood" I; 1, 2, 5, 6, upper views of four specimens, respectively UW-673 (Z), UW-672 (P), UW-670 (Q), and UW-670 B (M); 3, 4, lower and upper views of a large, robust specimen, UW-670 A (P); 7, lower view of UW-671 (P).

8-13 -- Icriodus cymbiformis Branson and Mehl, "Kenwood" I; 8, 9, upper and lateral views of UW-675 (Q); 10, 11, upper views of UW-676 (P) and UW-676 A (Q); 12, 13, upper and lateral views of UW-677 (P).

14-17 -- Icriodus symmetricus Branson and Mehl, "Kenwood" I (V); 14, 15, upper and lateral views of UW-689; 16, 17, upper views of UW-690 and UW-690 A.

18 -- Neoprioniodus pronus (Huddle), "Kenwood" I (P); lateral view of UW-706 B.

19 -- Neoprioniodus alatus (Hinde), "Kenwood" II (U); lateral view of UW-701.

20 -- Neoprioniodus armatus (Hinde), "Kenwood" I (P); lateral view of UW-703 A.

21 -- Lonchodina cf. L. arcuata Ulrich and Bassler, "Kenwood" I (B); inner lateral view of UW-700.

22 -- Diplododella sp. A, "Kenwood" I (P); posterior view of UW-662.

23-25, 27 -- Nothognathella typicalis Branson and Mehl; 23, 25, lateral views of UW-656 (G) and UW-654 (P), "Kenwood" I; 24, 27, lateral views of two specimens that resemble N. polygnathiodea Branson and Mehl, UW-657 (C) and UW-657 A (T), "Kenwood" II.

26 -- Nothognathella sublaevis Sannemann, "Kenwood" II (T); lateral view of UW-653.

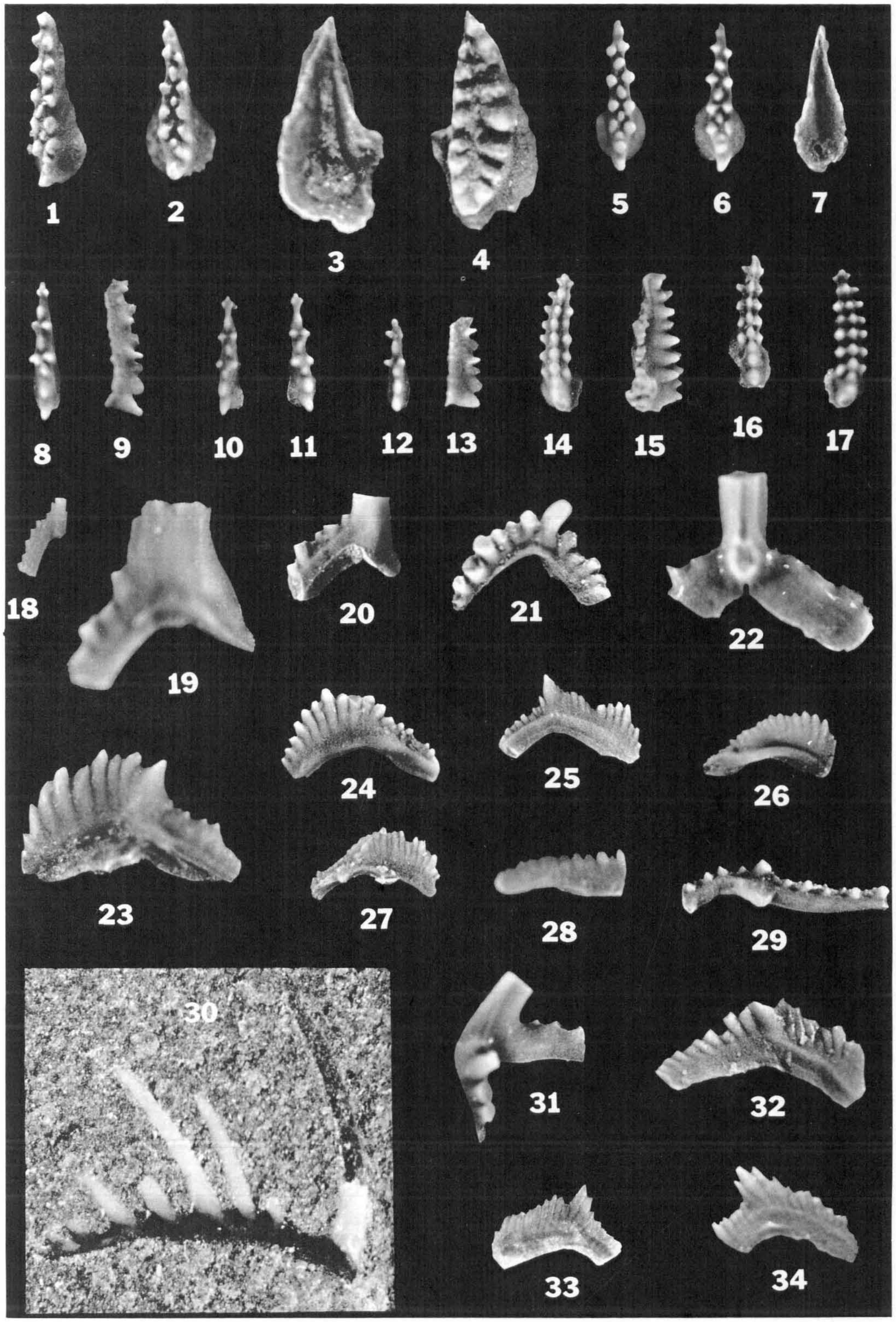
28 -- Spathognathodus sp., "Kenwood" I (S); lateral view of UW-799.

