Conodonts from Middle Devonian Strata of the Michigan Basin

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Conodonts from Middle Devonian Strata of the Michigan Basin

By R. WILLIAM ORR

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Conodonts from Middle Devonian Strata of the Michigan Basin

By R. WILLIAM ORR [1]

Abstract

Study of the stratigraphic distribution of 20 species of the platform genera *Icriodus, Polygnathus, Palmatolepis?,* and *Schmidtognathus* at 11 subsurface localities in northern Indiana and at 10 supplementary outcrop localities in northern Indiana, Michigan, and western Ontario makes possible the recognition of five conodont zones in middle Devonian strata of the Michigan Basin.

The lower part of the Detroit River Formation of northern Indiana contains a fauna characterized by *Polygnathus angusticostatus, P. robusticostatus,* and *P. "webbi."* This faunal association is similar to that of the *Spathognathodus bidentatus* Zone (Eifelian) of Europe. The upper Eifelian fauna of the Dundee Limestone of Michigan, Ohio, and western Ontario, which is characterized by *Icriodus angustus,* is not present in northern Indiana, where the Detroit River is succeeded unconformably by the Traverse Formation. The lower part of Traverse strata of Indiana and the Bell Shale, Rockport Quarry Limestone, Ferron Point Formation, Genshaw Formation, Newton Creek Limestone, and lowermost part of the Alpena Limestone (all the Traverse Group) of Michigan contain a lower Givetian fauna distinguished by *I. latericrescens latericrescens* below the lowest position of *P. varcus.* The upper part of the Traverse Formation of Indiana and the upper part of the Alpena Limestone and the Four Mile Dam Limestone, Norway Point Formation, Potter Farm Formation, and Thunder Bay Limestone (all the Traverse Group) of Michigan lie within the *P. varcus* Zone (upper Givetian). The lowermost part of the Antrim Shale of northern Indiana contains the fauna of the *Schmidtognathus hermanni-P. cristatus* Zone of probable late middle Devonian (Givetian) age.

Forty-four species of conodonts that are referable to 18 genera are present in the collection. The new taxon *Icriodus latericrescens robustus* is proposed herein.

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Introduction

PURPOSE AND SCOPE OF THE INVESTIGATION

Although Devonian carbonate rocks in northern Indiana have been correlated with the Detroit River and Traverse Groups of Michigan (Pinsak and Shaver, 1964) and placed in the middle Devonian, precise age determinations have not been made. A basis for more precise correlations than were heretofore possible has been provided by the recent work of, among others, Willi Ziegler, Hanspeter Wittekindt, Gilbert Klapper, and Charles Collinson. Bischoff and Ziegler (1957) and Ziegler (1962, 1966a) established a sequence of upper middle and upper Devonian conodont zones in the European reference sections of the Devonian System. Wittekindt (1966) restudied Bischoff and Ziegler's (1957) and additional sections and recognized a sequence of seven middle Devonian conodont zones in Germany. Orr (in preparation) has recognized a somewhat different sequence of six middle Devonian zones in the southern part of the Illinois Basin. Klapper and Ziegler (1967) studied the evolutionary development of the biostratigraphically important *Icriodus latericrescens* group and presented information concerning distribution of conodonts in the standard North American Devonian sequence in New York, as well as in several other states and Europe. Klapper and others (in press) summarized the status of middle Devonian zonation in North America.

The primary objective of this study is to determine the stratigraphic relationships between the sub-Antrim Devonian rocks of northern Indiana and the Detroit River and Traverse Groups of the type areas in Michigan and western Ontario. Other objectives are to illustrate the nature and stratigraphic divisions of the little-known middle Devonian rocks of northern Indiana and to correlate them with units in southern Indiana and New York.

In order to meet these objectives, collections of conodonts were obtained from 11 cores and one surface exposure from northern Indiana (fig. 1 and Appendix) and from nine of 10 outcrop localities in Michigan and western Ontario (figs. 2 and 3 and Appendix). Seven samples from Cummin's Quarry (locality 13) did not yield conodonts.

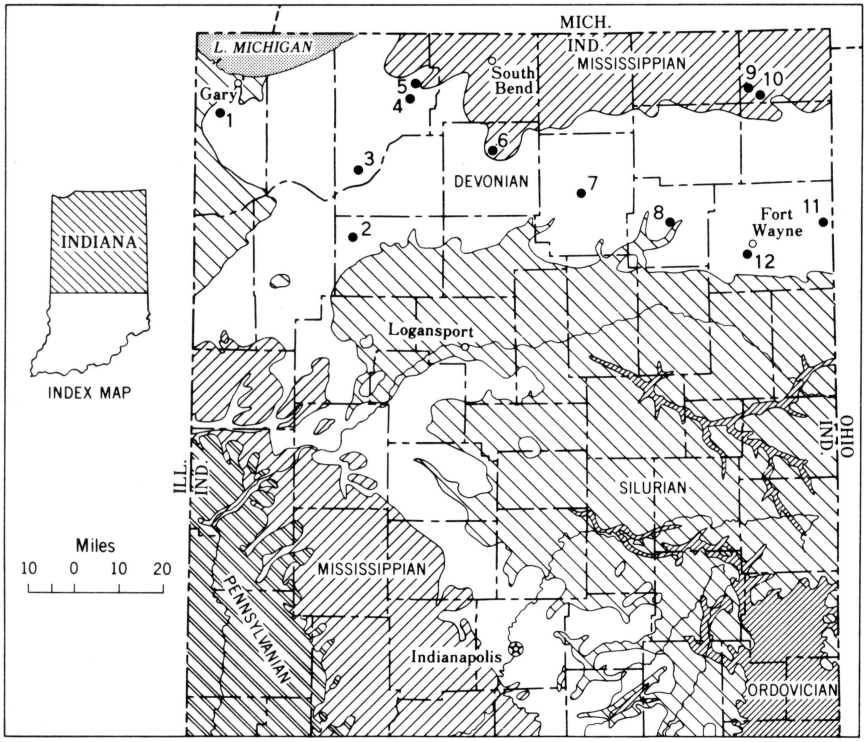

Figure 1. Generalized geologic map of northern Indiana showing localities of cores and outcrops from which conodonts were collected. Part of geology modified from Pinsak and Shaver, 1964.

Stratigraphic units that were sampled include the Detroit River Formation, Traverse Formation, and Antrim Shale of northern Indiana; the Bell Shale, Rockport Quarry Limestone, Ferron Point Formation, Genshaw Formation, Newton Creek Limestone, Alpena Limestone, Four Mile Dam Limestone, Norway Point Formation, Potter Farm Formation, and Thunder Bay Limestone (all the Traverse Group) of Michigan; the Amherstburg Formation (Detroit River Group) of Michigan; the Lucas Dolomite and Anderdon Limestone (both of the Detroit River Group) and the Dundee Limestone of western Ontario. Of these units, only the Rockport Quarry Limestone and the Amherstburg Formation failed to yield conodonts.

Five hundred seventy-three samples (average weight, 1 kilogram)

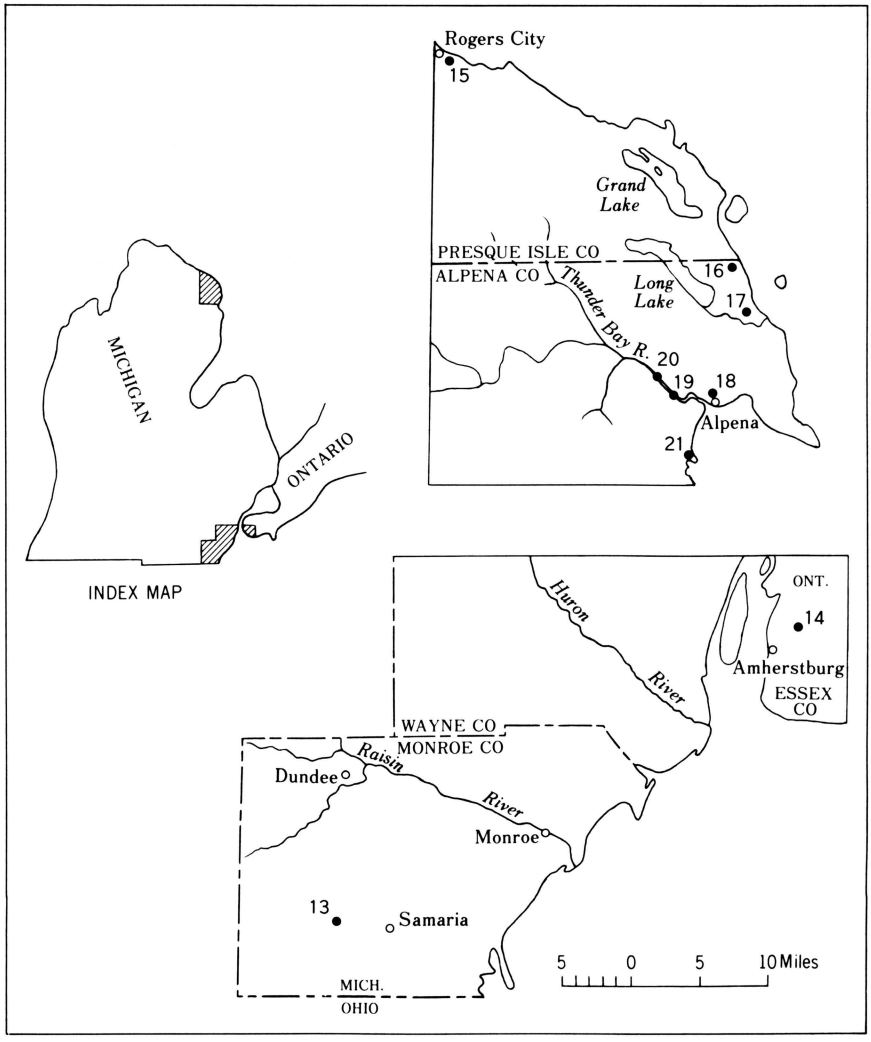

Figure 2. Locations of collecting sites in Michigan and western Ontario.

of limestone, dolomite, and shale from 21 localities were processed in the laboratory according to the procedure outlined by Collinson (1963). Three hundred thirty-three of these samples yielded conodonts. Most of the barren samples were from Detroit River strata. A collection of about 10,100 specimens representing 18 genera and 44 species was obtained.

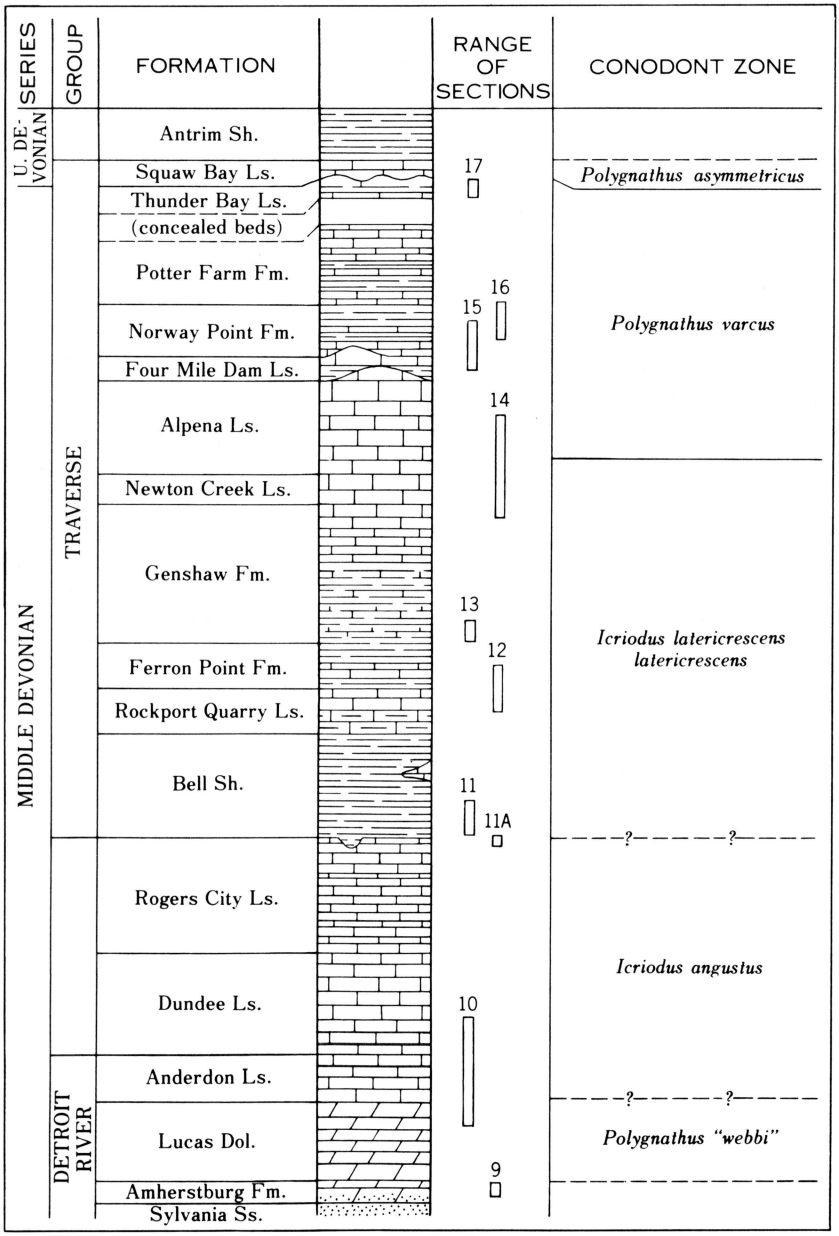

Figure 3. Composite section (after Warthin and Cooper, 1943, and Ehlers, Stumm, and Kesling, 1951) of middle and upper Devonian rocks in the eastern part of the Michigan Basin showing collation of conodont zones.

ACKNOWLEDGMENTS

This investigation was carried out in relation to a National Science Foundation project (GP5629) that was being conducted in the same area by Carl B. Rexroad, of the Indiana Geological Survey, and John B. Droste and Robert H. Shaver, of the Department of Geology, Indiana University. The Indiana Geological Survey and the NSF contributed to laboratory and field expenses. Carl B. Rexroad and Robert H. Shaver contributed valuable advice and assistance throughout this study. Discussions of taxonomy with Charles A. Pollock, formerly postdoctoral research associate in the Department of Geology, Indiana University, and presently with the Amoco Canada Co., Ltd., proved most useful. Dr. Pollock also accompanied me during a collecting trip to Michigan and western Ontario. Albert J. Rudman and Donald E. Hattin, of the Department of Geology, and Charles J. Krebs, of the Department of Zoology, Indiana University, critically read an earlier version of the manuscript as a doctoral dissertation at Indiana University. Information from Gilbert Klapper, University of Iowa, and his critical reading of the manuscript are gratefully acknowledged. Thanks are also due to the Northern Indiana Public Service Co. for furnishing cores and to the various quarry operators who granted access to their premises.

Stratigraphic Summary

David D. Owen (1839) was the first to recognize Devonian rocks in northern Indiana. He noted lithologic and faunal similarities between carbonate rocks below "black, bituminous, alumnious slate" near Logansport, Cass County, and similar strata in the southern part of the state. During the next 130 years several studies correlating these rocks with similar strata in southern Indiana were made. Thornbury and Deane (1955) summarized the use of Devonian stratigraphic nomenclature in northern Indiana and indicated that the lithology of the Devonian strata in the subsurface of the Miami County area, on the northeast side of the Cincinnati Arch, more closely resembles that of the Traverse Group of Michigan than it does that of the North Vernon Limestone, its correlative of southern Indiana and the Illinois Basin.

Northeast of the Cincinnati Arch in Indiana the pre-Pleistocene subcrop of Devonian rocks is a belt that crosses the state in an east-west orientation (fig. 1) and lies along the south flank of the Michigan Basin. In this belt the middle Devonian carbonate section is as much as about 200 feet thick. In the Jasper Sag (Pinsak and Shaver, 1964, p. 13, figs. 1 and 2), rocks of Devonian age extend across the broad crest of the Cincinnati Arch into the Illinois Basin, where they lie at the bedrock surface in a northwestward-southeastward-trending belt along the east flank of the basin.

Two divisions of middle Devonian carbonate rocks are recognized in northern Indiana. The Detroit River Formation (after a nomenclatural proposal for northern Indiana by Schneider and Keller, 1970) is unconformably overlain by the Traverse Formation. These two units are correlative with parts of the Detroit River and Traverse Groups, respectively, of Michigan.

The Detroit River Formation unconformably overlies the Salina Formation (Silurian) in the northern part of the state east of Lake County. The Detroit River pinches out westward in Porter County and extends as far south as Cass and Adams Counties. It attains a maximum thickness of about 140 feet in the northernmost tier of counties in Indiana (Pinsak and Shaver, 1964, pl. 2C). In the sections examined during this study (fig. 1 and Appendix), the Detroit River Formation ranges in thickness from 35.1 feet (locality 12) to 115.5 feet (locality 5).

The basal part of the Detroit River consists of dolomite that is light brown to gray and mostly fine grained and that generally is arenaceous in its lower part. The middle part of the Detroit River contains dolomite, dolomitic limestone, evaporites (gypsum and anhydrite), and thin shale partings in order of decreasing abundance. At or near the top of the formation is found gray to tan sublithographic to lithographic limestone that lithologically resembles similar beds in the Anderdon Limestone, which lies at the top of the Detroit River Group (fig. 3) at the Brunner, Mond Canada, Ltd., quarry (locality 14, type section of the Anderdon Limestone) near Amherst-

burg, Ontario. For a discussion of the nomenclature of the Detroit River Group in its type area, see Ehlers, Stumm, and Kesling (1951). Classification of the group in its outcrop as proposed by Ehlers (1950) after studying the units of Lane and others (1909) is followed herein. The Detroit River Group in its type area includes four formations, which are in ascending order the Sylvania Sandstone, Amherstburg Formation, Lucas Dolomite, and Anderdon Limestone.

In the central part of the Michigan Basin the Amherstburg Formation (including the Sylvania Sandstone as its basal member) consists of sandstone and dark-brown to black limestone and dolomite and attains a maximum thickness of about 600 feet (Landes, 1951). According to Landes (1951, p. 11, fig. 7) the Amherstburg pinches out southward in the northeast corner of Steuben County, Ind. Landes (1951) did not include the Anderdon Limestone in his subsurface stratigraphic section because the unit had not been identified farther than 8 miles from the outcrop area in southeastern Michigan.

The Detroit River Formation of northern Indiana lithologically resembles the Lucas Dolomite (fig. 3) of central and southern Michigan. In the deeper part of the Michigan Basin the Lucas consists, in order of decreasing abundance, of dolomite, evaporites, limestone, and sandstone and attains a maximum thickness of nearly 1,000 feet (Landes, 1951, p. 3). Pinsak and Shaver (1964) considered the Detroit River Formation of northern Indiana as probably correlative with the Lucas Dolomite of the Detroit River Group of Michigan. Study of conodont succession in the Michigan Basin and evidence from other fossils support this correlation.

The Traverse Formation unconformably overlies the Detroit River Formation in northern Indiana. The Dundee and Rogers City Limestones, which occupy a stratigraphic position between the Detroit River and Traverse Groups in Michigan, pinch out southward and are not present in the study area of northern Indiana (Cohee and Underwood, 1945). Southward-thinning Traverse rocks overlap the sub-

jacent Detroit River Formation southward and westward. At locality 1, near Griffith in Lake County, the Detroit River is absent and the Traverse rests on the Wabash Formation (Silurian) (Appendix, section 1). The Traverse Formation reaches a maximum thickness in Indiana of about 120 feet in the northern tier of counties (Pinsak and Shaver, 1964, pl. 1). In the cores examined during this study the Traverse, where overlain by the Antrim Shale, ranges in thickness from 40.6 feet (locality 2) to 97.3 feet (locality 9).

The Traverse Formation in the subsurface of northern Indiana is a carbonate sequence that consists largely of limestone, argillaceous limestone, dolomite, and thin beds of shale in order of decreasing abundance. Lithologically similar beds cropping out near Logansport, Cass County, are about 25 feet thick and previously were divided into Logansport Limestone (Cooper and Warthin, 1941), Little Rock Creek Limestone (Cooper, 1941), and Miami Bend Formation (Cooper and Phelan, 1966). Cooper and Warthin (1941) indicated the faunal affinities of the Logansport with the Four Mile Dam Limestone of Michigan. Galloway and St. Jean (1955) correlated the stromatoporoid fauna of the Little Rock Creek with that of the Potter Farm Formation of Michigan. Thornbury and Deane (1955) and Pinsak and Shaver (1964) correlated the middle Devonian beds of the Logansport area with part of the Traverse Group of Michigan. Orr (1969) proposed, on the basis of lithologic similarity, similar depositional history, and equivalent conodont faunas, that the name Traverse be used in Cass and Carroll Counties for middle Devonian rocks of Hamilton age previously designated Logansport, Little Rock Creek, and Miami Bend.

As determined by a study of conodont succession the Traverse Formation of northern Indiana includes strata equivalent to part of the Traverse Group of Michigan (fig. 4) below the Squaw Bay Limestone. For a thorough discussion of the stratigraphy of the Traverse Group in its type area near Thunder Bay, Mich., see Warthin and Cooper (1943).

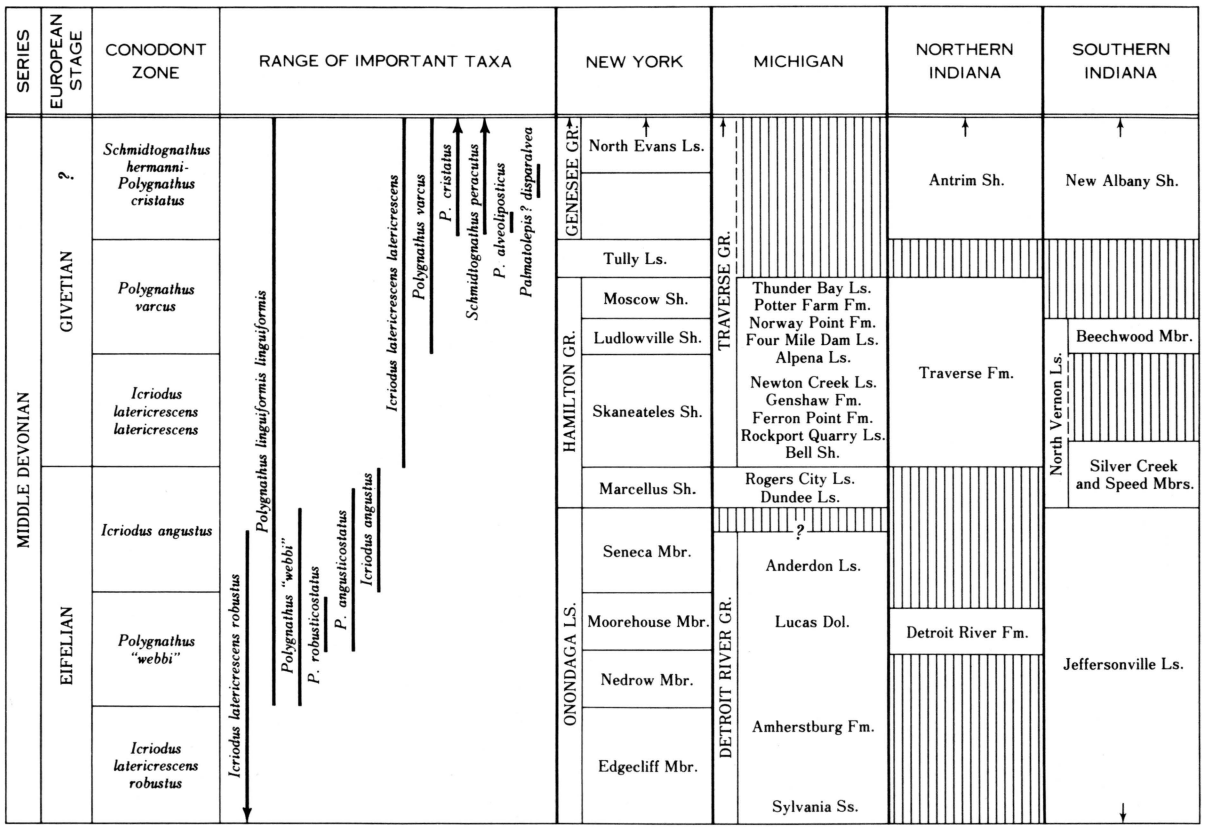

Figure 4. Chart showing correlation of middle Devonian formations of northern Indiana with equivalent units in southern Indiana, Michigan, and New York.

The Conodont Fauna

GENERAL ASPECTS

A collection of about 10,100 specimens of conodonts from Devonian strata of the Michigan Basin represents 18 genera, including the platform types *Icriodus, Polygnathus, Palmatolepis?,* and *Schmidtognathus,* as well as the nonplatform types *Acodina, Angulodus, Belodella, Coelocerodontus, Diplodella, Hibbardella, Hindeodella, Ligonodina, Lonchodina, Neoprioniodus, Ozarkodina, Prioniodina, Spathognathodus,* and *Synprioniodina.* Thirty-six species of conodonts are identified. Additional species of these genera are represented by single specimens and fragmentary material and are carried here in open nomenclature. One new taxon, *Icriodus latericrescens robustus,* is proposed.

Measured sections sampled for conodonts are described in the Appendix, sections 1 to 21. Conodonts are present in moderate abundance in rocks of the Dundee Limestone and in most parts of the Traverse Formation of northern Indiana and the Traverse Group of Michigan. Ten of the 11 formations in the Traverse Group in its type area near Thunder Bay, Mich., were sampled for conodonts (fig. 3). All but the Rockport Quarry Limestone yielded conodonts. Schumacher (written communication, 1968) obtained specimens of *Icriodus latericrescens latericrescens* from the Rockport Quarry. The Squaw Bay Limestone, not sampled, contains a diverse fauna described by Müller and Clark (1967).

In contrast, Detroit River strata contain few specimens. Only the dolomite and limestone beds that lie below the evaporites at localities 3 (unit 12), 4 (unit 11), and 5 (unit 17) have yielded significant numbers of conodonts. In both outcrop and subsurface the upper part of the Detroit River either is lacking in conodonts or yields only a few specimens.

In the subsurface section of northern Indiana the number of conodonts increases abruptly above the Detroit River-Traverse boundary. The lower part of the Traverse Formation generally yields several dozen specimens per kilogram. Conodonts, where present, in the

upper part of the Detroit River Formation average less than 5 per kilogram. *Icriodus latericrescens latericrescens* is not present in the Detroit River Formation, but it is present in moderate abundance in the lower part of the Traverse and ranges throughout the Traverse Formation of northern Indiana and sub-Squaw Bay part of the Traverse Group in the Thunder Bay area of Michigan.

CONODONT ZONES AND CORRELATIONS

Bischoff and Ziegler (1957) made an intensive study of conodont distribution in middle Devonian and related strata in Germany and named five subzones of the upper middle and lower upper Devonian. They found that the platform genera *Polygnathus* and *Icriodus* are particularly good stratigraphic indicators in the middle Devonian. Bischoff and Ziegler (1957) and Wittekindt (1966) based their zonation largely on these two genera and on *Spathognathodus* to a lesser extent. In 1962 Ziegler compiled a zonation of the entire upper Devonian and distinguished the *Polygnathus varcus* Zone (fig. 4) as a zone high in the middle Devonian (Givetian Stage). Recently (1966a) Ziegler recognized the *Schmidtognathus hermanni-Polygnathus cristatus* Zone between the *P. varcus* Zone and the Lower *P. asymmetricus* Zone (low in the upper Devonian, Frasnian Stage). Wittekindt (1966) established a series of seven conodont zones for the middle Devonian of Germany, and Orr (in preparation) has recognized a somewhat different sequence of six middle Devonian zones in the Illinois Basin and has related these zones to the standard North American Devonian sequence of New York (fig. 4). Klapper and others (in press) discussed the difficulties in relating Wittekindt's zones to the North American conodont succession.

The Scoharie Formation in eastern New York and Zone B in western New York of Oliver (1954), which unit Oliver now refers to the Bois Blanc Formation, contain a conodont fauna characterized by *Icriodus latericrescens robustus* and *I. latericrescens huddlei* (Klapper and Ziegler, 1967). This association is unknown in Europe, but *I. latericrescens huddlei* is present in the Princeps-, Zorgensis-, and Schönauer-Kalk of the upper lower Devonian (Emsian Stage) of

Germany, which suggests correlation of the Scoharie with upper Emsian strata.

