Stratigraphy and Conodont Paleontology of the Brassfield (Silurian) in the Cincinnati Arch Area

BULLETIN 36

DEPARTMENT OF NATURAL RESOURCES
GEOLOGICAL SURVEY

SCIENTIFIC AND TECHNICAL STAFF OF THE GEOLOGICAL SURVEY

JOHN B. PATTON, State Geologist
MAURICE E. BIGGS, Assistant State Geologist
MARY BETH FOX, Mineral Statistician

COAL SECTION
- CHARLES E. WIER, Geologist and Head
- S. A. FRIEDMAN, Geologist
- HAROLD C. HUTCHISON, Geologist
- RICHARD L. POWELL, Geologist
- MARVIN T. IVERSON, Geological Assistant

DRAFTING AND PHOTOGRAPHY SECTION
- WILLIAM H. MORAN, Chief Draftsman and Head
- ROBERT E. JUDAH, Geological Artist-Draftsman
- JOHN E. PEACE, Senior Geological Draftsman
- ROGER L. PURCELL, Geological Draftsman
- JAMES R. TOLEN, Geological Draftsman
- GEORGE R. RINGER, Photographer

EDUCATIONAL SERVICES
- R. DEE RARICK, Geologist and Head

GEOCHEMISTRY SECTION
- R. K. LEININGER, Geochemist and Head
- MAYNARD E. COLLER, Chemist
- LOUIS V. MILLER, Coal Chemist
- E. M. CRAIG, Geochemical Assistant
- RONALD W. KLUSMAN, Instrumental Analyst
- ALFRED E. WHITE, Geochemical Assistant

GEOLOGY SECTION
- ROBERT H. SHAVER, Paleontologist and Head
- HENRY H. GRAY, Head Stratigrapher
- WILLIAM J. WAYNE, Head Glacial Geologist
- CARL B. REXROAD, Paleontologist
- ALLAN F. SCHNEIDER, Glacial Geologist

GEOPHYSICS SECTION
- MAURICE E. BIGGS, Geophysicist and Head
- ROBERT F. BLAKELY, Geophysicist
- CHARLES S. MILLER, Instrument Maker
- JOSEPH F. WHALEY, Geophysicist
- CLARENCE C. HASKINS, Driller
- GLENN JOHNSON, Assistant Driller
- JOHN R. HELMS, Geophysical Assistant

INDUSTRIAL MINERALS SECTION
- LAWRENCE F. ROONEY, Geologist and Head
- DONALD D. CARR, Geologist
- ROBERT R. FRENCH, Geologist
- MARGARET V. PALMER, Geologist
- WILLIAM M. WEBB, Geologist

PETROLEUM SECTION
- T. A. DAWSON, Geologist and Head
- LEROY E. BECKER, Geologist
- G. L. CARPENTER, Geologist
- ANDREW J. HREHA, Geologist
- STANLEY J. KELLER, Geologist
- HOWARD SMITH, Geologist
- DAN M. SULLIVAN, Geologist
- JAMES T. CAZEE, Geological Assistant
- LOIS J. CHANEY, Draftsman
- ALLEN PRUETT, Geological Assistant
- JAMES F. THRASHER, Geological Assistant

PUBLICATIONS SECTION
- GERALD S. WOODARD, Editor and Head
- LEWIS W. NELLINGER, Sales and Record Clerk

Stratigraphy and Conodont Paleontology of the Brassfield (Silurian) in the Cincinnati Arch Area

By CARL B. REXROAD

DEPARTMENT OF NATURAL RESOURCES
GEOLOGICAL SURVEY BULLETIN 36

PRINTED BY AUTHORITY OF THE STATE OF INDIANA
BLOOMINGTON, INDIANA: 1967

STATE OF INDIANA
Roger D. Branigin, *Governor*

DEPARTMENT OF NATURAL RESOURCES
John E. Mitchell, *Director*

GEOLOGICAL SURVEY
John B. Patton, *State Geologist*

For sale by Geological Survey, Bloomington, Ind. 47401
Price $2.00

Contents

THIS PAGE INTENTIONALLY LEFT BLANK

Illustrations

THIS PAGE INTENTIONALLY LEFT BLANK

Stratigraphy and Conodont Paleontology of the Brassfield (Silurian) in the Cincinnati Arch Area

By CARL B. REXROAD

Abstract

Conodonts were collected from 49 sections of the Brassfield Formation (Brassfield Limestone) in its outcrop belt around the Cincinnati Arch in Indiana, Kentucky, and Ohio. Thirty-four indigenous species represent the genera *Acodus, Ambalodus, Distomodus, Drepanodus?, Euprioniodina, Icriodina, Ligonodina, Lonchodina, Neoprioniodus, Ozarkodina, Paltodus, Panderodus, Plectospathodus, Spathognathodus, Synprioniodina, Trichonodella,* and a generic group that includes species variously referred to *Keislognathus?, Rhynchognathodus?, Roundya,* and *Trichonodella.* Seven new species named herein are *Icriodina stenolophata, Ligonodina? extrorsa, Paltodus costulatus, P. debolti, P. dyscritus, P. migratus,* and *Spathognathodus oldhamensis.* The new subspecies *Panderodus unicostatus serratus* is also named.

Conodonts show that the Brassfield Limestone as it is now recognized belongs in the upper part of Bereich I of the European conodont zonation. Younger strata, which overlie the Brassfield from Jefferson County, Ind., into Bullitt County, Ky., possibly should be placed within the Brassfield, and if they were included, the formation in this area would include beds belonging in the *celloni*-Zone. The Brassfield correlates with the Kankakee Dolomite and the Sexton Creek Limestone of the Alexandrian Series in Illinois. Conodonts support the evidence based on brachiopods that the upper part of the Brassfield is younger west and north of the type area than in the type area of central Kentucky.

From about 5 miles southeast of Stanford, Ky., northeastward to northern Adams County, Ohio, the Brassfield Formation is overlain conformably or with slight unconformity by the Noland Formation, which also contains Bereich I conodonts. From Adams County north to Piqua, Ohio, the formation is unconformably overlain by the Dayton Limestone. In Indiana and Kentucky on the west side of the Cincinnati Arch, the Osgood Member of the Salamonie Dolomite or its equivalents overlie the Brassfield with major unconformity except where strata intermediate in age are present from Jefferson County, Ind., into Bullitt County, Ky. The Brassfield unconformably overlies Ordovician strata throughout the Cincinnati Arch area. The Ripley Island positive area of southeastern Indiana was the only active structure influencing Brassfield sedimentation in the area studied.

Introduction

Silurian conodonts are diversified, and Walliser's (1962, 1964) zonation of the Silurian System of Europe shows their practicality for use in Silurian stratigraphy. This paper describes the early Silurian conodonts from the Brassfield Limestone in Indiana and parts of adjacent states, where the unit is designated the Brassfield Formation, relates the conodont fauna to European zones, and interprets the stratigraphic relations of the formation.

Branson and Branson (1947) described conodonts from the Brassfield Formation from several localities near the central Kentucky type section of the formation. I noted that there are differences between the conodonts described from the type area and those from Indiana and that the lithology of the formation in the two areas is strikingly different. I therefore collected intermediate samples in Ohio and Kentucky on each side of the Cincinnati Arch to trace changes in fauna and lithology between Indiana and the type section. As a result, this study of the Brassfield conodonts is based on 245 samples from 49 sections measured around the margin of Ordovician exposures in the Cincinnati Arch area (pl. 1) and on a number of additional sections, including six from which the Brassfield is absent. At most localities overlying and underlying units were exposed, and collections made from them help delimit the Brassfield fauna.

Discussions and field study of the Silurian rocks of Kentucky and Ohio with E. R. Branson and M. O. Smith, Kentucky Geological Survey, Arthur C. McFarlan, University of Kentucky, Charles Summerson, The Ohio State University, Arthur J. Boucot, California Institute of Technology, and John Peck, U. S. Geological Survey, were extremely helpful. Branson and Smith suggested a number of Brassfield sections to collect, assisted with measuring, describing, and collecting several sections, and gave valuable criticism of the manuscript. Ruth Browne, of Louisville, assisted in selecting collecting localities between Raywick, Ky., and the Ohio River. Information from R. L. Ethington, University of Missouri, on several taxonomic problems and his reading of the manuscript are gratefully acknowledged.

Stratigraphic Nomenclature

The Brassfield Limestone was named by Foerste in 1906 (p. 18, 27) for exposures along the now-abandoned Louisville and Atlantic Railroad between Brassfield and Panola in Madison County, Ky. (pl. 1). For many years prior to 1906 the unit had been recognized as a formation first called the Clinton Group in Kentucky by D. D. Owen in 1857 and then in Ohio by Edward Orton in 1871. Foerste (1896, p. 189) recognized that the Clinton Formation of Ohio should not be identified with the Clinton Formation of New York, and he proposed the name Montgomery Formation for the Ohio unit, a name which was preoccupied, however.

In early usage in Indiana the term Clinton Limestone was used for a poorly defined interval that included rocks above and (or) below the Brassfield, but Foerste (1897, 1898) mapped the so-called Clinton in detail, and it is to the Clinton, essentially as he recognized it in the cited papers, that the term Brassfield subsequently has been applied. A review of the nomenclature and early investigations of the Brassfield Limestone in Indiana was made by Cumings (1922, p. 443-447). Foerste's many papers provide basic information on the stratigraphy of the Brassfield and associated formations. This information was summarized and slightly modified for the east-central Kentucky and southern Ohio area in a paper by Rexroad and others (1965).

In 1896 Foerste (p. 163, 164) applied the name Belfast Bed to argillaceous dolomitic silty-appearing beds in the base of the Brassfield. Placement of these beds has been a problem because of the general lack of megafossils and the complex physical relationships. The Belfast underlies the typical Brassfield in much of Ohio and in adjacent Kentucky east of the Cincinnati Arch, and in this study it is tentatively recognized west of the arch near the northern and southern limits of the Brassfield outcrop (localities 16, 22, and 52, pl. 1). Foerste (1931, p. 184) stated that the Belfast is continuous with beds considered to be the Brassfield in Kentucky and that the two are similar faunally. At that time he considered the Belfast to be a member of the Brassfield Limestone. Rexroad and others (1965, p. 8) recognized that the basal massive beds of the type section of the Brassfield belong in the Belfast and retained the term as the Belfast Member of the Brassfield Formation.

Distribution and Thickness

The Brassfield outcrop is nearly continuous around the margin of Ordovician exposures in the Cincinnati Arch area. From the type area in Madison County, Ky., exposures are found on the east side of the arch along a belt trending northeastward into Lewis County on the Ohio River (pl. 1). Across the river in Ohio the outcrop belt trends northward and then curves westward in an irregular pattern conforming to major drainage. A number of outliers are present in the Dayton area. In Indiana on the west side of the Cincinnati Arch, exposures are found near Richmond and near Connersville and thence southwestward to the Ohio River in the vicinity of Charlestown. The Brassfield is absent in some places along the Indiana outcrop band and also in some inliers as much as 15 miles to the west. South of the Ohio River, the outcrop belt trends southward to Raywick, Ky. The formation is not exposed immediately south of Raywick, but it reappears in southern Kentucky and adjacent Tennessee, which are beyond the area of study. From Raywick east to Stanford and immediately south of this line, the Brassfield is not exposed, because of Devonian overlap, except in a fault zone along Scrubgrass Creek near Mitchellsburg (locality 55). Excellent exposures are present from Stanford northeastward to the type area.

Although the Brassfield generally is much thicker on the east flank of the Cincinnati Arch than it is on the west, the depositional pattern of the formation is not related to the present arch. Rather, the positive area called Ripley Island by Foerste (1891) was the controlling structural element in the area studied and will be referred to in this paper as the Ripley positive area. The Brassfield is absent in parts of Decatur, Ripley, Jennings, Jefferson, and Scott Counties, Ind., along the east flank of the Ripley positive area. The thickness of the formation from here northward in Indiana to locality 24 is generally less than 4 feet (pl. 1). From locality 24 it thickens northward and in the vicinity of Richmond is about 10 to 14 feet thick. Eastward into Ohio as far as Dayton the Brassfield is about 15 feet thick, but north and east of a line connecting localities 13, 15, and 16 the formation is as much as 30 feet thick (pl. 1).

The greatest thickness recorded in this study, 51 feet, is in Adams County, Ohio (locality 10, pl. 1). From this area the formation thins gradually southward and at locality 6 in Kentucky is slightly more than

20 feet thick, a thinning of about 0.5 foot per mile. The formation is about 20 feet thick from here southward to Brassfield and Berea. Southwestward from Berea to Stanford it is thinner.

From the Ripley positive area in Indiana to southern Nelson County, Ky., the Brassfield is generally less than 4 feet thick except at locality 37, in an outlier, where it is 9½ feet thick. It increases in thickness abruptly south of the northwestward-trending monoclinal flexure that passes a few miles north of Bardstown and that was mapped by Shideler, Briggs, and Miller (1929) from Samuels to Woodlawn. In the Bardstown quarry (locality 51) the formation is 22 feet thick. At Raywick at the southern extremity of the outcrop belt it is only 10 feet thick.

Lithology

Near Brassfield and Berea, Ky., the Brassfield Formation is divided into three units that can be recognized in a general way south of Bath County, Ky. In ascending order they include (fig. 1): (1) the Belfast Member, consisting of massive argillaceous impure dolomite that appears silty, (2) thin- to medium-bedded dolomitic limestone having shale partings and interbeds that become more prominent in the upper part, and (3) medium-bedded calcarenite with *Cryptothyrella subquadrata* and distinctive crinoid columnals abundant near the top. The distinctive columnals are disk shaped and have irregularly serrate or crenulate margins. They have been found only in the top few feet of the formation, where they are characteristically concentrated in great abundance in a single bed referred to as the bead bed. Crossbedding, megaripples, and concentrations of ferruginous material commonly are present.

From Bath County northward to Todds Fork near Wilmington, Ohio, the Belfast, although variable in thickness, is generally present and is lithologically similar to the type Brassfield rocks. It does tend to be more argillaceous and less dolomitic than the Belfast to the south and in places is thin bedded. The upper unit of the Brassfield retains most of its distinctive characteristics northward. The bead bed has been observed in this study on the east side of the Cincinnati Arch from Dayton, Ohio (locality 15), to southern Kentucky in the Lake Cumberland area and has been recorded in Tennessee and Alabama. The columnals have not been found on the west side of the arch.

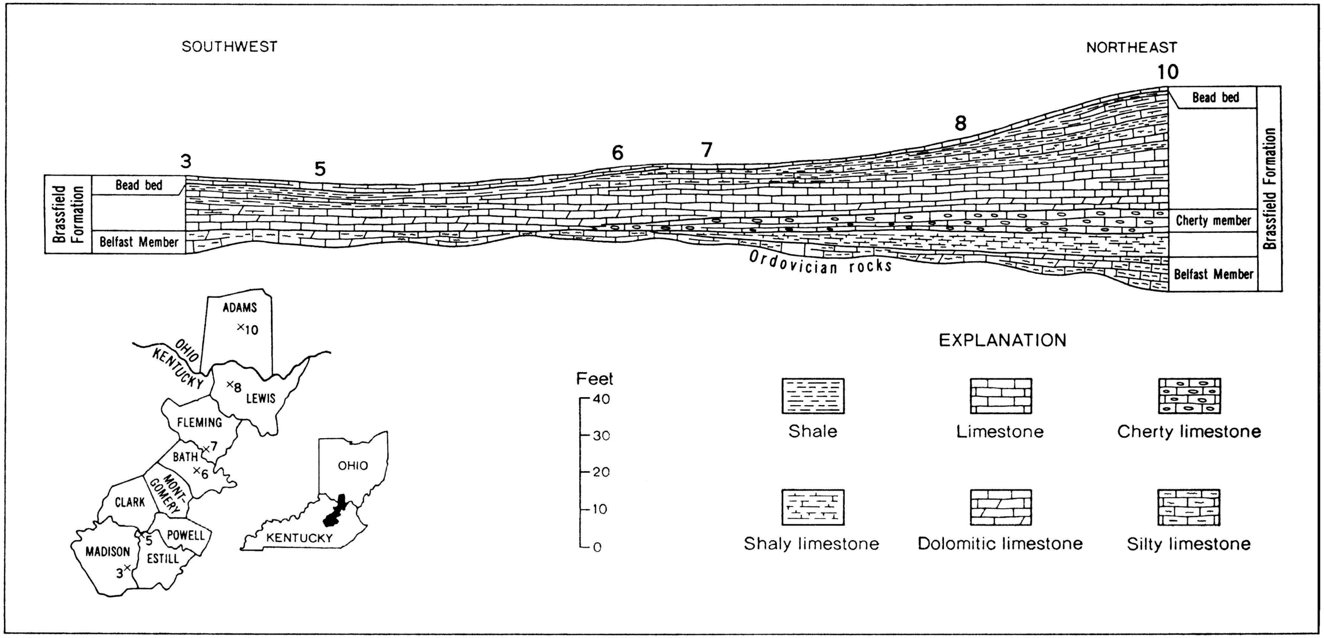


Figure 1. Schematic cross section of the Brassfield from locality 3, the type section in Madison County, Ky., north-northeastward to locality 10 in Adams County, Ohio, showing relationships of lithologic units in the formation. Numbers refer to localities shown on plate 1.