29 -- Hindeodella sp. A, "Kenwood" I (?); lateral view of a specimen with a distinct lateral flange, UW-669.

30, 31 -- Ligonodina panderi (Hinde), "Kenwood" I; 30, lateral view of a specimen embedded in shale, UW-695; 31, inner lateral view of UW-697 (Q).

32 -- Ozarkodina regularis Branson and Mehl, "Kenwood" I (P); lateral view of UW-710.

33, 34 -- Ozarkodina immersa (Hinde), "Kenwood" I; lateral views of UW-708 (Q) and UW-707 (Z).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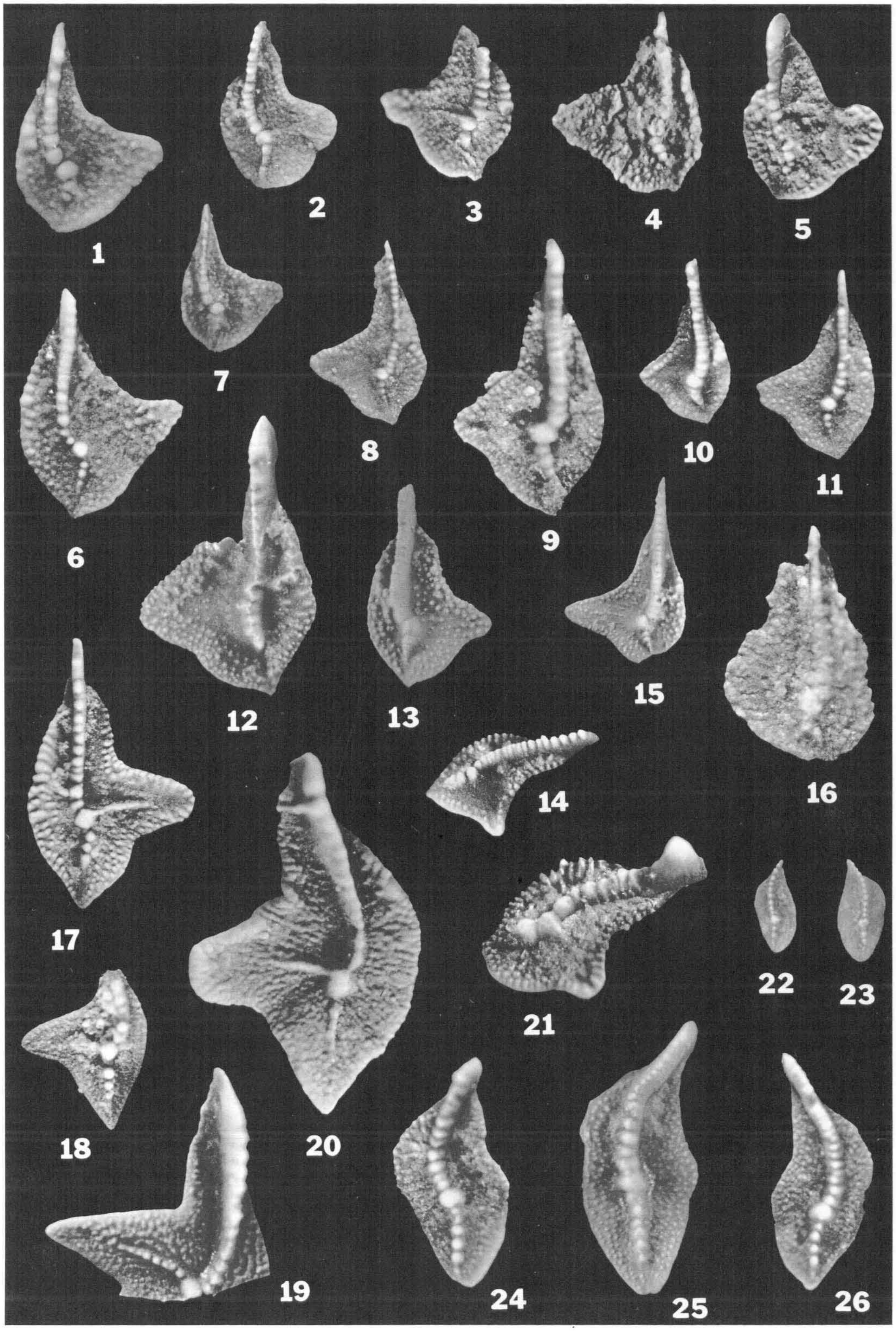
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EXPLANATION OF PLATE 14

"Kenwood" Conodonts

All photographs are X27; sample numbers in parentheses.

Figs. 1-3 -- *Palmatolepis subrecta* Miller and Youngquist, "Kenwood" I; upper views of three specimens, UW-728 A (O), UW-747 (P), and UW-751 (P).

4, 5 -- *Palmatolepis* cf. *P. punctata* (Hinde), "Kenwood" I (P); upper views of UW-726 and UW-727.

6-15 -- *Palmatolepis subrecta* Miller and Youngquist, "Kenwood" I; upper views of ten specimens, respectively UW-748 (A), UW-752 A (P), UW-749 (M), UW-753 (Z), UW-750 A (Q), UW-749 A (P), UW-752 B (P), UW-752 C (P), UW-750 (P), and UW-752 D (A).

16 -- *Palmatolepis foliacea* Youngquist, "Kenwood" I (E); upper view of UW-713.

17-20 -- *Palmatolepis gigas* Miller and Youngquist, "Kenwood" I; upper views of four specimens, respectively UW-718 (P), UW-715 (P), UW-716 (M), and UW-717 (Q).

21 -- *Palmatolepis unicornis* Miller and Youngquist, "Kenwood" I (Q); upper lateral view of UW-764.

22-26 -- *Palmatolepis linguiformis* Müller, "Kenwood" I; 22, 23, upper views of two "juvenile" specimens, UW-724 A (P) and UW-724 B (P); 24-26, upper views of UW-723 (Z), UW-725 A (P), and UW-722 (Q).

EXPLANATION OF PLATE 15

"Kenwood" Conodonts

All photographs are X27, except Figure 11 which is X15; sample numbers in parentheses.