The lowest conodont fauna assigned to the Eifelian in North America is characterized by *Icriodus latericrescens robustus* as the single platform taxon (Orr, in preparation). This fauna occurs in the Edgecliff Member of the Onondaga Limestone of New York and in the lower part of the Grand Tower Limestone of southern Illinois. As this important taxon has not yet been reported in the literature from Europe, the difficulty of assigning this fauna with certainty is apparent (Klapper and Ziegler, 1967). Oliver (1960), however, on the basis of coral faunas assigned the Edgecliff Member to the Eifelian Stage.

Similarly, the boundary between middle and upper Devonian rocks has been difficult to fix precisely in Europe and elsewhere because of a gap separating the vertical ranges of the cephalopods *Maenioceras* and *Pharciceras.* The *Polygnathus varcus* Zone and the superjacent *P. linguiformis transversus* Zone (Wittekindt, 1966) include upper middle Devonian (Givetian) strata and contain *Maenioceras.* The *Polygnathus asymmetricus* Zone (Ziegler, 1962) occupies a position low in the upper Devonian and is present in association with *Pharciceras.* Ziegler (1966a) recognized the *Schmidtognathus hermanni-Polygnathus cristatus* Zone in several feet of strata that lack cephalopods between rocks of proven middle and late Devonian age. The change from relatively narrow to broad polygnathids, which gave rise to characteristic upper Devonian genera such as *Ancyrodella* and *Palmatolepis,* occurs within this zone. In Europe, the zone cannot be assigned with certainty to either the middle or upper Devonian because of the aforementioned lack of cephalopods. Klapper and others (in press) indicate that two of the North American occurrences of the zone (in Iowa and Nevada) should possibly be assigned to the middle Devonian on the basis of brachiopods and corals.

The Tully Limestone of New York lies within the upper part of the *Polygnathus varcus* Zone (Klapper and Ziegler, 1967). The *P. linguiformis transversus* Zone of Europe has not been identified in

North America to date. Recognition of the zone depends on the presence of the name-giving taxon, which has not yet been reported from North America.

On the basis of conodonts Müller and Müller (1957, table 1) correlated the Squaw Bay Limestone at the top of the Traverse Group of Michigan with the Genundewa Limestone Lentil of New York and placed these two units in the lowermost part of the *Manticoceras* Stage of Europe. Orr and Klapper (1968) agreed with this correlation and indicated the assignment of both units to the upper part of the Lower *Polygnathus asymmetricus* Zone (upper Devonian). In New York, therefore, the boundary between middle and upper Devonian rocks lies between the Tully and the Genundewa. Hinde (1879) described and Bryant (1921) redescribed an abundant conodont fauna from the North Evans Limestone (="Conodont bed" of Hinde, 1879) below the Genundewa at Eighteenmile Creek, N.Y. This fauna is nearly identical to that of the *Schmidtognathus hermanni-Polygnathus cristatus* Zone of likely late middle Devonian age, but it also contains the upper Devonian taxon *Ancyrodella rotundiloba rotundiloba,* which indicates at least partial assignment of the North Evans to the upper Devonian.

The sequence of conodont zones recognized by Orr (in preparation) in the middle Devonian section of the Illinois Basin (fig. 4) is as follows: in ascending order, *Icriodus latericrescens robustus* Zone (lower Eifelian), the base of which is marked by the lowest position of the name bearer and the top of which is marked by the lowest position of *Polygnathus "webbi"; P. "webbi"* Zone (middle Eifelian), the base of which is marked by the lowest position of the name bearer and the top of which is marked by the lowest position of *Icriodus angustus; I. angustus* Zone (upper Eifelian), coincident with the range of the name bearer; *I. latericrescens latericrescens* Zone (lower Givetian), the base of which is marked by the lowest position of the name bearer and the top of which is marked by the lowest position of *P. varcus; P. varcus* Zone (upper Givetian; Ziegler, 1962); *Schmidtognathus hermanni-P. cristatus* Zone (Ziegler, 1966a). It may prove desirable to divide the *P. "webbi"* Zone into upper and lower

parts, the base of the upper part being defined by the lowest position of *P. robusticostatus.* Klapper and others (in press) recognized the *Spathognathodus insitus* fauna between the *Schmidtognathus hermanni-Polygnathus cristatus* Zone and the Lower *P. asymmetricus* Zone in North America and considered the *Spathognathodus insitus* fauna to be of possible late Devonian age, at least in part. Five of these zones are identified in Devonian rocks of the Michigan Basin (fig. 4).

The oldest fauna obtained during this study is below the evaporites in the lower part of the Detroit River Formation at localities 3-5 in northern Indiana and is that of the *Polygnathus "webbi"* Zone. The fauna is characterized by the association of *P. "webbi," P. robusticostatus, P. angusticostatus,* and rare juvenile specimens of *Spathognathodus bidentatus.* As pointed out by Klapper and others (in press), the true *P. webbi* Stauffer is an upper Devonian species. In Europe *P. angusticostatus* is restricted to the Eifelian Stage (Bischoff and Ziegler, 1957; Wittekindt, 1966) where the species is found in faunal association with *P. "webbi"* and *P. robusticostatus.* The latter species is found in association with *P. "webbi"* and *Icriodus latericrescens robustus* in the Moorehouse Member of the Onondaga Limestone (for subdivision of the Onondaga see Oliver, 1954) of New York (Klapper and Ziegler, 1967). The Seneca Member of the Onondaga contains a fauna with *P. "webbi," I. latericrescens robustus,* and *P.* cf. *P. trigonicus* (Klapper and Ziegler, 1967). In Europe *P. trigonicus* is confined to the *P. kockelianus* Zone at the top of the Eifelian Stage (Wittekindt, 1966). It is suggested that the part of the Detroit River Formation of northern Indiana that contains the fauna listed above is correlative with the Moorehouse Member of the Onondaga Limestone of New York and probably with Wittekindt's (1966) *Spathognathodus bidentatus* Zone (fig. 4). The middle part of the Grand Tower Limestone of southern Illinois and probably the middle part of the Jeffersonville Limestone of southern Indiana also lie within the *P. "webbi"* Zone.

Correlation of part of the Detroit River (Lucas equivalent) with the Moorehouse is consistent with Fagerstrom's (1966) correlation

on the basis of corals and brachiopods of the Amherstburg Formation, which underlies the Lucas Dolomite in southeastern Michigan, with the Edgecliff Member of the Onondaga Limestone of New York. Fagerstrom merely stated that Detroit River strata higher than the Amherstburg are post-Edgecliff in age. The Edgecliff Member of the Onondaga lies within the *Icriodus latericrescens robustus* Zone, as do the lower part of the Grand Tower Limestone of southern Illinois and the lower part of the Jeffersonville Limestone of southern Indiana (fig. 4).

The *Icriodus angustus* Zone is represented by the Dundee Limestone of western Ontario, Michigan, and northwestern Ohio. The lower part of the Dundee at the Brunner, Mond Canada, Ltd., quarry (locality 14) contains a fauna that is characterized by an association of *I. angustus* and *I. latericrescens robustus.* Klapper and Ziegler (1967) recorded a fauna from the upper part of the Dundee Limestone near Silica, Ohio, that contains *I. angustus* without *I. latericrescens robustus. Icriodus angustus* ranges stratigraphically higher than *I. latericrescens robustus* in the Lingle Formation of southern Illinois and the North Vernon Limestone of southern Indiana (Orr, in preparation).

In Germany *Icriodus angustus* is restricted to an interval in the upper Eifelian (Ziegler, written communication, 1964). The *I. angustus* Zone is equivalent to an interval high in the Eifelian Stage. In Germany the *Polygnathus kockelianus* Zone (Wittekindt, 1966) is the highest conodont zone in the Eifelian Stage (fig. 4). Klapper and Ziegler (1967) proposed that *I. angustus* apparently diverged from *I. latericrescens robustus* early in Eifelian time. The aboral configuration of the platform of *I. angustus* certainly suggests such a relationship to the *I. latericrescens* group. Klapper and Ziegler (1967, fig. 2) indicate that *I. angustus* ranges throughout most of the upper part of the Eifelian Stage.

Icriodus angustus has not yet been reported from New York despite systematic sampling and search for conodonts in limestone units in the middle Devonian part of the section by Gilbert Klapper

and by me among others. *Polygnathus eiflius,* which is confined to the *I. angustus* Zone in the Illinois Basin (Orr, in preparation), is an important constituent (with *P. kockelianus*) of the fauna of the Cherry Valley Limestone Member of the Marcellus Shale of New York (fig. 4). It is suggested that part of the Marcellus lies within the *I. angustus* Zone.

The upper part of the Grand Tower Limestone of southern Illinois and the upper part of the Jeffersonville Limestone and all but the uppermost part of the intertonguing Speed and Silver Creek Members of the North Vernon Limestone of southern Indiana lie within the *Icriodus angustus* Zone (Orr, in preparation). Stewart and Sweet (1956) reported *I. angustus* from the Columbus and Delaware Limestones of Ohio.

The lower part of the Traverse Formation of northern Indiana and that part of the Traverse Group of Michigan below the lower part of the Alpena Limestone lie within the *Icriodus latericrescens latericrescens* Zone. This zone is characterized by the range of the name bearer below the lowest position of *Polygnathus varcus.*

Klapper and Ziegler (1967) reported faunas that contain *Icriodus latericrescens latericrescens* without *Polygnathus varcus* from the Hamilton Group of New York. The lowest reported position of *P. varcus* is in the Centerfield Limestone Member of the Ludlowville Shale where the species is found in association with *I. latericrescens latericrescens* (Klapper and others, in press). Klapper and Ziegler (1967) also reported the latter taxon without *P. varcus* from the lower and middle limestones of the Silica Shale (Traverse Group) of northwestern Ohio. Orr (in preparation) recognized the *I. latericrescens latericrescens* Zone in the lower part of the Lingle Formation of southern Illinois and in the Saint Laurent Limestone of southeastern Missouri.

In southern Indiana the *Icriodus latericrescens latericrescens* Zone is represented by the highest part of the Silver Creek Member at the Atkins quarry in Clark County (Orr and Pollock, 1968); the overlying Beechwood lies within the *Polygnathus varcus* Zone. Physical

evidence for the unconformity between the intertonguing Speed and Silver Creek Members and the overlying Beechwood is marked by a conglomerate at the base of the Beechwood and has been presented by Butts (1915), Whitlatch and Huddle (1932), and Dawson (1941), who called it "the most striking disconformity of the [southern Indiana] region."

In Europe *Icriodus latericrescens latericrescens* is uncommon and is found only as isolated specimens in the *Polygnathus varcus* Zone (Wittekindt, 1966). The *I. latericrescens latericrescens* Zone is probably correlative with the lower part of the Givetian Stage below the *P. varcus* Zone. Wittekindt (1966) recognized the *P. eiflius* Zone subjacent to the *P. robusticostatus* Zone in the lower part of the Givetian Stage in Germany. The *P. varcus* Zone overlies the *P. robusticostatus* Zone (fig. 4). Wittekindt (1966) indicated the presence of *P. varcus* throughout most of the *P. robusticostatus* Zone. This situation is not consistent with Ziegler's (1962) definition of the base of the *P. varcus* Zone as the lowest position of the name bearer. Much of Wittekindt's *P. robusticostatus* Zone, therefore, is more properly assigned to the *P. varcus* Zone.

In the Michigan Basin the *Polygnathus varcus* Zone includes the upper part of the Traverse Formation of northern Indiana and the part of the Traverse Group of Michigan that lies above the lower part of the Alpena Limestone and below the Squaw Bay Limestone. The fauna of this zone is characterized by an association of *P. varcus* and *Icriodus latericrescens latericrescens.*

The upper part of the Hamilton Group (above the Centerfield Limestone Member of the Ludlowville Shale) and the Tully Limestone of New York, the upper limestone of the Silica Shale of northwestern Ohio (Klapper and Ziegler, 1967), the upper part of the Lingle Formation of southern Illinois (Orr, in preparation), and the Beechwood Member of the North Vernon Limestone of southern Indiana all lie within the *Polygnathus varcus* Zone.

Wittekindt (1966) reported the association of *Polygnathus varcus* with rare specimens of *Icriodus latericrescens latericrescens* in the

Terebratula pumilio layer of the *discoides*-Kalk of Germany. The *P. varcus* Zone is widespread and, in addition to observations by others, has been recognized by, among others, Ziegler (1962, 1966a, 1966b), Krebs (1959), Flajs (1966), and Wittekindt (1966).

The lower part of the Antrim Shale of northern Indiana contains a diverse fauna characterized by *Polygnathus cristatus, P. decorosus, P. pennatus, P. foliatus, Schmidtognathus peracutus,* and rare specimens of *Palmatolepis? disparalvea.* A similar fauna but lacking *Palmatolepis? disparalvea* is found in the *Schmidtognathus hermanni-Polygnathus cristatus* Zone (Ziegler, 1966a) in Germany. This conodont zone is present in beds that in Germany are considered problematical between proven middle and upper Devonian strata.

The North Evans Limestone (="Conodont bed," Hinde, 1879) of New York, the lowermost part of the New Albany Shale of southern Indiana (Orr and Pollock, 1968; Orr and Klapper, 1968), and the upper part of the Alto Formation of southern Illinois (Orr, 1964) all lie within the *Schmidtognathus hermanni-Polygnathus cristatus* Zone.

In the Thunder Bay area of Michigan the Squaw Bay Limestone, uppermost formation of the Traverse Group, contains the fauna of the upper Devonian Lower *Polygnathus asymmetricus* Zone (Müller and Clark, 1967). The subjacent Thunder Bay Limestone lies within the *P. varcus* Zone high in the middle Devonian part of the section.

Figure 4 shows suggested correlations between middle Devonian and related rocks of the Michigan Basin and standard sections in New York and Germany, as well as with the southern Indiana outcrop section. In addition to being based on the material obtained during this study, the correlation chart is based on information from the studies of Klapper and Ziegler (1967), Wittekindt (1966), Orr (in preparation), Orr and Klapper (1968), Orr and Pollock (1968), and Klapper and others (in press).

Summary and Conclusions

The *Icriodus latericrescens robustus* Zone (lower Eifelian) is not present in northern Indiana. The lower part of the Detroit River

Formation of northern Indiana lies within the *Polygnathus "webbi"* Zone (middle Eifelian) and is correlative with part of the Lucas Dolomite of the Detroit River Group of Michigan, with the Moorehouse Member of the Onondaga Limestone of New York, with the middle part of the Jeffersonville Limestone of southern Indiana, and with the middle part of the Grand Tower Limestone of southern Illinois.

In northern Indiana the Traverse Formation unconformably overlies the Detroit River Formation. In Michigan the Dundee and Rogers City Limestones are present between the Detroit River and Traverse Groups. The Dundee lies within the *Icriodus angustus* Zone (upper Eifelian) and correlates with part of the Marcellus Shale of the Hamilton Group of New York, with the lower part of the Speed and Silver Creek Members of the North Vernon Limestone of southern Indiana, and with the upper part of the Grand Tower Limestone of southern Illinois. The *I. angustus* Zone is not represented in northern Indiana.

The Traverse Formation of northern Indiana is correlative with that part of the Traverse Group of Michigan that lies below the Squaw Bay Limestone. The lower part of the Traverse Formation of northern Indiana and the Bell Shale, Rockport Quarry Limestone, Ferron Point Formation, Genshaw Formation, Newton Creek Limestone, and the lower part of the Alpena Limestone of the Traverse Group of Michigan lie within the *Icriodus latericrescens latericrescens* Zone (lower Givetian) and are correlative with the Skaneateles Shale of the Hamilton Group of New York and with part of the Lingle Formation of southern Illinois. Equivalent strata are present in southern Indiana in the highest part of the Silver Creek Member.

The upper part of the Traverse Formation of northern Indiana and the upper part of the Alpena Limestone and the Four Mile Dam Limestone, Norway Point Formation, Potter Farm Formation, and Thunder Bay Limestone of the Traverse Group of Michigan lie within the *Polygnathus varcus* Zone and are correlative with the Ludlowville Shale and with the Moscow Shale (both of the Hamilton Group

of New York, with the Beechwood Member of the North Vernon Limestone of southern Indiana, and with the upper part of the Lingle Formation of southern Illinois.

In the northernmost tier of Indiana counties the lowest part of the Antrim Shale lies within the *Schmidtognathus hermanni-Polygnathus cristatus* Zone. In this area, apparently no major interruption in sedimentation took place between deposition of the upper part of the Traverse Formation and the deposition of the lower part of the Antrim Shale. The lower part of the Antrim is correlative with the lowermost part of the New Albany Shale of southern Indiana, with the upper part of the Alto Formation of southern Illinois, and with part of the North Evans Limestone (=the "Conodont bed") of New York.

The Squaw Bay Limestone at the top of the Traverse Group in Michigan lies within the Lower *Polygnathus asymmetricus* Zone low in the upper Devonian.

Collecting Localities

Locations of the sections sampled during this study are given below and are followed by locality numbers assigned to these sections in the curatorial system of the Department of Geology, Indiana University. Lithologic descriptions of these sections may be found in the appendix.

1. Fenix and Scisson Wabash Pipe Line Co. No. 1 well near Griffith, Lake County, Ind. (SW¼SW¼SW¼ sec. 3, T. 35 N., R. 9 W.). Traverse Formation, 19.4 ft of rocks. IU10701.

2. Indiana Geological Survey drill hole 166 near Medaryville, Pulaski County, Ind. (NW¼SE¼SE¼ sec. 3, T. 30 N., R. 4 W.). Detroit River Formation through lower part of Antrim Shale, 107.0 ft of rocks. IU10718.

3. Indiana Geological Survey drill hole 168 near La Crosse, LaPorte County, Ind. (SE¼SW¼SW¼ sec. 14, T. 33 N., R. 4 W.). Detroit River Formation through lower part of Antrim Shale, 220.2 ft of rocks. IU10720.

4. Northern Indiana Public Service Co. James A. Leroy No. 2 well near Fish Lake, LaPorte County, Ind. (NE¼SW¼SE¼ sec. 18, T. 36 N., R. 1 W.). Detroit River Formation through Traverse Formation, 160.5 ft of rocks. IU10703.

5. Northern Indiana Public Service Co. Wes Worthington No. 1 well near Mill Creek, LaPorte County, Ind. (NE¼NW¼SW¼ sec. 8, T. 36 N., R. 1 W.). Detroit River Formation through lower part of Antrim Shale, 198.7 ft of rocks. IU10702.

6. Northern Indiana Public Service Co. Dean Readman No. 1 well near Bremen, Marshall County, Ind. (SE¼NE¼NW¼ sec. 12, T. 34 N., R. 2 E.). Detroit River Formation through Antrim Shale, 260.8 ft of rocks. IU10704.

7. Indiana Geological Survey drill hole 167 near Warsaw, Kosciusko County, Ind. (W½SE¼ sec. 12, T. 32 N., R. 5 E.). Detroit River Formation through lower part of Antrim Shale, 164.0 ft of rocks. IU10719.

8. Northern Indiana Public Service Co. Mosher No. 1 well near Columbia City, Whitley County, Ind. (NW¼NW¼NW¼ sec. 23, T. 31 N., R. 9 E.). Detroit River Formation through Traverse Formation, 92.9 ft of rocks. IU10705.

9. Northern Indiana Public Service Co. A. Tubbs No. 1 well near Helmer, Steuben County, Ind. (SW¼SE¼SW¼ sec. 27, T. 36 N., R. 12 E.). Detroit River Formation through lower part of Antrim Shale, 239.0 ft of rocks. IU10707.

10. Northern Indiana Public Service Co. Main Clingman No. 1 well near Hudson, Steuben County, Ind. (NE¼NE¼ sec. 35, T. 36 N., R. 12 E.). Lower part of Traverse Formation through lower part of Antrim Shale, 92.0 ft of rocks. IU10708.

11. Northern Indiana Public Service Co. Dohrman No. 1 well near Woodburn, Allen County, Ind. (NW¼NE¼NW¼ sec. 16, T. 31 N., R. 15 E.). Detroit River Formation through lower part of Traverse Formation, 44.8 ft of rocks. IU10706.

12. May Stone and Sand, Inc., Quarry, Fort Wayne, Allen County, Ind. (N½ sec. 29, T. 30 N., R. 12 E.). Detroit River Formation through lower part of Traverse Formation, 45.4 ft of rocks. IU10721.

13. Abandoned Cummin's Quarry near Samaria, Monroe County, Mich. (SE¼SE¼ sec. 2, T. 8 S., R. 6 E.). Amherstburg Formation, 13.6 ft of rocks. IU10709.

14. Active quarry of Brunner, Mond Canada, Ltd. ("Anderdon Quarry" of many authors), 1¼ miles northeast of Amherstburg, Essex County, Ontario. Upper part of Lucas Dolomite through lower part of Dundee Limestone, 71.2 ft of rocks. Type section of the Anderdon Limestone. IU10710.

15. Active quarry of Michigan Limestone, a division of United States Steel Corp., at Rogers City, Presque Isle County, Mich. Lower part of Bell Shale, 12.0 ft of rocks. IU10711.

16. Abandoned Rockport Quarry of Kelleys Island Lime and Transport Co. on Lake Huron at east end of Rockport Road, Alpena County, Mich. (sec. 6, T. 32 N., R. 9 E.). Lower part of Rockport Quarry Limestone through lower part of Ferron Point Formation, 53.5 ft of rocks. Type section of the Rockport Quarry Limestone and the Ferron Point Formation (in part). IU10712.

17. Abandoned shale pit of the Alpena Portland Cement Co. near east end of Monaghan Point Road, Alpena County, Mich. (SE¼ sec. 18, T. 32 N., R. 9 E.). Lower part of Genshaw Formation, 10.0 ft of rocks. Type section of the Genshaw Formation. IU10713.

18. Active quarry of Huron Cement Co. at Alpena, Alpena County, Mich. (secs. 13 and 14, T. 31 N., R. 8 E.). Upper part of Genshaw Formation through Alpena Limestone, 91.5 ft of rocks. Type area of the Newton Creek and Alpena Limestones. IU10714.

19. Exposure at Four Mile Dam on Thunder Bay River, Alpena County, Mich. (a quarter of a mile south of center, sec. 7, T. 31 N., R. 7 E.). Middle part of Four Mile Dam Limestone through middle part of Norway Point Formation, 25.3 ft of rocks. Type section of the Four Mile Dam Limestone. IU10715.

20. Exposure at Norway Point Dam on Thunder Bay River, Alpena County, Mich. (NE¼ sec. 12, T. 31 N., R. 7 E.). Lower part of Norway Point Formation through lower part of Potter Farm Formation, 46.1 ft of rocks. Type section of the Norway Point Formation. IU10716.

21. Low bluff on east shore of Partridge Point on Thunder Bay 3 miles south of Alpena, Alpena County, Mich. (SE¼ sec. 11, T. 30 N., R. 8 E.). Type section of the Thunder Bay Limestone, 13.5 ft of rocks. IU10717.

Systematic Paleontology

The figured specimens described and illustrated herein are reposited in the paleontologic collections of the Department of Geology, Indiana University. In the repository number the five digits before the hyphen indicate the locality from which the specimen was obtained. The first two digits following the hyphen indicate the sample number at the given locality, and the digits following the sample number indicate the individual specimen number. For example, in the number IU10707-08001 the locality number is 10707, the sample number is 8, and the specimen number is 1.

Only the formations that were sampled during this study are listed under the heading "Distribution." For exact stratigraphic locations of samples and distribution of important platform species, see Sections 1 to 21 in the Appendix. The section headed "Material studied" includes only the specimens collected during the present investigation.

Genus **Acodina** Stauffer, 1940

Acodina **Stauffer**, 1940, p. 418.

Type species by original designation, *Acodina lanceolata* Stauffer, 1940.

Acodina formosa (Stauffer)

Plate 1, figures 1, 2

Acodus formosus **Stauffer**, 1938, p. 417, pl. 49, fig. 33.
Acodus inopinatus **Stauffer**, 1938, p. 417, pl. 49, figs. 23, 34, 35.
Acodus zionensis **Stauffer**, 1938, p. 417, 418, pl. 49, fig. 30.
Acodina concava **Stauffer**, 1940, p. 418, pl. 60, fig. 31.
Acodina covina **Stauffer**, 1940, p. 418, pl. 60, fig. 33.
Acodina curvata **Stauffer**, 1940, p. 418, pl. 60, figs. 3, 14-16; **Sannemann**, 1955, p. 126, pl. 1, fig. 17; **Ziegler**, 1956, p. 98, pl. 7, fig. 25; **Helms**, 1959, p. 663, pl. 4, fig. 12; **Orr**, 1964, p. 6, pl. 1, fig. 11.
Acodina cuspidata **Stauffer**, 1940, p. 418, pl. 60, figs. 21-25.
Acodina delata **Stauffer**, 1940, p. 418, 419, pl. 60, fig. 7; **Sannemann**, 1955, p. 126, pl. 1, figs. 15, 16; **Lys** and others, 1961, p. 543, pl. 1, fig. 1.
Acodina lirata **Stauffer**, 1940, p. 419, pl. 60, figs. 18, 45; **Sannemann**, 1955, p. 126, pl. 1, fig. 18; **Helms**, 1959, p. 663, pl. 4, fig. 10.
Acodina ursa **Stauffer**, 1940, p. 419, pl. 60, figs. 1, 2.
Acodina zionensis (Stauffer), **Stauffer**, 1940, p. 419, pl. 60, fig. 38; **Sannemann**, 1955, p. 127, pl. 1, figs. 13, 14; **Lys** and others, 1961, p. 543, pl. 1, fig. 2.
Acodina cf. *A. lirata* Stauffer, **Helms**, 1959, p. 663, pl. 4, fig. 11.
Acodina sp. **Helms**, 1959, p. 663, pl. 4, fig. 9.
Acodina formosa (Stauffer), **Clark** and **Ethington**, 1966, p. 675, pl. 82, fig. 11.

Remarks: I have examined more than 500 specimens referable to *Acodina.* Representatives of this genus are common constituents of middle Devonian faunal assemblages from the Michigan Basin. Although most of Stauffer's species are based upon differences too minor to be of specific importance, two are considered sufficiently distinct to constitute valid species even though they have morpho-

logic gradations. Specimens having a base that is drawn out anteriorly and posteriorly and edges of the cusp that are either concave or nearly straight are referred to *Acodina formosa.* Those that lack an extended base and that have convex edges on the cusp are assigned to *A. lanceolata.*

Distribution: Detroit River and Traverse Formations of northern Indiana; Dundee Limestone of western Ontario; Bell Shale, Alpena Limestone, Four Mile Dam Limestone, and Norway Point Formation of Michigan.

Material studied: 568 specimens.

Repository: IU10707-59001 and IU10708-25001 (figured specimens).

Acodina lanceolata Stauffer

Plate 1, figures 3, 4

Acodina lanceolata **Stauffer,** 1940, p. 419, pl. 60, figs. 29, 30.
Acodina velva **Stauffer,** 1940, p. 419, pl. 60, figs. 19, 32, 39, 46.

Distribution: Traverse Formation of northern Indiana; Norway Point Formation of Michigan.

Material studied: 7 specimens.

Repository: IU10704-19001 and IU10704-19002 (figured specimens).

Genus **Angulodus** Huddle, 1934

Angulodus **Huddle,** 1934, p. 76.

Type species by original designation, *Angulodus demissus* Huddle, 1934.

Angulodus sp.

Plate 1, figures 14-16

Description: The bar is deflected downward both anteriorly and

posteriorly, is slightly twisted laterally in its anterior portion, and bears large, subequal, discrete denticles between which are interspersed some minute denticles in some specimens. The anteriormost denticles are nearly at right angles to the bar, but those to the rear become increasingly inclined in that direction posteriorly along the bar. The posteriormost denticles on the bar are so inclined as to be nearly at right angles to those at the anterior end. The cusp is slightly posterior to midlength and is parallel to the other denticles. A deep basal cavity that flares inwardly and posteriorly is beneath the cusp. The aboral edge of the bar is sharp and bears a fine groove that extends to both ends from the basal cavity.

Remarks: Although some specimens exhibit a few minute denticles interspersed between the larger ones, the alternate denticulation that is characteristic of *Angulodus walrathi* (Hibbard) is not present in *A.* sp. Hibbard's (1927, p. 205, figs. 4a, b) illustrated specimen exhibits large, closely spaced denticles posteriorly that are set in a recurved hooklike process at the end of the bar. Such a feature is not present in *A.* sp. Several specimens illustrated by Bischoff and Ziegler (1957, p. 44, pl. 8, figs. 1-6; pl. 20, fig. 7) as *A. walrathi* lack this so-called "hook" at the end of the posterior bar and closely resemble *A.* sp. in the nature of the basal cavity and the denticulation of the bar.