In central Bath County, Ky., a cherty unit overlies the Belfast Member, and the Brassfield thickens both above and below the chert beds northward into Ohio (fig. 1). The limestone between the Belfast and the cherty unit tends to be thin bedded, fine grained, fossiliferous, and shaly. The limestone between the chert and the top unit is variable and includes medium-bedded coarse-grained partly crinoidal limestone and thin-bedded fine- to medium-grained argillaceous limestone interbedded with greenish-gray shale. From the area about a mile north of locality 7 to the Ohio River the amount of shale increases greatly. The increase is abrupt. North of the Ohio River the amount of shale decreases northward nearly as abruptly.

Between Adams County, Ohio, and Dayton the middle portion of the Brassfield changes character. Although chert is present north of locality 10, it is scattered and not concentrated within a single unit. Shale decreases, the limestone is less argillaceous, and the dolomite content is low. Most of the limestone is fossiliferous, medium to coarse grained, partly crinoidal, and medium bedded, but both massive and thin beds occur. Bedding is commonly irregular. Color is variable and includes dark to light gray and brown to tan. Some lighter colored beds have a pink or yellow cast or are nearly white.

North of Dayton in Ohio the Brassfield has been divided into two unnamed units, a lower light-colored one and an upper dark-colored one. The lower unit tends to be more regularly and thicker bedded and generally lacks the stringers and blebs of green clay that are found in the upper unit. At locality 17 the lower unit is 12 feet thick and the upper one 7 feet thick; at locality 18 they are 21 and 7½ feet thick; and at locality 19 they are 26½ feet and 1 foot thick. At the last locality the white rock in the lower unit is cut, polished, and sold as commercial marble. Rexroad and others (1965, p. 13) suggested that the Brassfield of Ohio includes unconformities that are sufficiently prominent, so that the formation should be subdivided. The changes noted seem best explained by facies differences, but possibly the Brassfield, as it is known to the south, pinches out above the southern extension of a unit from the Michigan Basin.

At locality 20 the entire Brassfield is represented by lithology almost identical with that of the upper part of the formation at locality 17. Just a few miles southwest of locality 20 the lithology is generally characteristic of the Brassfield of Indiana, but a number of very dark-colored zones are present. Both of these Brassfield sections are much thicker than are those to the south in Indiana. The lower 2 feet at the latter section is tentatively considered to be the Belfast Member.

At most exposures in Indiana and as far south as locality 50 in Kentucky, the Brassfield is limestone that is salmon pink or yellowish brown, coarse grained, partly crinoidal, medium but irregularly bedded, and fossiliferous and rather pure despite irregular stringers of shale. Ordovician pebbles occur in places in the basal part, particularly in the Ripley positive area. At locality 23 and at Balls Quarry about 4 miles to the north (Foerste, 1898, p. 254) the formation is fine grained, reddish brown, and dolomitic, and here megafossils are lacking.

In Jefferson and Clark Counties, Ind., and across the Ohio River, a unit that differs lithologically and faunally from the typical Brassfield is found overlying Brassfield beds or at some localities occupying the total interval between the Saluda Limestone (Ordovician) and the Osgood Member of the Salamonie Dolomite. (See Pinsak and Shaver, 1964, and French, 1967, for Osgood and Salamonie terminology.) When future work clarifies the relationships of this unit, referral to the Brassfield is possible, but at present the unit is excluded from the Brassfield on the basis of lithology.

A change in lithology corresponds to the change in thickness of the Brassfield Formation north of Bardstown, Ky., and in the Bardstown area chert is characteristic of the formation. The formation is dolomitic, gray, dark gray, or tan, and fine grained. The lower beds are massive; higher beds are medium to thin bedded. At locality 52 the basal massive dark-gray fine-grained unit, 5 feet thick, is tentatively assigned to the Belfast Member.

The Conodont Fauna

Faunal analysis is based on more than 45,000 specimens from 245 samples (pl. 1 and list of collecting localities). Forty species and indeterminate fragments of *Hindeodella* are represented in the collection, but six species are represented by so few specimens that it is questionable whether or not they are indigenous. Of the 34 remaining species that make up the Brassfield conodont fauna, only 27 are named, and 7 of these are new. The new species include *Icriodina stenolophata, Ligonodina? extrorsa, Paltodus costulatus, P. debolti, P. dyscritus, P. migratus,* and *Spathognathodus oldhamensis*. The new subspecies *Panderodus unicostatus serratus* is also named. The seven unnamed species are represented by specimens too fragmental, too variable, or insufficient in number for adequate definition and description.

The genus *Panderodus* dominates the fauna, constituting over two-thirds of the specimens. Separate counts of each species of this genus were not made, but *P. unicostatus* is the most abundant species. Spot checks indicate that at least 85 percent of the panderodids belong in this species and about 10 percent in *P. simplex*. For the remaining genera the most abundant species is *Acodus unicostatus*. Also abundant are *Paltodus dyscritus* and *P. debolti*. Species considered common in order of decreasing abundance are *Acodus curvatus, Icriodina irregularis, Paltodus migratus, P. costulatus, Distomodus kentuckyensis, Trichonodella? edentata,* and *Icriodina stenolophata*. Uncommon or rare species, also in order of decreasing abundance, are *Drepanodus? suberectus, Trichonodella?* n. sp., *Ligonodina kentuckyensis, Ligonodina? extrorsa, Trichonodella* sp. A, *Trichonodella brassfieldensis, Drepanodus? arrectus, Roundya caudata, Euprioniodina* cf. *Prioniodus excavatus, Lonchodina walliseri, Trichonodella* sp. B, *Ozarkodina typica, Synprioniodina* cf. *S. bicurvata, Lonchodina?* n. sp., *Keislognathus?* sp., *Plectospathodus irregularis, Roundya truncialata, Neoprioniodus planus,* and *Rhynchognathodus?* sp. The six species which may not be indigenous are *Ambalodus triangularis* Branson and Mehl, *Neoprioniodus costatus* Walliser, *N. triangularis* Walliser, *N. subcarnulus* Walliser, *Ozarkodina edithae* Walliser, and *Trichonodella* cf. *T. inconstans* Walliser.

Most of the geographic variation in conodont abundance is dependent on changes in the abundance of the genus *Panderodus*, although the pattern is similar for the remaining genera. The most prolific sections are on the east side of the Cincinnati Arch in southern Ohio and northern Kentucky between localities 5 and 11 (pl. 1). Southwest of locality 5, east of the arch, and directly across the arch at localities 52, 53, and 54, abundances are above average. The lowest yields of conodonts were from the northernmost localities, localities 14, 17, 18, 19, and 21. Throughout the remaining area the distribution of conodonts is quite uniform and specimens are moderately abundant.

With few exceptions there is a close correlation between the total number of specimens of each species and the percentage of samples in which each species is found. Exclusive of the panderodids, the most abundant species, *Acodus unicostatus,* also occurs in the highest percentage of the 245 samples, and with decreasing numbers of specimens, nearly all species are found in proportionately fewer samples. *Drepanodus? arrectus,* however, is found in a much larger proportion of samples than would be expected from the small total number of specimens collected. *Paltodus costulatus, Drepanodus? suberectus,* and *Trichonodella* sp. B., on the other hand, are less widely distributed but are represented by proportionately larger numbers of specimens.

The geographic distribution of *Paltodus costulatus, Drepanodus? suberectus,* and *Spathognathodus oldhamensis* deviates from the general pattern. Each of the three is recorded from only a few localities on the west side of the arch north of locality 51, whereas they are present on the east side of the arch at nearly all localities from 2 to 15. In general, from the Ohio River southward these three species and *Panderodus unicostatus serratus* tend to be more common progressively higher in the section, and at the type section for the Brassfield Formation and the Oldham Limestone Member of the Noland Formation all three are rare in the Brassfield, but all except *D? suberectus* are abundant in the Plum Creek Clay Member of the Noland Formation and in the Oldham Limestone Member. This suggests stratigraphic control and also suggests that the Brassfield is progressively younger to the north and northwest, a conclusion agreeing well with the evidence of the brachiopods.

An anomaly in conodont distribution is peculiar to the bead bed northward from locality 3, the Brassfield type section, to locality 8. In this area there are a markedly greater abundance of *Icriodina* and many fewer specimens of *Panderodus* in the uppermost unit of the Brassfield Formation. In the overlying beds of the Plum Creek clay the relationship of these two species to each other and to the remaining species closely parallels their relationship in the beds below the bead bed, although the total aspect of the Plum Creek fauna in this area differs somewhat from that of the Brassfield. The top unit of the Brassfield differs markedly in megafauna and lithology from the underlying part of the formation, and so some ecologic control of the conodonts is probable.

At a few Belfast localities conodonts restricted to the Silurian System are rare or lacking, and long-ranging species and fragmental, abraded conodonts of Ordovician age are the only conodonts recovered. At some localities *Icriodina* is found in the basal Belfast sample, and at others the lower part is nearly barren of Silurian conodonts, but the upper part contains a typical Brassfield fauna. This difference may be found within a single massive bed. The Belfast is interpreted as having faunal unity with the Brassfield, although in some places the basal part may be representative of the top of the lower part of Bereich I.

Age and Correlation

The Brassfield Formation (Brassfield Limestone in Indiana) is time transgressive, but the age range of the formation as herein recognized is within that of the Kankakee Dolomite of northeastern Illinois (fig. 2) and the Sexton Creek Limestone of southwestern Illinois. Accordingly,

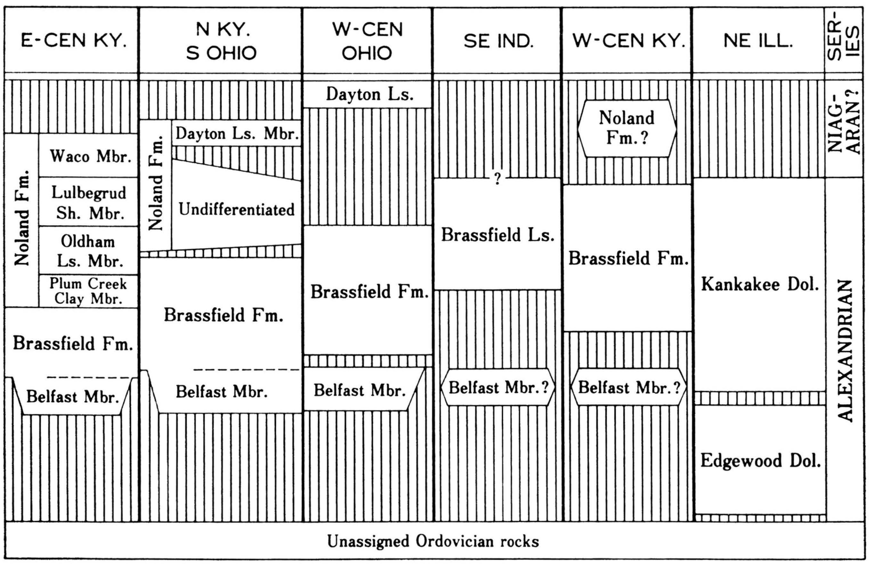


Figure 2. Chart showing correlation of the Brassfield in the area of the Cincinnati Arch and with the lower Silurian units of northeastern Illinois.

the Brassfield belongs in the upper part of the Alexandrian Series, an Illinois term that was proposed by Savage (1908) and that for Indiana usage is preferable to "Albion Series" of many published reports. Correlation of the Brassfield and the Illinois formations of the standard section of the Alexandrian Series is based on both brachiopods and conodonts.

At or near the top of the Kankakee and the Sexton Creek is found the brachiopod *Microcardinalia* (*Stricklandia* or *Stricklandinia* of early reports), and this genus has been found in the Brassfield in the bead bed at locality 15 (Foerste, 1885, p. 89; Rexroad and others, 1965, p. 12) and in the upper part of the section at locality 55 (Foerste, 1935, p. 169) and near New Hope, Ky. (Foerste, 1901, p. 440). *Platymerella* is widely distributed in the lower part of the Kankakee and the Sexton Creek and occurs in the lower part of the Brassfield below the chert beds but above the Belfast near Lawshe, Adams County, Ohio, and at locality 10 (Rexroad and others, 1965, p. 13). *Platymerella* was noted by Ross (1962, p. 1385) in the topmost beds of the Edgewood Dolomite.

The conodont genus *Icriodina* is present throughout the Brassfield, except that at several localities where the Belfast has a very limited fauna, it is absent from this lowermost part of the formation. In Illinois the genus is present in the Kankakee but is lacking from the underlying Edgewood Dolomite (Liebe, 1962). Possibly the Belfast Member of the Brassfield varies somewhat in age, and at some localities part of it may be equivalent to that part of the Edgewood just below the beds bearing *Platymerella manniensis*. Conodonts common to the Brassfield and Kankakee, in addition to *Icriodina*, include *Acodus unicostatus*, *Ligonodina? extrorsa*, *Ozarkodina typica*, *Paltodus dyscritus*, *P. migratus*, *Panderodus simplex*, *Trichonodella* sp. A, and *T.* sp. B.

Correlations of the Brassfield with the standard Silurian subdivisions of Great Britain by means of conodonts and brachiopods differ and on the basis of present knowledge cannot be successfully reconciled (fig. 3). The conodont genus *Icriodina* is a guide to the upper half of Bereich I of Walliser (1964, p. 94). It is associated with the brachiopod *Platymerella* in the lower part of the Brassfield and with the brachiopod *Microcardinalia* in the upper part of the formation, but the accepted range of the two brachiopods does not coincide with the accepted range of *Icriodina* as the ranges of both are related to the standard graptolite zones of Great Britain.

The Brassfield Formation as herein understood is entirely within conodont Bereich I, and the overlying Noland Formation in east-central

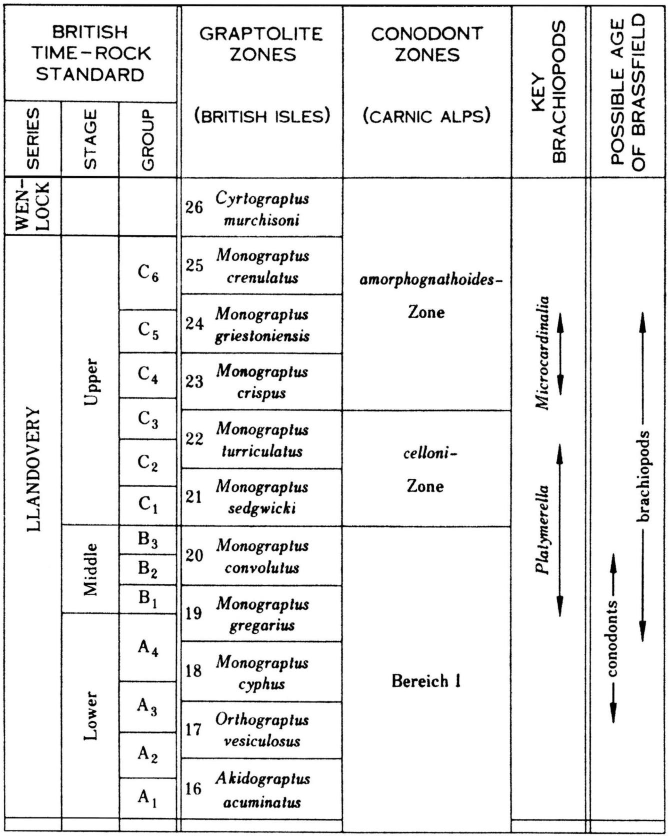


Figure 3. Chart showing possible ages of the Brassfield as indicated by brachiopods and conodonts.

Kentucky and southern Ohio is also within the limits of Bereich I. Walliser subdivided his lowermost Silurian conodont zone into two subdivisions that are distinguished by the presence of *Icriodina* in the upper part and by its absence from the lower part. In most sections of the Brassfield, *Icriodina* is found throughout the section, although it is not present throughout the Belfast Member in all sections. The base of the Brassfield, therefore, must nearly coincide with the base of the upper part of Bereich I. Bergstrom (written communication, November 1964) has found conodonts in Sweden in association with graptolites that apparently are representative of the *Monograptus sedgwicki* Zone (21) (fig. 3). They are either high Bereich I forms or low *celloni*-Zone forms, but in either case they are post-Brassfield and post-Noland in age. Thus the top of the Brassfield as it is now recognized is below the top of Bereich I and below graptolite zone 21 (fig. 3). Ross (1962) recorded graptolites of the *Diplograptus modestus* Subzone of the basal part of the *Orthograptus vesiculosus* Zone (17) in the lower part of the Edgewood Dolomite, stratigraphically about 45 feet below the zone of *Platymerella manniensis.* The approximate limits thus established for the top and bottom of the Brassfield show that the age of the Brassfield is within the range of the zones of *Monograptus cyphus* (18), *M. gregarius* (19), and *M. convolutus* (20), but that its age is probably mostly within the *M. gregarius* Zone and the upper part of the *M. cyphus* Zone. The limits in more general terms would be high in the Lower Llandovery Stage through the Middle Llandovery Stage.

In the brachiopod correlation, however, *Platymerella* has not been recorded below the Middle Llandovery Stage and ranges upward into the *Monograptus turriculatus* Zone (22) of late Llandovery age (fig. 3). With reference to British group terminology, *Microcardinalia* is considered to be C4 and C5 in age, corresponding approximately to the *Monograptus crispus* and *M. griestoniensis* Zones (23 and 24). Walliser (1964, p. 94), however, shows the *amorphognathiodes*-Zone in this position, beginning in the *M. crispus* Zone (23) and extending upward through the next two graptolite zones, and conodonts of this zone are present in the Estill Shale of Kentucky and Ohio and the Rockway Dolomite Member of the Irondequoit Limestone of the Niagara Gorge (Rexroad and Rickard, 1965). On the basis of the two brachiopod genera the Brassfield would be assigned an age represented by the *Monograptus gregarius* Zone to the *M. griestoniensis* Zone (19-24) inclusive. Thus the brachiopods suggest a much longer duration of Brassfield sedimentation and indicate that the unit is younger, the upper part appreciably more so, than do the conodonts when compared with the graptolites.