Figs. 1-4 -- Palmatolepis delicatula delicatula Branson and Mehl, "Kenwood" I; 1, 2, 4, upper views of UW-711 (P), UW-712 (Z), and UW-712 B (Q); 3, lower view of UW-712 A (P).

5-10 -- Palmatolepis triangularis Sannemann, "Kenwood" I; 5, 7-9, upper views of UW-756 (Z), UW-757 A (F), UW-760 (M), and UW-755 (Q); 6, lower view of UW-759 (M); 10, upper lateral view of UW-758 (Q).

11 -- Palmatolepis perlobata perlobata Ulrich and Bassler, "Kenwood" I (Z); upper view of UW-734.

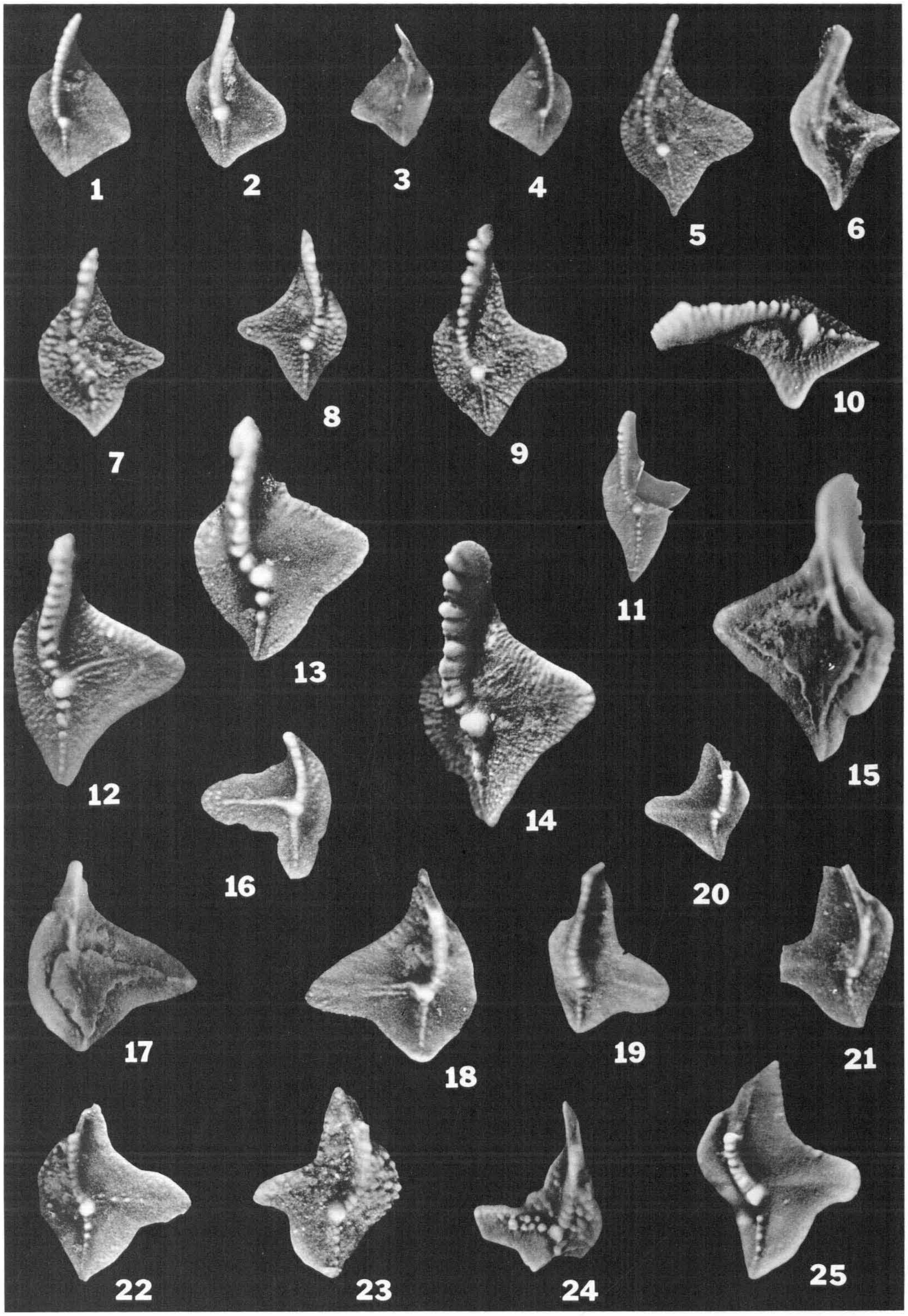
12-15 -- Palmatolepis sp. aff. P. triangularis Sannemann, "Kenwood" I; 12, 13, upper views of UW-763 (A) and UW-761 (Z); 14, 15, upper lateral and lower views of UW-762 (A). The presence of a straight rather than sigmoidal blade-carina and a more broadly triangular, less well-differentiated inner lateral lobe sets these specimens apart from more typical representitives of P. triangularis.