Distribution: Traverse Formation and Antrim Shale of northern Indiana; Dundee Limestone of western Ontario.

Material studied: 13 specimens.

Repository: IU10707-05001, IU10707-06001, and IU10707-08001 (figured specimens).

Genus **Belodella** Ethington, 1959

Belodella **Ethington**, 1959, p. 271, 272.

Type species by original designation, *Belodus devonicus* Stauffer, 1940.

Belodella devonicus (Stauffer)

Plate 1, figures 6, 7

Belodus devonicus **Stauffer,** 1940, p. 420, pl. 59, figs. 47, 48; **Spassov,** 1966, *in* Spassov and Ganev, p. 47, pl. 3, fig. 12.

Belodus cf. *B. devonicus* Stauffer, **Rhodes** and **Dineley,** 1957a, p. 359, pl. 37, fig. 3.

Belodella devonica (Stauffer), **Barnett** and others, 1966, pl. 58, fig. 1.

Belodella devonicus (Stauffer), **Clark** and **Ethington,** 1966, p. 677, pl. 82, figs. 8, 9.

Remarks: Although there once was considerable uncertainty regarding the age of this taxon because of its presence in stratigraphic admixtures, recent authors (Rhodes and Dineley, 1957b; Ethington, 1959; Clark and Ethington, 1966; and others) have indicated that it is a Devonian form. *Belodella devonicus* is a common faunal element in middle Devonian conodont assemblages from the Michigan Basin.

Belodella devonicus (Stauffer) differs from *B. resimus* (Philip) in possessing a delicate keel along its anterior edge. The latter species is narrowly triangular in cross section and bears a narrow anterior face that projects laterally as flanges perpendicular to the lateral faces.

Distribution: Detroit River Formation, Traverse Formation, and Antrim Shale of northern Indiana; Alpena Limestone, Four Mile Dam Limestone, and Norway Point Formation of Michigan.

Material studied: 281 specimens.

Repository: IU10704-16001 and IU10704-16002 (figured specimens).

Genus **Coelocerodontus** Ethington, 1959

Coelocerodontus **Ethington,** 1959, p. 273.

Type species by original designation, *Coelocerodontus trigonius* Ethington, 1959.

Coelocerodontus sp.

Plate 1, figures 10-13

Description: The cusp is long and is curved posteriorly. In cross section it is somewhat laterally compressed and biconvex with very weak costae along the lower parts of the anterior and posterior margins. The lateral faces are smooth. A very deep, conical basal cavity penetrates the cusp from the base to within a short distance of its tip. The basal cavity extends more than three-fourths the length of the cusp.

Remarks: Ethington established the genus *Coelocerodontus* for simple, hollow, horn-shaped cones recovered from the Galena Formation (Ordovician) of Iowa. Because of the deep basal cavity that extends to near the tip of the cone, the specimens are herein referred to this genus. This Devonian species resembles in its smooth convex lateral faces *C. digonius* Sweet and Bergström first described from the Pratt Ferry Formation (Ordovician) of Alabama.

Distribution: Detroit River Formation, Traverse Formation, and Antrim Shale of northern Indiana; Dundee Limestone of western Ontario; Alpena Limestone of Michigan.

Material studied: 530 specimens.

Repository: IU10710-09001 and IU10708-29001 (figured specimens).

Genus **Diplodella** Bassler, 1925

Diplodella **Bassler**, 1925, p. 219; **Ulrich** and **Bassler**, 1926, p. 41.

Type species by original designation, *Diplodella bilateralis* Bassler, 1925.

Diplodella sp.

Plate 1, figure 5

Description: The lateral processes are high and bear a series of closely

set denticles that are compressed anteroposteriorly and fused throughout most of their length. The apical denticle is high, slender, and sharp edged posteriorly. The lateral processes diverge at an angle of 40° to 50° below the posterior bar, which is broken near its anterior end in all the specimens studied. The pit either is lacking or is very minute.

Distribution: Traverse Formation of northern Indiana; Alpena Limestone of Michigan.

Material studied: 12 specimens.

Repository: IU10708-19001 (figured specimen).

Genus **Hibbardella** Bassler, 1925

Hibbardella **Bassler**, 1925, p. 219; **Ulrich** and **Bassler**, 1926, p. 37.
Roundya **Hass**, 1953, p. 88, 89.

Type species by original designation, *Prioniodus angulatus* Hinde, 1879.

Hibbardella sp.

Plate 3, figure 7

Roundya sp. c **Bischoff** and **Ziegler**, 1957, p. 113, pl. 21, fig. 13.
Hibbardella n. sp. **Rhodes** and **Dineley**, 1957a, p. 362, pl. 38, fig. 13.

Description: The lateral processes lie in a plane and intersect below the apical denticle at an angle of about 75°. Their oral surfaces are set with several discrete, unequal denticles that are interspersed with small subsidiary denticles. A narrow, triangular basal cavity is beneath the apical denticle.

Remarks: The illustrated specimen very closely resembles the one illustrated by Bischoff and Ziegler and likewise is found in the *Polygnathus varcus* Zone. *Roundya* sp. exhibits the minute subsidiary denticles of Rhodes and Dineley's specimen from a similar stratigraphic horizon in England.

Distribution: Detroit River and Traverse Formations of northern Indiana.

Material studied: 3 specimens.

Repository: IU10708-18001 (figured specimen).

Genus **Hindeodella** Bassler, 1925

Hindeodella **Bassler**, 1925, p. 218; **Ulrich** and **Bassler**, 1926, p. 38, 39.

Type species by original designation, *Hindeodella subtilis* Ulrich and Bassler, 1926.

Hindeodella germana Holmes

Plate 3, figure 9

Hindeodella germana **Holmes**, 1928, p. 25, pl. 9, fig. 9; **Sannemann**, 1955, p. 130, pl. 2, figs. 4, 5; **Bischoff** and **Ziegler**, 1957, p. 59, pl. 7, fig. 6; **Lys** and **Serre**, 1957b, p. 1044, pl. 3, fig. 2; **Dvorak** and **Freyer**, 1961, pl. 1, fig. 1; **Freyer**, 1965, pl. 1, fig. 11.
Hindeodella aculeata **Huddle**, 1934, p. 40, pl. 4, figs. 19-21; pl. 5, figs. 2, 3.
Hindeodella grandis **Huddle**, 1934, p. 41, pl. 4, fig. 22.
Hindeodella gracilis **Huddle**, 1934, p. 43, pl. 5, fig. 11.

Remarks: Hindeodella priscilla Stauffer closely resembles *H. germana* and differs from it only in having alternating large and small denticles on the anterior bar.

Distribution: Detroit River Formation, Traverse Formation, and Antrim Shale of northern Indiana; Norway Point Formation of Michigan.

Material studied: 47 specimens.

Repository: IU10708-14001 (figured specimen).

Genus **Icriodus** Branson and Mehl, 1938

Icriodus **Branson** and **Mehl**, 1934a, p. 225 [*nomen nudum*]; **Branson** and **Mehl**, 1938, p. 159, 160.
Latericriodus **Müller**, 1962, p. 114-116.

Type species by original designation, *Icriodus expansus* Branson and Mehl, 1938.

Icriodus angustus Stewart and Sweet

Plate 3, figures 10-13

Icriodus angustus **Stewart** and **Sweet**, 1956, p. 267, pl. 33, figs. 4, 5, 11, 15; **Klapper** and **Ziegler**, 1967, pl. 10, figs. 1-3.

Remarks: The high, bladelike extension of the middle row of denticles distinguishes this species from all other icriodids. The middle row of denticles of *Icriodus cymbiformis* Branson and Mehl extends considerably posterior to the platform but is composed of very small, tightly fused denticles that do not rise above the level of the platform.

Icriodus angustus has a short stratigraphic range and is known only from strata of late Eifelian age in which it is an important element in conodont faunal assemblages. According to Klapper and Ziegler (1967) *I. angustus* diverged from *I. latericrescens robustus* during Eifelian time.

Distribution: Dundee Limestone of western Ontario.

Material studied: 5 specimens.

Repository: IU10710-09004 and IU10710-01003 (figured specimens).

Icriodus cf. **I. angustus** Stewart and Sweet

Plate 2, figures 7-9

Remarks: These specimens differ from *Icriodus angustus* in having a short median extension of only two denticles, which are discrete rather than fused, but which rise considerably above the oral surface of the platform and are inclined posteriorly. Specimens of *I.* cf. *I. angustus* are shorter than specimens of *I. angustus* and possess denticles that are more offset transversely than those of the latter taxon. *Icriodus* cf. *I. angustus* closely resembles *I. angustus* in the subtriangular aboral configuration of the platform. *Icriodus* cf. *I. angustus*

is present in a stratigraphic interval below the lowest position of *I. angustus,* and it is suggested that the former gave rise to the latter taxon through enlargement and fusion of the posteriormost denticles of the middle row.

Distribution: Detroit River Formation of northern Indiana; Lucas Dolomite of western Ontario.

Material studied: 8 specimens.

Repository: IU10707-80001 (figured specimen).

Icriodus cymbiformis Branson and Mehl

Plate 2, figures 1-6

Icriodus cymbiformis **Branson** and **Mehl,** 1938, p. 164, pl. 26, figs. 27-29; **Stauffer,** 1940, p. 425, pl. 60, figs. 37, 51, 56-58, 68; **Lys** and **Serre,** 1957b, p. 1045, pl. 3, figs. 7a, b; **Panseri** and **Barsotti,** 1959, p. 157, 158, pl. 1, fig. 5.

Icriodus cymbiformis? Branson and Mehl, **Stauffer,** 1938, p. 430, pl. 52, figs. 11, 13.

Icriodus brevis **Stauffer,** 1940, p. 424, pl. 60, figs. 36, 43, 44, 52.

not *Icriodus cymbiformis* Branson and Mehl, **Ziegler,** 1956, p. 100, pl. 6, fig. 25.

Remarks: In contrast with the bladelike median extension of *Icriodus angustus,* that of *I. cymbiformis* does not rise above the oral surface of the platform but rather continues posteriorly at the same level. Although the median denticles on the platform tend to be more or less discrete, those of the median extension are tightly fused. In some specimens the posteriormost denticle is somewhat enlarged and slightly separated from the adjoining one. The length of the extension varies considerably. In many specimens it consists of four or five fused denticles and in others it is several times as long as the platform proper. In some specimens the lateral rows are represented by only a few small denticles near the anterior tip of the platform.

Icriodus cymbiformis and *I. expansus* are the most abundant constituents of conodont faunal assemblages of middle Devonian rocks of the Michigan Basin. More than 5,500 specimens of a total collection of 10,100 belong to these two taxa.

Distribution: Detroit River Formation, Traverse Formation, and Antrim Shale of northern Indiana; Ferron Point Formation, Genshaw Formation, Alpena Limestone, Norway Point Formation, and Thunder Bay Limestone of Michigan.

Material studied: 2,740 specimens.

Repository: IU10707-39001 and IU10707-39002 (figured specimens).

Icriodus expansus Branson and Mehl

Plate 3, figures 14-17

Icriodus expansus **Branson** and **Mehl**, 1934a, p. 225 [*nomen nudum*]; **Branson** and **Mehl**, 1938, p. 160, 161, 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; **Branson** and **Mehl**, 1944, *in* Shimer and Shrock, p. 245, pl. 94, fig. 63; **Mehl** and **Quigley** (part), 1944, *in* Branson, p. 153, pl. 26, figs. 8, 13, 14 only; **Stewart** and **Sweet**, 1956, p. 267, 268, pl. 33, figs. 1, 3, 9, 12-14; **Müller** and **Müller**, 1957, p. 1106, pl. 142, fig. 4; **Krebs** and **Ziegler**, 1966, pl. 2, figs. 8-10; **Clark** and **Ethington**, 1966, p. 680, pl. 83, fig. 9.

Icriodus alternatus Branson and Mehl, **Downs** and **Youngquist**, 1950, p. 669, pl. 87, figs. 8, 11, 12; **Orr**, 1964, p. 9, pl. 2, figs. 11, 12; **Ethington**, 1965, p. 573, pl. 67, fig. 8.

Icriodus symmetricus Branson and Mehl, **Orr**, 1964, p. 10, 11, pl. 2, figs. 13-15; **Merrill**, 1966, p. 379, 380, pl. 4, fig. 6.

Remarks: The robust, noncompressed median denticles serve to distinguish *Icriodus expansus* from *I. alternatus* Branson and Mehl, which has small, elongate, laterally compressed denticles in the middle row. Because they exhibit this character, specimens referred to *I. alternatus* by Downs and Youngquist (1950), Orr (1964), and Ethington (1965) are herein assigned to *I. expansus.* The middle row of denticles of *I. symmetricus* Branson and Mehl is set higher than the lateral rows and exhibits a tendency toward fusion into a longitudinal ridge. The lateral margins of the platform of *I. symmetricus* are nearly parallel in oral view, but the platform margins of *I. ex-*

pansus generally are convex, although this character is not so apparent in immature specimens. For these reasons, specimens assigned to *I. symmetricus* by Orr (1964) and Merrill (1966) are referred to *I. expansus.* Both *I. alternatus* and *I. symmetricus* are confined to rocks younger than middle Devonian.

Icriodus expansus is transitional with *I. nodosus* (Huddle), and distinction can be made only in specimens possessing well-preserved aboral margins. *Icriodus nodosus* has a notch on the inner side of the posterior expansion of the basal cavity that results in the formation of an anteriorly directed spur. Such a notch and spur are lacking in *I. expansus.*

Distribution: Detroit River Formation, Traverse Formation, and Antrim Shale of northern Indiana; Lucas Dolomite, Anderdon Limestone, and Dundee Limestone of western Ontario; Bell Shale, Ferron Point Formation, Genshaw Formation, Alpena Limestone, Norway Point Formation, Potter Farm Formation, and Thunder Bay Limestone of Michigan.

Material studied: 2,800 specimens.

Repository: IU10704-19003 and IU10704-19004 (figured specimens).

Icriodus latericrescens Branson and Mehl

Remarks: This species is a long-ranging form. It first appears in a fauna from the Transgression-horizon, Schübelebene, Frankenwald, Germany, which Bischoff and Sannemann (1958) regarded as possibly Siegennian in age, but which Walliser (1962) regarded as ranging anywhere from latest Gedinnian to earliest Emsian in age. According to Klapper and Ziegler (1967) the earliest representative of *Icriodus latericrescens* evolved from, and is transitional with, *I. woschmidti,* a form that is known from the lower part of the Gedinnian (Ziegler, 1960). The highest position of *I. latericrescens* is in the *Schmidtognathus hermanni-Polygnathus cristatus* Zone.

Five subspecies of *Icriodus latericrescens* have been recognized on the basis of differences in ornamentation and on evolutionary studies

(Klapper and Ziegler, 1967): *I. latericrescens latericrescens* Branson and Mehl, 1938, *I. latericrescens huddlei* Klapper and Ziegler, *I. latericrescens bilatericrescens* Ziegler, 1956, *I. latericrescens beckmanni* Ziegler, 1956, and *I. latericrescens robustus* Orr. Only the first and last of these subspecies are present in the faunas at hand.

Icriodus woschmidti Ziegler differs from *I. latericrescens* in possessing a posteriorly inclined main cusp, which is distinctly higher than the rest of the denticles, and transverse ridges rather than three longitudinal rows of discrete denticles. *Icriodus pesavis* Bischoff and Sannemann is distinguished by a distinct posterior process in addition to two lateral processes.

Icriodus latericrescens latericrescens Branson and Mehl

Plate 2, figures 10-13, 18, 19

Icriodus latericrescens **Branson** and **Mehl** (part), 1938, p. 164, 165, pl. 26, figs. 30-32, 34, 35 only [fig. 34 selected as lectotype by Klapper and Ziegler, 1967]; **Stauffer** (part), 1938, p. 430, pl. 52, figs. 30, 31, 34 only; **Youngquist**, 1947, p. 102, 103, pl. 25, fig. 12; **Orr**, 1964, p. 9, pl. 2, figs. 8-10; **Wittekindt**, 1966, p. 629, 630, pl. 1, figs. 6-8; **Klapper** and **Ziegler**, 1967, p. 74, 75, pl. 10, figs. 4-9; pl. 11, figs. 1-5.

Icriodus latericrescens cf. *latericrescens* Branson and Mehl, **Ziegler**, 1966b, pl. 1, figs. 5a, b.

not *Icriodus latericrescens latericrescens* Branson and Mehl, **Ziegler**, 1956, p. 100, 101, pl. 6, figs. 14-17; **Bischoff** and **Sannemann**, 1958, p. 95, pl. 12, fig. 8; **Jentzsch**, 1962, p. 967, pl. 1, fig. 16.

not *Icriodus latericrescens* cf. *latericrescens* Branson and Mehl, **Bischoff** and **Sannemann**, 1958, p. 95, 96, pl. 12, figs. 10, 11.

Remarks: The outer lateral process is long and denticulate and either is directed posteriorly or is at a right angle to the platform proper. The inner lateral process is short and nondenticulate and is directed anteriorly. *Icriodus latericrescens latericrescens* resembles *I. latericrescens robustus* in the character of the lateral processes, but it differs from the latter taxon in having laterally compressed rather than round denticles in the middle row.

Distribution: Traverse Formation of northern Indiana; Bell Shale, Ferron Point Formation, Genshaw Formation, Newton Creek Limestone, Alpena Limestone, Four Mile Dam Limestone, Norway Point Formation, Potter Farm Formation, and Thunder Bay Limestone of Michigan.

Material studied: 974 specimens.

Repository: IU10704-04001, IU10704-04002, and IU10705-04001 (figured specimens).

Icriodus latericrescens robustus Orr, n. subsp.

Plate 2, figures 14-17

Icriodus latericrescens **Branson** and **Mehl** (part), 1938, p. 164, 165, pl. 26, figs. 33, 36, 37 only; **?Grohskopf, Clark,** and **Ellison,** 1943, p. 16, pl. 2, figs. 4, 7; **Stewart** and **Sweet,** 1956, p. 268, 269, pl. 33, figs. 2, 6, 7; **Merrill,** 1966, p. 378, 379, pl. 4, fig. 8.

Icriodus sp. **Merrill,** 1966, p. 380, pl. 4, fig. 9.

Icriodus latericrescens n. subsp. **A Klapper** and **Ziegler,** 1967, p. 75, pl. 8, figs. 7, 9; pl. 9, figs. 1-7.

Derivation of name: Latin, *robustus,* solid and strong, in reference to the strong round denticles in the middle row, particularly in contrast to slender median denticles of *Icriodus latericrescens latericrescens.*

Diagnosis: Denticles of the middle row are discrete and round in cross section and lie in a trough between the lateral rows. The trough is particularly prominent in gerontic specimens whose median denticulation is obscure. The denticulate outer lateral process joins the main part of the platform somewhat anterior to its posterior tip.

Description: The platform is long, narrow, slightly laterally expanded posteriorly, nearly straight, and pointed at the anterior end. The oral surface bears three longitudinal rows of denticles. Those of the lateral rows are large, high, and subcircular in cross section. Denticles of the middle row are considerably smaller, subcircular to oval in cross section, and smaller toward the posterior end of the platform. In

many adult specimens the posteriormost denticles of the middle row are degenerate and consist of small, low nodes. The median denticles commonly lie in a shallow, longitudinal trough between the lateral rows. Denticles of the middle row are slightly offset transversely from those of the lateral rows. Several partly fused denticles extend posterior to the platform proper as a short ridge, the posteriormost denticle of which is considerably larger than the others. The denticulate outer lateral process joins the platform slightly anterior to its posterior tip at an angle of about 90°. A short nondenticulate inner lateral process is opposite the outer lateral one. Aborally the platform and lateral processes are deeply excavated.

Remarks: The round denticles in the middle row distinguish this taxon from *Icriodus latericrescens latericrescens.* Although the platform of the former subspecies generally is straight and tapers anteriorly, that of the latter is slightly bowed and has its greatest width near midlength. *Icriodus latericrescens huddlei* Klapper and Ziegler differs from *I. latericrescens robustus* n. subsp. Orr in that it has only one lateral process (and in some specimens a weak suggestion of a second) that joins the platform exactly at its posterior tip. *Icriodus latericrescens bilatericrescens* Ziegler has two large lateral processes that join the platform at its posterior tip. The middle row of denticles of both *I. latericrescens huddlei* Klapper and Ziegler and *I. latericrescens bilatericrescens* is higher than the lateral rows, but in *I. latericrescens robustus* the median denticles are lower than those of the lateral rows, particularly in adult specimens.

Distribution: Dundee Limestone of western Ontario.

Material studied: 14 specimens.

Repository: IU10710-09002 (holotype) and IU10710-09003 (paratype).

Icriodus nodosus (Huddle)

Plate 2, figures 20-23

Gondolella? nodosus **Huddle**, 1934, p. 94, pl. 8, figs. 24, 25.

Icriodus nodosus (Huddle), **Branson** and **Mehl** (part), 1938, p. 160, pl. 26, figs. 15-17, 22 only; **?Mehl** and **Quigley**, 1944, *in* Branson, p. 153, pl. 26, fig. 6; **Downs** and **Youngquist**, 1950, p. 670, pl. 87, figs. 17, 18, 21, 22; **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. 2a, b, 3a, b, 5; pl. 19, figs. 1-5a, b.

Icriodus symmetricus Branson and Mehl, **Bischoff** and **Ziegler**, 1957, p. 64, pl. 6, figs. 1, 4.

Remarks: Icriodus nodosus is transitional with *I. expansus* and differs from the latter species in having a notch and spur in the inner lateral expansion of the basal cavity, which is broadly rounded in *I. expansus.* Specimens that exhibit various stages of notch and spur development are common between the two end members of the series.

Distribution: Detroit River and Traverse Formations of northern Indiana; Dundee Limestone of western Ontario.

Material studied: 34 specimens.

Repository: IU10710-01001 and IU10710-01002 (figured specimens).

Genus **Ligonodina** Bassler, 1925

Ligonodina **Bassler**, 1925, p. 218; **Ulrich** and **Bassler**, 1926, p. 12, 13.

Type species by original designation, *Ligonodina pectinata* Ulrich and Bassler, 1926.

Ligonodina falciformis Ulrich and Bassler

Plate 1, figure 23

Ligonodina falciformis **Ulrich** and **Bassler**, 1926, p. 14, pl. 2, figs. 11-13; **Sannemann**, 1955, p. 130, 131, pl. 5, figs. 9, 10; pl. 6, fig. 20; **Bischoff**, 1956, p. 126, pl. 9, fig. 34; **Bischoff** and **Ziegler**, 1957, p. 65, pl. 11, figs. 1, 2, 6.

Ligonodina hindei **Ulrich** and **Bassler**, 1926, p. 14, pl. 2, figs. 14-16; **?Lys** and **Serre**, 1957a, p. 801, 802, pl. 10, fig. 1; **Huddle**, 1934, p. 60, 61, pl. 7, figs. 13, 22; pl. 12, figs. 13, 14.

Hindeodella longidens **Ulrich** and **Bassler**, 1926, p. 40, pl. 8, figs. 14, 15.

Ligonodina **sp. Huddle**, 1934, p. 60, pl. 7, fig. 8.

Ligonodina bicincta **Huddle**, 1934, p. 62, pl. 12, fig. 15.
Ligonodina cryptodens **Huddle**, 1934, p. 62, 63, pl. 12, figs. 16, 17.
Ligonodina conidens **Huddle**, 1934, p. 63, pl. 12, figs. 18, 19.
Ligonodina arcuata **Huddle**, 1934, p. 63, pl. 12, figs. 20, 21.
Ligonodina cf. *falciformis* Ulrich and Bassler, **Bischoff** and **Ziegler**, 1957, p. 65, pl. 20, fig. 36.

Remarks: Most of the specimens at hand have incomplete posterior bars. However, these very closely resemble complete specimens of the same species from the lower part of the New Albany Shale of southern Indiana, as well as Ulrich and Bassler's illustrated specimens.

Distribution: Traverse Formation of northern Indiana; Alpena Limestone and Norway Point Formation of Michigan.

Material studied: 14 specimens.

Repository: IU10716-09001 (figured specimen).

Ligonodina sp.

Plate 1, figure 17

Ligonodina sp. **Huddle**, 1934, p. 61, pl. 7, fig. 18.

Description: The posterior bar is long, laterally compressed, and slightly arched. It bears large, laterally compressed denticles that alternate with smaller ones along the bar. The anterolateral process is bent downward slightly anterior to the terminal fang and bears several large denticles. A shallow, elongate basal cavity that extends into the posterior bar as a narrow groove is beneath the terminal fang.

Remarks: The specimen studied very closely resembles Huddle's specimen from the upper part of the New Albany Shale of southern Indiana in the alternate denticulation and the compressed nature of the bar and denticles. Unfortunately Huddle's specimen has been lost and no direct comparison can be made.

Distribution: Antrim Shale of northern Indiana.

Material studied: 1 specimen.

Repository: IU10707-04001 (figured specimen).

Genus **Lonchodina** Bassler, 1925

Lonchodina **Bassler**, 1925, p. 218; **Ulrich** and **Bassler**, 1926, p. 30, 31.

Type species by original designation, *Lonchodina typicalis* Ulrich and Bassler, 1926.

Lonchodina discreta Ulrich and Bassler

Plate 1, figure 8

Lonchodina discreta **Ulrich** and **Bassler**, 1926, p. 36, pl. 10, figs. 1, 2; **Sannemann**, 1955, p. 131, 132, pl. 4, fig. 24; **Bischoff** and **Ziegler**, 1957, p. 67, 68, pl. 10, figs. 9a-13.
Subbryantodus humilis **E. R. Branson**, 1934, p. 328, pl. 25, fig. 4.
Lonchodina disjuncta **Stauffer**, 1938, p. 435, pl. 51, fig. 7.

Distribution: Traverse Formation of northern Indiana.

Material studied: 1 specimen.

Repository: IU10707-31001 (figured specimen).

Lonchodina ramulata Bischoff and Ziegler

Plate 1, figure 9

Lonchodina ramulata **Bischoff** and **Ziegler**, 1957, p. 69, 70, pl. 10, figs. 1a-3.

Distribution: Traverse Formation of northern Indiana.

Material studied: 11 specimens.

Repository: IU10708-30001 (figured specimen).

Lonchodina sp.

Plate 1, figure 26

Description: The anterior part of the bar is strongly deflected inward

and curved downward near the cusp and bears six discrete, robust denticles that are nearly at right angles to the bar. The posterior part of the bar is slightly twisted and bears several very large denticles that are inclined posteriorly. The apical denticle is nearly equal in size to the larger denticles on the bar. A large basal cavity that is somewhat expanded inwardly is beneath the apical denticle.

Distribution: Traverse Formation of northern Indiana.

Material studied: 1 specimen.

Repository: IU10708-12001 (figured specimen).

Genus **Neoprioniodus** Rhodes and Müller, 1956

Neoprioniodus **Rhodes** and **Müller**, 1956, p. 698, 699.

Type species by original designation, *Prioniodus conjunctus* Gunnell, 1931.

Neoprioniodus alatus (Hinde)

Plate 3, figure 6

Prioniodus? alatus **Hinde**, 1879, p. 361, pl. 16, fig. 5; **Grabau**, 1899, p. 153, fig. 331.

Prioniodus alatus Hinde, **Bryant**, 1921, p. 15, 16, pl. 3, fig. 10; pl. 4, figs. 1-7; **Ulrich** and **Bassler**, 1926, p. 11, pl. 1, figs. 25, 26; **Holmes**, 1928, p. 20, pl. 3, fig. 40; **Branson** and **Mehl**, 1933b, p. 134, pl. 11, fig. 13; **Huddle**, 1934, p. 37, pl. 1, figs. 1-3; **Cooper**, 1939, p. 404, pl. 45, fig. 55; pl. 46, figs. 6, 8; **Mehl** and **Quigley** (part), 1944, *in* Branson, p. 156, pl. 27, fig. 46 only; **Youngquist**, 1947, p. 111, pl. 26, fig. 11; **Youngquist, Hibbard**, and **Reimann**, 1948, p. 58, pl. 14, figs. 15, 16.

Prioniodus confluens **Branson** and **Mehl**, 1934a, p. 206, pl. 15, figs. 6, 7.

Nothognathella irregularis Branson and Mehl, **Mehl** and **Quigley**, 1944, *in* Branson, p. 156, pl. 27, fig. 42.

Euprioniodina magnidens **Youngquist, Hibbard**, and **Reimann**, 1948, p. 52, 53, pl. 14, fig. 13.