In east-central Kentucky there is no physical evidence that the deposition of the Brassfield took appreciably longer than did deposition of each of the overlying units, the Noland Formation, the Estill Shale, and the Bisher Formation. Yet the brachiopod *Eocelia sulcata* in the Bisher indicates a late Llandovery or early Wenlock age for the Bisher. Thus the Brassfield Formation of Kentucky, on the basis of brachiopod evidence, would range through six graptolite zones, whereas the remaining three formations, including an unconformity, would be limited to two or three zones. For this reason the age suggested by conodonts is favored at present.

Age differences in the Brassfield in different areas have been noted. From the type section of the Brassfield Formation and the Oldham Limestone Member of the Noland Formation northward as far as Indian Fields, Ky., *Microcardinalia* is found only in the upper part of the Oldham. To the north and west it is found in the upper part of the Brassfield. Thus the upper part of the Brassfield north and west of the type area is progressively younger. Transgression is suggested also by the distribution of conodonts, particularly *Spathognathodus oldhamensis, Paltodus costulatus,* and *Panderodus unicostatus serratus.* The time-transgressive nature of the formation, together with the changes in thickness and lithology associated with the Ripley positive area, show that the Brassfield sea encroached from the south and east, spread across the axis of the present Cincinnati Arch, and probably did not reach the Ripley positive area until late in the depositional history of the formation. The unit overlying the Brassfield from Jefferson County, Ind., into Bullitt County, Ky., although differing in fauna and lithology, may represent a final depositional sequence related to the Brassfield. Eventually it may be found desirable to include this unit with the Brassfield.

Stratigraphic Relations

The Brassfield Formation (Limestone) overlies Ordovician strata and is overlain by Silurian strata in the area studied except along the southern margin, where it is overlain by Devonian strata. On the west side of the Cincinnati Arch between Raywick, Ky. (locality 54), and southern Indiana, the Saluda or Whitewater Formation underlies the Brassfield Limestone. From the area of Madison, Ind., northward, the Brassfield lies on progressively younger beds of the Whitewater Formation, including in the Richmond area beds of the facies that in Indiana was formerly called the Elkhorn Formation (Utgaard and Perry, 1964). The regional relationships show a major hiatus to the south that diminishes northward. Along the outcrop belt in Ohio east of the arch, the Brassfield is underlain by the Elkhorn Formation and to the south in Kentucky by equivalent shales of the Richmond Group.

In those areas where the Belfast Member is absent and the basal part of the Brassfield is in the upper part of Bereich I, the Brassfield is unconformable at its base. An unconformity at the base of the Belfast also seems certain. The presence of *Icriodina* in many Belfast sections eliminates correlation of these sections and the Edgewood Dolomite (Silurian) of Illinois and the lower pre-*Icriodina* part of Bereich I. Even in localities where *Icriodina* is absent from a few feet of Belfast rocks, this unit could hardly represent all Edgewood time. Further, there is no evidence that very youngest Ordovician strata are present in the area, and the variable thickness of the Belfast and its local absence along its outcrop belt indicate that the Belfast was deposited on an irregular Ordovician surface. Thus evidence for a hiatus before Belfast deposition is established.

At locality 14 beds questionably referred to the Belfast (Summerson, 1963, p. 32) appear transitional with the underlying Ordovician strata. They differ lithologically from the overlying Brassfield, and the conodonts except for a single specimen of *Acodus unicostatus* are Ordovician in age. These beds are considered, then, Ordovician in age and unconformable with the Brassfield.

East of the Cincinnati Arch the Noland Formation overlies the Brassfield in Kentucky and southernmost Ohio. In Lewis and Fleming Counties, Ky., the Brassfield-Noland contact appears to be gradational and no sharp faunal break is present between the two formations. Here the bead bed is the best criterion for recognizing the boundary. Both north and south of these counties the lithologies of the two formations differ more sharply, as do the faunas, and the faunal and lithologic difference, together with the megaripples, crossbedding, oolitic hematite, and similar features in the uppermost part of the Brassfield, suggests a hiatus between the two. The lower part of the Noland Formation wedges out between the Brassfield and the Dayton Limestone in southern Ohio. Throughout the remainder of the Ohio outcrop area, the Brassfield is overlain unconformably by the Dayton Limestone.

West of the Cincinnati Arch in Indiana the Brassfield Limestone is uncomformably overlain by the Osgood Member of the Salamonie Dolomite as far south as southern Jefferson County. From here south into Bullitt County, Ky., a unit of uncertain relationships is present between the Brassfield and Osgood at many localities; the Osgood from southern Jefferson County, Ky., southward is represented by a facies that might more appropriately be referred to the Crab Orchard shales.

The oldest beds of the Osgood are in the south, where much of the unit belongs in the *amorphognathoides*-Zone, but the Osgood is progressively younger to the north, where the *amorphognathoides*-Zone is absent.

Collecting Localities

1. Carter Coordinates 5-L-59, 3,250 feet east of west line, 3,400 feet south of north line of L-59, Lincoln County, Ky.; south bank of Neals Creek just east of bridge and about 275 yards downstream from church; Halls Gap Quadrangle. Locality 1 CO-NE of Foerste (1906, p. 147, 148). He states: "This is the most western exposure of the Brassfield bed on the eastern side of the Cincinnati geanticline, in central Kentucky." Field designation is Neals Creek.

2. Carter Coordinates 19-N-63, 9,525 feet east of west line, 10,075 feet north of south line of N-63, Madison County, Ky.; road cut on east side of U. S. Highway 25 about 1.6 miles north of Berea; Berea Quadrangle. Locality 1788 of Branson and Branson (1947, p. 556). Field designation is Kentucky, Silver Creek.

3. Carter Coordinates 3-N-65, from 9,950 to 11,400 feet east of west line, from 175 to 1,300 feet south of north line of N-65, Madison County, Ky.; cuts on abandoned railroad line between Brassfield and Panola, from 0.7 to 1.15 miles northeastward from Panola; Moberly Quadrangle. Locality 2 R-SE of Foerste (1906, p. 176) and section 1 of Rexroad and others (1965, p. 9). Field designations are Panola, Ky., and Panola-Brassfield Composite.

4. Carter Coordinates 5-O-65, 3,200 feet east of west line, 3,100 feet south of north line of O-65, Madison County, Ky.; cut on north side of Kentucky Highway 52 at east end of bridge over Muddy Creek 0.5 mile west of Waco; Moberly Quadrangle. Localities 1784 and 1826 of Branson and Branson (1947, p. 556). Field designation is Waco West.

5. Carter Coordinates 5-P-66, 4,125 feet east of west line, 5,475 feet south of north line of P-66, Estill County, Ky.; road cut on east side of Kentucky Highway 89 near top of south bluff of Red River; Palmer Quadrangle. Section 6 of Rexroad and others (1965, p. 18). Samples were also taken from the less complete section along the

highway on the north bluff of the river, and this latter section is locality 1840 of Branson and Branson (1947, p. 556). Field designation is Red River South.

6. Carter Coordinates 6-T-70, 2,800 feet east of west line, 8,050 feet south of north line of T-70, Bath County, Ky.; cut on north side of U. S. Highway 60 about 1.3 miles east of Owingsville near top of Slate Creek bluff; Colfax Quadrangle. Field designation is Owingsville West.

7. Carter Coordinates 7-U-71, 10,300 feet south of north line, 8,600 feet east of west line of U-71, Fleming County, Ky.; cuts on road about 0.6 mile north of Colfax and south of stream; Colfax Quadrangle. Section 4 of Rexroad and others (1965, p. 16). Field designation is Colfax, Ky.

8. Carter Coordinates, southern part of 3-Y-72 and northern part of 8-Y-72, Lewis County, Ky.; road cuts on Kentucky Highway 10 on both bluffs of Cabin Creek about 2.5 miles east of junction with Kentucky Highway 57 in Tollesboro, lower part of section to west, upper to east; Tollesboro Quadrangle. Section 5 of Rexroad and others (1965, p. 17). Field designation is Silurian Tollesboro.

9. Carter Coordinates 18-AA-73, 11,900 feet east of west line, 6,120 feet north of south line of AA-73, Adams County, Ohio; road cut and gully on north side of U. S. Highway 52 on northern bluff of Ohio River; Concord Quadrangle. Field designation is Ohio Brush Creek.

10. Adams County, Ohio; road cut on west side of Ohio Highway 41 just south of bridge over Ohio Brush Creek; Peebles Quadrangle. Stop 1 of Summerson (1963, p. 16, fig. 3) and section 2 of Rexroad and others (1965, p. 11). Field designation is Jacksonville, Brush Creek.

11. Highland County, Ohio; north bank of Turtle Creek and abandoned quarry southwest of road junction at Sharpsville; Martinsville Quadrangle. Field designations are Sharpsville, Turtle Creek, and Sharpsville Quarry.

12. Clinton County, Ohio; stream cut and abandoned quarry on north side of Todd Fork about 400 yards upstream from Center Road.

Top sample from stream bed about 350 yards downstream from U. S. Highway 68; Wilmington Quadrangle. Section described by Foerste (1888, p. 413; 1896, p. 167). Field designation is Todd Fork.

13. Line between NW¼SW¼ sec. 19 and NE¼SE¼ sec. 25, T. 2 N., R. 6 W., Montgomery County, Ohio; west side of north lake in abandoned quarry; Dayton South Quadrangle. Locality 16 of Foerste (1906, p. 170). Thickness is 17 feet (Foerste, 1904, p. 325). Field designation is Centerville Quarry.

14. NE¼NW¼ sec. 14, T. 3 N., R. 8 E., Green County, Ohio; cut on northeast side of Ohio Highway 235 and in abandoned Southwestern Portland Cement Co. quarry; Yellow Springs Quadrangle. Stop 8 of Summerson and others (1963, p. 31, 32). Field designation is Fairborn, Ohio.

15. NE¼SE¼ sec. 1, T. 1 N., R. 5 E., Montgomery County, Ohio; abandoned quarry dump on grounds of Veterans Administration Hospital [Soldiers Home]; Miamisburg Quadrangle. Section first described by Foerste (1885, p. 70-73). Field designation is V. A., Dayton.

16. NE¼SW¼ sec. 11, T. 7 N., R. 2 E., Preble County, Ohio; east bank of Seven Mile Creek about 75 yards downstream from U. S. Highway 127; West Alexandria Quadrangle. See also Eaton South Quadrangle. Stop 6 of Shaver and others (1961, p. 34, fig. 13). Field designation is Eaton South.

17. SE¼SW¼ sec. 21, T. 7 N., R. 3 E., Preble County, Ohio; quarry face of Lewisburg Quarry and Mine, Marble Cliff Co.; Lewisburg Quadrangle. Stop 5 of Shaver and others (1961, p. 31, 32, fig. 11). Field designation is Lewisburg, Ohio.

18. SW¼SE¼ sec. 16, T. 4 N., R. 5 E., nearly on south line of section, Miami County, Ohio; road cut on south side of Ohio Highway 71 in east bluff of Stillwater River about 0.3 mile east of West Milton; West Milton Quadrangle. Field designation is West Milton.

19. SW¼ sec. 29, R. 11 T. 1 (Miami River Survey), Miami County, Ohio; in sump and from north and east quarry face of south pit of Aramco Steel Quarries, Piqua; Troy Quadrangle. See also Piqua East Quadrangle. Field designation is Piqua, Ohio.

20. NW¼ sec. 11, T. 13 N., R. 1 W., Wayne County, Ind., DeBolt Concrete Co. quarry near corner of Wernle and Garwood Roads southeast of Richmond; New Paris Quadrangle. Field designation is DeBolt Quarry.

21. SW¼SW¼NW¼ sec. 12, T. 14 N., R. 1 W., Wayne County, Ind.; Indiana Geological Survey drill hole 57, Leslie Cook farm; Whitewater Quadrangle. Field designation is C-176.

22. SE¼NW¼ sec. 22, T. 13 N., R. 1 W., Wayne County, Ind.; Elkhorn Falls on Elkhorn Creek just southwest of Indiana Highway 227; New Paris Quadrangle. Field designation is Elkhorn Falls.

23. NE¼SW¼ sec. 5, T. 13 N., R. 12 E., Fayette County, Ind.; abandoned quarry of Fall Creek Stone Co.; Alpine Quadrangle. Field designation is Bunker Hill.

24. SW¼NE¼ sec. 7, T. 12 N., R. 12 E., Franklin County, Ind.; southeast bank of gully in bluff of Sains Creek; Alpine Quadrangle. Locality 235 of Foerste (1898, p. 252) and locality 1 of Mound (1961, p. 13). Field designation is Sains Creek Tributary.

25. Line between NE¼SW¼ and NW¼SE¼ sec. 22, T. 11 N., R. 11 E., Franklin County, Ind.; natural exposure near top of east bluff of Righthand Fork; Clarksburg Quadrangle. Field designation is Hamburg West.

26. NW¼NW¼ sec. 17, T. 10 N., R. 11 E., Decatur County, Ind.; south end of New Point Stone Co. quarry; New Point Quadrangle. Field designation is New Point Quarry.

27. NW¼NE¼ sec. 8, T. 9 N., R. 13 E., Ripley County, Ind.; east side of small abandoned quarry with lake; Spades Quadrangle. Location given by Huddle (1931, p. 214). Field designation is Sunman Northeast.

28. SE¼SW¼ sec. 3, T. 8 N., R. 11 E., Ripley County, Ind.; north bank of Plum Creek; Osgood Quadrangle. Locality 107 of Foerste (1897, p. 265) and locality 3 of Mound (1961, p. 13). Field designation is Osgood North.

29. SE¼NE¼ sec. 30, T. 9 N., R. 10 E., Decatur County, Ind.; east bank of Squaw Creek [Square Run] about 50 yards below bridge;

Milhousen Quadrangle. Brassfield is missing. Locality 178 of Foerste (1897, p. 280). Field designation is F-178.

30. SE¼NE¼ sec. 5, T. 9 N., R. 9 E., Decatur County, Ind.; west bank of Sand Creek at east end of hill and just below road; Forest Hill Quadrangle. Locality 189 of Foerste (1897, p. 282). Field designation is F-189.

31. NW¼NW¼ sec. 13, T. 8 N., R. 9 E., Jennings County, Ind.; bed and bank of tributary gully on north of Wolf Creek below long-abandoned road; Milhousen Quadrangle. Locality 182 of Foerste (1897, p. 281). Field designation is F-182.

32. NW¼SE¼ sec. 5, T. 8 N., R. 9 E., Decatur County, Ind.; east bank of Painter [Penther] Creek about 100 yards south of road; Westport Quadrangle. Brassfield is absent. Locality 194 of Foerste (1897, p. 283). Field designation is F-194.

33. NE¼NW¼ sec. 31, T. 7 N., R. 12 E., Ripley County, Ind.; bed of gully west of Laughery Creek about 150 yards east of Indiana Highway 129; Milan Quadrangle. Field designation is Versailles South-Smith.

34. SW¼NE¼ sec. 21, T. 6 N., R. 11 E., Ripley County, Ind.; banks of Vestal Branch above and below secondary road; Rexville Quadrangle. Locality 81 of Foerste (1897, p. 258). Field designation is Vestal Branch.

35. SW¼NE¼ sec. 36, T. 7 N., R. 10 E., Ripley County, Ind.; cut on east side of Michigan Road on south bluff of Big Graham Creek; Versailles Quadrangle. Brassfield is absent. Locality 131 of Foerste (1897, p. 270). Field designation is New Marion.

36. NW¼SW¼ sec. 34, T. 7 N., R. 9 E., Jennings County, Ind.; northwest bank of South Fork Vernon Fork just upstream from bridge; Butlerville Quadrangle. Brassfield is absent. Locality 170 of Foerste (1897, p. 278 [Otter Creek]). Field designation is F-170.

37. NE¼NW¼ sec. 9, T. 5 N., R. 12 E., Switzerland County, Ind.; Tri-County Stone Co. quarry; Cross Plains Quadrangle. Stop 4 of Patton, Perry, and Wayne (1953, p. 14). Field designation is Cross Plains.

38. SE¼NW¼ sec. 20, T. 5 N., R. 11 E., Jefferson County, Ind.; road cut on north side of Indiana Highway 62; Canaan Quadrangle. Locality 59 of Foerste (1897, p. 254) misnamed as Dry Branch. Field designation is Indian-Kentuck Church.

39. NW¼NE¼ sec. 34, T. 4 N., R. 10 E., Jefferson County, Ind.; cut on east side of Indiana Highway 7; Clifty Falls Quadrangle. Locality 38 of Foerste (1897, p. 248) and locality 5 of Mound (1961, p. 14). Field designation is Hanging Rock.

40. NW¼NW¼ sec. 5, T. 3 N., R. 10 E., Jefferson County, Ind.; road cut on north side of Indiana Highway 62; Madison West Quadrangle. Locality 35 of Foerste (1897, p. 247) and stop 1 of Esarey, Malott, and Galloway (1947, p. 5). Field designation is Clifty Creek West.

41. NW¼NW¼ sec. 30, T. 3 N., R. 10 E., Jefferson County, Ind.; near top of Ohio River bluff about 200 yards north of Harts Falls Creek; Madison West Quadrangle. Locality 6 of Mound (1961, p. 14). Field designation is Indiana Harts Falls.

42. NW¼NW¼ sec. 29, T. 2 N., R. 10 E., Jefferson County, Ind.; bed and bank of intermittent stream on Ohio River bluff; Bethlehem Quadrangle. About the same as locality 18 of Foerste (1897, p. 241). Field designation is Marble Hill.