16-18 -- Palmatolepis subperlobata Branson and Mehl, "Kenwood" I; 16, upper view of an atypical specimen, UW-745 (Z); 17, 18, lower and upper views of UW-743 (Z).

19-21 -- Palmatolepis subperlobata Branson and Mehl, "Kenwood" II; upper views of three "typical" representatives of this species, UW-746 (T), UW-742 (T), and UW-742 A (X).

22-24 -- Palmatolepis quadrantinodosalobata Sannemann, "Kenwood" II (T); upper views of three specimens, respectively UW-735, UW-735 A, and UW-736.

25 -- Palmatolepis tenuipunctata Sannemann, "Kenwood" II (T) upper view of UW-741.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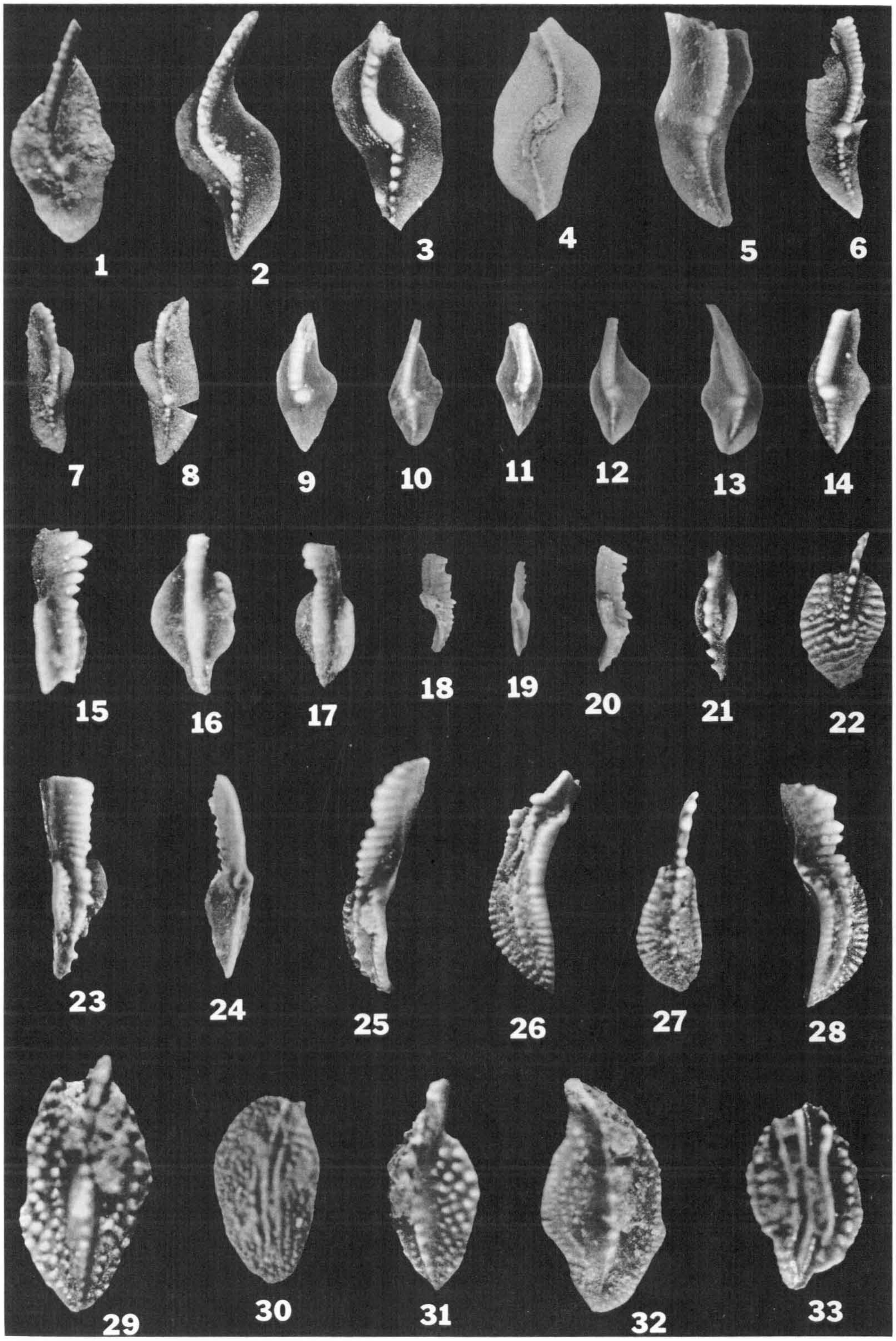
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EXPLANATION OF PLATE 16