Prioniodina alata (Hinde), **Sannemann**, 1955, p. 151, pl. 3, figs. 5, 6; **Bischoff**, 1956, p. 134, 135, pl. 10, figs. 26-28; **Bischoff** and **Ziegler**, 1957, p. 104, pl. 9, figs. 7, 11; pl. 21, figs. 20, 22, 24.

Neoprioniodus alatus (Hinde), **Cloud, Barnes,** and **Hass,** 1957, p. 812, pl. 4, fig. 3; **Müller** and **Clark,** 1967, p. 915, pl. 117, fig. 1.

Remarks: The specimens studied do not exhibit the extreme fusion of denticles as does the holotype, but rather they possess closely set, fused denticles that are free at the tips. *Neoprioniodus alatus* is transitional with *N. armatus* (Hinde), which has discrete denticles on the posterior bar.

Distribution: Traverse Formation of northern Indiana.

Material studied: 5 specimens.

Repository: IU10708-26001 (figured specimen).

Neoprioniodus armatus (Hinde)

Plate 3, figure 8

Prioniodus armatus **Hinde,** 1879, p. 360, 361, pl. 15, figs. 20, 21; **Grabau,** 1899, p. 152, fig. 33F; **Holmes,** 1928, p. 20, pl. 3, figs. 9, 10; **Branson** and **Mehl,** 1933b, p. 134, 135, pl. 11, figs. 14, 20.

Prioniodus undosus **Ulrich** and **Bassler,** 1926, p. 12, pl. 1, figs. 18, 20.

Prioniodus dillensis **Matern,** 1933, p. 13, 14, fig. 8.

Prioniodus n. sp. A **Matern,** 1933, p. 14, fig. 9.

Prioniodus semiseparatus **Branson** and **Mehl,** 1934a, p. 206, 207, pl. 15, figs. 9, 10.

Prioniodus idoneus **Stauffer,** 1938, p. 440, pl. 49, fig. 19.

Prioniodus bellatulus **Miller** and **Youngquist,** 1947, p. 516, pl. 72, fig. 11.

Prioniodina armata (Hinde), **Sannemann,** 1955, p. 151, pl. 3, figs. 2, 3; **Bischoff,** 1956, p. 135, pl. 10, figs. 15-17; **Bischoff** and **Ziegler,** 1957, p. 105, pl. 9, figs. 4a, b, 6a, b, 9.

Neoprioniodus armatus (Hinde), **Helms,** 1959, p. 644, pl. 4, fig. 18.

Neoprioniodus armata (Hinde), **Scott** and **Collinson,** 1961, p. 127, pl. 2, figs. 22, 24; **Orr,** 1964, p. 12, pl. 2, fig. 5.

Remarks: Neoprioniodus armatus is quite variable, particularly in the angle at which the posterior bar joins the main cusp and as interpreted by Sannemann (1955) and Bischoff and Ziegler (1957), by me, and by others includes forms that several authors have considered distinct species. In the Indiana University collection are specimens having

partly fused denticles that are transitional with *Neoprioniodus alatus* (Hinde).

Distribution: Traverse Formation and Antrim Shale of northern Indiana.

Material studied: 20 specimens.

Repository: IU10707-18001 (figured specimen).

Genus **Ozarkodina** Branson and Mehl, 1933

Ozarkodina **Branson** and **Mehl**, 1933a, p. 51.

Type species by original designation, *Ozarkodina typica* Branson and Mehl, 1933a.

Ozarkodina lata Bischoff and Ziegler

Plate 1, figures 24, 25

Ozarkodina lata **Bischoff** and **Ziegler**, 1957, p. 76, 77, pl. 20, figs. 9-16.

Remarks: Ozarkodina willsi Rhodes and Dineley is somewhat similar to *O. lata* but differs from it in having denticles that tend to be mostly discrete rather than fused and in being distinctly bowed.

Distribution: Traverse Formation of northern Indiana.

Material studied: 10 specimens.

Repository: IU10708-30002 and IU10708-29004 (figured specimens).

Ozarkodina cf. **O. versa** (Stauffer)

Plate 1, figures 18, 19

Bryantodus versus **Stauffer**, 1940, p. 421, pl. 59, figs. 10, 14-16, 21.

Remarks: The specimens in the present collection resemble Stauffer's material but generally are somewhat longer. *Ozarkodina* cf. *O. versa* resembles *O. willsi* Rhodes and Dineley in the character of the denticles but differs from that species in being nearly straight rather than distinctly arched and in being only slightly bowed.

Distribution: Traverse Formation of northern Indiana.

Material studied: 8 specimens.

Repository: IU10708-29002 and IU10708-29003 (figured specimens).

Ozarkodina willsi Rhodes and Dineley

Plate 1, figures 20-22

Ozarkodina willsi **Rhodes** and **Dineley**, 1957a, p. 364, pl. 38, figs. 1, 5.

Remarks: Ozarkodina willsi is the most common ozarkodinid found in conodont faunal assemblages from middle Devonian rocks of the Michigan Basin. The character of the denticles and the bowing of the blade distinguish this species from other members of the genus.

Distribution: Detroit River Formation, Traverse Formation, and Antrim Shale of northern Indiana; Dundee Limestone of western Ontario; Alpena Limestone, Four Mile Dam Limestone, and Norway Point Formation of Michigan.

Material studied: 83 specimens.

Repository: IU10702-51001, IU10707-17001, and IU10702-51002 (figured specimens).

Genus **Palmatolepis** Ulrich and Bassler, 1926

Palmatolepis **Ulrich** and **Bassler**, 1926, p. 49.

Type species by original designation, *Palmatolepis perlobata* Ulrich and Bassler, 1926.

Palmatolepis? disparalvea Orr and Klapper

Plate 5, figures 11, 12

Palmatolepis? disparalvea **Orr** and **Klapper**, 1968, p. 1071, 1072, pl. 140, figs. 1-11.

Remarks: The very large basal cavity of *Palmatolepis? disparalvea* distinguishes the species from all other palmatolepids. The species

probably was derived from *Polygnathus cristatus* Hinde through enlargement of the basal cavity, which is asymmetrical in some specimens of *P. cristatus,* and development of an asymmetrical platform.

Palmatolepis? disparalvea resembles *P. punctata* (Hinde) in platform outline and oral ornamentation, but it differs from that species in having a less well-differentiated lateral lobe and an inconspicuous azygous node, as well as in having a huge basal cavity. *Palmatolepis transitans* Müller differs from the new species in having a less well-developed lateral lobe and, generally, finer sculpture. Both *P. punctata* and *P. transitans* have minute basal cavities. Orr and Klapper (1968) discussed the relationships of *P.? disparalvea.*

Distribution: Antrim Shale of northern Indiana.

Material studied: 4 specimens.

Repository: IU10707-08002 (figured specimen).

Genus **Polygnathus** Hinde, 1879

Polygnathus **Hinde,** 1879, p. 361, 362.

For a discussion of the type species of *Polygnathus* see Orr and Klapper (1968, p. 1072).

Polygnathus alveoliposticus Orr and Klapper

Plate 4, figures 6-8

Polygnathus alveoliposticus **Orr and Klapper,** 1968, p. 1073, 1074, pl. 139, figs. 10-18.

Remarks: Despite the lack of a true free blade, this species is referred to *Polygnathus* because of a typical polygnathid basal cavity and an anterior extension of the carina, which extension in aboral view appears distinct from the platform. Although it bears only nodes rather than denticles, the anterior extension of the carina is analogous to the free blade of other members of the genus *Polygnathus.* See Orr and Klapper (1968) for a comparison of the species with similar taxa.

Distribution: Antrim Shale of northern Indiana.

Material studied: 1 specimen.

Repository: IU10707-19002 (figured specimen).

Polygnathus angusticostatus Wittekindt

Plate 4, figures 12-17

Polygnathus cf. *subserrata* Branson and Mehl, **Bischoff** and **Ziegler**, 1957, p. 97, pl. 4, figs. 10, 11.

Polygnathus angusticostatus **Wittekindt**, 1966, p. 631, pl. 1, figs. 15-18.

Remarks: Polygnathus angusticostatus differs from *P. angustipennatus* Bischoff and Ziegler in possessing a markedly shorter free blade. The two taxa probably intergrade. The taxon is present in association with *P. robusticostatus* and *P. "webbi"* below the Detroit River evaporites in northern Indiana.

Distribution: Detroit River Formation of northern Indiana.

Material studied: 12 specimens.

Repository: IU10702-52001 and IU10702-52002 (figured specimens).

Polygnathus caelatus Bryant

Plate 5, figures 9, 10

Polygnathus caelatus **Bryant**, 1921, p. 27, pl. 13, figs. 1-13.

Polygnathus caelata Bryant, **Huddle**, 1934, p. 101, 102, pl. 8, figs. 29-32; **Bischoff** and **Ziegler**, 1957, p. 86, pl. 18, figs. 18, 19a, b; **Ziegler**, 1966a, pl. 5, fig. 11.

Remarks: Polygnathus caelatus resembles *P. beckmanni* Bischoff and Ziegler but differs from the latter species in having a smaller and narrower platform as well as a free blade.

Distribution: Traverse Formation of northern Indiana.

Material studied: 2 specimens.

Repository: IU10707-11002 (figured specimen).

Polygnathus cristatus Hinde

Plate 6, figures 1, 2

Polygnathus cristatus **Hinde**, 1879, p. 366, pl. 17, fig. 11; **Grabau**, 1899, p. 156, fig. 41; **Holmes**, 1928, p. 17, pl. 7, fig. 7.

Polygnathus cristata Hinde, **Branson** and **Mehl**, 1933b, p. 147, pl. 11, fig. 10; **Bischoff** and **Ziegler**, 1957, p. 86, 87, pl. 15, figs. 1a-13b, 16; pl. 17, figs. 12, 13; **Krebs**, 1959, pl. 1, fig. 16; **Orr**, 1964, p. 13, 14, pl. 3, figs. 4-8, 10; **Flajs**, 1966, pl. 23, fig. 8; pl. 25, fig. 4; **Ziegler**, 1966a, p. 670, 671, pl. 4, figs. 17-23; pl. 5, figs. 1-5; **?Adrichem Boogaert**, 1967, p. 184, pl. 2, fig. 41.

Polygnathus ectypa **Huddle**, 1934, p. 103, pl. 8, fig. 38.

Remarks: Polygnathus asymmetricus ovalis Ziegler and Klapper differs from *P. cristatus* in having a shorter free blade, central basal cavity, finer platform ornamentation, and a more pointed anterior end of the platform.

Distribution: Traverse Formation and Antrim Shale of northern Indiana.

Material studied: 13 specimens.

Repository: IU10707-10005 (figured specimen).

Polygnathus decorosus Stauffer

Plate 4, figures 1-5

Polygnathus decorosus **Stauffer**, 1938, p. 438, pl. 53, figs. 1, 5, 6, 10, 11, 15, 16, 20, 30.

Polygnathus decorosa Stauffer, **Youngquist**, 1947, p. 109, pl. 24, fig. 21; **?Youngquist** and **Peterson**, 1947, p. 250, pl. 36, figs. 10-12; **Miller and Youngquist**, 1947, p. 514, 515, pl. 74, figs. 6, 7; **?Downs** and **Youngquist**, 1950, p. 670, pl. 87, figs. 3, 4, 23-26; **?Krebs**, 1959, pl. 1, fig. 12; **?Spassov** and **Stefanov**, 1962, p. 61, pl. 1, figs. 14, 15; **Orr**, 1964, p. 14, 16, pl. 1, figs. 3-5, 7; pl. 3, fig. 2.

Polygnathus aff. *P. decorosus* Stauffer, **Lys** and **Serre**, 1957b, p. 1048, pl. 5, fig. 3.

Polygnathus decorosa s. l. Stauffer, **Ziegler** (part), 1966a, pl. 3, figs. 1-4 only.

Remarks: The relatively small specimens studied closely resemble similar ones illustrated by Stauffer (1938, particularly pl. 53, figs. 11, 15, and 20). *Polygnathus decorosus* differs from *P. normalis* Miller and Youngquist in having a narrower platform that is strongly concave upward in cross section. The platform of *P. normalis* is strongly incurved posteriorly and bears distinct transverse ridges; that of *P. decorosus* is nearly straight and bears low, narrow ridges along its margins. Ethington and Furnish (1962, p. 1282) noted that in *P. decorosus* the "oral and aboral margins of the blade are nearly parallel, whereas the free blade in *P. normalis* increases somewhat in height toward the anterior end." The specimens from the Michigan Basin consistently display this character of the blade.

Distribution: Traverse Formation and Antrim Shale of northern Indiana.

Material studied: 175 specimens.

Repository: IU10707-04002 and IU10707-06002 (figured specimens).

Polygnathus foliatus Bryant

Plate 5, figures 15, 16

Polygnathus foliatus **Bryant** (part), 1921, p. 24, pl. 10, figs. 13, 15?, 16 only; **Müller** and **Clark**, 1967, p. 916, pl. 115, fig. 4.

Polygnathus pennatus Hinde, **Bryant** (part), 1921, p. 23, 24, pl. 10, figs. 3, 7 only.

Polygnathus foliata Bryant, **Huddle**, 1934, p. 99, pl. 8, figs. 14-17; **Müller** and **Müller**, 1957, p. 1086, 1087, pl. 135, figs. 1a, b; **Ethington**, 1965, p. 582, pl. 67, fig. 10.

Polygnathus decorosa Stauffer, **Bischoff**, 1956, p. 132, pl. 9, figs. 15-17, 20, 23.

Polygnathus pennata Hinde, **Bischoff** and **Ziegler**, 1957, p. 94, 95, pl. 17, figs. 14, 16-30; pl. 21, fig. 32; **Cloud, Barnes,** and **Hass,** 1957, p. 812, pl. 4, fig. 2; **Hass**, 1959, pl. 50, fig. 19; **Krebs**, 1959, pl. 1, figs. 7, 8, 11, 13; **Orr**, 1964, p. 18, 20, pl. 1, fig. 6; pl. 4, figs. 5, 6; **Ziegler**, 1966a, pl. 6, fig. 12; **?Spassov**, 1966, *in* **Spassov and Ganev**, pl. 4, figs. 12a, b.

Polygnathus decorosa s. l. Stauffer, **Ziegler** (part), 1966a, pl. 4, figs. 1-4; pl. 6, figs. 7-11 only.

Remarks: Polygnathus foliatus exhibits a wide range of variability as indicated by Bischoff and Ziegler (1957, p. 94, 95, pl. 17, figs. 14, 16-30; pl. 21, fig. 32). *Polygnathus decorosus* Stauffer resembles *P. foliatus* but differs from the latter in possessing a narrower, less distinctly ornamented platform with nearly parallel margins and a somewhat longer blade.

Distribution: Traverse Formation and Antrim Shale of northern Indiana.

Material studied: 75 specimens.

Repository: IU10707-10003 and IU10707-10004 (figured specimens).

Polygnathus linguiformis linguiformis Hinde

Plate 6, figure 3

Polygnathus linguiformis **Hinde**, 1879, p. 367, pl. 17, fig. 15; **Grabau**, 1899, p. 157, fig. 44; **Bryant**, 1921, p. 25, pl. 11, figs. 1-9; pl. 14, fig. 2; **Holmes**, 1928, p. 18, pl. 7, fig. 22; **Branson** and **Mehl**, 1933b, p. 148, 150, pl. 12, figs. 6, 7; **Huddle**, 1934, p. 95, 96, pl. 8, figs. 4, 5; **Müller**, 1956, pl. 145, figs. 19, 20; **Stewart** and **Sweet**, 1956, p. 270, 271, pl. 34, figs. 9, 11; **Ziegler** (part), 1956, p. 103, 104, pl. 7, figs. 15-18 only; **Bischoff** and **Ziegler**, 1957, p. 92, 93, pl. 1, figs. 1-13; pl. 16, figs. 30-35; pl. 17, figs. 1-8; **Cloud, Barnes,** and **Hass**, 1957, p. 812, pl. 4, fig. 1; **Lys** and **Serre**, 1957b, p. 1048, pl. 5, fig. 5; **Rhodes** and **Dineley**, 1957a, p. 365, 366, pl. 37, figs. 17-19, 21; pl. 38, fig. 3; **Hass**, 1959, pl. 50, fig. 11; **Spassov**, 1960, p. 71, pl. 1, figs. 17, 18; **Budurov**, 1961, p. 264, pl. 1, figs. 5a, b, 7a-10b, 12; **Reichstein**, 1962, pl. 1, figs. 17, 18; **Orr**, 1964, p. 16, 18, pl. 4, figs. 8, 9; **Merrill**, 1966, p. 392, pl. 4, fig. 12; **Spassov**, 1966, *in* Spassov and Ganev, pl. 1, fig. 6; **Clark** and **Ethington**, 1966, p. 683, 684, pl. 84, figs. 7, 9; **Ziegler**, 1966b, pl. 1, figs. 7-10.

Polygnathus? simplex **Hinde**, 1879, p. 367, pl. 17, fig. 18; **Grabau**, 1899, p. 157, 158, fig. 46.

Polygnathus simplex Hinde, **Holmes**, 1928, p. 19, pl. 7, fig. 5.

Polygnathus sanduskiensis **Stauffer**, 1938, p. 438, pl. 53, figs. 27, 36, 37; **Stauffer**, 1940, p. 430, pl. 60, figs. 80, 82, 89, 90.

Polygnathus webbi Stauffer, **Bischoff** and **Ziegler** (part), 1957, p. 100, pl. 19, figs. 12-14 only.

Polygnathus linguiformis linguiformis Hinde, **Wittekindt**, 1966, p. 635, 636, pl. 2, figs. 10-12.

Remarks: Polygnathus linguiformis is one of the most widespread and well-known Devonian conodont species. It is present throughout the middle Devonian and also has been reported from lower (Bischoff and Sannemann, 1958; Ziegler, 1956) and upper Devonian strata (Ziegler, 1962, 1966a).

Wittekindt (1966) separated three subspecies of *Polygnathus linguiformis. Polygnathus linguiformis mucronatus* differs from the nominal subspecies in lacking cross ridges on the posterior part of the platform. *Polygnathus linguiformis transversus* is distinguished by diagonal rows of nodes on the anterior part of the platform.

Distribution: Detroit River Formation, Traverse Formation, and Antrim Shale of northern Indiana; Dundee Limestone of western Ontario; Bell Shale, Alpena Limestone, and Norway Point Formation of Michigan.

Material studied: 950 specimens.

Repository: IU10708-29008 (figured specimen).

Polygnathus pennatus Hinde

Plate 5, figures 13, 14

Polygnathus pennatus **Hinde**, 1879, p. 366, pl. 17, fig. 8; **Clarke**, 1887, pl. A-1, fig. 9; **Grabau**, 1899, p. 156, fig. 39; **Bryant** (part), 1921, p. 23, 24, pl. 10, figs. 1, 2, 4?, 5, 6, 8?, 9 only; **Holmes**, 1928, p. 18, pl. 7, figs. 10, 12.

Polygnathus ordinata Hinde, **Bryant** (part), 1921, p. 24, pl. 10, fig. 11 only.

Polygnathus pennata Hinde, **Branson** and **Mehl**, 1933b, p. 144, 145, pl. 11, fig. 3; **Huddle**, 1934, p. 96, 97, pl. 8, figs. 6, 7; **Beckmann** (part), 1949, p. 155, pl. 1, figs. 4a-c?; pl. 4, fig. 3 only; **?Freyer**, 1965, pl. 2, fig. 22; **Flajs**, 1966, pl. 25, fig. 5; **?Krebs** and **Ziegler**, 1966, pl. 1, figs. 4, 5.

Polygnathus rugosa **Huddle**, 1934, p. 98, pl. 8, figs. 12, 13; **Bischoff** and **Ziegler**, 1957, p. 96, 97, pl. 17, figs. 9-11, 15; **Ziegler**, 1966a, p. 669, pl. 5, fig. 14.

Polygnathus cf. *rugosa* Huddle, **Ziegler,** 1966a, p. 669, pl. 5, figs. 12, 13.

Remarks: The very small, slitlike basal cavity and the regular series of robust transverse ridges distinguish *Polygnathus pennatus* from other polygnathids. *Polygnathus foliatus* Bryant is a similar species but also differs from *P. pennatus* in having the platform margins ornamented with nodes and ridges, which are narrower and less regular than those of *P. pennatus.* The synonymy of *P. pennatus* was compiled after studying photographs of Hinde's type specimens supplied by Charles Collinson.

Distribution: Antrim Shale of northern Indiana.

Material studied: 6 specimens.

Repository: IU10707-10002 (figured specimen).

Polygnathus pseudofoliatus Wittekindt

Plate 4, figures 18-22

Polygnathus foliata Bryant, **Bischoff** and **Ziegler,** 1957, p. 90, pl. 4, figs. 1-4.
Polygnathus xylus Stauffer, **Bischoff** and **Ziegler,** 1957, p. 101, pl. 5, figs. 11-17.
Polygnathus n. sp. **Ziegler,** 1962, p. 88; **Flajs,** 1966, p. 232, 233, pl. 23, figs. 5-7.
Polygnathus pseudofoliata **Wittekindt,** 1966, p. 637, 638, pl. 2, figs. 19-23.

Remarks: Polygnathus eiflius Bischoff and Ziegler differs from *P. pseudofoliatus* in exhibiting prominent diagonal ledges on either side of the carina in the anterior part of the platform. A number of juvenile specimens, mostly having broken blades, are included here in *P. pseudofoliatus.* Many of these small specimens exhibit the characteristic aboral configuration of the platform of adults and are found in similar stratigraphic horizons with adult specimens of *P. pseudofoliatus.* The juvenile specimens of *P. pseudofoliatus* from the Michigan Basin resemble those specimens figured by Bischoff and Ziegler (1957, p. 101, pl. 5, figs. 11-17) as *P. xylus,* which specimens are herein referred to *P. pseudofoliatus.*

Distribution: Traverse Formation of northern Indiana; Alpena Limestone of Michigan.

Material studied: 54 specimens.

Repository: IU10714-11001 and IU10707-53001 (figured specimens).

Polygnathus robusticostatus Bischoff and Ziegler

Plate 6, figures 4-8

Polygnathus robusticostata **Bischoff** and **Ziegler**, 1957, p. 95, 96, pl. 3, figs. 4-10; **Wittekindt**, 1966, p. 638, pl. 2, figs. 24-26.

Remarks: Although the ridges on the platform are not quite as broad as those on Bischoff and Ziegler's (1957) figured specimens, nearly all other characters of the Detroit River specimens are similar to those of the German authors.

Distribution: Detroit River Formation of northern Indiana.

Material studied: 3 specimens.

Repository: IU10702-52003 and IU10703-44002 (figured specimens).

Polygnathus varcus Stauffer

Plate 5, figures 4-8

Polygnathus varcus **Stauffer**, 1940, p. 430, pl. 60, figs. 49, 53, 55; **Rhodes** and **Dineley**, 1957a, p. 366, pl. 37, figs. 22, 23; pl. 38, fig. 7.

Polygnathus hulkus **Stauffer**, 1940, p. 429, pl. 60, figs. 75-77.

Polygnathus juvensis **Stauffer** (part), 1940, p. 429, 430, pl. 60, figs. 26-28, 34, 35 only.

Polygnathus strongi Stauffer, **Stauffer** (part), 1940, p. 430, pl. 60, figs. 83-85 only.

Polygnathus xylus **Stauffer**, 1940, p. 430, 43l, pl. 60, figs. 42, 50, 54, 65-67, 69, 72-74, 78, 79; **Downs** and **Youngquist**, 1950, p. 671, pl. 87, figs. 15, 16; **?Flajs**, 1966, pl. 25, figs. 7, 8.

Polygnathus stainbrooki **Downs** and **Youngquist**, 1950, p. 671, pl. 87, figs. 19, 20.

Polygnathus varca Stauffer, **Bischoff** and **Ziegler**, 1957, p. 98, 99, pl. 18, figs. 32-35; pl. 19, figs. 7-9; **Flajs**, 1966, pl. 25, fig. 6; **Glenister** and **Klapper**, 1966, p. 830, 831, pl. 95, figs. 12-16; **Ziegler**, 1966b, pl. 1, fig. 6; **Wittekindt**,

1966, p. 639, 640, pl. 3, figs. 5-10; **Adrichem Boogaert**, 1967, p. 185, pl. 3, fig. 6.

Distribution: Traverse Formation and Antrim Shale of northern Indiana; Alpena Limestone, Four Mile Dam Limestone, Norway Point Formation, and Thunder Bay Limestone of Michigan.

Material studied: 460 specimens.

Repository: IU10708-28001 and IU10708-26003 (figured specimens).

Polygnathus variabilis Bischoff and Ziegler

Plate 5, figures 1-3

Polygnathus? variabilis **Bischoff and Ziegler**, 1957, p. 99, 100, pl. 18, figs. 8-17, 21-24; pl. 19, figs. 10, 11, 16, 17; **Wittekindt**, 1966, p. 640, 641, pl. 3, figs. 11-14.

Remarks: The specimens from the Antrim Shale closely resemble Bischoff and Ziegler's (1957) material, especially the holotype (their pl. 18, fig. 13) and those figured specimens (pl. 18, figs. 11, 15, 24; pl. 19, figs. 10, 11) that possess distinct platforms rather than only a bulging of the lower part of the blade at midlength. Because it possesses both an anterior free blade and a posterior platform having a distinct polygnathid basal cavity, this species is assigned to the genus *Polygnathus.*

Distribution: Antrim Shale of northern Indiana.

Material studied: 3 specimens.

Repository: IU10707-10001 (figured specimen).

Polygnathus "webbi" Stauffer

Plate 4, figures 9, 10

Polygnathus webbi **Stauffer**, 1938, p. 439, pl. 53, figs. 25, 26, 28, 29; **Ziegler**, 1956, p. 104, pl. 7, figs. 13, 14, 22, 23; **Bischoff and Ziegler** (part), 1957, p. 100, pl. 5, figs. 7-10b only; **?Freyer**, 1965, pl. 2, fig. 23; **Merrill**, 1966, p. 392, pl. 4, fig. 14; **Wittekindt**, 1966, p. 641, pl. 3, figs. 15, 17.

Remarks: Polygnathus normalis Miller and Youngquist differs from *P. "webbi"* in having a more distinctly asymmetrical platform that is flatter posteriorly and that possesses narrower transverse ridges, which commonly are directed anteriorly. Klapper and others (in press) propose the recognition of several subspecies of *P. "webbi,"* one of which is similar to the specimen illustrated herein (pl. 4, figs. 9, 10). The specimens of this study are merely designated *P. "webbi"* pending further study of taxonomy. They closely resemble those specimens figured by Ziegler (1956), Bischoff and Ziegler (1957), and Wittekindt (1966) as *P. webbi.*

Distribution: Detroit River Formation of northern Indiana; Dundee Limestone of western Ontario.

Material studied: 13 specimens.

Repository: IU10703-44001 (figured specimen).

Genus **Prioniodina** Bassler, 1925

Prioniodina **Bassler**, 1925, p. 219; **Ulrich** and **Bassler**, 1926, p. 18.
Prioniodella **Bassler**, 1925, p. 219; **Ulrich** and **Bassler**, 1926, p. 18.

Type species by original designation, *Prioniodina subcurvata* Ulrich and Bassler, 1926.

Prioniodina sp.

Plate 4, figures 24, 25

Prioniodina aversa Stauffer, **Bischoff** and **Ziegler**, 1957, p. 106, pl. 20, fig. 24.
Prioniodina cf. *aversa* Stauffer, **Bischoff** and **Ziegler**, 1957, p. 106, pl. 20, fig. 23.
?Prioniodella? torta Branson and Mehl, **Sannemann**, 1955, p. 150, pl. 6, fig. 15; **Lys** and others, 1961, p. 552, pl. 5, fig. 4.

Description: Denticles on the anterior bar are discrete and nearly equal in size. The cusp is slightly larger than the adjacent denticles and is parallel to them. The posterior bar is about half the length of the anterior bar and bears denticles that are similar in size to the anterior ones. The bar is expanded and deeply excavated aborally in the area of the cusp. The basal cavity tapers into shallow grooves anteriorly and posteriorly along the bar.

Remarks: This species differs from *Prioniodina aversa* Stauffer and *Prioniodella? torta* Branson and Mehl in having the bar deeply excavated beneath the cusp. *Prioniodina aversa* has a shallow pit below the cusp. In *Prioniodella? torta* the pit is either absent or very minute.

Distribution: Traverse Formation of northern Indiana.

Material studied: 2 specimens.

Repository: IU10708-26002 (figured specimen).