43. NW¼SE¼ sec. 32, T. 2 N., R. 10 E., Clark County, Ind.; exposure in draw and along road north of abandoned quarry in Ordovician rocks; Bethlehem Quadrangle. Brassfield is absent. Field designation is Miles Point.

44. Center of west line of sec. 8, T. 1 N., R. 10 E., Clark County, Ind.; cut on northeast side of road near top of Ohio River bluff about 1 mile west of Bethlehem; Bethlehem Quadrangle. Locality 8 of Mound (1961, p. 14). Field designation is Bethlehem.

45. Carter Coordinates 15-X-49, 4,350 feet east of west line, 14,050 feet south of north line, Oldham County, Ky.; near top of Ohio River bluff at "Y" junction of private roads to house and to river bottom north of Dunbar Hollow; LaGrange Quadrangle. Field designation is George Eggers property.

46. S¼S¼ lot 121, Clark's Grant, Clark County, Ind.; road cut on northwest side of Indiana Highway 62 on east bluff of Fourteenmile Creek; Owen Quadrangle. Brassfield may be absent. Section described by Esarey, Malott, and Galloway (1947, p. 6), Murray (1955, p. 10, 11), and Hattin and others (1961, p. 325, 326). Field designation is Fourteenmile Creek.

47. Carter Coordinates 24-W-48, 7,275 feet east of west line, 4,050 feet north of south line of W-48, Oldham County, Ky.; cut on west side of Brownsboro Road 0.35 mile south of bridge over South Fork Harrods Creek; Anchorage Quadrangle. Stop 14 of Browne and others (1958, p. 31). Field designation is Brownsboro Road.

48. Carter Coordinates 8-T-48, 9,950 feet west of east line, 9,800 feet south of north line of T-48, Jefferson County, Ky.; road cut just above abandoned quarry on north side of Seatonville Road on bluff of Floyds Fork about 1 mile west of Seatonville; Jeffersontown Quadrangle. Locality given and section photographed by Butts (1915, p. 72, pl. 22). Field designation is Floyds Bluff.

49. Carter Coordinates 4-S-48, 8,850 feet east of west line, 5,800 feet south of north line of S-48, Bullitt County, Ky.; road cut on east side of U. S. Highway 31E on hill about 1.6 miles north of junction with Kentucky Highway 44 in Mt. Washington; Mt. Washington Quadrangle. Field designation is Mt. Washington North.

50. Carter Coordinates 7-R-48, 7,250 feet east of west line, 9,450 feet south of north line of R-48; Bullitt County, Ky.; cut on northeast side of Kentucky Highway 480 near top of bluff of Rocky Run and Cox Creek; Samuels Quadrangle. Field designation is Solitude.

51. Carter Coordinates 12-Q-47, 5,150 feet west of east line, 14,300 feet south of north line of Q-47, Bullitt County, Ky.; bed and banks of gully in east valley wall of Overalls Fork slightly more than 0.5 mile upstream from Wilson Creek-Harrison Fork Road; Samuels Quadrangle. See Cravens Quadrangle also. Section 2 of figure 5 of Browne (1958, p. 46, 47) and cited on page 41. Field designation is Overalls Fork.

52. Carter Coordinates 14-P-49, 9,000 feet east of west line, 12,600 feet south of north line of P-49, Nelson County, Ky.; south end of abandoned quarry 0.6 mile south of U. S. Highway 31E on ex-

tension of 4th Street, south edge of Bardstown; Bardstown Quadrangle. Stop 4 of Nosow (1959, p. 16, fig. 5). Field designation is Old Bardstown.

53. Carter Coordinates 10-N-48, 2,875 feet west of east line, 10,250 feet south of north line of N-48, Nelson County, Ky.; small abandoned quarry north of road about 0.3 mile north of north edge of New Hope; New Haven Quadrangle. Stop 10 of Nosow (1959, p. 25, fig. 11). Field designation is New Hope.

54. Carter Coordinates 10-M-49, 3,300 feet west of east line, 8,000 feet south of north line of M-49, Marion County, Ky.; road cut on east side of Kentucky Highway 527 on north edge of Raywick; Raywick Quadrangle. Field designation is Raywick, Ky.

55. Carter Coordinates 5-M-55, 2,250 feet east of west line, 3,600 feet south of north line of M-55, Boyle County, Ky.; west bluff and east bank of stream in Webb Hollow tributary to Scrubgrass Creek about 3.4 miles southwest of Mitchellsburg; Parksville Quadrangle. Field designation is Scrubgrass Creek.

Systematic Descriptions

All type and figured specimens are reposited in the Indiana University-Indiana Geological Survey collections. Numbers in parentheses following each repository number refer to the locality and sample number for that specimen. Under the heading "Material studied" only the specimens from the present collection are listed.

Genus **Acodus** Pander, 1856

Type species: Acodus erectus Pander, 1856.

Diagnosis: This genus includes simple curved conical conodonts with anterior and posterior costae and a costa on one lateral face.

Remarks: Acodus is a widespread and long-ranging genus that is known from strata ranging in age from early Ordovician to middle Silurian. The two Brassfield species referred to the genus are closely related to three of the species assigned to *Paltodus, P. debolti, P. dyscritus,* and *P. migratus.* Schematic comparisons of the species of *Acodus* and *Paltodus* are made in figure 4.

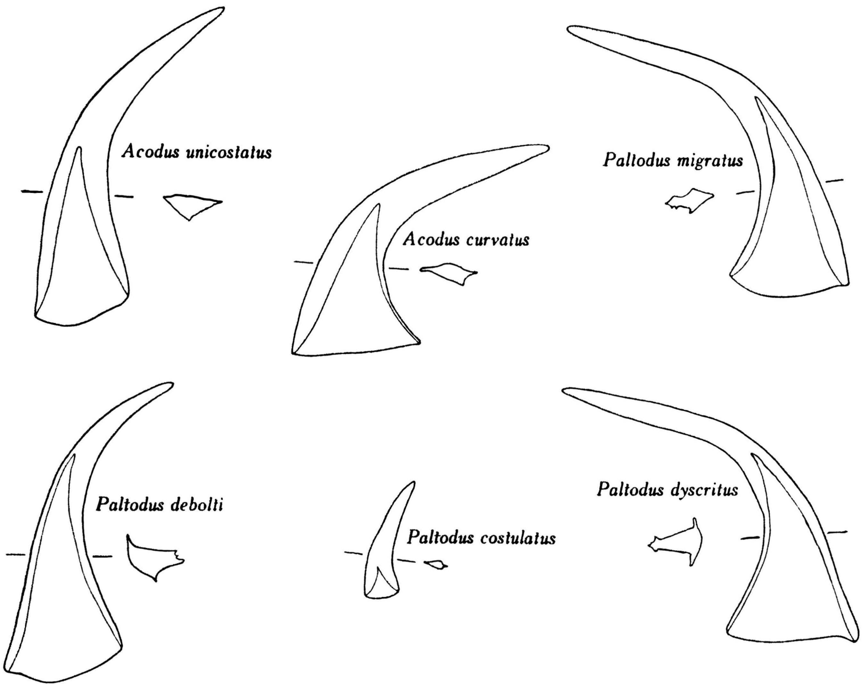


Figure 4. Sketches showing lateral outlines, transverse sections, and basal cavities of the species of *Acodus* and *Paltodus* from the Brassfield. Magnification is X 40.

Lindström (1959, p. 433) thought that *Sagittodontus* Rhodes, 1953, was a junior synonym of *Acodus*, but both are here considered valid as the two do not seem to be closely related in form or in associations. *Sagittodontus* has a robust pyramidal shape and lacks keels although the faces meet in a sharp margin. Faces tend to be concave in the lower part.

Acodus curvatus Branson and Branson

Plate 4, figures 9-12

Acodus curvatus Branson and Branson, 1947, Jour. Paleontology, v. 21, p. 554, pl. 81, fig. 20.

Acodus cfr. *mutatus* (Branson and Mehl), Serpagli and Greco, 1964, Soc. paleont. italiana Boll., v. 3, p. 196, pl. 34, figs. 2a, b.

?*Acontiodus procerus* (Ethington), Serpagli and Greco, 1964, Soc. paleont. italiana Boll., v. 3, p. 198, pl. 37, figs. 5, 6.

Remarks: Acodus curvatus is a variable species whose cusp typically is sharply recurved near midlength and is twisted somewhat inward. The sharp anterior and posterior edges are produced as costae that are less apparent distally. In most specimens a lateral costa is present only on the inner side, well posterior to the midline, and not quite extending to the basal margin. The conical basal cavity extends to a point about midlength of the cusp and near the anterior margin.

The anterior position of the inner lateral costa suggests a relationship with *Paltodus debolti,* and some specimens indicate transition with this genus. Transitional specimens have an additional costa posteriorly on the inner face or a costa on the outer face or both.

Material studied: 692 specimens.

Repository: 10001 (12-9), 10002 (12-11), 10003 (24-2), and 10004 (26-1) (figured specimens).

Acodus unicostatus Branson and Branson

Plate 4, figures 13-16

Acodus unicostatus BRANSON and BRANSON, 1947, Jour. Paleontology, v. 21, p. 554, pl. 82, figs. 9, 10, 41, 43.

Paltodus acostatus BRANSON and BRANSON (part), 1947, Jour. Paleontology, v. 21, p. 554, pl. 82, figs. 23, 24.

Remarks: The holotype of *Acodus unicostatus* is listed in the text of the Branson and Branson paper as University of Missouri C678-3, and it is shown as figure 43 of plate 82 rather than figure 41 as indicated in the plate legend. Figure 41 is found on slide C678-4 and is the only specimen on that slide belonging in the species. The only paratype slide listed is C678-1, but a spathognathodid is found on this slide. The specimens shown in figures 9, 10, and 41 apparently are represented among the 15 specimens of the species found on slides C684-3 and C685-1 that are not listed in the publication but have "paratype" written on them.

Of the specimens figured as *Paltodus acostatus* by Branson and Branson, only the specimen shown in figures 23 and 24 on plate 82 belongs in *Acodus unicostatus.* Because this is the holotype of *P. acostatus,* and thus the name bearer, *P. acostatus* must be considered as a synonym of *Acodus unicostatus.* The remaining figured paratypes of *Paltodus acostatus* are referred to *Panderodus simplex* (Branson and Mehl).

Material studied: 2,227 specimens.

Repository: 10005 (22-5), 10006 (26-2), 10007 (U. S. Highway 150 at Clear Creek, Ky.), and 10008 (27-3) (figured specimens).

Genus **Ambalodus** Branson and Mehl, 1933

Type species: Ambalodus triangularis Branson and Mehl, 1933.

Diagnosis: This genus is characterized by a triangular to crescent-shaped platform completely excavated aborally and bearing orally anterior, posterior, and outer lateral rows of denticles with a larger denticle at their point of union.

Remarks: Mound and Ethington (1964) requested that the International Commission on Zoological Nomenclature use their plenary powers to validate *"Ambalodus"* and reject *"Ambolodus."* They summarized usage.

Ambalodus spp.

Plate 3, figure 4

Eighteen specimens of a three-rayed or triangular platform type are referred to *Ambalodus.* The material represents differing ontogenetic stages, is morphologically variable, and generally is fragmental. These factors, together with the small number of specimens available, preclude speciation, but one specimen provisionally is referred to *A. triangularis* Branson and Mehl. That species is recorded by Walliser (1962, 1964) from his zone I, the lowest of the Silurian zones, in association with *Icriodina. Ambalodus galerus* from the *celloni-* and the *amorphognathoides*-Zones is not represented.

Material studied: 18 specimens.

Repository: 10009 (11-14) (figured specimen).

Genus **Distomodus** Branson and Branson, 1947

Type species: Distomodus kentuckyensis Branson and Branson 1947.

Diagnosis: The unit consists of a main cusp, a short denticulate posterior bar, and an anticusp that may or may not be denticulate. The entire aboral surface is excavated and the basal cavity extends upward as a cone into the cusp.

Remarks: Although originally described as a simple cone, the general form of *Distomodus* corresponds to that of *Neoprioniodus* Rhodes and Müller and *Synprioniodina* Ulrich and Bassler. *Distomodus* differs from the Silurian and Devonian types of those two genera in the total excavation of its undersurface and in the size and position of the conical portion of the basal cavity. Because the basal cavity is one of the more basic features for taxonomic differentiation of conodonts, *Distomodus* tentatively is considered separate from *Neoprioniodus* and *Synprioniodina*. Little distinction can be made in morphology between *Distomodus* and *Cordylodus* Pander or *Cyrtoniodus* Stauffer except for the denticulation of the anticusp in some specimens of *Distomodus,* but the genera do not seem to be closely related.

Distomodus kentuckyensis Branson and Branson

Plate 2, figures 11-14

Distomodus kentuckyensis Branson and Branson, 1947, Jour. Paleontology, v. 21, p. 553, pl. 81, figs. 21-23, 27, 29-33, 36-41.

Remarks: Emphasis should be given to the increasing convexity of the inner side of the main cusp toward the base, where it joins with the widely flaring lip of the basal cavity. Costae may be present on the anterior and posterior margins of the main cusp toward the base, and the anterior costa on the anticusp may show incipient dentition or may be replaced by strongly compressed denticles fused nearly to their apices. The posterior bar, illustrated but not previously described, is short and low, is excavated basally, and bears laterally compressed, partially fused denticles.

Although the holotype and several paratypes are missing, the remaining paratypes adequately represent the species.

Material studied: 248 specimens.

Repository: 10017 (20-4), 10018 (11-3), 10019 (22-5), and 10020 (5-7) (figured specimens).

Genus **Drepanodus** Pander, 1856

Type species: Drepanodus arcuatus Pander, 1856.

Diagnosis: This genus includes almost symmetrical simple conical conodonts with sharp anterior and posterior edges and noncostate lateral faces. As viewed laterally the posterior margin is smoothly curved to the base.

Remarks: Drepanodus? arrectus does not readily fit the genus, as is indicated in the remarks about the species, and the original generic assignment is followed only for lack of any other suitable designation.

Drepanodus? arrectus Rexroad, n. name

Plate 2, figures 1-3

Drepanodus simplex BRANSON and BRANSON, 1947, Jour. Paleontology, v. 21, p. 522, pl. 81, figs. 24-26; pl. 82, fig. 38.

Derivation of name: Latin, *arrectus,* upright, in reference to the erect attitude of the main cusp.

Diagnosis: This conodont has an erect cusp that bears a denticulate anterior process and that flares basally both posteriorly and laterally to form an extended lip for the shallow basal cavity.

Description: The main cusp is straight or very slightly recurved, and its anterior margin is sharp edged. The posterior margin tends to be rounded but is nearly flat in the lower portions, although in some specimens it is angular, a fact that suggests possible representation of a second species that is not separable on the basis of present material. The posterior and posterolateral margins of the base of the cusp flare broadly to form an expanded shallow basal cavity that is deepest and conical near the center of the cusp. In a very few specimens there is some evidence of posterior denticles on the upper surface of the flaring lip. The basal cavity is continuous under the anterior process, which bears subround to laterally compressed, partially fused denticles confluent with the anterior edge of the cusp. The anterior process is directed anteriorly downward and in most specimens is twisted laterally a small amount.

Remarks: Drepanodus simplex Branson and Branson, 1947, is a junior synonym of *D. simplex* Branson and Mehl, 1933. This was discussed with Carl C. Branson, coauthor of the junior synonym, who suggested that I propose a new name for the Brassfield species and further suggested the trivial name *arrectus,* a most appropriate name (written communication, August 10, 1964).

Several taxonomic problems remain to be solved, and unfortunately the holotype and one paratype are missing from their slides in the University of Missouri collection. In order to stabilize the concept of the species the paratype shown by Branson and Branson as figure 38 on plate 82, one of two specimens on University of Missouri slide C681-3, is hereby designated as the neotype to replace the missing holotype. Slide C681-3 has had written on it the words holotype and paratype, but slide C673-3, which is designated as the holotype in the text and in the figure legend for figures 25 and 26 of plate 81, is not so designated on the slide. The Brassfield location marked on the type slides is locality 1785, which is not identified in the "List of Brassfield Localities" given on page 556 of Branson and Branson (1947).

Comparison of the figures of the holotype with the remaining paratype raises doubt as to whether the two actually are conspecific. This cannot be resolved without the lost holotype, and it seems best to regard the characteristics of the neotype as definitive. The description given by Branson and Branson is accurate, except that because so much of the flaring base was broken away description of the denticulate anterior process was not given. Denticles are suggested by figure 24 of plate 82, and the attachment area of the process is quite apparent in the neotype.

The generic assignment of the species is in doubt. Because of the denticulate anterior process, the genus does not fit in *Drepanodus*. The main cusp, denticulate anterior process, and nondenticulate posterior process result in a form similar to *Falodus* Lindström, but a phylogenetic relationship is doubtful. Common forms of *Falodus* can be recognized as an oistodid with denticulation developing on the anterior margin. The species may represent a new genus, but material is not adequate for a thorough definition. For the present the original generic designation is retained but followed by a question mark to indicate the uncertainty.

Material studied: 88 specimens.

Repository: 10021 (28-1), 10022 (31-bulk), and 10023 (11-1) (figured specimens).

Drepanodus suberectus (Branson and Mehl)

Plate 2, figure 4

Oistodus suberectus Branson and Mehl, 1933, Missouri Univ. Studies, v. 8, p. 111, pl. 9, fig. 7; Rhodes, 1953, Royal Soc. London Philos. Trans., ser. B, no. 647, v. 237,

p. 295, pl. 21, figs. 93, 94; pl. 22, figs. 166, 167; GLENISTER, 1957, Jour. Paleontology, v. 31, p. 726, pl. 86, figs. 12, 14.