"Kenwood" Conodonts

All photographs are X27, except Figures 15 and 16 which are X36; sample numbers in parentheses.

Figs. 1 -- Palmatolepis termini Sannemann, "Kenwood" II (T); upper view of UW-754.

2-4 -- Palmatolepis cf. P. regularis Cooper, "Kenwood" II (T); 2, upper view of UW-739; 3,4, upper and lower views of UW-740.

5, 6 -- Palmatolepis glabra elongata Holmes, "Kenwood" II (T); upper views of UW-719 A and UW-719.

7, 8 -- Palmatolepis glabra glabra Ulrich and Bassler, "Kenwood" II (T); upper views of UW-721 and UW-720.

9-14 -- Palmatolepis minuta minuta Branson and Mehl, "Kenwood" II (T); upper and upper lateral views of six specimens, respectively UW-730 A, UW-730 B, UW-730 C, UW-730 D, UW-730 E, and UW-733.

15-17 -- Polygnathus glaber glaber Ulrich and Bassler, "Kenwood" II (T); upper lateral, upper, and upper lateral views of UW-776, UW-775, and UW-774.

18-20 -- Polygnathus foliatus Bryant, "Kenwood" I; 18-20, upper lateral, lower, and upper lateral views of three immature specimens identical to P. xylus Stauffer, UW-796 A to UW-796 C (P) respectively. 24, 25, lower lateral and upper lateral views of two large specimens, UW-771 (M) and UW-772 (Q).

21, 23 -- Polygnathus brevilaminus Branson and Mehl, "Kenwood" I (P); upper lateral views of two specimens, UW-768 and UW-769.

22 -- Polygnathus granulosus Branson and Mehl, "Kenwood" I (P); upper view of UW-777.

26-28 -- Polygnathus normalis Miller and Youngquist, "Kenwood" I; upper lateral, upper, and upper lateral views of three specimens, UW-786 (Q), UW-788 (P), and UW-787 (Q).

29, 30, 32 -- Polygnathus nodocostatus nodocostatus Branson and Mehl, "Kenwood" II; upper views of three specimens, UW-782 (T), UW-784 (X), and UW-781 (C).

31 -- Polygnathus nodocostatus ovatus Helms, "Kenwood" II (K); upper lateral view of UW-785.

33 -- Polygnathus sp. A, "Kenwood" II (C), upper lateral view of a polygnathid of the "nodocostatus-Group" possessing well-developed rostral ridges, UW-797.