Genus **Schmidtognathus** Ziegler, 1966

Schmidtognathus **Ziegler**, 1966a, p. 661-664.

Type species by original designation, *Schmidtognathus hermanni* Ziegler, 1966.

Schmidtognathus peracutus (Bryant)

Plate 6, figure 9

Polygnathus peracutus **Bryant**, 1921, p. 25, pl. 10, fig. 12.
Polygnathus peracuta Bryant, **Huddle**, 1934, p. 97, pl. 8, fig. 8; **Bischoff** and **Ziegler**, 1957, p. 95, pl. 16, fig. 29.
Polygnathus cf. *P. peracuta* Bryant, **Orr**, 1964, p. 20, 22, pl. 4, figs. 3, 4.
Schmidtognathus peracuta (Bryant), **Ziegler**, 1966a, p. 668, pl. 1, figs. 1-10.

Distribution: Antrim Shale of northern Indiana.

Material studied: 2 specimens.

Repository: IU10702-05001 (figured specimen).

Genus **Spathognathodus** Branson and Mehl, 1941

Ctenognathus **Pander**, 1856, p. 32 [not Fairmair, 1843].
Spathodus **Branson** and **Mehl**, 1933a, p. 46 [not Boulenger, 1900].
Spathognathodus **Branson** and **Mehl**, 1941, p. 98.
Mehlina **Youngquist**, 1945, p. 363.
Branmehla **Hass**, 1959, p. 381.

Ctenognathodus **Fay**, 1959, p. 195.
Spathognathodus (*Bispathodus*) **Müller**, 1962, p. 114.

Type species by original designation, *Spathodus primus* Branson and Mehl, 1933 [=*Ctenognathus murchisoni* Pander, 1856].

Spathognathodus bidentatus Bischoff and Ziegler

Plate 4, figure 11

Spathognathodus bidentatus **Bischoff** and **Ziegler**, 1957, p. 114, 115, pl. 6, figs. 8-13; **Wittekindt**, 1966, p. 642, pl. 3, figs. 16, 20-22.

Remarks: Both specimens studied are juveniles but resemble Bischoff and Ziegler's types in the shape and location of the basal cavity and in the relative sizes of the anterior and posterior denticles, as well as in their spacing along the blade.

Distribution: Detroit River Formation of northern Indiana.

Material studied: 2 specimens.

Repository: IU10702-50001 (figured specimen).

Spathognathodus planus Bischoff and Ziegler

Plate 4, figure 23

Spathognathodus planus **Bischoff** and **Ziegler**, 1957, p. 117, pl. 19, figs. 34, 35; **Wittekindt**, 1966, p. 643, 644, pl. 3, fig. 30.

Remarks: Spathognathodus planus is similar to *S. obliquus* Wittekindt from the Eifelian Stage of Germany. *Spathognathodus planus* differs from *S. obliquus* only in having more numerous and narrower denticles. The size and position of the basal cavity, degree of inclination of the denticles, and lateral outline of the blade are closely similar in the two species.

Distribution: Traverse Formation of northern Indiana.

Material studied: 1 specimen.

Repository: IU10708-11001 (figured specimen).

Genus **Synprioniodina** Bassler, 1925

Synprioniodina **Bassler**, 1925, p. 219; **Ulrich** and **Bassler**, 1926, p. 42.

Type species by original designation, *Synprioniodina alternata* Ulrich and Bassler, 1926.

Synprioniodina regularis (Branson)

Plate 3, figures 1-4

Euprioniodina regularis **Branson**, 1934, p. 330, pl. 28, fig. 1.
Euprioniodina prona **Huddle**, 1934, p. 52, pl. 6, fig. 9; pl. 11, fig. 8.
Prioniodina bownockeri **Stauffer**, 1938, p. 440, pl. 49, fig. 27.
?Synprioniodina gracilis **Stauffer**, 1938, p. 441, pl. 49, gis. 12, 13.
Synprioniodina forsenta **Stauffer**, 1940, p. 432-434, pl. 59, figs. 31-33, 38-41; **Rhodes** and **Dineley**, 1957a, p. 367, pl. 38, fig. 4; **Lys** and **Serre**, 1957b, p. 1051, pl. 7, fig. 6.
Synprioniodina tropa **Stauffer**, 1940, p. 434, pl. 59, fig. 60.
Euprioniodina iowaensis **Thomas**, 1949, p. 420, pl. 1, fig. 8.
Euprioniodina lateralis **Thomas**, 1949, p. 420, 421, pl. 1, fig. 9.
Prioniodina prona (Huddle), **Sannemann** (part), 1955, p. 152, pl. 3, fig. 7 only; **Bischoff** and **Ziegler** (part), 1957, p. 106, 107, pl. 8, figs. 12a, b, 14; pl. 9, figs. 3a, b, 5; pl. 21, figs. 14-16 only; **Ziegler**, 1957, *in* Flügel and Ziegler, p. 43, pl. 4, fig. 6; **Dvorak** and **Freyer**, 1961, pl. 1, fig. 14; **Freyer**, 1961, p. 79, pl. 5, figs. 116, 117; **Spassov** and **Stefanov**, 1962, p. 61, 62, pl. 2, fig. 14; **?Freyer**, 1965, pl. 2, fig. 24; **?Spassov**, 1966, *in* Spassov and Ganev, p. 57, pl. 5, fig. 9.
Prioniodina cf. *prona* (Huddle), **Lys** and **Serre**, 1957a, p. 805, 806, pl. 12, fig. 3.
Prioniodina aff. *P. prona* (Huddle), **Lys** and **Serre**, 1957b, p. 1049, 1050, pl. 6, fig. 4.
Neoprioniodus pronus (Huddle), **Müller** and **Clark**, 1967, p. 915, pl. 118, figs. 13, 16.

Remarks: This widespread and long-ranging species is quite variable, particularly in the angle at which the posterior bar joins the main cusp and in degree of denticulation of the anticusp. Several forms included here in *Synprioniodina regularis* have been interpreted as distinct species by other authors.

Distribution: Detroit River Formation, Traverse Formation, and Antrim Shale of northern Indiana; Dundee Limestone of western Ontario; Bell Shale, Alpena Limestone, and Norway Point Formation of Michigan.

Material studied: 115 specimens.

Repository: IU10708-29005, IU10708-29006, IU10708-29007, and IU10708-18001 (figured specimens).

Synprioniodina sp.

Plate 3, figure 5

Prioniodina prona (Huddle), **Sannemann** (part), 1955, p. 152, pl. 3, fig. 1 only; **Bischoff** and **Ziegler** (part), 1957, p. 106, 107, pl. 8, figs. 13a, b only.

Description: The posterior bar is very long and slightly arched. It bears a series of discrete, robust, subequal denticles that are largest in the middle part of the bar, slightly curved inward, and subround in cross section. The cusp is high, curved inward, oval in cross section, and essentially parallel to the denticles on the bar. The anticusp bears several small, partially erupted denticles. The area below the cusp is broadly excavated and flared inward. A narrow, shallow groove extends from the basal cavity and pinches out on the sharp underside of the bar.

Remarks: Synprioniodina sp. bears some resemblance to *S. regularis* but differs from the latter species in having large, discrete, subround denticles rather than small, closely set, laterally compressed denticles on the bar.

Distribution: Antrim Shale of northern Indiana.

Material studied: 2 specimens.

Repository: IU10707-19001 (figured specimen).

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Appendix

Following are lithologic descriptions of all sections, both well cores and outcrop exposures, that were sampled for conodonts during this study. The vertical footage represented by each sample is given. Important platform species are listed following descriptions of lithologic units.

Continuous samples were taken in well cores throughout the Devonian part of the section. For several cores, samples taken in noncalcareous black shale and in gypsum and anhydrite were not processed for conodonts because of the difficulty involved in satisfactorily disaggregating such materials under normal laboratory procedures. Those samples not processed are designated by an asterisk under the heading "Sample No." Samples that yielded conodonts are designated by C.

Section 1 (IU10701). Log of core from Fenix and Scisson Wabash Pipe Line Co. No. 1 well near Griffith, Lake County, Ind. (SW¼SW¼SW¼ sec. 3, T. 35 N., R. 9 W.). Altitude, 628 ft. After log by Robert H. Shaver, Indiana Geological Survey, June 16, 1965.

	Sample No.	Depth (ft)
Quaternary System:		
1. Surficial materials stated to be to		134.0
Devonian System:		
Traverse Formation, 19.4 ft cored:		
2. Dolomite of varying kind, light-gray, light-tan, and brown, partly in mottled and vermiform pattern. Brown dolomite is fine to medium grained and fairly pure; lighter colored dolomite is fine grained and earthy to lithographic; unit has bands of light-colored chert that in part is chalk textured, thin bands of dark shale, and two thin zones of very coarse vugs; 10.2 ft.	1 2C 3	137.5-141.3 141.3-145.2 145.2-147.7
3. Dolomite, mostly brown, some tan, mostly very fine-grained, some sublithographic, very finely vuggy in part; unit has zones of dark shaly laminae, a few dark thin shale bands, and zones of very coarse vugs; bottom foot is tan, very fine grained, and pure; to Wabash	4 5 6	147.7-152.1 152.1-154.1 154.1-156.9

Devonian System—Continued
Traverse Formation—Continued
Formation (Silurian); 9.2 ft; fauna includes *Icriodus latericrescens latericrescens.*

Section 2 (IU10718). Log of core from Indiana Geological Survey drill hole 166 near Medaryville, Pulaski County, Ind. (NW¼SE¼SE¼ sec. 3, T. 30 N., R. 4 W.). Altitude, 686 ft. After log by Robert H. Shaver, Indiana Geological Survey, February 7, 1967.

	Sample No.	Depth (ft)
Devonian System:		
Antrim Shale, 48.1 ft cored:		
1. Shale, black and dark-gray, pyritic, carbonaceous; pyrite scattered in thin bands and nodules; has some light-gray partly calcareous shale in scattered stringers and beds, including a bed that is 1.0 ft thick in lower few feet; bottom 3 in. is sandstone, poorly sorted, gray, calcareous, pyritic, having a shale band in middle; sand grains very fine to coarse, consisting of well-rounded quartz grains and dark grains; most of unit (60.0-100.0 ft) not processed for conodonts; 48.1 ft; fauna includes upper Devonian palmatolepids with *P. gigas* and *P. subrecta.*	1C 2C 3C	100.0-104.0 104.0-107.8 107.8-108.1
Traverse Formation, 40.6 ft:		
2. Dolomite, mottled dark brownish-gray and tan, very fine- to coarse-grained, highly fossiliferous, somewhat vuggy, slightly cherty; fossils are in large fragments, consisting mostly of dolomitized corals and stromatoporoids and making up the light-colored fraction; vugs are both open and spar filled; 6.6 ft; fauna includes *Icriodus latericrescens latericrescens* and *Polygnathus foliatus.*	4C 5C	108.1-112.0 112.0-114.7
3. Dolomite grading down in 1 or 2 ft to limestone, gray and very light-gray, coarse-grained,	6C 7C	114.7-118.0 118.0-121.0

Devonian System—Continued		
Traverse Formation—Continued		
conspicuously biofragmental in part; middle part is dark-gray fine-grained limestone having many dark wavy shaly laminae; 8.2 ft; fauna includes *Icriodus latericrescens latericrescens, Polygnathus varcus,* and *P. linguiformis linguiformis.*	8C	121.0-122.9
4. Limestone, mottled light-tan and light gray-tan, very fine-grained, earthy-lustered, argillaceous, highly fossiliferous; gray-tan part of mottling produced by large fossil fragments (particularly corals) and by both irregular bands and pebbles of lithographic limestone; also by more granular areas; has 25 in. of core loss or removal; 10.4 ft.	9 10 11C	122.9-126.0 126.0-130.0 130.0-133.3
5. Limestone, very light-gray, very coarse-grained, conspicuously biofragmental;matrix is chalky white very finely divided material; 10.3 ft; fauna includes *Icriodus latericrescens latericrescens.*	12C 13C 14C	133.3-137.0 137.0-140.0 140.0-143.6
6. Mostly dolomite, gray and brownish-gray, fine-grained, earthy, argillaceous; upper few inches is purer tan fine-grained poorly laminated limestone; has some dark shaly laminae and a few coral fossils; has 26 in. of core loss or removal; 5.1 ft; fauna includes *Icriodus latericrescens latericrescens.*	15C	143.6-148.7
Detroit River Formation, 18.3 ft:		
7. Dolomite, grayish-brown and light-tan, very fine-grained and dense to sublithographic; upper part is thinly color banded, laminated; lower part is the light-colored dense material characteristic of upper Detroit River strata; lower contact of unit is arbitrary inasmuch as some sublithographic rock is in unit 8; 1.3 ft.	16	148.7-150.0
8. Dolomite; mostly very fine grained but ranges from sublithographic to fine grained, light	17C 18	150.0-153.2 153.2-156.6

Devonian System–Continued		
Detroit River Formation–Continued		
gray and tan gray, cherty; much is finely color banded and conspicuously thinly laminated, but this ranges from no laminae through the vermiform mottling to poker chip aspect; chert is chalky textured to fresh looking and is in irregular nodules, laminae, blebs, and impure masses that probably are dolomitic and have laminae extending through; 9.6 ft.	19	156.6-159.6
9. Dolomite; basically like that of unit 8 (earthy, dense, argillaceous) but set apart because of lack of conspicuous laminae; chert is less abundant and is in fewer but larger masses; unit shows slickensiding and brecciation; bottom 2 in. is dark-gray fine-grained dolomitic sandstone; sand consists of both carbonate and well-rounded quartz grains; very few sand grains above this 2-in. layer; to Salina Formation (Silurian); 7.4 ft.	20 21	159.6-164.0 164.0-167.0

Section 3 (IU10720). Log of core from Indiana Geological Survey drill hole 168 near La Crosse, LaPorte County, Ind. (SE¼SW¼SW¼ sec. 14, T. 33 N., R. 4 W.). Altitude, 670 ft. After log by Robert H. Shaver, Indiana Geological Survey, June 30, 1967.

	Sample No.	Depth (ft)
Devonian System:		
Antrim Shale, 82.2 ft cored:		
1. Shale, black to brown, carbonaceous, pyritic; also some blue-gray shale that is interbedded in layers as much as a few inches thick and that is closely interlaminated (upper part) on a very fine scale; pyrite is in bands and in crystalline nodules; bottom 2 in. of unit is brown fine-grained sandstone consisting of subrounded quartz grains and larger, ap-	1C	120.0-122.2

Devonian System—Continued

Antrim Shale—Continued

parently phosphatic grains; most of unit (40.0-120.0) not processed for conodonts; 82.2 ft.

Traverse Formation, 66.9 ft:

2. Dolomite, gray, very fine-grained, argillaceous, dense; grades through the middle foot of the unit to dolomite that is gray, pure, coarse grained, pyritic, and finely vuggy and that consists of euhedral dolorhombs and is petroliferously stained in part; possibly upper 1 or 2 ft is equivalent in other sections that has been included in the Antrim Shale; 2.1 ft; fauna includes *Polygnathus cristatus, P. foliatus,* and *P. varcus.*	2C 3C	122.2-123.4 123.4-124.3
3. Limestone, light grayish-tan overall but abundantly speckled gray-brown, sublithographic to very fine-grained, earthy and (or) chalky; speckled appearance produced by abundant medium- to coarse-grained dolomite rhombs in the light-colored matrix; favositid corals at 1 ft above base of unit; has 2-in. white chalky chert band 1 in. below top of unit; 4.9 ft.	4	124.3-129.2
4. Limestone, light grayish-tan, sublithographic in part at top; grades down in middle to fine-grained and earthy-appearing material and in bottom to fine-grained material having many fossils and some coarser grained fossil debris; upper middle part is faintly color banded and finely laminated; fossils mostly favositid corals; bottom foot is oil stained; 14.1 ft.	5 6 7 8	129.2-132.0 132.0-136.0 136.0-138.8 138.8-143.3
5. Dolomite, dark-gray, fine- to coarse-grained, pyritic; has coarse calcite-filled vugs and few open vugs; has strong petroleum odor and has been petroleum saturated; 3.6 ft.	9	143.3-146.9

Devonian System—Continued

Traverse Formation—Continued

6. Dolomite (mostly but some limestone) that in downward order is (a, to 148.0 ft) gray, fine grained; (b, to 148.7 ft) light tan, thinly laminated, sublithographic, consisting of a tumbled stromatoporoid colony (biostructures now upside down); (c, to 154.0 ft) gray, fine grained, coarsely vuggy in part, having petroleum odor and formerly petroleum saturated in part; and (d) variably grayish tan and gray, fine grained, argillaceous, having considerable coarse bioclastic material (including some stromatoporoids), and having many irregular shaly partings in most parts; 29.2 ft; fauna includes *Icriodus latericrescens latericrescens.*	10 11 12 13C 14C 15C 16C 17C 18C 19C	146.9-147.9 147.9-148.7 148.7-152.0 152.0-154.0 154.0-158.0 158.0-162.0 162.0-165.2 165.2-169.4 169.4-173.1 173.1-176.1
7. Limestone, light tannish-gray, very fine-grained to dense or sublithographic; has 1-in. shale bed 6 in. below top of unit; 2.0 ft.	20	176.1-178.1
8. Dolomite, gray, fine-grained; has gray and white banded impure chert layer and nodules in lower part; 2.8 ft.	21	178.1-180.9
9. Dolomite, grayish-tan, very fine-grained, earthy-appearing, probably argillaceous, cherty; has some dark shaly partings; chert is earthy and white and in small irregular nodules; 8.2 ft.	22 23	180.9-185.1 185.1-189.1

Detroit River Formation, 71.1 ft:

10. Dolomite, light grayish-tan; much of it brecciated and has dark irregular shaly partings and much of it thinly laminated and color banded, very fine-grained to sublithographic (laminated part), earthy-appearing, argillaceous in part; brecciated part consists of carbonate pebbles in matrix; laminated part has inclined bedding; has some calcite veins and other fillings; 8.2 ft.	24 25	189.1-192.7 192.7-197.3
11. Dolomite and some limestone; mostly coarsely mottled in shades of rich tan, light tan, and	26 27	197.3-200.0 200.0-203.9

Devonian System—Continued		
Detroit River Formation—Continued		
grays, mostly fine-grained to lithographic, probably stromatoporoidal (tan sublithographic parts), finely vuggy in part, probably once brecciated in part; has calcite spar and other veins and fillings; has stylolites; 10.4 ft.	28	203.9-207.7
12. Dolomite in three closely related kinds; all very fine grained to dense and earthy appearing: (a, to 220.6 ft) grayish tan and tan, finely vuggy in part, possibly once brecciated in part, and having many coarse calcite-spar fillings and crystals in upper part; (b, to 220.9 ft) grayish tan grading down to gray, having black carbonaceous slickensided and irregular shale laminae; and (c) grayish tan and tan, apparently having shell fragments; 29.8 ft; fauna includes *Polygnathus "webbi," P. linguiformis linguiformis,* and *P. angusticostatus.*	29 30C 31C 32C 33C 34C 35C 36C 37C	207.7-210.0 210.0-214.0 214.0-218.0 218.0-220.6 220.6-222.0 222.0-225.9 225.9-229.9 229.9-233.8 233.8-237.5
13. Dolomite, banded light- and dark-gray, very fine-grained, earthy- and argillaceous-appearing, thinly laminated in most parts, brecciated and otherwise disturbed in part, sandy; shaly in most obviously laminated parts; sand consists of fine subrounded quartz grains, present in most parts; 7.0 ft.	38 39	237.5-241.2 241.2-244.5
14. Dolomite, light grayish-tan grading down to medium-gray, very fine-grained and earthy-appearing to sublithographic, brecciated and calcite-veined in part, finely sandy as unit 13; sand is present in parts from top to bottom but irregularly distributed; apparently has a little glauconite; to Salina Formation (Silurian); 15.7 ft.	40 41 42 43 44	244.5-248.0 248.0-251.9 251.9-255.8 255.8-259.4 259.4-260.2

Section 4 (IU10703). Log of core from Northern Indiana Public Service Co. James A. Leroy No. 2 well near Fish Lake, LaPorte County, Ind. (NE¼SW¼SE¼ sec. 18, T. 36 N., R. 1 W.). Altitude, 710 ft. After log by Robert H. Shaver, Indiana Geological Survey, May 20, 1966.

	Sample No.	Depth (ft)
Devonian System:		
Traverse Formation, 67.7 ft measured:		
(Strip log shows 5 ft more limestone at top than does core.)		
1. Limestone, grayish-tan and brown, very fine-grained, earthy, and chalk-textured (chalky material dominating fabric), fossiliferous; has scattered to dominant medium-size grains, probably mostly fossil fragments, and pieces of fine-grained limestone, possibly originating as rubble; has fossil debris and especially coralline material concentrated in zones a few inches thick; has fine irregular dark laminae; grades within a few inches to unit 2; 18.9 ft.	1 2 3 4 5	280.0-283.8 283.8-287.6 287.6-291.2 291.2-295.0 295.0-298.9
2. Dolomite (especially above) and limestone, dark brownish-gray and tan, medium-grained and crystalline to fine-grained, shaly, and highly fossiliferous in zones; coarsely vuggy in part; shaly zones are dark grayish black and have much fossil material (brachiopod and coral fragments); much of unit is fossil "hash"; has conspicuous 2-ft zone of light-colored coralline layers interbedded with dark material 4 to 6 ft below top and thinner few-inch zones below; contact with unit 3 is somewhat arbitrary, similar material being on either side and color being a separating criterion; 17.2 ft; fauna includes *Icriodus latericrescens latericrescens*.	6 7C 8C 9 10C	298.9-303.1 303.1-306.8 306.8-310.1 310.1-314.0 314.0-316.1
3. Limestone, medium-brown, fine- to coarse-grained, highly fossiliferous; most of unit consists of fossils and fossil debris; has dark	11C 12C 13C	316.1-319.5 319.5-323.4 323.4-327.2

Devonian System—Continued		
Traverse Formation—Continued		
shaly zones containing many brachiopods, some representing breccias that show distortion of original bedding; coral colonies dominate parts of unit; 16.8 ft; fauna includes *Icriodus latericrescens latericrescens.*	14C 15C	327.2-330.5 330.5-332.9
4. Limestone; tan-gray above grades to gray below; coarse-grained and fossil-fragmental above grades to fine-grained below; grades in upper 1 ft from unit 3 and in lower few inches to unit 5; 8.1 ft; fauna includes *Icriodus latericrescens latericrescens.*	16C 17C 18C	332.9-336.0 336.0-339.0 339.0-341.0
5. Limestone, brown and tan; fairly fine grained and somewhat earthy and chalk textured for most part to coarse grained and fossil fragmental (especially in lower few inches); fossiliferous; combines characteristics of units 1, 2, and 3; has a few dark shaly zones and zones of highly fossiliferous (especially coralline) material; has few-inch band of spotted tan and gray chert 1.3 ft above base; contact with Detroit River Formation is sharp but irregular on fine scale, having solution features and apparently inclusions of unit 5 in unit 6, all within 1 in.; also, a few-inch zone of concentrated, finely developed stylolites is in top of the Detroit River; 6.7 ft; fauna includes *Icriodus latericrescens latericrescens.*	19 20C	341.0-343.9 343.9-347.7
Detroit River Formation, 92.8 ft:		
6. Limestone, gray to brown, mostly sublithographic to lithographic; has zones of dark irregular laminae and fine fossil fragments; disconformable contact with Traverse Formation described above; 17.4 ft.	21 22 23 24C 25 26	347.7-351.4 351.4-354.6 354.6-356.5 356.5-360.2 360.2-363.0 363.0-365.1
7. Gypsum zone, gray, brown, and white; consists mostly of coarsely cleavable gypsum but has zones of lithographic limestone mixed with	27* 28*	365.1-367.8 367.8-371.2

Devonian System—Continued

Detroit River Formation—Continued

gypsum in breccias? and otherwise intimate intercalations; has some grayish-blue fine-grained anhydrite in bottom of unit; not processed for conodonts; 6.1 ft.		
8. Anhydrite zone, mostly light grayish-blue, fine-grained; has some intimate mixtures of gray fine-grained earthy limestone (as in unit 7) and a several-inch zone of gypsum near top; also has gypsum crystals as much as three-fourths in. throughout but especially in bottom 2 ft; not processed for conodonts; 14.2 ft.	29* 30* 31* 32*	371.2-375.0 375.0-377.6 377.6-381.6 381.6-385.4
9. Gypsum zone, as that of unit 7 but has very little gray argillaceous fine-grained limestone; has very little anhydrite as that of unit 8; bottom contact is sharp and inclined about 30°; not processed for conodonts; 4.1 ft.	33*	385.4-389.5
10. Dolomite, light-tan, very fine-grained and chalk-textured above to brown and fine- to medium-grained below; has prominent calcite-lined vug at base; contact below is somewhat arbitrary but picked at change to limestone and presence of scattered dark irregular shaly laminae; 23.0 ft.	34C 35 36 37C 38C 39	389.5-393.0 393.0-397.0 397.0-401.0 401.0-405.0 405.0-409.0 409.0-412.5
11. Limestone (top 9.5 ft) and dolomite; tan in upper two-thirds and gray in lower one-third; mostly very fine grained; middle one-third mostly uniform, the part either above or below having irregular dark shaly laminae; lower part has 2-ft brecciated zone at base and a similar 1-ft zone about 9½ ft above base; to Salina Formation (Silurian); 28.0 ft; fauna includes *Polygnathus linguiformis linguiformis, P. "webbi," P. robusticostatus, P. angusticostatus,* and *Spathognathodus bidentatus* juvenile.	40 41C 42C 43C 44C 45 46 47	412.5-416.0 416.0-420.0 420.0-424.0 424.0-428.0 428.0-432.0 432.0-434.7 434.7-437.8 437.8-440.5

Section 5 (IU10702). Log of core from Northern Indiana Public Service Co. Wes Worthington No. 1 well near Mill Creek, LaPorte County, Ind. (NE¼NW¼ SW¼ sec. 8, T. 36 N., R. 1 W.). Altitude, 731 ft. After log by Robert H. Shaver, Indiana Geological Survey, June 8, 1965.