Drepanodus suberectus (Branson and Mehl), LINDSTROM, 1954, Geol. fören. Stockholm Förh., v. 76, p. 568, pl. 2, figs. 21, 22; SANNEMANN, 1955, Neues Jahrb. Geologie u. Paläontologie Abh., v. 102, p. 27, pl. 1, fig. 22; pl. 2, fig. 1; ETHINGTON, 1959, Jour. Paleontology, v. 33, p. 276, pl. 39, fig. 17; STONE and FURNISH, 1959, Jour. Paleontology, v. 33, p. 222, pl. 31, fig. 7; SWEET and OTHERS, 1959, Jour. Paleontology, v. 33, p. 1049, pl. 130, fig. 4; PULSE and SWEET, 1960, Jour. Paleontology, v. 34, p. 253, pl. 35, figs. 2, 7.

Remarks: Walliser (1964, fig. 2, and pl. 10, figs. 1-4) illustrated a series of conodonts that show progressive fusion of discrete simple conical forms resulting in multidenticulate forms. The same development appears to occur in *Drepanodus suberectus,* but material is too fragmental to determine this with certainty.

Material studied: 146 specimens.

Repository: 10024 (3-6) (figured specimen).

Genus **Euprioniodina** Ulrich and Bassler *in* Bassler, 1925

Type species: Euprioniodina deflecta Ulrich and Bassler, 1926.

Diagnosis: This compound conodont consists of a main cusp, a moderately long denticulate posterior bar, and a short, sharply down-turned anterior process bearing discrete denticles. The pit is small and beneath the main cusp.

Remarks: Ulrich and Bassler (1926, p. 42) stated that there is a close relationship between *Synprioniodina* and *Euprioniodina* and that the essential difference is the almost complete lateral fusion of the denticles of the former. Their illustrations of *Euprioniodina deflecta,* type species of *Euprioniodina,* also suggest that this genus has a short anterior process rather than an anticusp as *Synprioniodina* does. Whether these differences are sufficient to maintain the identity of both genera is questionable.

Euprioniodina cf. **Prioniodus excavatus** Branson and Mehl

Plate 3, figures 7, 8

Prioniodus excavatus BRANSON and MEHL, 1933, Missouri Univ. Studies, v. 8, p. 45, pl. 3, figs. 7, 8.

Diagnosis: The unit consists of a subround, recurved main cusp with a flaring inner lateral lip, an anteriorly projecting anticusp typically bearing a single discrete denticle, and a posterior bar arising from an eccentric position and bearing discrete denticles.

Remarks: The general plan of the species is lonchodinid. If the longitudinal axis of the main cusp is considered to define anterior and posterior, the posterior bar arises from a posterolateral (outer) position, and the anticusp, which extends only slightly below the base of the cusp, arises from an anterolateral (inner) position. In some specimens the symmetry more closely approaches typical synprioniodid-neoprioniodid forms. The anticusp generally bears a single laterally compressed to subround denticle, but from none to three may occur.

This species is very close to both *Prioniodus excavatus* Branson and Mehl and *Neoprioniodus multiformis* Walliser. It differs from both in the orientational relation of the main cusp to the posterior bar and in having a shorter posterior bar. The main cusp of *P. excavatus* is nearly flat on the outer surface with sharp anterior and posterior margins rather than being subround. The anterior margin of the holotype of *P. excavatus* is broken, but topotype material indicates that the anticusp may be produced anteriorly with a laterally compressed denticle present. Except for the holotype, figured specimens of *N. multiformis* differ in the shape of the main cusp, which is relatively flat and sharp edged.

It seems probable that *Euprioniodina* cf. *P. excavata* is ancestral to *Prioniodus excavatus* and to *Neoprioniodus multiformis* as shown by its holotype.

Material studied: 55 specimens.

Repository: 10025 (9-11) and 10026 (18-2) (figured specimens).

Genus **Icriodina** Branson and Branson, 1947

Type species: Icriodina irregularis Branson and Branson, 1947.

Diagnosis: This genus is a cruciform conodont that bears denticles, nodes, or ridges on the oral surface. The entire aboral surface is excavated.

Remarks: The specimens of *Icriodina irregularis* upon which the genus was founded are broken, and in the type area only single lobes or processes were recovered during the course of this study. The original generic description, consequently, was based on only one-fourth of each specimen. Branson and Branson's figures of the holotype, in particular figures 4 and 18 of plate 81, clearly show the nature of the break. All the type specimens and other specimens now in their Brassfield collection were examined and were found to be incomplete. Thus the definition of the genus, which also was followed by Hass (1962, p. W62), must be modified to fit the type species. In addition, the definition is emended here to include platform conodonts of this form that have a row of denticles on the oral surface of each lobe or process rather than the irregular nodes or ridges characteristic of *I. irregularis.*

The genus almost without doubt is derived from the Ordovician genus *Scyphiodus* Stauffer of which *Icriodella* Rhodes is a junior synonym. A very few specimens of *Icriodina stenolophata* n. sp. are closely similar to *Scyphiodus,* but the former lacks the prominent central cusp characteristic of *Scyphiodus* and has well developed, opposed, and ornamented processes rather than the lateral flanges that lack oral surface ornamentation characteristic of *Scyphiodus.* These features readily distinguish *Icriodina* and *Scyphiodus.*

The general form of *Astrognathus* Walliser is closely similar to that of *Icriodina,* and it is quite possible that the former marks an extension of the stratigraphic range of *Icriodina.* The failure of the four processes of *Astrognathus* to meet in a common point may be sufficient to distinguish the genus. For the present it will not be placed in synonymy.

Icriodina irregularis Branson and Branson

Plate 2, figures 18-21

Icriodina irregularis Branson and Branson, 1947, Jour. Paleontology, v. 21, p. 551, pl. 81, figs. 3-11, 18, 19.

Diagnosis: This conodont is a cruciform platform with broad lobes bearing irregular and coalescing nodes on the oral surface of adults. The entire aboral surface is deeply excavated.

Description: The longitudinal axis is straight or slightly bowed, and the anterior and posterior processes are longer than the lateral processes. Generally the transverse axis is slightly bowed, and the bowing is interpreted as being concave toward the posterior end. Young specimens have irregular but discrete nodes or denticles on the oral surface of all four processes. With maturity these tend to coalesce to form an irregularly nodose to ridged surface of low relief without any consistent differences in the pattern on the longitudinal and the transverse processes. All four processes tend to be lanceolate shaped as viewed orally, and commonly toward the point of union each bears a single row of nodes. This gave rise to the idea of a short, poorly developed blade cited by Hass (1962, p. W62). All processes are deeper than wide and are broadest near the oral surface. The entire aboral surface of the unit is deeply excavated, and greatest depth is near the middle of this unit.

Remarks: The specimens figured by Walliser (1964, pl. 11, figs. 10, 11, and 12) are broken. They probably represent fragments of *Scyphiodus* rather than of *I. irregularis.*

Material studied: 430 specimens.

Repository: 10027 (28-bulk), 10028 (28-bulk), 10029 (31-2), and 10097 (Dog Falls, Jefferson County, Ind.) (figured specimens).

Icriodina stenolophata Rexroad, n. sp.

Plate 2, figures 22-24

Diagnosis: This species is a cruciform conodont in which the longitudinal and transverse axes are nearly straight and are approximately at right angles to each other. The four processes are narrow, and orally each normally bears a single row of fused denticles that are less well developed on the short transverse processes.

Description: The two longitudinal processes are nearly equal in length and bear erect, partially fused denticles. Commonly a few of the denticles near the end of one process are broad and nodelike and may bifurcate. In a few specimens this tendency involves a larger area and represents a transition with *Icriodina irregularis.* The denticles on each process, if not precisely erect, incline distally so that the curvature of the denticles cannot be used to determine the anterior. Although each process is nearly straight, they may be slightly out of line, so that the longitudinal axis is slightly bowed. The process on the concave side is considered inner and is wider and slightly longer than the outer lateral process. Both lateral processes are no more than one-half the length of the longitudinal processes. The denticles on them may be so fused as to be separable only in transmitted light. The entire aboral surface is excavated, so that the walls of the processes are thin.

Remarks: This species is much closer in form to *Scyphiodus* than is *Icriodina irregularis.* It also resembles *Astrognathus tetractis* Walliser, differing in the unequal length of the processes, the common point of union of the four processes, and the denticulation. Like *Icriodina irregularis,* it is not uncommon for the basal plate of this species to be attached.

Material studied: 205 specimens.

Repository: 10031 (31-2) (holotype); 10032 (28-bulk) and 10033 (28-bulk) (paratypes); and 10034 (28-bulk) (transitional specimen).

Genus **Ligonodina** Ulrich and Bassler *in* Bassler, 1925

Type species: Ligonodina pectinata Ulrich and Bassler, 1926.

Diagnosis: The unit consists of a denticulate posterior bar and an anterior main cusp that bears a denticulate inner lateral process ("anticusp" of some authors) arising from the lateral face of the cusp near the base and toward the anterior. The basal cavity is minute.

Ligonodina kentuckyensis Branson and Branson

Plate 2, figure 5

Ligonodina kentuckyensis Branson and Branson, 1947, Jour. Paleontology, v. 21, p. 555, pl. 82, figs. 28, 35.

Remarks: The specimens of this study are broken, and little can be added to the original description. Two specimens have a complete posterior bar, and each has six denticles. The posterior four are inclined sharply to the posterior, and the middle two are the largest. A few specimens have five rather than four denticles on the lateral process, and in some specimens the lateral process is not inclined as much anteriorly as is typical. The fragmented material suggests a species with a moderate amount of variability, and probably the specimens figured by Walliser (1964, pl. 32, figs. 8, 10) as *Ligonodina salopia* Rhodes belong here.

At least two species of *Ligonodina* are present in the Bainbridge Formation of Branson and Mehl's (1933) usage. One is *L. siluricus*

Branson and Mehl, and the other is here considered conspecific with *L. kentuckyensis,* thus considerably extending the range of the species.

The holotype is University of Missouri slide C684-5 rather than the listed C674-5, which is correctly listed as a paratype of *Distomodus kentuckyensis.*

Material studied: 124 specimens.

Repository: 10035 (12-8) (figured specimen).

Ligonodina? extrorsa Rexroad, n. sp.

Plate 2, figures 9, 10, 15-17

Neoprioniodus? cf. *brevirameus* WALLISER, 1964, Hess. Landesamt Bodenf., Abh., no. 41, pl. 29, fig. 11.

Derivation of name: Latin, *extrorsus,* in an outward direction, in reference to the pronounced outer lateral flare of the lip of the basal cavity.

Diagnosis: This species consists of a short excavated denticulate posterior bar and a main cusp bearing a short delicate anticusp twisted somewhat inward. The outer lateral lip of the basal cavity is greatly flared.

Description: The main cusp is slender, sharp edged anteriorly and posteriorly, recurved in many specimens, flexed near the base, and asymmetrical. The inner lateral margin of the main cusp is flat or slightly convex; the outer margin is strongly convex and flares over the basal cavity. The basal cavity viewed aborally reflects the shape of the cusp and is flat on the inner side and expanded on the outer. It continues on the underside of the posterior bar and the anticusp. Viewed laterally the basal cavity is conical, is pointed up and forward, and ends near the anterior margin of the main cusp.

The anticusp is short and delicate and is twisted slightly inward. There are both denticulate and nondenticulate specimens, the latter dominating. In some specimens a low costa is common to the anticusp and the proximal portion of the anterior edge of the main cusp. The posterior bar is excavated and apparently short. It bears subround to laterally compressed, closely spaced denticles, which on some specimens are continuous on the posterior margin of the main cusp in a cordylodid type of dentition.

Remarks: The generic assignment of *Ligonodina? extrorsa* must be questioned on the basis of morphology and phylogeny. Its morphology is grossly similar to that of *Distomodus* but does not precisely fit any described genus. Some specimens transitional with *L.? egregia* Walliser, but still retained in *L.? extrorsa,* do have well-developed denticulate anticusps and could correctly be referred to *Ligonodina* on a morphologic basis alone (pl. 2, fig. 10). The species is questionably placed in *Ligonodina,* then, because some specimens fit this morphology and because *L.? extrorsa* is the obvious precursor of *L.? egregia.*

The relationship between *L.? extrorsa* and *L.? egregia* is shown by the fact that in collections containing both species numerous transitional specimens are present (R. S. Nicoll, oral communication, March 1966). Because the lineage is from *L.? extrorsa* to *L.? egregia* and does not belong within the phylogeny of contemporaneous species of *Ligonodina s. s.,* the generic assignment of *L.? egregia* has also been questioned.

Material studied: 116 specimens.

Repository: 10011 (33-3) (holotype); 10012 (28-bulk), 10013 (3-1), 10014 (33-3), 10015 (47-5) (paratypes); and 10016 (2-7) (a variant).

Genus **Lonchodina** Ulrich and Bassler *in* Bassler, 1925

Type species: Lonchodina typicalis Ulrich and Bassler, 1926.

Diagnosis: This arched unit consists of nearly equal anterior and posterior denticulate bars that are bowed and offset from each other and an apical denticle under which the small basal cavity is located. The denticles tend to be discrete.

Lonchodina walliseri Ziegler

Plate 3, figure 6

Lonchodina walliseri ZIEGLER, 1960, Paläont. Zeitschr., v. 34, p. 188, pl. 14, figs. 2, 6, 7; WALLISER, 1964, Hess. Landesamt Bodenf., Abh., no. 41, p. 44, 45, pl. 8, fig. 17; pl. 30, figs. 26-33.

Lonchodina n. sp. (b) WALLISER, 1957, Hess. Landesamt Bodenf., Notizbl., v. 85, p. 40, pl. 3, figs. 27, 28.

Remarks: The species had not been recognized previously in rocks older than those of the *sagitta*-Zone of Ludlow age. Brassfield occurrences extend the known range, which is now shown to be early Silurian into early Devonian.

Lonchodina walliseri grades into *Euprioniodina* cf. *Prioniodus excavatus* Branson and Mehl by an increase in the length of the anterior limb and in the number of denticles it bears. It is also gradational with *Lonchodina*? n. sp., which lacks an apical denticle and has a shorter posterior limb.

Material studied: 47 specimens.

Repository: 10036 (11-2) (figured specimen).

Lonchodina? sp.

Plate 3, figure 5

Description: From broken specimens it appears that this unit consists of a bar, sigmoidal in both lateral and oral view. The bar bears about 10 denticles of nearly equal size that are laterally compressed on the anterior part of the bar and subround posteriorly. The aboral surface is broadest in the middle third and is pointed anteriorly and posteriorly. A groove runs its length and broadens as a slight pit about one-third of the length from the anterior end.

Remarks: In typical lonchodinids the main cusp is above the pit, and even though the twisting of both ends of the bar fits the lonchodinid pattern, a main cusp is lacking, which accounts for the questionable generic reference. The species is gradational with *Lonchodina walliseri* as noted above.

Material studied: 23 specimens.

Repository: 10037 (12-7) (figured specimen).

Genus **Neoprioniodus** Rhodes and Müller, 1956

Type species: Prioniodus conjunctus Gunnell, 1931.

Diagnosis: This compound conodont consists of a main cusp, a denticulate posterior bar, and an anticusp which may or may not bear fused denticles. The pit is small and beneath the main cusp.

Remarks: Some authors have regarded *Euprioniodina, Synprioniodina,* and *Neoprioniodus* as junior synonyms of *Prioniodina* Ulrich and

Bassler. *Prioniodina* consists of subequal anterior and posterior denticulate limbs with an apical denticle above the pit in the middle third of the unit. The other three genera have a posterior bar, terminal cusp, and anticusp. The anticusp of *Synprioniodina* typically bears fused denticles, that of *Neoprioniodus* "may or may not be denticulated" (Rhodes and Müller, 1956, p. 698), and for apparently nondenticulate forms, germ denticles may be apparent in transmitted light. Denticulate and nondenticulate forms occur in the same species. It is only with considerable reluctance that the genus *Neoprioniodus* as now defined is considered valid.

Neoprioniodus planus Walliser

Plate 3, figure 11

Neoprioniodus planus Walliser, 1964, Hess. Landesamt Bodenf., Abh., no. 41, p. 51, pl. 4, fig. 10; pl. 6, fig. 3; pl. 29, figs. 12, 13, 15.

Remarks: The posterior bar is relatively straight in the Brassfield specimens. The species differs from *Euprioniodina* cf. *Prioniodus excavatus* by lacking a denticulate anterior process and by having a shorter posterior bar. Walliser (1964) recorded a range from Bereich I through the *amorphognathoides*-Zone.

Material studied: 12 specimens.

Repository: 10099 (11-4) (figured specimen).

Genus **Ozarkodina** Branson and Mehl, 1933

Type species: Ozarkodina typica Branson and Mehl, 1933.

Diagnosis: This genus is an arched bladelike unit with an apical denticle near midlength and laterally compressed confluent denticles that are nearly equal in number anterior and posterior to the apical denticle. The basal cavity is essentially limited to the area beneath the apical denticle.

Ozarkodina typica Branson and Mehl

Plate 2, figures 7, 8

Ozarkodina typica Branson and Mehl, 1933, Missouri Univ. Studies, v. 8, no. 1, p. 51, pl. 3, figs. 43-45; Rhodes, 1953 (part), Royal Soc. London Philos. Trans., ser. B, v. 237, no. 647, p. 320, 321, pl. 23, figs. 261, 262 only.