	Sample No.	Depth (ft)
Devonian System:		
Antrim Shale, 13.3 ft measured:		
1. Shale, mostly brownish-black, carbonaceous, fossiliferous; contains *Lingulella;* has some gray laminae and pyrite nodules; not processed for conodonts; 5.3 ft.	1* 2*	325.1-329.0 329.0-330.4
2. Shale, gray; becomes vermiform mottled in bottom few feet; calcareous or dolomitic; 8.0 ft; fauna includes *Polygnathus cristatus, P. decorosus, P. pennatus,* and *Schmidtognathus peracutus.*	3C 4C 5C	330.4-333.4 333.4-335.9 335.9-338.4
Traverse Formation, 69.9 ft:		
3. Dolomite, brown and gray; of variable aspect; some is argillaceous and fine grained, but most is fine to coarse grained (partly recrystallized) and vuggy and contains much sparry calcite, some in euhedral dolomite and calcite crystals; fossiliferous and bioclastic in part, containing corals and other macroinvertebrates; 2.0 ft; fauna includes *Polygnathus cristatus, P. pennatus, P. decorosus, P. varcus,* and *Icriodus latericrescens latericrescens.*	6C	338.4-340.4
4. Dolomite, as the purer part of unit 3; contains more silicified fossils and more obviously bioclastic; 2.4 ft; fauna includes *Polygnathus varcus* and *Icriodus latericrescens latericrescens.*	7C	340.4-342.8
5. Dolomite, gray, mostly medium- to coarse-grained, vuggy; has distorted bedding, veins of white calcite, and petroliferous residue; shaly and finely sandy to coarsely bioclastic in lower 4 in.; sand is carbonate debris; 1.3 ft; fauna includes *Polygnathus varcus.*	8C	342.8-344.1

Devonian System—Continued

Traverse Formation—Continued

6. Limestone, off-white; consists of light-gray very coarse carbonate debris in cream-colored chalk-textured calcite matrix composed of fossil material (bryozoan mats in part); has some petroliferous residue and few stylolites; fine grained near base; 14.7 ft; fauna includes *Icriodus latericrescens latericrescens.*	9C 10C 11C 12C	344.1-348.0 348.0-351.8 351.8-355.5 355.5-358.8
7. Limestone, white; mostly chalky material as that of unit 6, containing very little coarse matter; has 5-in. zone of unit 6 lithology; 3.4 ft.	13	358.8-362.2
8. Limestone and some dolomitic limestone, greenish, gray, and brown, mostly granular, somewhat argillaceous, bioclastic, fine- to coarse-grained; has many shaly laminae that are irregular and also wrapped around other fossils (tetracorals and other debris); some is pure and fine grained; some (388-392 ft) is slightly glauconitic and phosphatic; 32.5 ft; fauna includes *Icriodus latericrescens latericrescens.*	14 15C 16 17C 18C 19C 20C 21C 22C	362.2-366.3 366.3-370.2 370.2-374.2 374.2-377.8 377.8-381.6 381.6-385.0 385.0-388.4 388.4-391.8 391.8-394.7
9. Limestone, brown, medium-grained, pure; also limestone as in unit 6, gray-tan, finely bioclastic in chalky matrix, bearing irregular coarse-grained bioclastic brown zones containing corals, brachiopods, and other fossil debris; 13.6 ft; fauna includes *Icriodus latericrescens latericrescens.*	23C 24C 25 26C	394.7-399.0 399.0-403.0 403.0-406.3 406.3-408.3

Detroit River Formation, 115.5 ft:

10. Limestone, tan and gray, lithographic and sublithographic; has black shaly irregular laminae and some fine-grained bioclastic zones, especially in bottom few feet; 17.5 ft.	27 28 29 30C 31C	408.3-411.6 411.6-414.8 414.8-418.7 418.7-422.5 422.5-425.8
11. Limestone, gray, tan, and brown; mostly lithographic as above but contains 1- to 2-in. zones of dark shale and shaly carbonate that has irregular or inclined bedding; 6.3 ft.	32C 33	425.8-428.9 428.9-432.1

Devonian System—Continued

Detroit River Formation—Continued

12. Limestone, gypsum, and anhydrite; limestone as unit 11 but mostly as breccia and concentrated in bottom and top 2 ft and also in a shaly sulfate zone near top that has sulfate veins and other sulfate fillings; most sulfate probably is gypsum; middle few feet is coarsely crystalline gypsum not processed for conodonts; 7.3 ft.	34 35* 36	432.1-433.9 433.9-437.5 437.5-439.4
13. Anhydrite mostly; blue white, finely crystalline, bearing larger, apparently isolated crystals of gypsum as much as one-eighth in. by one-half in., especially bottom and top 1 ft as unit 12, containing laminae and irregular intercalations of fine-grained and lithographic limestone and coarsely crystalline gypsum; not processed for conodonts; 14.6 ft.	37* 38* 39* 40*	439.4-443.2 443.2-447.0 447.0-450.8 450.8-454.0
14. Gypsum mostly; much as unit 12 but having nearly pure coarsely crystalline gypsum at top and breccia and laminae of fine-grained earthy dolomite in bottom 1 ft; not processed for conodonts; 4.2 ft.	41*	454.0-458.2
15. Dolomite, tan, very fine-grained, earthy, sparsely stylolitic; has small white chalk-textured chert nodules near middle and some lamination near top; 10.9 ft.	42C 43 44C	458.2-461.8 461.8-465.0 465.0-469.1
16. Dolomite, brown, very fine-grained, saccharoidal, fairly pure, finely vuggy, uniform; has sparse irregular black shale laminae; 15.2 ft.	45C 46C 47 48	469.1-472.8 472.8-478.6 478.6-481.4 481.4-484.3
17. Dolomite, tan and brown, somewhat gray-mottled and irregularly banded, very fine-grained and earthy to saccharoidal; has common irregular shaly to stylolitic partings and some disseminated gypsum crystals and veins; has more shale and inclined bedding in bottom 2 ft; 20.3 ft; fauna includes	49C 50C 51C 52C 53C 54	484.3-487.7 487.7-491.7 491.7-495.0 495.0-498.0 498.0-502.0 502.0-504.6

Devonian System—Continued

Detroit River Formation—Continued

Polygnathus linguiformis linguiformis, P. "webbi," P. robusticostatus, P. angusticostatus, and *Spathognathodus bidentatus* juvenile.

	Sample No.	Depth (ft)
18. High clastic zone; irregularly color banded and mottled; breccia that consists of cream-colored fine-grained earthy dolomite; this dolomite also in irregular thin beds; gray lithographic dolomite; dark shaly carbonate in irregular partings and beds, partly around brecciated fragments; has veins and irregular pockets of gypsum; 15.7 ft.	55 56 57 58	504.6-508.3 508.3-512.3 512.3-516.3 516.3-520.3
19. Dolomite, brown to gray, fine-grained to sublithographic, earthy; bottom 1 ft has fine-grained subrounded disseminated quartz grains; to Salina Formation (Silurian); 3.5 ft.	59	520.3-523.8

Section 6 (IU10704). Log of core from Northern Indiana Public Service Co. Dean Readman No. 1 well near Bremen, Marshall County, Ind. (SE¼NE¼NW¼ sec. 12, T. 34 N., R. 2 E.). Altitude, 809 ft. After log by Robert H. Shaver, Indiana Geological Survey, July 22, 1966.

	Sample No.	Depth (ft)
Mississippian System:		
Ellsworth Shale, 45.0 ft:		
(Represented on strip log, probably from bedrock surface down.)		
1. Shale, gray-green, very finely silty; unit has some gray dolomite, shale, and some black shale; not processed for conodonts; 30.0 ft.		240.0-270.0
2. Shale, as above, and an even amount of black carbonaceous very finely silty shale; not processed for conodonts; 15.0 ft.		270.0-285.0
Mississippian and Devonian Systems:		
Antrim Shale, 95.3 ft:		
3. Shale, black, carbonaceous, pyritic at 305-315		285.0-365.0

Mississippian and Devonian Systems—Continued

Antrim Shale—Continued

ft; has red-brown spores; lower 10 ft is brownish black and has coarser silt and probably more spores; not processed for conodonts; 80.0 ft.

4. Calcareous shale, light-gray, very calcareous; not processed for conodonts; 15.3 ft.		365.0-370.3
	1*	370.3-374.1
	2*	374.1-377.7
	3*	377.7-380.3

Devonian System:

Traverse Formation, 71.9 ft:

5. Limestone and some dolomitic limestone (upper 1½ ft), brownish-gray; dominantly coarse grained but has middle finer grained and darker parts; bioclastic, fossiliferous; has carbonaceous fragments; finer grained part (in middle) has black carbonaceous irregular shaly laminae; has few stylolites; has large, uniformly cleavable crystals that probably are matrix cement; 12.8 ft; fauna includes *Polygnathus varcus, P. linguiformis linguiformis,* and *Icriodus latericrescens latericrescens.*	4C	380.3-383.9
	5C	383.9-386.2
	6C	386.2-389.6
	7C	389.6-393.1
6. Limestone, light-gray, uniformly fine-grained but apparently bioclastic and finely oolitic, somewhat stylolitic; lower part has pods of lithology as unit 7; 19.6 ft.	8C	393.1-396.7
	9	396.7-400.4
	10	400.4-404.1
	11	404.1-408.2
	12	408.2-412.7
7. Limestone, tan, fine-grained to very coarse-grained and abundantly fossiliferous, bioclastic; has dark shaly highly irregular laminae associated with most fossiliferous parts; large coral fragments particularly conspicuous; 9.3 ft; fauna includes *Icriodus latericrescens latericrescens.*	13C	412.7-416.0
	14	416.0-419.7
	15C	419.7-422.0
8. Alternating intervals of two kinds of limestone: (a) limestone, light-gray; as that of unit 6, ranging to coarsely bioclastic and having	16C	422.0-425.7
	17C	425.7-429.6
	18C	429.6-433.5

Devonian System—Continued

Traverse Formation—Continued

abundant brachiopods; (b) limestone, brownish-gray; mostly fine grained and approaching earthy and argillaceous; has many irregular shaly laminae and some coarse fossil debris; contact with unit 9 somewhat arbitrary; 16.4 ft; fauna includes *Polygnathus varcus* and *Icriodus latericrescens latericrescens.*	19C 20C	433.5-436.3 436.3-438.4
9. Limestone, light-brown; mostly fine grained and approaching earthy texture but probably all bioclastic; has much fossil debris and large fossil fragments (especially corals and bryozoans); lower 2 ft is darker brown and coarse grained but has many dark irregular shaly laminae; unit much as unit 7; 9.4 ft.	21C 22 23	438.4-441.2 441.2-445.1 445.1-447.8
10. Limestone, dark-gray and brown, rather uniformly grained, medium- and coarse-grained, bioclastic; lower contact sharp and at average of 30° in core along curved surface; 4.4 ft; fauna includes *Icriodus latericrescens latericrescens.*	24C 25C	447.8-450.6 450.6-452.2

Detroit River Formation, 93.6 ft:

11. Limestone; in shades of gray and tan; mostly sublithographic and lithographic; some fine grained; some has good thin lamination, in part inclined; has stylolitic and other irregular dark shaly partings; lower 2½ ft has some white sulfate stringers and grades down to tan fine-grained probably bioclastic limestone as that of unit 6; 20.1 ft.	26 27 28 29 30C 31	452.2-456.0 456.0-460.0 460.0-463.8 463.8-467.6 467.6-469.4 469.4-472.3
12. Limestone, thinly banded (somewhat irregularly); tan and gray; has some mottling and is fine grained and thinly and well laminated; 2.4 ft.	32	472.3-474.7
13. Limestone and dolomite, rich-brown; also tan in middle part but has conspicuous bands and splotches of tan (in rich brown); mostly very fine grained; earthy but apparently	33 34 35C 36C	474.7-478.7 478.7-482.5 482.5-486.0 486.0-490.4

Devonian System—Continued

Detroit River Formation—Continued

rather pure and bioclastic; tan bands and splotches are laminated and are probably stromatoporoidal; has some coarse bioclastic parts; has stringers, veins, and more or less isolated crystals of gypsum; 15.7 ft.		
14. Dolomitic limestone and dolomite, tan, very fine-grained; mostly as that of middle part of unit 13 but lacking stromatoporoids and coarse fossil debris; has faint to well-developed laminae; lower part grades to unit 15 and has some brecciation; 7.6 ft.	37C 38C	490.4-494.5 494.5-498.0
15. Dolomite of two alternating kinds: (a) dolomite, tan and gray with some vermiform mottling, approaching sublithographic, earthy, apparently argillaceous; has some dark irregular carbonaceous partings; (b) dolomite, tan, very fine-grained, thinly laminated in part; unit has several few-inch bands of coarsely crystalline gypsum; 15.6 ft.	39C 40 41 42	498.0-502.0 502.0-505.8 505.8-509.6 509.6-513.6
16. Gypsum, white to colorless, very coarsely crystalline; has little white anhydrite; not processed for conodonts; 5.0 ft.	43*	513.6-518.6
17. Anhydrite and dolomite in about equal amounts; dolomite of both kinds of unit 15; anhydrite, ice-blue, fine-grained; sulfate and carbonate rocks are both interbedded on medium scale (1 to 2 ft) and very intimately intercalated; some gypsum as that of unit 16 is present; upper 3.8 ft not processed for conodonts; 12.7 ft.	44* 45 46	518.6-522.4 522.4-526.3 526.3-531.3
18. Dolomite and gypsum in about equal amounts; dolomite, banded brown and tan, very fine-grained, thinly laminated, as part of that of units 15 and 17; gypsum, as that of unit 16; gypsum and dolomite are both interbedded on medium scale and intimately intercalated; unit has little anhydrite and earthy dolomite	47* 48C 49	531.3-534.9 534.9-538.8 538.8-544.7

Devonian System–Continued

Detroit River Formation–Continued

as that of units 15 and 17; lower 1 ft consists mostly of carbonate and pebbles in an earthy matrix; upper 3.6 ft not processed for conodonts; 13.4 ft; fauna includes *Icriodus* cf. *I. angustus.*

19. Sandstone, greenish-gray, very fine-grained, highly dolomitic, apparently somewhat brecciated; sand is composed of finely rounded quartz grains; contact with unit below is sharp and irregular, having 1-in. relief; upper 10 ft of unit below has pods and irregular fillings of greenish, clayey, and dolomitic sand from above, suggesting a fractured unconformable surface; to Salina Formation (Silurian); 1.1 ft. — 50 — 544.7-545.8

Section 7 (IU10719). Log of core from Indiana Geological Survey drill hole 167 near Warsaw, Kosciusko County, Ind. (W½SE¼ sec. 12, T. 32 N., R. 5 E.). Altitude, 825 ft. After log by Robert H. Shaver, Indiana Geological Survey, April 28, 1967.

	Sample No.	Depth (ft)
Devonian System:		
Antrim Shale, 24.3 ft cored:		
1. Shaly limestone, gray, very fine-grained to dense and earthy, fossiliferous; fossil material is in coarse fragments and larger pieces (corals and bryozoans) and tends to be concentrated in few-inch bands but also is diffuse; has sparse small pyrite nodules; units 1 and 2 are called "Antrim" here but may correspond to the so-called "Traverse lime" of the Michigan Basin; 7.2 ft; fauna includes *Palmatolepis? disparalvea, Polygnathus ordinatus, P. foliatus, P. cristatus,* and *P. varcus.*	1C 2C	200.0-204.0 204.0-207.2

Devonian System—Continued

Antrim Shale—Continued

2. Limy shale, dark-gray; unit is much like unit 1, but fossils (brachiopods in part) are inconspicuous and pyrite in thin granular bands and small pods is conspicuous; bottom inch is a finely brecciated mixture of material; 17.1 ft; fauna includes *Polygnathus varcus* and *P. cristatus.*	3 4 5C 6 7C 8C	207.2-210.0 210.0-214.0 214.0-218.0 218.0-221.1 221.1-224.2 224.2-224.3

Traverse Formation, 107.3 ft:

3. Limestone, light-gray and gray (lower middle part), medium to very coarse-grained, bioclastic in part; has some dark shaly irregular to stylolitic partings and thin bands of shale; pyrite evident at 15 in. below top and 18 in. above bottom of unit; 9.5 ft; fauna includes *Polygnathus varcus, P. linguiformis linguiformis,* and *Icriodus latericrescens latericrescens.*	9C 10C 11C 12C	224.3-225.0 225.0-228.2 228.2-232.0 232.0-233.7
4. Limestone, brown, fine-grained, cherty; has some black carbonaceous irregular to stylolitic partings; chert is in light tan-gray fresh- to chalky-appearing nodules and bands; 4.5 ft; fauna includes *Icriodus latericrescens latericrescens.*	13C 14C	233.7-236.0 236.0-238.2
5. Limestone, light-tan, coarsely biogranular for most part; appears to consist both of light-colored chalk-textured matrix and of coarse fossil fragments that in part retain original outlines and in part are rhombically cleaved grains; corals and bryozoans very abundant; 13.1 ft; fauna includes *Polygnathus varcus* and *Icriodus latericrescens latericrescens.*	15C 16C 17C 18C	238.2-242.0 242.0-245.2 245.2-248.0 248.0-251.3
6. Limestone, tan-gray (upper 1 ft) and dark-gray and gray, coarse-grained and probably bioclastic for most part; has dark shale stringers and irregular to stylolitic partings; has gray chert band 21 in. below top and two tan	19C 20C 21C	251.3-254.0 254.0-258.0 258.0-262.1

Devonian System—Continued

Traverse Formation—Continued

fossiliferous chert bands in bottom 6 in. of unit; differs from unit 5 and from part of unit 7 by lacking chalk-textured matrix and readily recognized fossil fragments; 10.8 ft; fauna includes *Polygnathus varcus, P. linguiformis linguiformis,* and *Icriodus latericrescens latericrescens.*		
7. Limestone; consists of four alternating and partly intergrading parts: light tan, gray, gray tan, and brown (downward order); the top and middle parts mostly like unit 6; has shale stringers and stylolitic partings but lacks chert; bottom 3 in. of unit is brecciated mixture of unit 7 and 8 lithologies; 11.6 ft; fauna same as in unit 6.	22C 23C 24C	262.1-266.0 266.0-270.0 270.0-273.7
8. Shaly limestone and limestone, dark-gray and gray, fine-grained, dense, and shaly to medium-grained and argillaceous; granular parts are finely bioclastic and unit has sparse larger fossils (spiriferoid brachiopods); 5.3 ft; fauna includes *Polygnathus linguiformis linguiformis* and *Icriodus latericrescens latericrescens.*	25C 26C	273.7-276.0 276.0-279.0
9. Limestone, tan-gray, fine- to medium-grained and bioclastic; 1.8 ft; fauna includes *Icriodus latericrescens latericrescens.*	27C	279.0-280.8
10. Limestone, light tan-gray, lithographic, faintly laminated; has dark incipiently stylolitic seams; 3.1 ft.	28C	280.8-283.9
11. Limestone, light tan-gray; a unit that is transitional, consisting of fine-grained bioclastic material and very fine-grained to sublithographic material; 1.4 ft; fauna includes *Icriodus latericrescens latericrescens.*	29C	283.9-285.3
12. Limestone; consists of alternating thick and thin and subtly intergrading parts, light tan-gray and gray, fine-grained to coarsely biogranular; has dark partings and stylolitic	30C 31C 32C 33C	285.3-289.3 289.3-292.0 292.0-296.0 296.0-300.0

Devonian System—Continued		
Traverse Formation—Continued		
seams; 24.0 ft; fauna includes *Icriodus latericrescens latericrescens.*	34C	300.0-303.1
	35C	303.1-306.0
	36C	306.0-309.3
13. Limestone and chert, interbedded, coarsely banded grayish-tan and whitish-tan; limestone is mostly fine grained but has some coarser bioclastic material; chert is mostly chalky textured and dull lustered; 7.6 ft; fauna includes *Icriodus latericrescens latericrescens.*	37C	309.3-313.7
	38C	313.7-316.9
14. Limestone, brown, brownish-gray, and tan-gray, mostly fine-grained and probably argillaceous, fossiliferous; has parts more coarsely bioclastic, appearing similar to unit 5 lithology; has parts that are stromatoporoidal layers and masses; has dark irregular partings and stylolitic seams; lower few inches is a brecciated mixture of lithologies of units 13 and 14; 14.7 ft; fauna includes *Icriodus latericrescens latericrescens.*	39	316.9-320.0
	40C	320.0-324.0
	41C	324.0-328.0
	42C	328.0-331.6
Detroit River Formation, 32.4 ft:		
15. Dolomite in alternating parts; eight parts are light gray, very fine grained, and earthy appearing and are probably argillaceous to finely silty; the other parts are mostly thinly banded brown and tan, very fine grained to sublithographic, and laminated; gray parts have some black shale bands, stylolites, and zones of brecciation; part of brown units have inclined to highly contorted laminae; entire unit begins with brown dolomite at top and ends with few inches of gray dolomite that is silty to sparsely sandy and that has some black brecciated shale intercalations in bottom 1 in.; to Salina Formation (Silurian); 32.4 ft.	43	331.6-334.0
	44	334.0-336.7
	45	336.7-341.1
	46	341.1-342.2
	47	342.2-346.8
	48	346.8-348.8
	49	348.8-350.0
	50	350.0-353.4
	51	353.4-355.4
	52	355.4-358.1
	53	358.1-360.0
	54	360.0-362.7

Section 8 (IU10705). Log of core from Northern Indiana Public Service Co. Mosher No. 1 well near Columbia City, Whitley County, Ind. (NW¼NW¼NW¼ sec. 23, T. 31 N., R. 9 E.). Altitude, 829 ft. After log by Robert H. Shaver, Indiana Geological Survey, October 28, 1964.

	Sample No.	Depth (ft)
Quaternary System:		
1. Surficial materials (from driller's log) to		210.0
Devonian System:		
2. No core in the collection.		210.0-220.0
Traverse Formation, 52.6 ft:		
3. Limestone, tan and gray, dense to fine-grained, both argillaceous and shaly, fossiliferous (especially brachiopods); grades to and is laminated or otherwise intercalated with brown coarse-grained limestone; has dark carbonaceous partings throughout; 6.3 ft; fauna includes *Polygnathus varcus, P. linguiformis linguiformis,* and *Icriodus latericrescens latericrescens.*	1C 2C 3C	220.0-222.0 222.0-224.1 224.1-226.3
4. Limestone, light-tan to light-brown, fine- to coarse-grained and fossil-fragmental, vuggy where coarse-grained, fossiliferous; has gray-white porcellaneous chert nodules in lower middle part; 6.7 ft; fauna same as in unit 3.	4C 5C 6C 7C	226.3-228.3 228.3-230.0 230.0-231.5 231.5-233.0
5. Limestone, mostly as in unit 3; medium brown to gray brown; varies from shaly limestone to dense to medium-grained argillaceous limestone; has irregular pods of coarser material; fairly fossiliferous (especially brachiopods); has zones of dark carbonaceous wavy laminae; 15.1 ft; fauna includes *P. linguiformis linguiformis, P. pseudofoliatus,* and *Icriodus latericrescens latericrescens.*	8C 9C 10C 11C 12C 13C 14C 15C	233.0-235.0 235.0-236.9 236.9-238.7 238.7-240.0 240.0-242.4 242.4-244.3 244.3-246.0 246.0-248.1
6. Limestone, dark-gray, dense to fine-grained, argillaceous to shaly, fossil-fragmental in coarser phases; has light-gray dense to fine-grained rounded large-gravel size silicified carbonate nodules; has dark shaly wavy	16C 17C	248.1-250.1 250.1-253.9

Devonian System—Continued

Traverse Formation—Continued

partings; 5.8 ft; fauna includes *Polygnathus pseudofoliatus* and *Icriodus latericrescens latericrescens.*		
7. Limestone, dark-tan to brown, mostly fine-grained, fairly pure; grades both at top and bottom to limestone like that of unit 6; 4.6 ft; fauna includes *Icriodus latericrescens latericrescens.*	18C 19C	253.9-256.0 256.0-258.5
8. Limestone, like that of unit 6; 2.5 ft; fauna includes *Icriodus latericrescens latericrescens.*	20C	258.5-261.0
9. Limestone, tan, fine- to medium-grained, fossiliferous (especially brachiopods); has coarser grained fossil-fragmental parts and black carbonaceous irregular partings; 11.6 ft; fauna includes *Icriodus latericrescens latericrescens.*	21C 22C 23C 24C 25C	261.0-263.0 263.0-265.0 265.0-267.0 267.0-269.8 269.8-272.6

Detroit River Formation, 40.3 ft:

10. Limestone, tan-brown, sublithographic to very fine-grained; 0.7 ft.	26	272.6-273.3
11. Dolomitic limestone and dolomite, gray-tan, fine-grained, earthy, argillaceous; has little tan fine-grained purer dolomitic limestone; has solution and (or) brecciation features; 9.4 ft.	27C 28 29	273.3-276.0 276.0-278.6 278.6-282.7
12. Dolomite, tan and brown, fine-grained; 0.7 ft.	30	282.7-283.4
13. Limestone, light-tan, dense, earthy; part has finely vermiform gypsum (selenite) intercalations; 1.4 ft.	31	283.4-284.8
14. Dolomite, gray and light-brown, partly color-banded, dense to fine-grained; has stringers and pods of gypsum (selenite); 1.1 ft.	32C	284.8-285.9
15. Dolomite, gray and tan, fine-grained; has drusy vugs, solution structures (stylolites and brecciation), and stringers of sparry calcite; 6.0 ft.	33 34	285.9-289.9 289.9-291.9
16. Dolomite, tan and brown, somewhat color-banded, fine-grained saccharoidal to medium-grained, finely vuggy; 2.0 ft.	35	291.9-293.9

Devonian System—Continued		
Detroit River Formation—Continued		
17. Dolomite, light-gray, mostly dense, argillaceous, earthy, and sparsely silty to finely sandy; also fine grained and argillaceous; has dark carbonaceous shaly partings; sandy part has fine angular to subangular quartz grains; 1.3 ft.	36	293.9-295.2
18. Dolomite, tan to brown, mostly faintly color-banded, fine-grained, mostly saccharoidal, pure, vuggy and approaching reefy aspect in few-inch zones; bottom few inches apparently were oolitic but now are honeycombed with tiny spherical vugs; coarse vugs are drusy and one probably has celestite or barite; 11.7 ft.	37 38 39 40 41 42	295.2-297.0 297.0-299.0 299.0-301.0 301.0-303.0 303.0-305.0 305.0-306.9
19. Dolomite in clastic zone including breccia of gray dolomite and tan dolomite that is very fine grained and light tan, faintly color banded, dense, earthy, argillaceous, silty to sandy; pyritic; stylolitic in part; sand consists of fine rounded quartz grains; has partings and thin beds of dark gray-green shaly dolomite to dark carbonaceous shale bearing light-colored sulfate veinlets; has sparry calcite veins in brecciated zones; to Salina Formation (Silurian); 6.0 ft.	43	306.9-312.9

Section 9 (IU10707). Log of core from Northern Indiana Public Service Co. A. Tubbs No. 1 well near Helmer, Steuben County, Ind. (SW¼SE¼SW¼ sec. 27, T. 36 N., R. 12 E.). Altitude, 944 ft. After log by Robert H. Shaver, Indiana Geological Survey, March 14, 1966.

	Sample No.	Depth (ft)
Devonian System:		
Antrim Shale, 64.0 ft examined:		
1. Dolomite and shale; dolomite is grayish brown, dense, earthy, and argillaceous and grades	1C 2C	614.0-616.0 616.0-618.0

Devonian System—Continued

Antrim Shale—Continued

down in a few feet to dolomitic shale that	3C	618.0-620.0
is dark grayish brown and that is calcareous	4C	620.0-622.0
in lower part; unit is biofragmental in part	5C	622.0-624.0
of upper part and also has near-coquinas,	6C	624.0-625.9
including brachiopods; grades to unit 2; 11.9 ft; fauna includes *Polygnathus cristatus, P. variabilis, P. decorosus, P. pennatus, P. foliatus, P. caelatus,* and *Palmatolepis? disparalvea.*		
2. Shale, calcareous, brownish-black, carbona-	7*	625.9-630.0
ceous; has fossils as above but fewer; grades	8C	630.0-633.3
to unit 3; most of unit not processed for	9*	633.3-636.0
conodonts; 16.6 ft; fauna includes *Palmato-*	10*	636.0-639.0
lepis? disparalvea and *Polygnathus decorosus.*	11*	639.0-640.6
	12*	640.6-642.5
3. Calcareous shale and shaly limestone, grading	13*	642.5-644.9
in short intervals from one to the other;	14*	644.9-648.0
mostly brownish gray, dense; has pyrite	15C	648.0-650.0
veins and nodules and fossils as above; grades to unit 4; upper part not processed for conodonts; 7.5 ft.		
4. Dolomitic limestone and limestone, brown,	16C	650.0-653.0
fine-grained, argillaceous; grades down to	17C	653.0-655.3
carbonate rocks that have many shaly and	18C	655.3-658.2
carbonaceous laminae and stylolitic seams;	19C	658.2-660.8
has near-coquinas; lower 2 ft is light colored, coarser grained, and biofragmental and has gray fossiliferous intercalations of shale; 13.7 ft; fauna includes *Polygnathus cristatus, P. decorosus, P. linguiformis linguiformis, P. varcus, P. alveoliposticus,* and *Icriodus latericrescens latericrescens.*	20C	660.8-663.7
5. Shale, calcareous, dark gray-brown to black,	21C	663.7-666.0
carbonaceous; has some fossils and pyrite	22*	666.0-670.0
nodules; 7-ft loss of core presumed in this	23*	670.0-674.0
interval; lower part not processed for cono-	24*	674.0-678.0
donts; 14.3 ft; fauna includes *Polygnathus varcus.*		

Devonian System—Continued

Traverse Formation, 97.3 ft:

6. Limestone; in shades of gray and brown; fine- to medium-grained, biofragmental, fossiliferous; has many shaly and very fossiliferous irregular laminae and thin shale beds; has large chert nodules that are fossiliferous, light colored, and tripolitic to unaltered; 24.0 ft; fauna includes *P. varcus, P. linguiformis linguiformis,* and *Icriodus latericrescens latericrescens.*	25C 26C 27C 28C 29C 30C 31C	678.0-680.8 680.8-683.9 683.9-686.8 686.8-689.5 689.5-692.0 692.0-694.7 694.7-702.0
7. Limestone, tan, mostly coarse-grained, biofragmental; has larger fossil fragments, finely vuggy in part; grades to lower part that has many dark irregular very fossiliferous laminae and intercalations; grades to unit 8; 12.5 ft; fauna same as in unit 6.	32C 33C 34C 35C 36C	702.0-704.0 704.0-704.8 704.8-707.5 707.5-710.0 710.0-714.5
8. Shale, calcareous, gray, very fossiliferous in upper and lower parts; grades to unit 9; 6.7 ft; fauna includes *Icriodus latericrescens latericrescens.*	37C 38C 39C	714.5-716.4 716.4-718.9 718.9-721.2
9. Shaly limestone and limestone in alternating few-foot units; shaly limestone units are mottled to banded in shades of gray, are highly fossiliferous, and consist of intimate mixtures of shale and biofragmental limestone; limestone units are dense and argillaceous to coarse grained and biofragmental and have many thin dark laminae and stylolitic seams; entire unit apparently has sparse chalklike chert nodules; 36.5 ft; fauna includes *Icriodus latericrescens latericrescens, Polygnathus linguiformis linguiformis,* and *P. pseudofoliatus.*	40C 41C 42C 43C 44C 45C 46C 47C 48C 49C 50C 51C 52C 53C	721.2-724.0 724.0-726.8 726.8-729.0 729.0-731.0 731.0-733.0 733.0-735.4 735.4-736.9 736.9-740.7 740.7-743.7 743.7-746.8 746.8-750.0 750.0-753.2 753.2-756.0 756.0-757.7
10. Limestone, brown, mostly fine-grained, argillaceous, very fossiliferous; apparently has many tan irregular chalk-textured impure chert nodules; corals conspicuous; has a few	54C 55C 56C 57C	757.7-760.0 760.0-762.0 762.0-764.7 764.7-767.4

Devonian System—Continued		
Traverse Formation—Continued		
coarse stylolites; grades to unit 11; 11.6 ft; fauna includes *Icriodus latericrescens latericrescens.*	58C	767.4-769.3
11. Limestone grading down to dolomite, gray-brown, dense to fine-grained, argillaceous, fossiliferous; 6.0 ft; fauna includes *Icriodus latericrescens latericrescens* and *Polygnathus linguiformis linguiformis.*	59C 60C 61C	769.3-771.7 771.7-773.7 773.7-775.3
Detroit River Formation, 77.7 ft:		
12. Dolomite breccia; in shades of tan and brown; dense, argillaceous, and earthy to fine grained and purer; breccia cemented in part by veins and inclusions of coarsely cleavable gypsum; 10.0 ft.	62C 63C 64 65	775.3-777.5 777.5-779.7 779.7-783.0 783.0-785.3
13. Dolomite, brown, fine-grained; has few veins of cleavable gypsum; 4.2 ft.	66 67	785.3-788.4 788.4-789.5
14. Dolomite and evaporitic rocks; dolomite is gray to brown, sublithographic to dense, argillaceous and earthy to fine-grained and purer, the different types being intimately mixed to dominant in few-foot intervals; evaporitic rocks consist of few-foot intervals of coarsely cleavable, mostly colorless gypsum and of bluish-white fine-grained anhydrite; evaporitic rocks have interbeds and other inclusions of carbonate rocks, and evaporite minerals are also included in veins, fillings, and crystals in the dominantly carbonate intervals; highly gypsiferous units are at 796.5-798.5, 804.5-805.7, and 839.5-843.0 ft; highly anhydritic units are at 805.7-810.0, 824.3-831.0, and 835.5-839.5 ft; these evaporite-dominant intervals have inclusions of the one evaporite in the other; bottom of unit at base of lowest prominent gypsum band, but unit grades to unit 15; part not processed for conodonts; 53.5 ft.	68 69 70 71 72 73 74 75* 76 77 78 79 80C 81 82 83* 84 85 86 87* 88	789.5-792.5 792.5-795.2 795.2-798.0 798.0-800.6 800.6-803.3 803.3-806.2 806.2-808.6 808.6-810.2 810.2-812.6 812.6-815.0 815.0-817.1 817.1-819.3 819.3-822.5 822.5-824.8 824.8-827.0 827.0-830.0 830.0-832.6 832.6-835.2 835.2-838.7 838.7-840.0 840.0-843.0

Devonian System–Continued

Detroit River Formation–Continued

	Sample No.	Depth (ft)
15. Dolomite, gray, mostly dense to fine-grained, argillaceous in part; has intimately intercalated gypsum in veins, fillings, and disseminated grains; lower part has abundant fine-grained subrounded quartz sand and silt; lower few inches is a greenish-gray silty (quartz) dolomitic shale; to Salina Formation (Silurian); 10.0 ft.	89	843.0-845.7
	90	845.7-848.6
	91	848.6-851.9
	92	851.9-853.0

Section 10 (IU20708). Log of core from Northern Indiana Public Service Co. Main Clingman No. 1 well near Hudson, Steuben County, Ind. (NE¼NE¼ sec. 35, T. 36 N., R. 12 E.). Altitude, 952 ft. After log by Robert H. Shaver, Indiana Geological Survey, December 21, 1964.

	Sample No.	Depth (ft)
Devonian System:		
Antrim Shale, 18.0 ft cored:		
1. Shale and limestone, interbedded on thin to medium scale; shale is black, carbonaceous, calcareous, pyritic, and fossiliferous; limestone is dark brown, dense, argillaceous, and fossiliferous; fossils are brachiopods, more or less pyritized, especially in the shale; 18.0 ft; fauna includes *Polygnathus decorosus.*	1	668.0-670.0
	2	670.0-672.0
	3C	672.0-674.0
	4	674.0-676.0
	5	676.0-677.8
	6C	677.8-679.4
	7	679.4-681.2
	8C	681.2-683.0
	9	683.0-684.8
	10	684.8-686.0
Traverse Formation, 74.0 ft cored:		
2. Dolomitic limestone, brown, fine-grained, stylolitic, slightly pyritic; grades through 1 ft to unit 3; 10.1 ft; fauna includes *Polygnathus caelatus, P. linguiformis linguiformis, P. varcus,* and *Spathognathodus planus.*	11C	686.0-686.7
	12C	686.7-687.7
	13C	687.7-688.6
	14C	688.6-690.6
	15C	690.6-692.6
	16C	692.6-694.6
	17C	694.6-696.1

Devonian System—Continued

Traverse Formation—Continued

3. Limestone, dark-brown, sublithographic, fossiliferous; has thin dark partings; fossils are abundant (especially small brachiopods), partly in few-inch zones of shell "hash" and in part are pyritized to carbonized; grades in lower 1 ft to limestone as in unit 2; 2.7 ft; fauna includes *Polygnathus varcus* and *P. linguiformis linguiformis.*	18C 19C	696.1-697.8 697.8-698.8
4. Shale, black to dark-brown, calcareous, very fossiliferous (especially brachiopods); 0.6 ft; fauna same as in unit 3.	20C	698.8-699.4
5. Dolomite, alternating light-gray and tan to brown; light-colored dolomite is coarse to very coarse grained, vuggy, reeflike and consists especially of crinoidal debris; brown dolomite is medium to coarse grained, not vuggy; unit has two few-inch beds of color-banded chert; 8.9 ft; fauna same as in unit 3 and *Icriodus latericrescens latericrescens.*	21C 22C 23C 24C	699.4-702.0 702.0-704.7 704.7-706.4 706.4-708.3
6. Limestone; three intergrading and interbedded (to medium scale) types: (a) dark-brown, sublithographic, argillaceous, fossiliferous, having some coarse fossil detritus; (b) brown, medium-grained, somewhat glauconitic; (c) brown, very coarse-grained, fossil-detrital, having many irregular dark shaly laminae; fossil detritus of limestone c is in pods in shaly limestone and in large fragments; has considerable banded gray and brown chert 1 ft above base; 16.4 ft; fauna same as in unit 5.	25C 26C 27C 28C 29C 30C 31C	708.3-711.0 711.0-713.9 713.9-716.0 716.0-718.0 718.0-720.0 720.0-722.0 722.0-724.7
7. Limestone, light-gray and tan to brown, medium- to coarse-grained, slightly stylolitic; much is fossil fragmental; has 2-in. white tripolitic chert band in middle; brown dolomite is glauconitic; 4.7 ft; fauna same as in unit 5.	32C 33C	724.7-727.4 727.4-729.4

Devonian System—Continued

Traverse Formation—Continued

8. Limestone, light-brown and brown, mostly coarse-grained, fossil-fragmental; has shaly laminae and pods of fossil debris, larger fragments, and brachiopods; much is as limestone c of unit 6; grades to unit 9; 5.8 ft; fauna includes *Icriodus latericrescens latericrescens, Polygnathus linguiformis linguiformis,* and *P. pseudofoliatus.*	34C 35C 36C	729.4-731.6 731.6-733.9 733.9-735.2
9. Shale, black to dark-brown, calcareous, very fossiliferous, coarsely interlaminated in part with fossil debris; grades to limestone at top and bottom; has many strophomenid brachiopods; 5.8 ft; fauna includes *Icriodus latericrescens latericrescens* and *Polygnathus pseudofoliatus.*	37C 38 39C	735.2-737.0 737.0-738.8 738.8-741.0
10. Limestone; brown and shaly above, as that of unit 9; grades downward to limestone that is sublithographic and has many carbonaceous shaly partings and that is intimately intercalated with coarse-grained fossil-fragmental limestone; has many fossils (especially brachiopods and corals); grades to unit 11; 6.0 ft; fauna same as in unit 8.	40C 41C 42C	741.0-743.1 743.1-745.2 745.2-747.0
11. Limestone; much as that of unit 10 but less shaly; has much fossil detritus and many irregular carbonaceous laminae and consists of intermixed sublithographic and very coarse-grained fossiliferous limestone; has large tetracorals and brachiopods; bottom 3 ft is shalier; to total depth; 13.0 ft; fauna same as in unit 8.	43C 44C 45C 46C 47C 48C	747.0-749.2 749.2-751.4 751.4-753.4 753.4-755.8 755.8-758.0 758.0-760.0

Section 11 (IU10706). Log of core from Northern Indiana Public Service Co. Dohrman No. 1 well near Woodburn, Allen County, Ind. (NW¼NE¼NW¼ sec. 16, T. 31 N., R. 15 E.). Altitude, 747 ft. After log by Robert H. Shaver, Indiana Geological Survey, February 15, 1965.

	Sample No.	Depth (ft)
Quaternary System:		
1. Surficial materials to		52.0
Devonian System:		
Traverse Formation, 2.6 ft:		
2. Dolomite, tannish-gray, medium-grained, very finely vuggy; has small sparry dolomite crystals lining vugs; has coarse splotches of brown petroliferous stain; 2.6 ft; fauna includes *Icriodus latericrescens latericrescens* and *Polygnathus linguiformis linguiformis*.	1C	52.0-54.6
Detroit River Formation, 42.2 ft:		
3. Dolomite in brecciated zone (recemented), light-tan, very fine-grained, nearly sublithographic; has some brown fine-grained dolomite in highly brecciated zones; contact with unit 1 is disconformable, and dolomite of Traverse age, probably originally in the form of loose sediment, has penetrated unit 2 in the form of wedges or veins, matrix, and other filling; 4.7 ft.	2C 3	54.6-56.9 56.9-59.3
4. Dolomite of two kinds: (a) somewhat mottled, partly in vermiform pattern, tan and gray, very fine grained to sublithographic (as that indigenous to unit 2); (b) gray tan, fine grained, somewhat finely vuggy, having more or less conspicuous fine laminations (1 mm) that are somewhat wavy, carbonaceous, and in part inclined and distorted and having heavy brown petroliferous stain. Two kinds more or less alternate on 1- to 2-ft scale but intergrade; few-inch brecciated zones at 70.3 and 87.2 and other minor stylolitic and (or) brecciated zones; 29.3 ft.	4 5 6 7 8 9 10 11 12 13	59.3-61.7 61.7-65.0 65.0-69.0 69.0-71.8 71.8-74.5 74.5-78.0 78.0-80.7 80.7-82.7 82.7-84.7 84.7-88.6
5. Dolomite; like that of unit 4(a) but has some black shale partings and more conspicuous mottling; 1.1 ft.	14	88.6-89.7
6. Dolomite, light-tan, very fine-grained; has some indistinct lamination, in part inclined; 3.5 ft.	15	89.7-93.2

Devonian System—Continued		
Detroit River Formation—Continued		
7. Dolomitic breccia and shaly zone; dolomite is gray, ranging from sublithographic and argillaceous to fine grained and purer, the two types having considerable intimacy; mottled in part; some lamination and significant brecciation; has shale partings that are dark and green, irregular, partly slickensided, and stylolitic; 3.5 ft.	16 17	93.2-94.7 94.7-96.7
8. Shale, gray-green, sandy; bears fine subrounded clear quartz grains; not processed for conodonts; to Salina Formation (Silurian); 0.1 ft.	18*	96.7-96.8

Section 12 (IU10721). Exposure in active May Stone and Sand, Inc., Quarry, Fort Wayne, Allen County, Ind. (N½ sec. 29, T. 30 N., R. 12 E.).

	Sample No.	Ft
Devonian System:		
Traverse Formation, 10.3 ft measured:		
1. Limestone, light- to medium-gray, fine- to coarse-grained, abundantly fossiliferous (contains corals, stromatoporoids, bryozoans, and brachiopods); contains black carbonaceous partings throughout; separated from underlying Detroit River Formation by erosion surface with as much as 8 in. relief; has slabby appearance on weathering; 10.3 ft; fauna includes *Icriodus latericrescens latericrescens.*	1C 2C 3C 4C	0.0- 2.9 2.9- 5.8 5.8- 8.3 8.3-10.3
Detroit River Formation, 35.1 ft:		
2. Dolomite; mostly gray in upper part to mostly brown in lower part; fine grained; 5.8 ft.	5 6 7	10.3-11.7 11.7-13.6 13.6-16.1
3. Dolomite; gray dolomite in brown matrix; 2.3 ft.	8	16.1-18.4
4. Dolomite of two types: fine-grained gray dolomite and fine-grained laminated brown dolomite; 14.9 ft; fauna includes *Icriodus* cf. *I. angustus.*	9 10 11 12	18.4-19.9 19.9-21.4 21.4-23.9 23.9-26.2

Devonian System—Continued

Detroit River Formation—Continued

	13C	26.2-27.6
	14	27.6-30.4
	15	30.4-33.3
5. Dolomite, fine-grained, gray, argillaceous; shaly at top with distinct shale parting; 3.7 ft.	16	33.3-35.5
	17	35.5-37.0
6. Shale, yellow-green, limonitic; 0.3 in.	18	37.0-37.3
7. Dolomite, fine-grained, brown, thinly laminated; has dark shale partings and some sand in lower 8 in.; to Silurian; 8.1 ft; section described by A. P. Pinsak and Jack Sunderman in Shaver and others (1961, p. 42).	19	37.3-38.3
	20	38.3-40.8
	21	40.8-42.9
	22	42.9-44.8
	23	44.8-45.4

Section 13 (IU20709). Exposure in abandoned Cummin's Quarry near Samaria, Monroe County, Mich. (SE¼SE¼ sec. 2, T. 8 S., R. 6 E.).

	Sample No.	Ft
Devonian System:		
Amherstburg Formation, 13.6 ft exposed:		
1. Dolomite, light-gray and buff, fine- to medium-grained; unit has numerous slitlike cavities and contains molds of fossils; contains small amount of quartz sand; 9.7 ft.	1	0.0- 3.0
	2	3.0- 5.5
	3	5.5- 6.9
	4	6.9- 9.7
2. Dolomite, light-gray with some bluish-gray mottled areas; more arenaceous than unit 1 and becoming increasingly so toward bottom; contact with Sylvania Sandstone is 1 to 2 ft below bottom of unit (Ehlers in Ehlers, Stumm, and Kesling, 1951, p. 6); 3.9 ft.	5	9.7-10.8
	6	10.8-11.5
	7	11.5-13.6

Section 14 (IU10710). Exposure in active quarry of Brunner, Mond Canada, Ltd., 1¼ miles northeast of Amherstburg, Essex County, Ontario.

	Sample No.	Ft
Devonian System:		
Dundee Limestone, 36.7 ft measured:		
1. Limestone of two kinds: (a) gray and light brown, fine grained; has few fossils other than broken crinoid columnals; (b) light	1C	0.0- 0.2
	2C	0.2- 4.7
	3C	4.7-10.0

Devonian System—Continued

Dundee Limestone—Continued

gray and white, coarse grained, bioclastic, fossiliferous; 10.0 ft; fauna includes *Icriodus angustus* and *Polygnathus linguiformis linguiformis.*

2. Limestone, brown, fine- to medium-grained; contains some discontinuous dark fine laminae (1 mm); 12.3 ft; fauna includes *Polygnathus linguiformis linguiformis* and *P. "webbi."*	4C 5C 6C	10.0-15.0 15.0-18.8 18.8-22.3
3. Dolomitic limestone, light-brown and gray, fine-grained; contains chalky white chert near base and scattered pockets of calcite crystals; lower part contains some quartz sand; contact with Anderdon Limestone is disconformable; 14.4 ft; fauna includes *Icriodus angustus, I. latericrescens robustus,* and *Polygnathus linguiformis linguiformis.*	7C 8C 9C 10C	22.3-27.3 27.3-31.0 31.0-34.0 34.0-36.7

Anderdon Limestone, 21.5 ft:

4. Limestone, gray, bluish-gray, and buff, fine-grained; lower part is mottled with small irregular dark areas and contains small pockets of calcite; 5.9 ft.	11 12C 13	36.7-38.0 38.0-40.4 40.4-42.6
5. Limestone, light-gray and buff, fine-grained to sublithographic; has vugs lined with calcite and small disseminated calcite crystals; some beds are very thinly laminated; sublithographic beds are very pure and fracture conchoidally; 15.6 ft.	14 15 16 17 18 19C 20	42.6-44.8 44.8-47.1 47.1-49.6 49.6-51.6 51.6-54.7 54.7-56.9 56.9-58.2

Lucas Dolomite, 13.0 ft exposed:

6. Dolomitic limestone, buff, brown, and dark-brown (darkest at top), fine- to medium-grained; contains many corals and stromatoporoids and thin (a few millimeters) undulating seams of carbonaceous material; 6.3 ft.	21 22 23	58.2-59.9 59.9-62.0 62.0-64.5

Devonian System—Continued		
Lucas Dolomite—Continued		
7. Limestone, gray, sublithographic; has scattered small veins and crystals of calcite; 1.4 ft.	24C	64.5-65.9
8. Dolomitic limestone, buff to brown, fine- to medium-grained; has numerous discontinuous carbonaceous laminae, especially in upper part; 5.3 ft; fauna includes *Icriodus* cf. *I. angustus.*	25 26	65.9-68.4 68.4-71.2

Section 15 (IU10711). Exposure in active quarry of Michigan Limestone, a division of United States Steel Corp., at Rogers City, Presque Isle County, Mich.

	Sample No.	Ft
Devonian System:		
Bell Shale, 12.0 ft measured:		
1. Shale, bluish-gray, calcareous; has bed of crinoid columnals 1 ft above base; abundantly fossiliferous where filling depressions in Rogers City Limestone; sample A taken in such a depression; 12.0 ft; fauna includes *Icriodus latericrescens latericrescens* and *Polygnathus linguiformis linguiformis.*	1C 2C 3C 4C AC	0.0- 3.0 3.0- 7.0 7.0-11.5 11.5-12.0 0.0- 5.0
Rogers City Limestone, 69.5-72.5 ft:		
2. Limestone, dolomitic limestone, and dolomite, buff to gray, fine- to medium-grained; has thin layer of pyrite at top. 69.5-72.5 ft. (For detailed section see Ehlers and Radabaugh in Ehlers, Smith, and Bergquist, 1937, p. 8.)		

Section 16 (IU10712). Exposure in abandoned Rockport Quarry of Kelleys Island Lime and Transport Co. on Lake Huron at east end of Rockport Road, Alpena County, Mich. (sec. 6, T. 32 N., R. 9 E.).

	Sample No.	Ft
Devonian System:		
Ferron Point Formation, 18.0 ft:		
1. Argillaceous limestone and calcareous shale,	1C	0.0- 2.7

Devonian System—Continued		
Ferron Point Formation—Continued		
gray, fossiliferous; uppermost bed is crinoidal fine- to medium-grained limestone; 5.6 ft; fauna includes *Icriodus latericrescens latericrescens.*	2C	2.7- 5.6
2. Covered interval.		5.6-18.0
Rockport Quarry Limestone, 35.5 ft:		
3. Limestone, gray, fine-grained to sublithographic, pure; has half-inch layer of pyrite at top; contains small scattered calcite crystals; 10.7 ft.	3 4 5 6	18.0-21.7 21.7-24.9 24.9-26.9 26.9-28.7
4. Limestone; gray at base becoming nearly black in upper part; fine grained, bituminous, fossiliferous; much of unit is biostromal, composed of corals and stromatoporoids; has many dark shale partings and layers of calcareous shale; 24.8 ft.	7 8 9 10 11 12 13	28.7-32.2 32.2-35.9 35.9-39.4 39.4-43.4 43.4-46.9 46.9-49.7 49.7-53.5

Section 17 (IU10713). Exposure in abandoned shale pit of the Alpena Portland Cement Co. near east end of Monaghan Point Road, Alpena County, Mich. (SE¼ sec. 18, T. 32 N., R. 9 E.).

	Sample No.	Ft
Devonian System:		
Genshaw Formation, 21.5 ft:		
1. Limestone, gray, fine-grained, argillaceous, fossiliferous; 3.0 ft; fauna includes *Icriodus latericrescens latericrescens.*	1C	0.0- 3.0
2. Shale, gray, calcareous, fossiliferous (especially brachiopods); 1.0 ft; fauna same as in unit 1.	2C	3.0- 4.0
3. Limestone, as in unit 1; 3.0 ft; fauna same as in unit 1.		
4. Shale, as in unit 2; 3.0 ft; fauna same as in unit 1.	4C	7.0-10.0
5. Covered interval; according to Ehlers, Smith, and Bergquist (1937, p. 12) this unit consists of calcareous gray shale overlying a		

Devonian System—Continued

Genshaw Formation—Continued

0.5-ft bed of argillaceous limestone at the base; to Ferron Point Formation; 11.5 ft.

Section 18 (IU10714). Exposure in active quarry of Huron Cement Co. at Alpena, Alpena County, Mich. (secs. 13 and 14, T. 31 N., R. 8 E.).

	Sample No.	Ft
Devonian System:		
Alpena Limestone, 60.8 ft measured:		
1. Limestone; light gray in lower part and becomes somewhat darker toward top, medium to coarse grained, pure, fairly uniform throughout; much is bioclastic and contains much crinoidal debris; 31.5 ft; fauna includes *Icriodus latericrescens latericrescens* and *Polygnathus varcus.*	1C	0.0- 4.7
	2C	4.7- 7.4
	3C	7.4-11.7
	4C	11.7-15.4
	5C	15.4-18.8
	6C	18.8-23.3
	7C	23.3-27.3
	8C	27.3-31.5
2. Covered interval; 5.0 ft.		31.5-36.5
3. Limestone, as in unit 1; 1.6 ft; fauna includes *Polygnathus linguiformis linguiformis.*	9C	36.5-38.1
4. Limestone, gray, fine- to medium-grained, fairly uniform throughout, fossiliferous; has 1-ft bed of calcareous very fossiliferous (especially brachiopods; abundant *Atrypa*) gray shale 20 ft above base; 21.7 ft; fauna includes *Icriodus latericrescens latericrescens, Polygnathus linguiformis linguiformis,* and *P. varcus.*	10C	38.1-41.9
	11C	41.9-45.9
	12C	45.9-49.8
	13C	49.8-53.1
	14C	53.1-56.4
	15C	56.4-59.8
5. Shale, black, bituminous, calcareous, platy, fossiliferous; 1.0 ft.	16	59.8-60.8
Newton Creek Limestone, 24.8 ft:		
6. Limestone, dark-gray and light-brown, fine- to medium-grained; has several thin partings of dark shale in lower part of unit; 19.8 ft; fauna includes *Icriodus latericrescens latericrescens.*	17	60.8-63.3
	18	63.3-66.4
	19	66.4-70.3
	20	70.3-73.5
	21	73.5-77.4
	22C	77.4-80.6
7. Covered interval; 5.0 ft.		80.6-85.6

Devonian System—Continued

Genshaw Formation, 5.9 ft:

8. Argillaceous limestone and calcareous shale, dark-gray to black, bituminous, highly fossiliferous (especially corals and stromatoporoids); much of unit is biostromal; 5.9 ft; fauna includes *Icriodus latericrescens latericrescens.*	23C 24C	85.6-88.0 88.0-91.5

Section 19 (IU10715). Exposure at Four Mile Dam on Thunder Bay River, Alpena County, Mich. (a quarter of a mile south of center, sec. 7, T. 31 N., R. 7 E.).

	Sample No.	Ft
Devonian System:		
Norway Point Formation, 16.8 ft:		
1. Limestone, gray, fine-grained, highly argillaceous; has shaly partings; 2.3 ft; fauna includes *Polygnathus varcus, P. linguiformis linguiformis,* and *Icriodus latericrescens latericrescens.*	1C	0.0- 2.3
2. Shale, bluish-gray, calcareous, fairly soft; 1.8 ft.	2C	2.3- 4.1
3. Calcareous shale and argillaceous limestone; predominantly shale, gray, platy; limestone as that of unit 1; both lithologies somewhat fossiliferous and irregularly interbedded; 12.7 ft; fauna includes *Polygnathus varcus* and *P. linguiformis linguiformis.*	3C 4C 5C 6 7C	4.1- 5.4 5.4- 8.1 8.1-11.1 11.1-14.3 14.3-16.8
Four Mile Dam Limestone, 8.5 ft:		
4. Limestone, gray and white, fine- to coarse-grained, biohermal and fossiliferous, brecciated in part; has numerous intercalations and fillings of bluish-green clay and scattered small pockets of crystalline calcite; to water level; 8.5 ft; fauna includes *Polygnathus varcus* (sample 8 only) and *Icriodus latericrescens latericrescens.*	8C 9C 10C	16.8-19.6 19.6-23.0 23.0-25.3

Section 20 (IU10716). Exposure at Norway Point Dam on Thunder Bay River, Alpena County, Mich. (NE¼ sec. 12, T. 31 N., R. 7 E.).

	Sample No.	Ft
Devonian System:		
Potter Farm Formation, 1.3 ft exposed:		
1. Limestone, gray, medium-grained, crinoidal, somewhat argillaceous; near base of formation; exposed along road above dam; 1.3 ft; fauna includes *Icriodus latericrescens latericrescens.*	1C	0.0- 1.3
Norway Point Formation, 44.8 ft:		
2. Covered interval; this part of the section was observed and described by Ehlers, Smith, and Bergquist (1937, p. 15); approximately 30 ft.		1.3-31.3
3. Shale, gray, highly calcareous, platy; probably equivalent to unit 3 at Four Mile Dam; 8.4 ft; fauna includes *Polygnathus varcus* and *Icriodus latericrescens latericrescens.*	2C	31.3-39.7
4. Limestone, gray to very light-brown, fine- to medium-grained, stylolitic near base, very fossiliferous; has a near-coquina (mostly brachiopods) 1 ft above base; to water level; 6.4 ft; fauna same as in unit 3.	3C 4C 5C 6C	39.7-40.2 40.2-42.6 42.6-44.6 44.6-46.1

Section 21 (IU10717). Exposure in low bluff on east shore of Partridge Point on Thunder Bay 3 miles south of Alpena, Alpena County, Mich. (SE¼ sec. 11, T. 30 N., R. 8 E.).

	Sample No.	Ft
Devonian System:		
Thunder Bay Limestone, 13.5 ft:		
1. Limestone, gray, fine-grained to dense, irregularly bedded; 2.0 ft.	1	0.0- 2.0
2. Calcareous shale and shaly limestone, gray, silty, abundantly fossiliferous (especially corals and brachiopods); limestone is in	2C 3C 4C	2.0- 4.1 4.1- 6.1 6.1- 9.5

Devonian System—Continued

Thunder Bay Limestone—Continued

lenses, is fine grained in lower part of unit, and becomes coarser toward top; 7.5 ft; fauna includes *Icriodus latericrescens latericrescens.*		
3. Covered interval; 3.0 ft.		9.5-12.5
4. Limestone, bluish-gray, fine-grained, argillaceous; has some fragmental crinoidal debris; to lake level; 1.0 ft; fauna includes *Polygnathus varcus* and *Icriodus latericrescens latericrescens.*	5C	12.5-13.5

Plates 1-6

PLATE 1

All figures × 40

1, 2 *Acodina formosa* (Stauffer). Lateral views IU10708-25001 and IU10707-59001.

3, 4 *Acodina lanceolata* Stauffer. Lateral views IU10704-19001 and IU10704-19002.

5 *Diplodella* sp. Posterior view IU10708-19001.

6, 7 *Belodella devonicus* (Stauffer). Lateral views IU10704-16001 and IU10704-16002.

8 *Lonchodina discreta* Ulrich and Bassler. Inner lateral view IU10707-31001.