Ozarkodina typica typica Branson and Mehl, Walliser, 1964, Hess. Landesamt Bodenf., Abh., no. 41, p. 61, pl. 9, fig. 21; pl. 25, figs. 20, 21; pl. 26, figs. 1, 2.

Remarks: Most of the specimens are broken, and even though they seem moderately consistent in morphology, critical features cannot be studied in all. A number of specimens vary toward *Ozarkodina edithae,* and five specimens tentatively are assigned to that species. A few specimens that exhibit less arching than is typical might represent a separate species.

Material studied: 35 specimens.

Repository: 10038 (10-9) and 10039 (9-9) (figured specimens).

Genus **Paltodus** Pander, 1856

Type species: Paltodus subaequalis Pander, 1856.

Diagnosis: This genus includes simple curved conical conodonts that are asymmetrical and multicostate.

Remarks: Because the definition of the genus is broadly conceived, a variety of forms that probably are not closely related have been referred to the genus. The unifying characteristics of one group within the genus in the broad sense was recognized by Ethington (1959), who erected the genus *Panderodus* for forms with a very deep basal cavity and a basal outline that tends to be broadly rounded anteriorly and narrow posteriorly. Several Brassfield species are unquestionably referred to *Panderodus.* Four others differ in outline or in the form of the basal cavity from *Panderodus.* It is best to retain them in the genus *Paltodus s. l.* As the knowledge of the paltodid type of conodont increases, it is expected that other generic groups will be recognized and separated from *Paltodus* as it is now defined. Among Brassfield paltodids, *P. dyscritus, P. debolti,* and *P. migratus* have unifying characteristics that might set them apart.

Paltodus costulatus Rexroad, n. sp.

Plate 4, figures 26-29

Derivation of name: Latin, *costulata,* diminutive of costa, in reference to the small costae of the species.

Diagnosis: This species is a slightly bowed biconvex simple conodont with a main posterior costa separated from two poorly developed posterolateral costae by slight grooves and with a conical basal cavity extending one-fourth to one-third of its length.

Description: The simple uniformly curved cusp is nearly symmetrical in cross section but is bowed to produce a definite asymmetry. The anterior margin is sharp edged and in its lower portion is costalike because the area in front of the basal cavity tends to be compressed. The lateral faces are about equally convex, being flatter distally and more convex in the area of the basal cavity. Both are marked by very fine longitudinal striations. A posterior costa extends from the base nearly to the tip. The lateral faces on each side of it are slightly flexed inward so that a costalike ridge is present on either side of the posterior costa. The entire base of the cone is excavated, and the symmetrical basal cavity narrows to a point at about one-fourth to one-third the height of the cusp. Because the cusp is curved, the tip of the cavity is near the anterior margin.

Remarks: The cross-sectional shape is virtually the same as that of *Acontiodus rectus* and *A. reclinatus,* both of Lindström, and the form of the species differs only by the lack of an expanded base in *Paltodus costulatus.* It is best to restrict *Acontiodus* to species with a broad posterior face and to refer these and similar species to *Paltodus* as suggested by Ethington (1959, p. 268).

Material studied: 359 specimens.

Repository: 10041 (9-11) (holotype); 10042 (9-11), 10043 (11-5), and 10044 (12-1) (paratypes).

Paltodus debolti Rexroad, n. sp.

Plate 4, figures 22-25

Paltodus unicostatus Branson and Mehl, BRANSON and BRANSON (part), 1947, Jour. Paleontology, v. 21, p. 554, pl. 82, figs. 20-22.

Derivation of name: Named in honor of G. G. DeBolt, president, DeBolt Concrete Co., Richmond, Ind., who, like quarry operators throughout the state, has been most cooperative in assisting geologic studies.

Diagnosis: This species is an asymmetrical curved cone with a well-developed costa on the anterior margin of the anterolateral face and another on its posterior margin. Between these costae is a partially developed costa. The posterior margin of the cusp generally bears another prominent costa, and additional secondary costae may be present. The basal cavity terminates about midheight of the cusp.

Description: The anterolateral face of the cusp is convex and in its lower half to two-thirds normally is divided by a poorly developed costa, which apparently is analogous to one of the lateral costae of the anterior face in *Paltodus dyscritus* n. sp. In some specimens the area between the dividing costa and the prominent costa of the posterolateral margin could be considered as a narrow lateral face. On the opposite side of the cusp, considered to be the inner side of the cusp, a nearly flat lateral face is present between the anterolateral costa and the costae of the posterior margin. The most prominent costa on the posterior margin is on the outer side, and it continues upward to join the lateral margin of the cusp near its tip. Here the cusp is biconvex with sharp-edged or costate margins twisted so that the prominent posterior costa joins the posterolateral margin and the other costa the anterolateral margin. In most specimens the posterior margin of the cusp bears another prominent costa and two minor ones, but the number is variable. The entire base is excavated, and the basal cavity extends upward about one-half the height of the cusp. Like the cusp, it is asymmetrical.

Remarks: The similarity of this species and *Paltodus dyscritus* n. sp. has been noted. It seems likely that evolution was from the more nearly symmetrical form to the less symmetrical. Perhaps a continuation of the trend led to the development of *P. migratus,* but the direction of evolution is not clear. A few specimens placed by Branson and Branson in *Paltodus unicostatus* belong in this species, and their figured specimen placed here has been noted in the synonymy.

Material studied: 1,056 specimens.

Repository: 10045 (25-6) (holotype); 10046 (3-9), 10047 (22-4), and 10048 (25-4) (paratypes).

Paltodus dyscritus Rexroad, n. sp.

Plate 4, figures 30-34

Paltodus unicostatus Branson and Mehl, BRANSON and BRANSON (part), 1947, Jour. Paleontology, v. 21, p. 554, pl. 82, figs. 17-19 and ?, fig. 6.

Drepanodus altipes Henningsmoen, Serpagli and Greco, 1964, Soc. paleont. italiana Boll., v. 3, p. 199, pl. 35, fig. 1.

Derivation of name: Greek, *dyskritos,* hard to determine, uncertain, in reference to the difficulty of generic assignment.

Diagnosis: This species is a nearly symmetrical sharply curved cone with a basal cavity terminating about midheight of the cusp. The anterior face is nearly flat and is produced on each side by prominent costae for at least two-thirds of its length. The posterior margin is rounded and typically bears three costae that twist off center.

Description: The cusp viewed laterally is broad at its base and gently curved to about midpoint, where it is sharply curved, but distally from here it is nearly straight and is slender. The anterior face of the cusp is only slightly convex in its basal portion but near the tip of the cone is more convex. Both lateral margins of the anterior face are produced as strong costae from the base upward, but toward the tip they become less pronounced and may not be present. The slender distal third of the cusp is nearly round. Triangular lateral faces are present on the lower half of the cusp. These are nearly flat but tend to be slightly concave basally. The posterior margin of the cusp is round and in approximately its basal two-thirds bears three costae, one of which is very poorly developed. One costa is median at the base and tends to bifurcate and disappear at about midheight of the cusp. The two unequal costae on the sides of the posterior margin normally do not reach the basal edge but extend upward considerably beyond the median costa, and the more prominent one may extend nearly to the tip of the cusp. The entire base of the cone is excavated, and the basal cavity projects upward, terminating at about midheight of the cusp.

Remarks: This species is not a typical paltodid, but in spite of its near symmetry fits Lindström's redefinition in that it is multicostate and asymmetrical. Its limited basal cavity and shape in cross section differentiate it from *Panderodus.* It is closely related to the asymmetrical new species *P. debolti,* differing primarily in the degree of symmetry. Because both are found in the same stratigraphic zone, their phylogenetic relationships cannot now be solved.

Included among the specimens described by Branson and Branson (1947) as *Paltodus unicostatus* are a number now referable to *P.*

dyscritus as they suggested. Their figured specimens placed here are noted in the synonymy.

Material studied: 1,524 specimens.

Repository: 10049 (26-2) (holotype); 10050 (17-2), 10051 (14-6), 10052 (26-2), and 10053 (27-3) (paratypes).

Paltodus migratus Rexroad, n. sp.

Plate 4, figures 17-21

Derivation of name: Latin, *migratus,* to move, migrate; in reference to the change in position of costae between this species and *Paltodus debolti.*

Diagnosis: This is a nearly symmetrical sharply curved simple conodont with six well-developed costae, one anterior, one posterior, and two on each side. The basal excavation extends about one-half the length of the specimen.

Description: The base of the unit viewed aborally is a flattened oval, elongate in an anterior-posterior direction. It is completely excavated. The basal cavity in lateral view tapers upward to a point at about midheight of the specimen and near the anterior margin. As viewed laterally the unit is longest at the base and tapers upward in a gentle curve to about midlength, where it is sharply recurved and from which point the cusp is very slender.

There are six main costae, which may branch into supplemental costae. One is along the posterior margin; another is along the anterior margin and is inclined slightly inward. Two costae are present on each side, one on each side near the midline of the lateral face, the other one on each side near the posterior margin. The more posterior one on the inner side in some specimens coalesces upward with the posterior costa, which may bifurcate at its base and give rise to a branch extending upward along the outer side. The more posterior costa on the outer side commonly bifurcates downward near the base.

Remarks: This species is more nearly symmetrical than are many paltodids, but it falls within the broad limits of the genus and is closely related to *Paltodus debolti.* The posterior and two posterolateral costae of *P. migratus* apparently represent the posterior cluster of costae of *P. debolti,* the anterior one the anterolateral costa of *P. debolti,* and the outer anterior one the outer lateral costa of *P. debolti*. Apparently the differences in position of corresponding costae are the result of migration, which was accompanied by the change in symmetry between the two.

Material studied: 112 specimens.

Repository: 10054 (9-11) (holotype); 10055 (12-1), 10056 (11-4), 10057 (12-9), and 10058 (11-2) (paratypes).

Genus **Panderodus** Ethington, 1959

Type species: Paltodus unicostatus Branson and Mehl, 1933.

Diagnosis: This genus includes simple asymmetrical costate curved cones with a deep basal cavity. The anterior margin tends to be rounded in the lower part and the posterior portion tends to be narrow.

Remarks: The relationship to *Paltodus* was discussed in connection with that genus. Those panderodids in which the basal cavity extends nearly to the tip of the cusp are similar to *Coelocerodontus* Ethington, but they have somewhat thicker walls, longitudinal furrows, and a different development of the base.

Panderodus simplex (Branson and Mehl)

Plate 4, figures 7, 8

Paltodus simplex Branson and Mehl, 1933, Missouri Univ. Studies, v. 8, no. 1, p. 42, pl. 3, fig. 4.

Paltodus acostatus Branson and Branson, 1947 (part), Jour. Paleontology, v. 21, p. 554, pl. 82, figs. 1-5 only; Rhodes, 1953, Royal Soc. London Philos. Trans., ser. B, v. 237, no. 647, p. 296, pl. 21, figs. 111, 112; pl. 22, figs. 163, 164; pl. 22, figs. 212, 213; Bergstrom, 1961, Arkiv för Mineralogi och Geologi, v. 3, p. 48, pl. 1, figs. 13, 14; Clark and Ethington, 1966, Jour. Paleontology, v. 40, p. 682, pl. 82, figs. 10, 14.

Paltodus? acostatus Branson and Branson, Glenister, 1957, Jour. Paleontology, v. 31, p. 727, pl. 85, fig. 7.

Paltodus cf. *P. acostatus* Branson and Branson, Walliser, 1960, Canada Geol. Survey Bull. 65, p. 31, pl. 7, fig. 10.

Panderodus acostatus (Branson and Branson), Serpagli and Greco, 1964, Soc. paleont. italiana Boll., v. 3, p. 204, pl. 36, figs. 4a, b.

Remarks: On the basis of illustrations and descriptions, the Brassfield specimens would have been referred to *Panderodus compressus* (Branson and Mehl). Three characteristic Brassfield specimens, however, were compared directly with the Bainbridge types of *P. simplex* (Branson and Mehl) by R. L. Ethington, who stated that there is no question but that they are conspecific and indicated that in the illustrations of *P. simplex* the convexity of the lateral face appears to be much greater than it actually is (written communication, September 22, 1964). As noted in the discussion of *Acodus unicostatus,* the figured paratypes of *Paltodus acostatus* from the Brassfield (Branson and Branson, 1947, pl. 82, figs. 1-5) are not the same species as the holotype and are assigned to *P. simplex.* If *P. compressus* and *P. simplex* are not conspecific, the former is almost certainly the direct ancestor of the latter.

Material studied: About 3,000 specimens.

Repository: 10059 (28-2) and 10060 (28-2) (figured specimens).

Panderodus unicostatus (Branson and Mehl)

Panderodus unicostatus is a widespread and very long-ranging species that is known from rocks of middle Ordovician to early Devonian age. It is the most abundant species of the Brassfield Limestone.

In the Oldham Limestone Member of the Noland Formation of central Kentucky and in the upper part of the Brassfield in southern Ohio, in time-correlative beds, a number of individuals have a posterior margin modified by the presence of exceedingly fine denticulation. Because of the readily recognizable difference in form and because of the apparent time-stratigraphic limitation of the form, which appears characteristic of the Cincinnati Arch area, the new subspecies *Panderodus unicostatus serratus* is proposed below.

Panderodus unicostatus unicostatus (Branson and Mehl)

Plate 4, figures 1, 2

Paltodus unicostatus Branson and Mehl, 1933, Missouri Univ. Studies, v. 8, p. 42, pl. 3, fig. 3; Branson and Branson, 1947 (part), Jour. Paleontology, v. 21, p. 554, pl. 82, figs. 14-16 only; Rhodes, 1953, Royal Soc. London Philos. Trans., ser. B, v. 237, no. 647, p. 298, pl. 21, figs. 84-88; pl. 22, figs. 155, 156; pl. 23, figs. 214-216; Walliser, 1957, Hess. Landesamt Bodenf., Notizbl., v. 85, p. 43, pl. 2, fig. 1.

Paltodus? unicostatus Branson and Mehl, Glenister, 1957, Jour. Paleontology, v. 31, p. 729, pl. 85, fig. 1.

Paltodus cf. *P. unicostatus* Branson and Mehl, Rhodes, 1955, Geol. Soc. London Quart. Jour., v. 111, p. 127, pl. 10, figs. 1, 3; Hamar, 1964, Norsk geol. tidsskr., v. 44, p. 272, pl. 1, figs 28, 29.

Panderodus unicostatus (Branson and Mehl), SWEET, TURCO, WARNER, and WILKIE, 1959, Jour. Paleontology, v. 33, p. 1057, pl. 131, fig. 3; WOLSKA, 1961, Acta Palaeont. Polonica, v. 6, p. 353, pl. 4, figs. 3a, b; KOCKEL and STOPPEL, 1962, Inst. geol. min. España, Notes and Commun., no. 68, p. 161, pl. 1, fig. 2; SWEET and BERGSTROM, 1962, Jour. Paleontology, v. 36, p. 1234, text-fig. 1D; SERPAGLI and GRECO, 1964, Soc. paleont. italiana Boll., v. 3, p. 206, pl. 36, fig. 7; pl. 37, figs. 1a, b; ?OLIVIERI, 1965, Soc. paleont. italiana Boll., v. 4, p. 52, pl. 6, fig. 16; MERRILL, 1965, Texas Jour. Sci., v. 17, p. 390, pl. 2, fig. 8; WINDER, 1966, Jour. Paleontology, v. 40, pl. 9, fig. 27; HAMAR, 1965, Norsk geol. tidsskr., v. 46, p. 67, pl. 1, fig. 6; CLARK and ETHINGTON, 1966, Jour. Paleontology, v. 40, p. 683, pl. 82, figs. 17, 19.

Material studied: About 27,000 specimens.

Repository: 10061 (31-2) and 10062 (13-5) (figured specimens); 10065 (9-11) and 10066 (11-2) (comparative specimens).

Panderodus unicostatus serratus Rexroad, n. subsp.

Plate 4, figures 3, 4

Derivation of name: Latin, *serratus,* notched or toothed, in reference to the finely denticulate posterior margin.

Diagnosis: This subspecies differs from previously described specimens of *Panderodus unicostatus* only by the presence of a serrate posterior margin, caused by the development of germ denticles along approximately two-thirds of the length of the cone starting near the base.

Remarks: Because *Panderodus unicostatus* is a well-known species, further description is unncessary. In some specimens of *P. unicostatus serratus* the denticles are so small that they are difficult to distinguish if illumination is not at the correct angle. The development of denticles apparently is a reiterative feature, and this species is not believed to be closely related to the similar form genus *Belodus.*

This subspecies is found in beds containing abundant specimens of *Paltodus costulatus* and *Spathognathodus oldhamensis* and immediately below beds containing the brachiopod *Microcardinalia.* It seems to be a marker for a very limited stratigraphic zone.

Material studied: 23 specimens.

Repository: 10063 (3-10) (holotype) and 10064 (3-10) (paratype).

Genus **Plectospathodus** Branson and Mehl, 1933

Type species: Plectospathodus flexuosus Branson and Mehl, 1933.

Diagnosis: This genus includes asymmetrical compound conodonts with two denticulate processes diverging at different angles from the main cusp, one flexed and twisted. Typically there is a small basal cavity beneath the main cusp, and in some forms it is extended as grooves or troughs along the base of the processes.

Remarks: Topotype material of *Plectospathodus flexuosus* verifies Walliser's (1957, p. 43, 51) expanded description and his remarks concerning the morphology and the relationships to *Lonchodina* and *Trichonodella.* Although many writers have reaffirmed Branson and Mehl's (1933) statement of the close relationship of *Plectospathodus* to *Ozarkodina,* neither in form nor phylogeny do they seem to be close. The transition between *P. extensus* and *Trichonodella excavata* demonstrated by Walliser can likely be shown for other pairs of the two genera, as many trichonodellids show some degree of asymmetry.