9 *Lonchodina ramulata* Bischoff and Ziegler. Inner lateral view IU10708-30001.

10-13 *Coelocerodontus* sp. 10, 11, Posteroaboral and lateral views IU10710-09001. 12, 13, Posteroaboral and lateral views IU10708-29001.

14-16 *Angulodus* sp. Inner lateral views IU10707-05001, IU10707-06001, and IU10707-08001.

17 *Ligonodina* sp. Inner lateral view IU10707-04001.

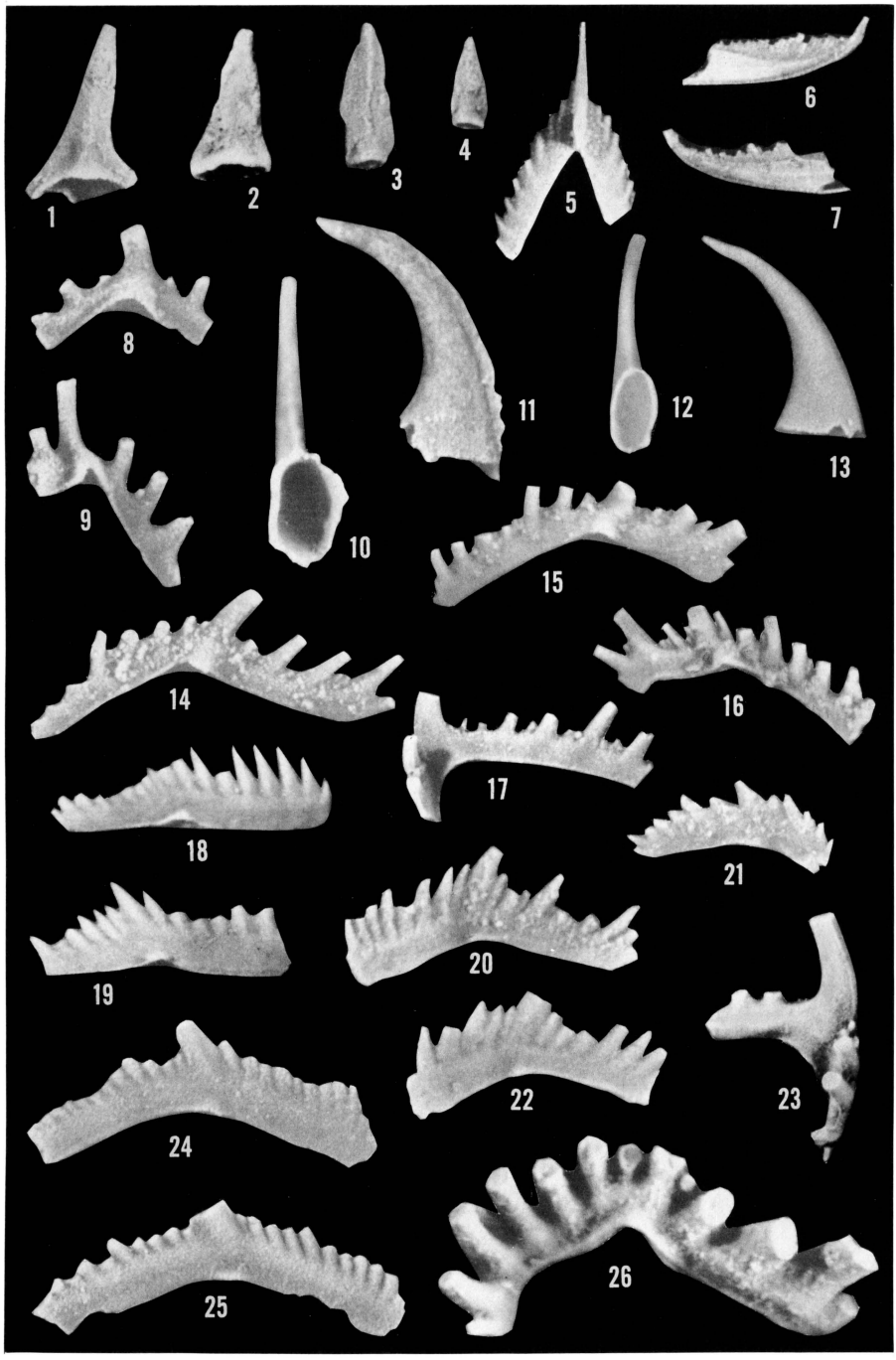
18, 19 *Ozarkodina* cf. *O. versa* (Stauffer). Inner lateral views IU10708-29002 and IU10708-29003.

20-22 *Ozarkodina willsi* Rhodes and Dineley. Inner lateral views IU10702-51001, IU10707-17001, and IU10702-51002.

23 *Ligonodina falciformis* Ulrich and Bassler. Inner lateral view IU10716-09001.

24, 25 *Ozarkodina lata* Bischoff and Ziegler. Inner lateral views IU10708-30002 and IU10708-29004.

26 *Lonchodina* sp. Inner lateral view IU10708-12001.



DEVONIAN CONODONTS

PLATE 2

All figures X 40

1-6 *Icriodus cymbiformis* Branson and Mehl. 1, 2, 3, Oral, aboral, and inner lateral views IU10707-39001. 4, 5, 6, Oral, aboral, and inner lateral views IU10707-39002.

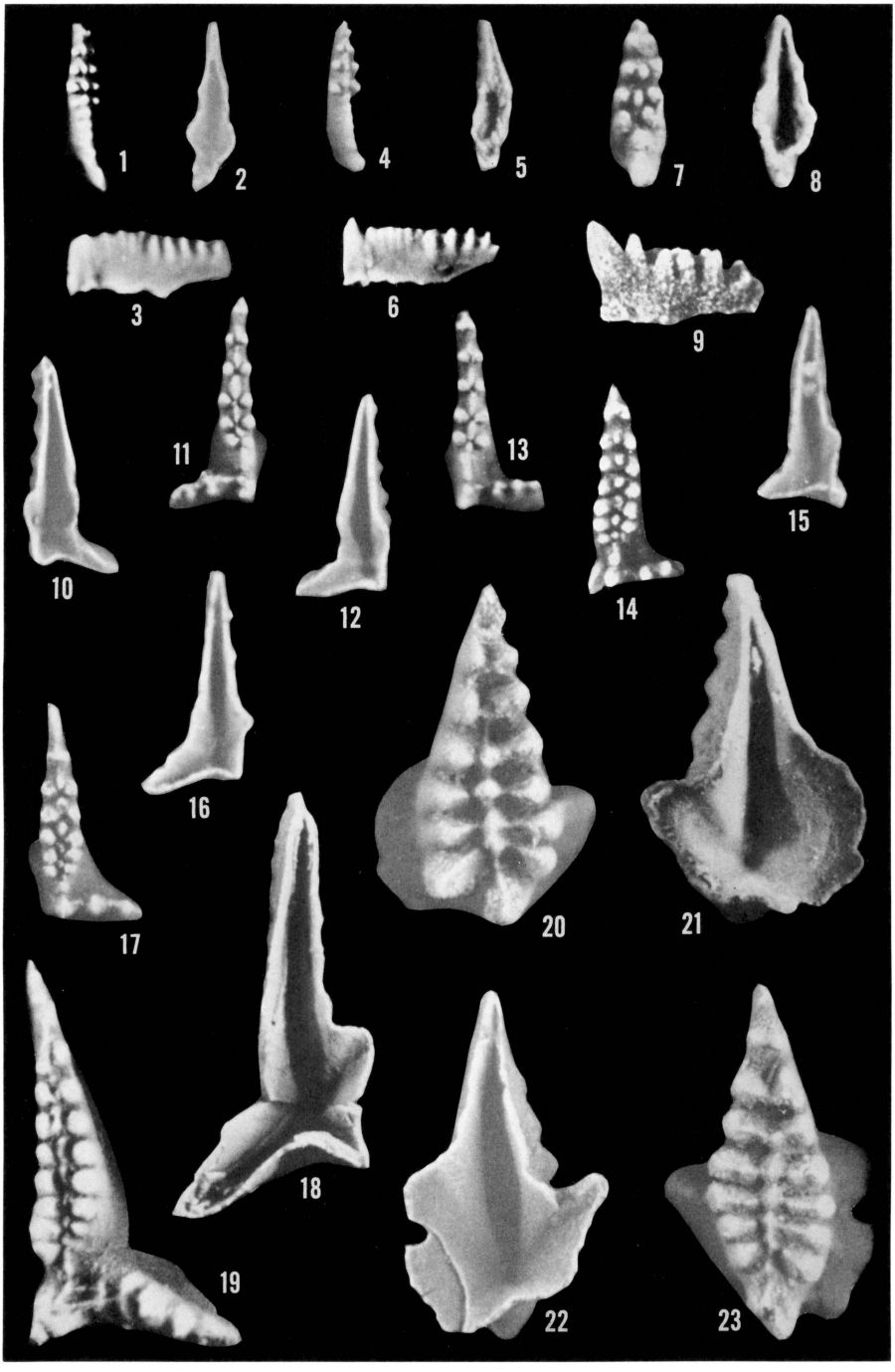
7-9 *Icriodus* cf. *I. angustus* Stewart and Sweet. Oral, aboral, and inner lateral views IU10707-80001.

10-13 *Icriodus latericrescens latericrescens* Branson and Mehl. 10, 11, Aboral and oral views IU10704-04001. 12, 13, Aboral and oral views IU10704-04002.

14-17 *Icriodus latericrescens robustus* n. subsp. 14, 15, Oral and aboral views of holotype IU10710-09002. 16, 17, Aboral and oral views of paratype IU10710-09003.

18, 19 *Icriodus latericrescens latericrescens* Branson and Mehl. Aboral and oral views IU10705-04001.

20-23 *Icriodus nodosus* (Huddle). 20, 21, Oral and aboral views IU10710-01001. 22, 23, Aboral and oral views IU10710-01002.



DEVONIAN CONODONTS

PLATE 3

All figures X 40

1-4 *Synprioniodina regularis* (Branson). Inner lateral views IU10708-29005, IU10708-29006, IU10708-29007, and IU10708-18001.

5 *Synprioniodina* sp. Inner lateral view IU10707-19001.

6 *Neoprioniodus alatus* (Hinde). Inner lateral view IU10708-26001.

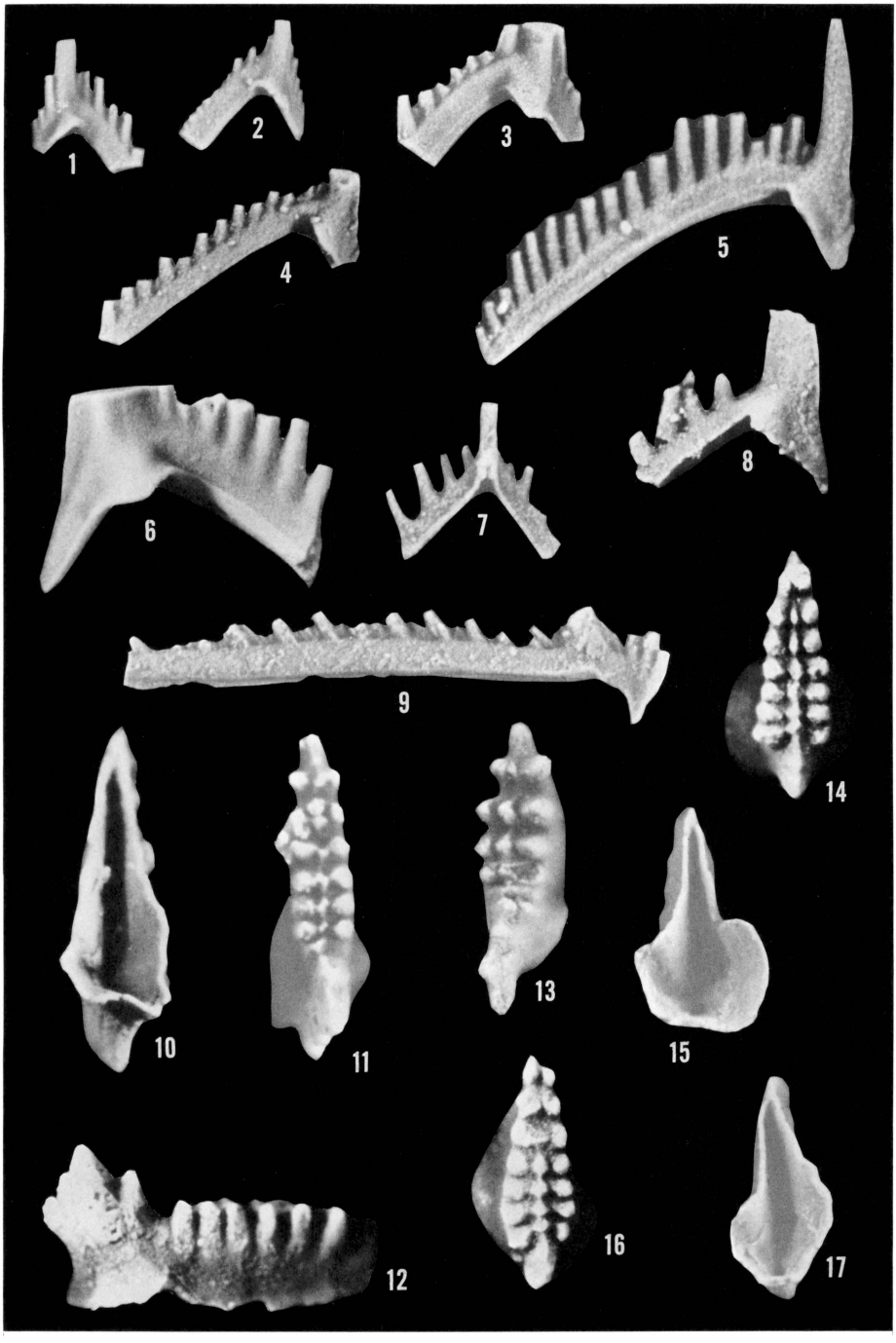
7 *Hibbardella* sp. Posterior view IU10708-18001.

8 *Neoprioniodus armatus* (Hinde). Inner lateral view IU10707-18001.

9 *Hindeodella germana* Holmes. Inner lateral view IU10708-14001.

10-13 *Icriodus angustus* Stewart and Sweet. 10, 11, 12, Aboral, oral, and outer lateral views IU10710-09004. 13, Oral view IU10710-01003.

14-17 *Icriodus expansus* Branson and Mehl. 14, 15, Oral and aboral views IU10704-19003. 16, 17, Oral and aboral views IU10704-19004.



DEVONIAN CONODONTS

PLATE 4

All figures X 40

1-5 *Polygnathus decorosus* Stauffer. 1, 2, Oral and inner lateral views IU10707-04002. 3, 4, 5, Oral, aboral, and inner lateral views IU10707-06002.

6-8 *Polygnathus alveolipositicus* Orr and Klapper. Oral, lateral oblique, and aboral views IU10707-19002.

9, 10 *Polygnathus "webbi"* Stauffer. Oral and aboral views IU10703-44001.

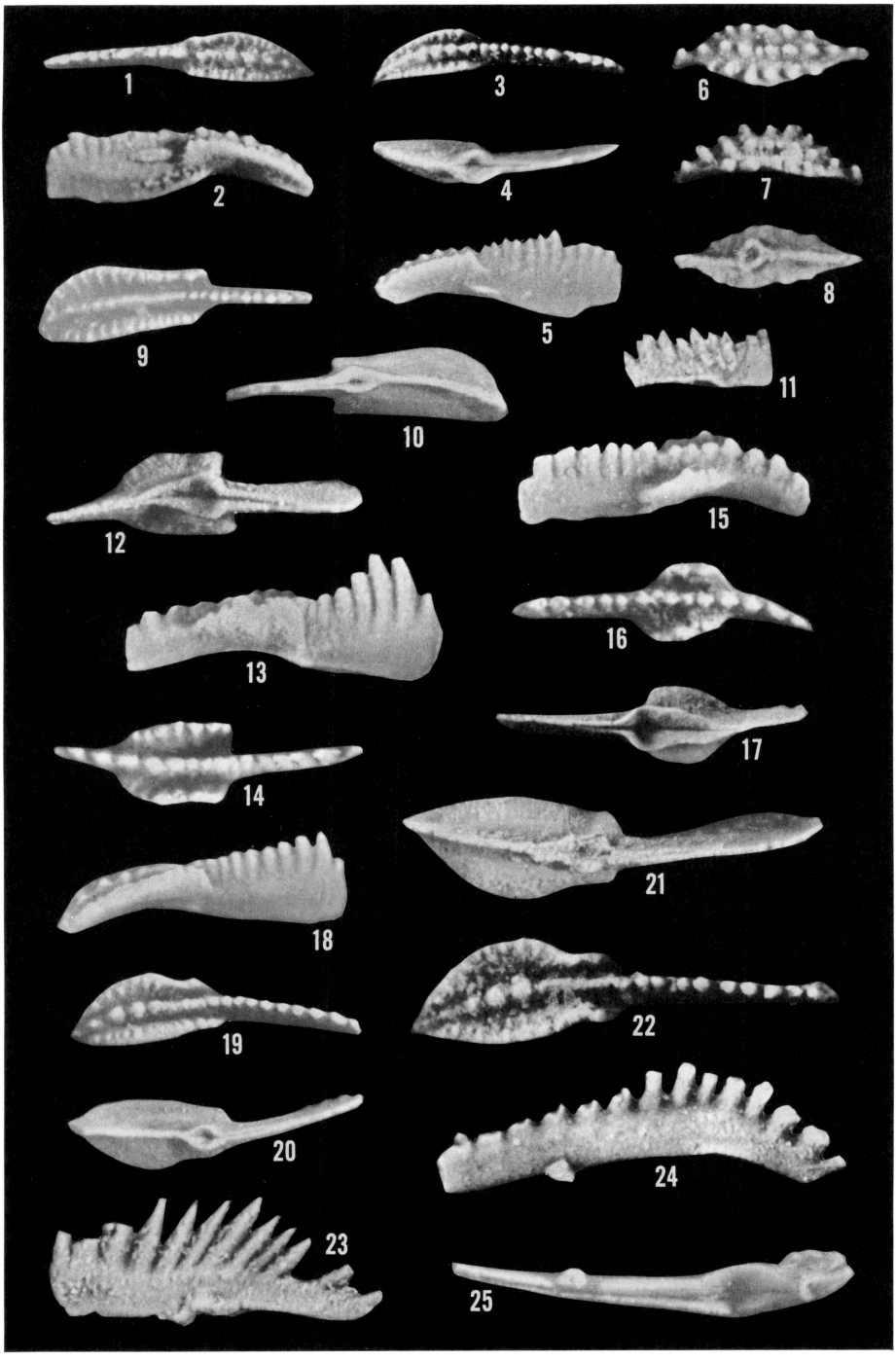
11 *Spathognathodus bidentatus* Bischoff and Ziegler. Lateral view of juvenile IU10702-50001.

12-17 *Polygnathus angusticostatus* Wittekindt. 12, 13, 14, Aboral, outer lateral, and oral views IU10702-52001. 15, 16, 17, Inner lateral, oral, and aboral views IU10702-52002.

18-22 *Polygnathus pseudofoliatus* Wittekindt. 18, 19, 20, Inner lateral, oral, and aboral views IU10714-11001. 21, 22, Aboral and oral views IU10707-53001.

23 *Spathognathodus planus* Bischoff and Ziegler. Lateral view IU10708-11001.

24, 25 *Prioniodina* sp. Inner lateral and aboral views IU10708-26002.



DEVONIAN CONODONTS

PLATE 5

All figures X 40

1-3 *Polygnathus variabilis* Bischoff and Ziegler. Outer lateral, oral, and aboral views IU10707-10001.

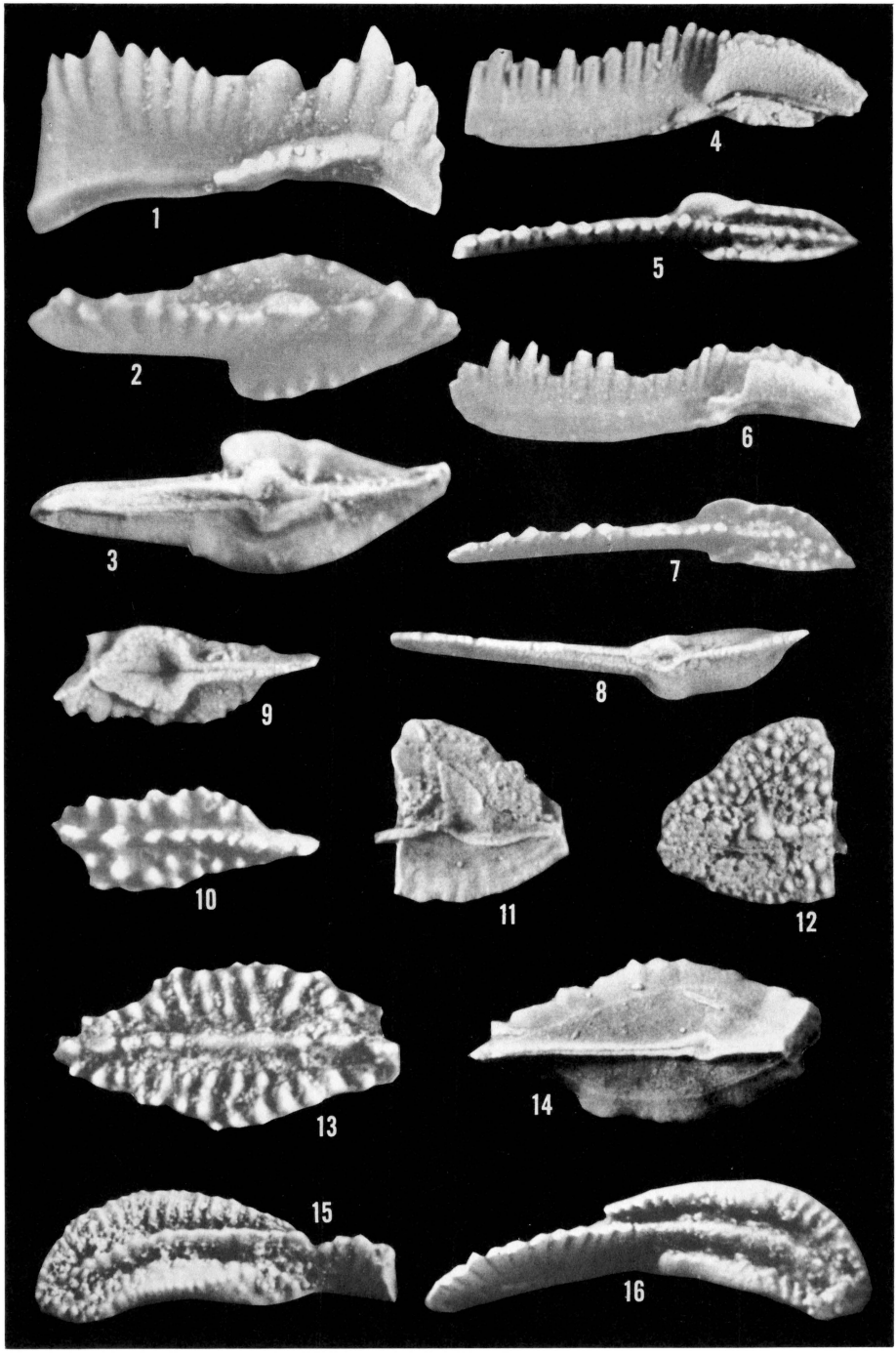
4-8 *Polygnathus varcus* Stauffer. 4, 5, Inner lateral and oral views IU10708-28001. 6, 7, 8, Inner lateral, oral, and aboral views IU10708-26003.

9, 10 *Polygnathus caelatus* Bryant. Aboral and oral views of incomplete specimen IU10707-11002.

11, 12 *Palmatolepis? disparalvea* Orr and Klapper. Aboral and oral views of incomplete specimen IU10707-08002.

13, 14 *Polygnathus pennatus* Hinde. Oral and aboral views of incomplete specimen IU10707-10002.

15, 16 *Polygnathus foliatus* Bryant. Oral views IU10707-10003 and IU10707-10004.



DEVONIAN CONODONTS

PLATE 6

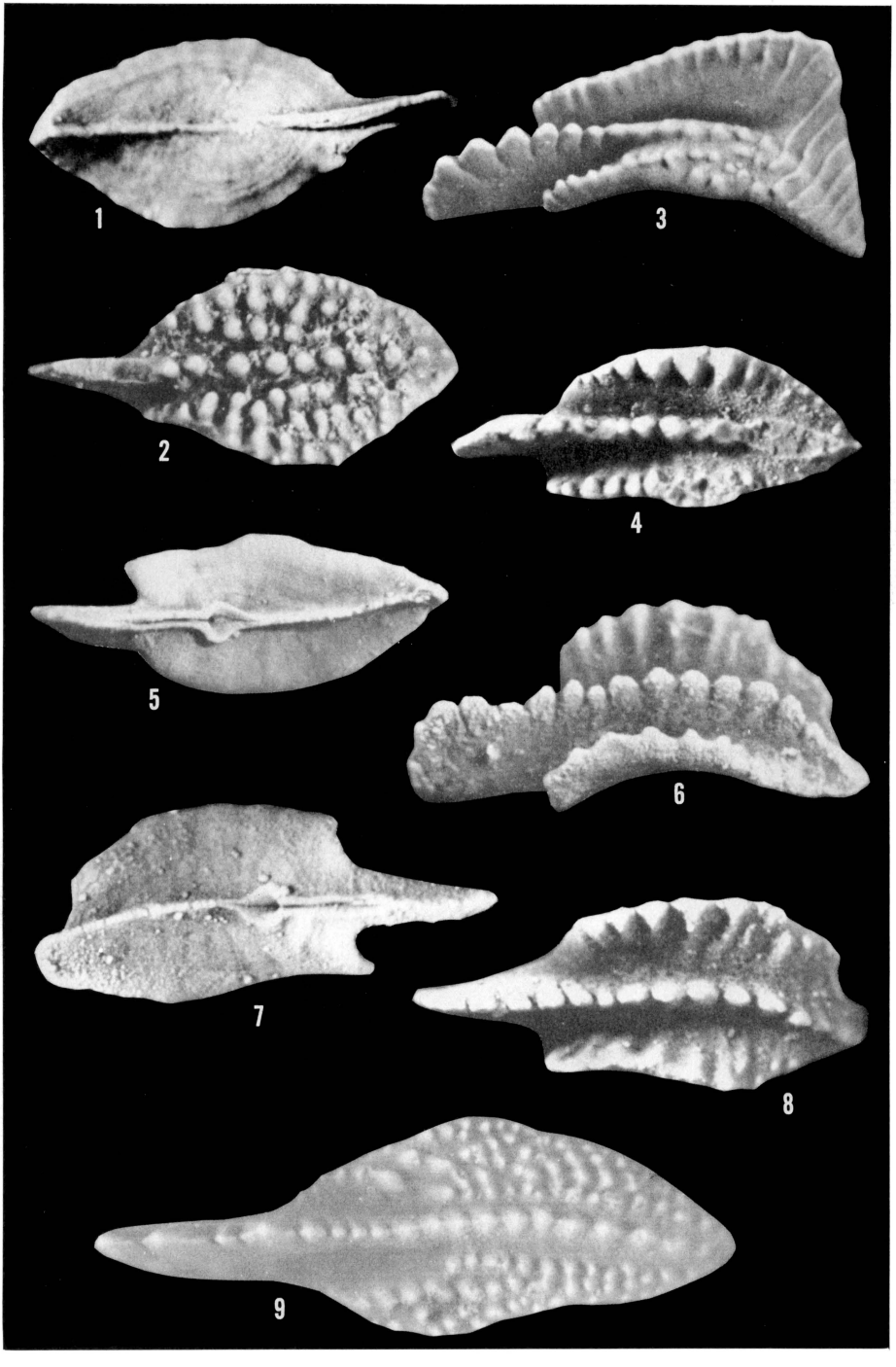
All figures X 40

1, 2 *Polygnathus cristatus* Hinde. Aboral and oral views IU10707-10005.

3 *Polygnathus linguiformis linguiformis* Hinde. Oral view IU10708-29008.

4-8 *Polygnathus robusticostatus* Bischoff and Ziegler. 4, 5, Oral and aboral views of specimen with damaged platform IU10702-52003. 6, 7, 8, Inner lateral oblique, aboral, and oral views IU10703-44002.

9 *Schmidtognathus peracutus* (Bryant). Oral view IU10702-05001.



DEVONIAN CONODONTS

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