Although Rhodes (1953, p. 322) stated that Branson and Mehl regarded the unit as being oriented transverse to the jaw, their labeling of inner and outer lateral views of the syntypes (1933, pl. 3, figs. 31, 32) shows that they oriented the genus with anterior and posterior limbs comparable to the orientation of *Ozarkodina,* with which they compared the genus. Although that orientation would fit the forms transitional with *Lonchodina,* Walliser (1957) pointed out that the main denticle is recurved posteriorly and that the limbs are lateral. This orientation is consistent with the morphology of the genus and with that of *Trichonodella* and is the one followed here.

Plectospathodus irregularis (Branson and Branson)

Plate 3, figure 15

Prioniodina irregularis Branson and Branson, 1947, Jour. Paleontology, v. 21, p. 555, pl. 82, figs. 30, 31.

Remarks: Only a few specimens of *Plectospathodus irregularis* were recognized, but additional representatives may be present among the incomplete and variable specimens assigned to *Trichonodella* sp. A. If the lateral processes are broken near the main cusp, the asymmetry of *Plectospathodus* and the fact that one process is shorter than the corresponding process of *Trichonodella* sp. A may not be apparent.

The species is reassigned from *Prioniodina* to *Plectospathodus* because the processes are lateral rather than being the anterior and posterior portions of a bar with an apical denticle.

Material studied: 10 specimens.

Repository: 10067 (13-1) (figured specimen).

Genus **Spathognathodus** Branson and Mehl, 1941

Type species: Spathodus primus Branson and Mehl, 1933.

Diagnosis: The unit is bladelike and may be slightly bowed and slightly arched, but the main axis is nearly straight. Typically the basal cavity is in the middle one-third of the unit, but it may extend to the posterior tip.

Spathognathodus oldhamensis Rexroad, n. sp.

Plate 3, figures 1, 2

Derivation of name: From Oldham Branch near Brassfield, Madison County, Ky., because of the abundance of specimens from the type section of the Oldham Limestone Member of the Noland Formation near the branch from which the member name is derived.

Diagnosis: The species has an oval pit with broadly flared lips about one-third the distance from the posterior tip. The three or four denticles above and immediately anterior to the pit tend to be completely fused. Immediately above the pit may be a gap in the dentition. Denticles on the long, low blade number 13 to 16 on the majority of the specimens.

Description: The long, thin blade, unarched and very slightly bowed, is about 2½ times as long as high. It bears 13 to 18 laterally compressed denticles; those on the anterior half are fused nearly to their apices but are sharp pointed. One denticle immediately above the pit tends to be shorter than those adjacent to it, or a gap in the denticles may be located here. Just anterior to this are four completely fused denticles, and the denticles to the posterior tend to be more completely fused than are the anterior denticles. The shallow pit is about one-third the distance from the posterior tip and has widely flared lips that give it an oval shape with the greatest dimension transverse. The inner lip tends to be slightly more flared than is the outer one.

Remarks: The spathognathodids in the collection are poorly preserved. The nearly complete specimens suggest that two divergent morphotypes are present, but whether these represent intraspecific variations or separate species is uncertain. In addition to the form named and described above, the second group has a uniformly convex oral margin that is highest just anterior to the pit in the posterior third of the unit with a more prominent denticle suggestive of an ozarkodinid. Some specimens of this latter group are closely similar to *Spathognathodus* [*Ozarkodina*] *fundementatus* Walliser, particularly to the specimens shown in Walliser's (1964) figures 17 and 18 of plate 23. The species has not been recorded below the *crassa*-Zone in Europe. Walliser's Silurian studies have shown clearly the value of *Spathognathodus* in stratigraphic zonation of the Silurian System, but an attempt to relate Brassfield forms to younger spathognathodids is premature.

Branson and Branson (1947) figured a spathognathodid (pl. 81, fig. 2, and pl. 82, fig. 36), now missing from the collection, that closely resembles an upper Devonian species. No similar specimens were found in the present study, and so the question of whether this is a homeomorph, a stratigraphic leak, or a contaminant cannot be answered.

Material studied: 15 specimens from the Brassfield Formation, about 90 from the Oldham Limestone Member of the Noland Formation, and about 20 from the Manitoulin Dolomite of Luce County, Mich.

Repository: 10068 (8-15) (holotype), 10069 (14-11) (paratype), and 10070 (3-10) (comparative specimen).

Genus **Synprioniodina** Ulrich and Bassler *in* Bassler, 1925

Type species: Synprioniodina alternata Ulrich and Bassler, 1926.

Diagnosis: This compound conodont consists of a main cusp, a denticulate posterior bar, and an anticusp which bears fused denticles. The pit is small and beneath the main cusp.

Synprioniodina cf. **Prioniodus bicurvatus** Branson and Mehl

Plate 3, figures 9, 10

Prioniodus bicurvatus Branson and Mehl, 1933, Missouri Univ. Studies, v. 8, no. 1, p. 44, pl. 3, figs. 9-12.

Remarks: This species is closely similar to the younger species named by Branson and Mehl (1933) as *Prioniodus bicurvatus.* With the reinterpretation of *Prioniodus* (Öpik, 1936; Lindström, 1954), the species can no longer be placed in *Prioniodus,* but its generic assignment is uncertain. The present specimens tend to be more delicate than the younger ones, and most have definite fused denticles on the anterior margin. Many specimens of *P. bicurvatus* in my topotype collection from the Bainbridge Group (Moccasin Springs Formation) of Missouri also display a denticulate anterior margin of the main cusp. The main cusp of the Brassfield specimens is slightly more symmetrical than that of *P. bicurvatus.*

If these specimens are conspecific with the Bainbridge forms, the range of *P. bicurvatus* would be greatly extended. In Europe Walliser (1964) recorded it from rock no greater in age than the *crispus*-Zone, the second zone above the *siluricus*-Zone in which the Bainbridge forms occur. The known range of middle Silurian to early Devonian would be expanded to early Silurian to early Devonian.

Material studied: 29 specimens.

Repository: 10071 (12-9) and 10072 (11-4) (figured specimens).

Genus **Trichonodella** Branson and Mehl, 1948

Type species: Trichognathus prima Branson and Mehl, 1933.

Diagnosis: The unit consists of an apical denticle with two denticulate lateral processes that form an essentially symmetrical arch. Typically the base is deeply excavated beneath the apical denticle, which commonly is recurved.

Remarks: At present there is division of opinion as to whether both forms with and forms without a denticulate posterior bar should be included in *Trichonodella.* On the basis of Mississippian material, the genus *Roundya* Hass (1953, p. 88) was proposed for species characterized by a denticulate arch, deeply excavated main cusp, and denticulate posterior bar. In the same paper Hass (p. 89) indicated that he was emending *Trichonodella,* but his emended description does not differ appreciably from the original generic description by Branson and Mehl. The intent was to place forms with the posterior bar in *Roundya* and those without the bar in *Trichonodella.* Both Sweet (1955, p. 257) and

Ethington (1959, p. 289) stated that the Ordovician forms with posterior bars are more closely related to *Trichonodella* than to *Roundya* and advocated their retention in *Trichonodella*. I agree that the Ordovician forms are not as closely related to *Roundya*, but I believe with Hass that the presence or absence of the posterior bar is of sufficient taxonomic importance to warrant eliminating these forms from *Trichonodella*. A new genus is needed, but the material of this study is insufficient to do this. Several species found in the Brassfield have been referred to *Roundya* or *Trichonodella*, but asymmetry suggests that they do not fit either group.

In present usage *Trichonodella* is restricted to include only symmetrical forms without a posterior bar. I believe that this usage is compatible with the form of the fragmentary holotype on which the type species, *T. prima*, is based, but Ethington (written communication, April 28, 1965) considers the holotype to be fragmented in the critical area in such a manner that a question remains whether a bar was formerly present. He suggests, therefore, that the name is a *nomen dubium*.

Trichonodella sp. A

Plate 3, figures 16, 18

Description: No specimens of this group are complete, and the fragmental material is so variable that a composite cannot be created. Therefore, only a general description is given and the species is not named. The main cusp is recurved, is round in section near the tip, is oval near midlength, and basally has a flat anterior face and a posterior flare above the basal cavity. The lateral processes bear discrete subround to slightly compressed denticles, which are variable in number but generally are four or more. As viewed posteriorly, the angle between the bases of the processes is about 90° but may be slightly less or appreciably more, and the limbs may be asymmetrical. The basal cavity underlies the entire base of the cusp but is deepest anteriorly where it becomes conical. It is extended as a groove along the basal surface of the processes.

Remarks: Indications of asymmetry suggest that, if complete, some of the specimens might be sufficiently modified to be classed as *Plectospathodus*, and a few suggest specimens described as *Prioniodina irregularis* by Branson and Branson. In some specimens the main cusp is elongated near the base, and these specimens are exceedingly close in form to *Trichonodella excavata* (Branson and Mehl). Another group of specimens differs in that an angular posterior margin is present on the lower part of the cusp.

Possibly several species, including *Trichonodella excavata,* are represented, but more likely this is a highly variable species ancestral to *T. excavata* and perhaps other species. It is similar to Ordovician forms like *T. flexa* Rhodes and *T. tenuis* Branson and Mehl and may represent one segment of a continuous lineage.

Material studied: 104 specimens.

Repository: 10077 (28-1) and 10078 (14-6), a variant morphologically similar to *Trichonodella excavata* (Branson and Mehl), (figured specimens).

Trichonodella sp. B

Plate 3, figure 17

Description: Like specimens of *Trichonodella* sp. A, the material is fragmental and variable and warrants only a general description. The main cusp is slightly recurved, has a nearly flat to slightly convex anterior face and a convex posterior face, and therefore has sharp lateral margins in the lower part. The cusp tends to be more rounded toward the tip. Basal posterior flare of the cusp is slight. Viewed posteriorly, the angle between the lateral processes usually is between 130° and 150° and the limbs may be asymmetrical as related to the cusp. The processes bear compressed denticles that generally are partially fused. The number is probably five or more. The basal cavity underlies all the cusp and is conical in its central part.

Remarks: The asymmetrical forms suggest a relationship with *Plectospathodus* and possibly with *Hindeodella.* Chief differences between this species and *Trichonodella* sp. A are the shape of the cusp including lesser basal flare in *T.* sp. B, the partial fusion and compression of the denticles on the lateral processes of *T.* sp. B., and the greater angle between the processes in *T.* sp. B.

Material studied: 43 specimens.

Repository: 10079 (9-9) (figured specimen).

Trichonodella cf. T. inconstans Walliser

Plate 3, figure 19

Trichonodella inconstans Walliser, 1957, Hess. Landesamt Bodenf., Notizbl., v. 85, p. 50, pl. 3, figs. 10-17.

Two specimens are closely similar to Walliser's (1957) variable species, but they seem to differ slightly in the arrangement of the lateral processes. Although they may fall within the range of variability, it seems unwise to extend the range of *Trichonodella inconstans* on the basis of two questionable specimens.

Material studied: 2 specimens.

Repository: 10080 (18-12) (figured specimen).

Generic group A

Definition: This group includes forms with two lateral processes, generally denticulate, a deeply excavated main cusp, and a denticulate posterior bar, the whole being asymmetrical.

Remarks: In this group are species which have been referred to *Roundya* and to *Trichonodella,* depending to some degree on the importance attached by the various authors to the presence or absence of a posterior bar. Some of these forms are nearly enough symmetrical to be considered members of these genera. The less asymmetrical forms, however, are very closely related to the more asymmetrical forms that could not be referred to *Roundya* or *Trichonodella,* and separation based on degree of asymmetry would be very artificial. The general form of some specimens corresponds to that of *Prioniodus* Pander *s. s.,* and on morphology alone a few individuals might be placed here. Again this practice is artificial. The species least typical of the group are similar in morphology to the Ordovician genera *Keislognathus* Rhodes and *Rhynchognathodus* Ethington, and possibly additional study will show by lineage and association that they truly belong with these genera. At present these two names are used with a question mark to show similarity of morphology alone.

Because of the uncertain generic assignment, the original author's name is used without change for each species. Hass in his original discussion of *Roundya* referred *Trichonodella brassfieldensis* and *T.*?

edentata, both of Branson and Branson (1947), to his new genus, but he undoubtedly was not aware of the degree of asymmetry of these species that certainly do not fit the type species, *R. barnettana,* nor his definition of a bilaterally symmetrical unit. Those few specimens of *T.? edentata* that lack dentition and have an unusually broad base could readily be placed in the genus *Sagittodontus.* These specimens, however, are few in number and represent an extreme variation. If the trend within the generic group is toward an increase in dentition, it seems probable that *Sagittodontus* is ancestral. When the phylogenies of this group are worked out, they may show that a number of the species listed form a naturally related unit distinct from other genera to which a new generic name should be given. Evidence at present is inconclusive.

Trichonodella? edentata Branson and Branson

Plate 3, figures 31-34

Trichonodella? edentata BRANSON and BRANSON, 1947, Jour. Paleontology, v. 21, p. 552, pl. 81, fig. 28; pl. 82, figs. 40, 44, 48.

Trichonodella brassfieldensis BRANSON and BRANSON (part), 1947, Jour. Paleontology, v. 21, p. 551, pl. 82, fig. 49 only; also three specimens on paratype slide C678-5.

Trichonodella carinata BRANSON and BRANSON (part), 1947, Jour. Paleontology, v. 21, p. 552, pl. 82, figs. 27, 34 only (holotype of *T. carinata).*

Diagnosis: The unit consists of a stout triangular deeply excavated cusp, a posterior bar generally denticulate, and two processes, the larger being lateral, the other anterolateral.

Description: The cusp is stout and erect or slightly recurved near its expanded base. The three faces of the cusp are flat or slightly convex; one is anterior, one is essentially lateral, and one faces to the side rear. The lateral processes are continuous with the margins of the anterior face, margins that in some specimens have poorly developed costae. The smaller process is directed downward as a continuation of the cusp. It may bear denticles but on many specimens does not. The larger process is directed downward and outward and on most specimens bears short, partially fused denticles. The posterior bar may have a sharp oral edge or may bear low, fused denticles. As viewed laterally, the bar makes an angle of about 70° to 120°, commonly slightly greater than 90°, with the posterior margin of the cusp. A costa may extend from the posterior bar along the posterior margin of the cusp nearly to its apex. The entire unit is deeply excavated.

Remarks: This species is very similar to *Sagittodontus* Rhodes, but its affinities and generic assignment remain in doubt. The broken type specimens of *S. robustus* and *S. robustus* var. *erectus,* as well as the holotype of *S. robustus distaflexus,* all of Rhodes, strongly suggest a cusp with three limbs. Thus *T.*? *edentata* differs from *Sagittodontus* only by having a slimmer cusp and in the fact that some specimens of *T.*? *edentata* are denticulate.

Material studied: 207 specimens.

Repository: 10081 (28-bulk), 10082 (28-2), 10083 (12-10), and 10084 (28-2) (figured specimens).

Trichonodella brassfieldensis Branson and Branson

Plate 3, figures 27, 28

Trichonodella brassfieldensis Branson and Branson (part), 1947, Jour. Paleontology, v. 21, p. 551, pl. 82, fig. 47 only (holotype); pl. 81, fig. 12 only.

Diagnosis: The unit consists of an asymmetrical recurved cusp bearing two unequal lateral limbs and a posterior bar, all typically denticulate, the entire unit being deeply excavated.

Description: The cusp is stout, recurved, slightly twisted, and nearly triangular in cross section; costae, more prominent proximally, extend along each of the three edges of the cusp from each limb and the posterior bar nearly to the tip of the cusp. The convex anterior face of the cusp faces obliquely forward and twists more to the side distally. One lateral face is broader than the other, is flat or slightly convex, and is nearly parallel to the longitudinal axis of the unit. The lateral process at the union of this face and the anterior margin is directed sharply downward and generally slightly forward. It is the shorter process and normally bears three or four appressed, laterally compressed denticles, but it may appear to lack denticles. The third face of the cusp is narrow, is flat or concave, and is posterolateral. The lateral process on this side extends downward and laterally or posterolaterally, commonly becoming recurved distally. It usually bears about six laterally compressed denticles which tend to be discrete. The posterior bar is short, starting as a posterior expansion of the base of the cusp, and bears about four or five laterally compressed denticles, although a few specimens may lack dentition. The cusp is deeply excavated, and the basal cavity extends outward nearly to the tips of each lateral process and the posterior bar.

Remarks: Of the type specimens now in the collection, only the holotype remains in the species. In addition, the specimen illustrated by Branson and Branson (1947, pl. 81, fig. 21) belongs in *T. brassfieldensis.* It is on slide C685-4 rather than one of the three listed in the plate legend and is neither listed nor labeled as a paratype. A summary of the listed paratypes follows: C672-1, plate 81, figure 16, *Roundya caudata* Walliser; C672-2, plate 81, figures 13, 14, *R. caudata,* specimen of figure 15 missing, and three unfigured poorly preserved specimens; C672-3, plate 81, specimen of figure 17 missing; C678-5, four unfigured paratypes representing *T.? edentata* and *R. caudata;* C683-2, plate 82, figure 39, an aberrant form not specifically identifiable; C679-2 is a spathognathodid; C683-3, listed as a paratype only in the legend of plate 82 (figure 49), and therefore not a paratype, *T.? edentata.*

Trichonodella brassfieldensis appears to be closely related to *T.? edentata, Roundya detorta* Walliser, and *R. caudata* Walliser, but its high degree of asymmetry suggests that it is not a transitional link between *T.? edentata* and either of the other two. Although most individuals are separable, the intermediate forms and common stratigraphic ranges suggest that *T. brassfieldensis* may be a variety of *T.? edentata.* Until the evolution of early Silurian forms is better known it seems best to let both species stand.

Material studied: 97 specimens.

Repository: 10086 (22-5) and 10087 (22-5) (figured specimens).

Trichonodella? n. sp.

Plate 3, figures 24-26

Description: The asymmetrical cusp is sharply recurved just above the base and is three sided in cross section proximally but tends to be oval distally. A costa is present along the line of union of the two inner faces, one of which faces obliquely forward. The base of the cusp is excavated and is expanded, particularly along the lines of union of the three faces, so as to form three processes. In most specimens the posterior process bears one or a few denticles; the inner process, which tends to be the best developed, shows germ denticles in a few specimens. The basal cavity as viewed laterally tapers upward to a sharp point near the anterior margin.

Remarks: This species differs from *Trichonodella? edentata* in being sharply recurved rather than erect, in being much less stout, and in having very short processes. Extreme variants of the two, however, are quite similar. Although similar to *Gothodus costulatus,* this species is readily distinguished by the fewer denticles on the less well-developed posterior process and in the sharp recurvature of the cusp.

Material studied: 127 specimens.

Repository: 10094 (31-2), 10095 (38-2), and 10096 (37-5) (figured specimens).

Roundya caudata Walliser

Plate 3, figures 29, 30

Roundya caudata WALLISER, 1964, Hess. Landesamt Bodenf., Abh., no. 41, p. 70, pl. 5, fig. 8; pl. 31, figs. 15-17.

Trichonodella brassfieldensis BRANSON and BRANSON (part), 1947, Jour. Paleontology, v. 21, p. 551, pl. 81, figs. 13, 14, 16 only.

Keislognathus sp., SERPAGLI and GRECO, 1964, Soc. paleont. italiana Boll., v. 3, p. 202, pl. 35, figs. 5a, b, c, d.

Remarks: Within this variable group are several specimens which cannot be distinguished from *Roundya detorta* Walliser. The cross section of the cusp is variable and shows all gradation between *R. detorta* and *R. caudata.* The two are not now put into synonymy because an arbitrary distinction can be made on the basis of the angle of the posterior bar and on the cross-sectional shape and because the stratigraphic relations are not sufficiently clear to understand the phylogeny.

Material studied: 84 specimens.

Repository: 10088 (3-2) and 10089 (25-5) (figured specimens).

Roundya truncialata Walliser

Plate 3, figure 22

Roundya truncialata WALLISER, 1964, Hess. Landesamt Bodenf., Abh., no. 41, p. 72, pl. 4, fig. 7; pl. 31, figs. 3-6.

Remarks: This species is closely similar to *Trichonodella gracilis* Rhodes, from the Gelli-grin and Pen-y-garnedd Limestones, Ordovician

System of Wales, and may be a junior synonym. The denticulation of the posterior bar of Walliser's specimen shown as figure 4 on plate 31 is closely similar to that of Rhodes' paratype CIC2d, which is the only type specimen with a bar sufficiently complete to show the denticles. Walliser's (1964, pl. 31, fig. 6) figure of his holotype of *R. truncialata,* on the other hand, appears to bear denticles of nearly equal size.

Because the phylogenies of the species are not yet known and because there may be slight differences in form, *Roundya truncialata* is not now put in synonymy with *Trichonodella gracilis.*

Material studied: 10 specimens.

Repository: 10090 (3-7) (figured specimen).

Keislognathus? n. sp.

Plate 3, figures 20, 21

Diagnosis: The unit consists of a costate recurved cusp, nearly triangular in section, bearing a long, fragile anticusp, a denticulate lateral process, and a denticulate posterior bar. The entire underside is excavated.

Description: The triangular cusp is recurved and nearly symmetrical. Its anterior face is convex with a costa at each edge, where it unites with the two lateral faces that are nearly flat and that join in a posterior edge continuous with the posterior bar. The posterior bar bears discrete, subround denticles, but none of the specimens is sufficiently complete to describe in full.

The anterior aboral process, unlike typical keislognathids, does not bear a proximal denticle, but rather a costa is continuous with that on the cusp. In some specimens the costa is modified by the development of denticles, and complete gradations exist on the few specimens available for study.

The lateral process is directed sharply downward, laterally and somewhat to the rear. It bears discrete, subround to laterally compressed denticles that are in line with the lateral costa of the cusp.

A deep conical basal cavity in the fang is extended as excavations along the bottom of each process and the posterior bar.

Remarks: This species is similar to *Trichonodella brassfieldensis* but differs in the length and orientation of the anterior aboral process and in other detail of form. Its marked asymmetry and denticulate posterior bar preclude placing it in *Trichonodella* and the asymmetry from considering it as *Roundya*. Some specimens lack denticles on the anterior aboral process as does *Keislognathus,* but some specimens have denticles and would be in a different genus from the rest of the species if a strict morphologic classification were followed. In conodonts, as in all animals, morphologic gradations are the rule, and marked differences without transition generally represent gaps in recorded evolution. Thus it is as difficult to devise an artificial classification based on form, that is, a "nuts and bolts" classification, as to devise a natural one despite Lindström's (1959, p. 431) statement to the contrary. In highly variable species each individual could represent a separate artificial taxon, and many form genera might be recognized. In earlier stages of classification arbitrary morphology may be the only criterion available, but as information on phylogenies and associations becomes available, it must be incorporated into the scheme of classification. Therefore, Lindström's (1959, p. 431) statement that "a really great danger lies in the tendency to make nomenclatural and taxonomic decisions according to some routine developed at an early stage of the work" must be given considerable weight.

Material studied: 20 specimens.

Repository: 10091 (34-3) and 10092 (22-6) (figured specimens).

Rhynchognathodus? n. sp.

Plate 3, figure 23

Diagnosis: This species includes small slightly asymmetrical conodonts consisting of a curved cusp that expands basally where a posterior bar and two denticulate lateral processes, joined by sheath lamellae, are present.

Description: The recurved distal part of the cusp is three sided with a broad anterior face slightly convex in section and lateral faces that meet in a sharp posterior margin. One face is somewhat narrower and tends to be concave in section. It may not reach the top of the cusp, which in these specimens is twisted and has only two faces. Proximally, the two anterior lateral edges of the cusp bear laterally compressed denticles fused nearly to their apices. The denticulate margins extend slightly beyond the lamellae of the base as lateral processes. The posterior margin of the proximal part of the cusp normally bears partially fused denticles and is extended as a posterior bar. The processes, posterior bar, and lamellae enclose a deep, pointed basal cavity.

Remarks: In rhynchognathodids the processes are anterior, lateral, and posterior. This species differs in that two are lateral and the third posterior. Because of the asymmetry of the unit, however, one lateral process is appreciably more anterior than the other. Because of this difference and the uncertainty of stratigraphic continuity of the two, the generic name is questioned. The form of *Rhynchognathodus?* n. sp. is similar to that of *Roundya pyramidalis* Sweet and Bergstrom but differs in that the latter is bilaterally symmetrical.

Material studied: 9 specimens.

Repository: 10093 (9-10) (figured specimen).

Literature Cited

Branson, E. B., and Branson, C. C.

1947—Lower Silurian conodonts from Kentucky: Jour. Paleontology, v. 21, p. 549-556, pls. 81, 82.

Branson, E. B., and Mehl, M. G.

1933—Conodonts from the Bainbridge (Silurian) of Missouri: Missouri Univ. Studies, v. 8, p. 39-52, pl. 3.

Browne, Ruth

1958—The geology of Bernheim Forest: Kentucky Naturalist, v. 12, p. 27-53, pls. 1-5, 5 figs.

Browne, Ruth, Conkin, James, Conkin, Barbara, and MacCary, L. M.

1958—Sedimentation and stratigraphy of Silurian and Devonian rocks in the Louisville area, Kentucky: Kentucky Geol. Soc. Field Trip Itinerary, 46 p.

Butts, Charles

1915—Geology and mineral resources of Jefferson County, Kentucky: Kentucky Geol. Survey, ser. 4, v. 3, pt. 2, 270 p., 65 pls.

Cumings, E. R.

1922—Nomenclature and description of the geological formations of Indiana: Indiana Dept. Conserv. Pub. 21, pt. 4, p. 403-570, 31 figs.

Esarey, R. E., Malott, C. A., and Galloway, J. J.

1947—Silurian and Devonian formations in southeastern Indiana: Indiana Div. Geology Field Conf. Guidebook 1, 24 p., 2 pls.

Ethington, R. L.

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

Foerste, A. F.
1885—The Clinton Group of Ohio: Denison Univ., Sci. Lab., Bull., v. 1, p. 63-120.
1888—Notes on a geologic section at Todd's Fork, Ohio: Am. Geologist, v. 2, p. 412-418.
1891—The age of the Cincinnati anticlinal: Am. Geologist, v. 7, p. 97-109.
1896—An account of the middle Silurian rocks of Ohio and Indiana: Cincinnati Soc. Nat. History Jour., v. 18, p. 161-200.
1897—A report on the geology of the middle and upper Silurian rocks of Clark, Jefferson, Ripley, Jennings, and southern Decatur Counties, Indiana: Indiana Dept. Geology and Nat. Resources, Ann. Rept. 21, p. 213-288, 4 pls.
1898—A report on the Niagara limestone quarries of Decatur, Franklin, and Fayette Counties, with remarks on the geology of the middle and upper Silurian rocks of these and neighboring (Ripley, Jennings, Bartholomew, and Shelby) counties: Indiana Dept. Geology and Nat. Resources, Ann. Rept. 22, p. 195-256, 5 pls.
1901—Silurian and Devonian limestones of Kentucky and Tennessee: Geol. Soc. America Bull., v. 12, p. 395-444.
1904—The Ordovician-Silurian contact in the Ripley Island area of southern Indiana, with notes on the age of the Cincinnati geanticline: Am. Jour. Sci., ser. 4, v. 18, p. 321-342.
1906—The Silurian, Devonian, and Irvine formations of east-central Kentucky, with an account of their clays and limestones: Kentucky Geol. Survey Bull. 7, 369 p.
1931—The Silurian fauna of Kentucky, *in* Jillson, W. R., The paleontology of Kentucky: Frankfort, Ky., Kentucky Geol. Survey, p. 167-214, pls. 17-26.
1935—Correlation of Silurian formations in southwestern Ohio, southeastern Indiana, Kentucky, and western Tennessee: Denison Univ., Sci. Lab., Jour., v. 30, p. 119-205.

French, R. R.
1967—Crushed stone resources of the Devonian and Silurian carbonate rocks of Indiana: Indiana Geol. Survey Bull. 37, 127 p., 5 pls., 9 figs., 8 tables.

Hass, W. H.
1953—Conodonts of the Barnett Formation of Texas: U. S. Geol. Survey Prof. Paper 243-F, p. 69-94, pls. 14-16.
1962—Conodonts, *in* Treatise on invertebrate paleontology: Geol. Soc. America and Kansas Univ. Press, pt. W, p. 3-69, figs. 1-42.

Hattin, D. E., and others
1961—Field excursion to the Falls of the Ohio: Geol. Soc. America, Guidebook for field trips, Cincinnati meeting, 1961.

Huddle, J. W.
1931—Notes on outcrops of Silurian near Sunman, Ripley County, Indiana: Indiana Acad. Sci. Proc. for 1930, v. 40, p. 213-215, 1 fig.

Liebe, R. M.

1962—Conodonts from the Alexandrian and Niagaran Series (Silurian) of the Illinois Basin [Ph. D. thesis]: Iowa City, State Univ. of Iowa.

Lindström, Maurits

1954—Conodonts from the lowermost Ordovician strata of south-central Sweden: Geol. fören. Stockholm Förh., v. 76, no. 479, p. 517-604, pls. 1-7.

1959—Conodonts from the Crug Limestone (Ordovician, Wales): Micropaleontology, v. 5, p. 427-452, pls. 1-4.

Mound, M. C.

1961—Arenaceous Foraminifera from the Brassfield Limestone (Albion) of southeastern Indiana: Indiana Geol. Survey Bull. 23, 38 p., 3 pls., 5 figs., 3 tables.

Mound, M. C., and Ethington, R. L.

1964—*Ambalodus* Branson and Mehl, 1933 or *Ambolodus* Branson and Mehl, 1934 (conodonts): proposed rejection of *Ambolodus* under the plenary powers. Z. N. (S.) 1633: Bull. Zool. Nomenclature, v. 21, p. 310-314.

Murray, H. H.

1955—Sedimentation and stratigraphy of the Devonian rocks of southeastern Indiana: Indiana Geol. Survey Field Conf. Guidebook 8, 73 p., 7 pls.

Nosow, Edmund

1959—Stratigraphy of Nelson County and adjacent areas: Geol. Soc. Kentucky, Field Trip 1959, 37 p., 14 figs.

Opik, A.

1936—Konodontidest: Aratrükk Eesti Loodusest, no. 3, p. 105-107, text-fig. 57-59.

Orton, Edward

1871—Report on the geology of Montgomery County: Ohio Geol. Survey [Rept. Prog. for 1869], p. 143-171.

Owen, D. D.

1857—General report: Second report of the Geological Survey in Kentucky, made during the years 1856 and 1857: Frankfort, Ky., 391 p.

Patton, J. B., Perry, T. G., and Wayne, W. J.

1953—Ordovician stratigraphy, and the physiography of part of southeastern Indiana: Indiana Geol. Survey Field Conf. Guidebook 6, 29 p., 4 pls.

Pinsak, A. P., and Shaver, R. H.

1964—The Silurian formations of northern Indiana: Indiana Geol. Survey Bull. 32, 87 p., 2 pls., 6 figs., 6 tables.

Rexroad, C. B., Branson, E. R., Smith, M. O., Summerson, Charles, and Boucot, A. J.

1965—The Silurian formations of east-central Kentucky and adjacent Ohio: Kentucky Geol. Survey, ser. X, Bull. 2, 34 p., 3 figs.

Rexroad, C. B., and Rickard, L. V.

1965—Zonal conodonts from the Silurian strata of the Niagara Gorge: Jour. Paleontology, v. 40, p. 1217-1220, 1 text-fig.

Rhodes, F. H. T.

1953—Some British lower Paleozoic conodont faunas: Royal Soc. London Philos. Trans., ser. B, Biol. Sci., no. 647, v. 237, p. 261-334, pls. 20-23.

Rhodes, F. H. T., and Müller, K. J.

1956—The conodont genus *Prioniodus* and related forms: Jour. Paleontology, v. 30, p. 695-699.

Ross, C. A.

1962—Early Llandoverian (Silurian) graptolites from the Edgewood Formation, northeastern Illinois: Jour. Paleontology, v. 36, p. 1383-1386.

Savage, T. E.

1908—On lower Paleozoic stratigraphy of southwestern Illinois: Am. Jour. Sci., ser. 4, v. 25, p. 431-443.

Shaver, R. H., and others

1961—Geology from Chicago to Cincinnati: Geol. Soc. America, Guidebook for field trips, Cincinnati meeting, 1961, p. 1-44.

Shideler, W. H., Briggs, G. H., Jr., and Miller, Raymond

1929—Geologic map of Nelson County, Kentucky: Kentucky Geol. Survey, ser. VI.

Summerson, C. H.

1963—Road log of first day, *in* Summerson, C. H., Forsyth, J. L., Hoover, K. V., and Ulteig, J. R., Stratigraphy of the Silurian rocks in western Ohio: Michigan Basin Geol. Soc., Ann. Field Excursion, p. 12-34.

Sweet, W. C.

1955—Conodonts from the Harding Formation (Middle Ordovician) of Colorado: Jour. Paleontology, v. 29, p. 226-262, pls. 27-29.

Ulrich, E. O., and Bassler, R. S.

1926—A classification of the toothlike fossils, conodonts, with descriptions of American Devonian and Mississippian species: U. S. Natl. Museum Proc., v. 66, art. 12, p. 1-63, pls. 1-11.

Utgaard, John, and Perry, T. G.

1964—Trepostomatous bryozoan faunas of the upper part of the Whitewater Formation (Cincinnatian) of eastern Indiana and western Ohio: Indiana Geol. Survey Bull. 33, 111 p., 23 pls., 1 fig., 62 tables.

Walliser, O. H.

1957—Conodonten aus dem oberen Gotlandium Deutchlands und der Karnischen Alpen: Hess. Landesamt Bodenf., Notizbl., v. 85, p. 28-52, 3 pls., 3 figs.

1962—Conodontenchronologie des Silurs (=Gotlandiums) und des tieferen Devons mit besonderer berücksichtigung der Formationsgrenze: Symposiums-Band der 2. Internationalen Arbeitstagung über die Silur/Devon-Grenze und die Stratigraphie von Silur und Devon, Bonn-Bruxelles 1960, p. 281-287.

1964—Conodonten des Silurs: Hess. Landesamt Bodenf., Abh., no. 41, 106 p., 32 pls.

PLATES 2-4

PLATE 2

All figures are × 40

Numbers in parentheses refer to locality and sample numbers; for example, (28-1) refers to locality 28, sample 1.

1-3 *Drepanodus? arrectus* Rexroad, n. name (p. 29).
Inner lateral views 10021 (28-1), 10022 (31-bulk), and 10023 (11-1).

4 *Drepanodus suberectus* (Branson and Mehl) (p. 30).
Oblique lateral view 10024 (3-6).

5 *Ligonodina kentuckyensis* Branson and Branson (p. 35).
Inner lateral view 10035 (12-8).

6 *Ozarkodina edithae* Walliser (p. 40).
Outer lateral view 10040 (10-9).

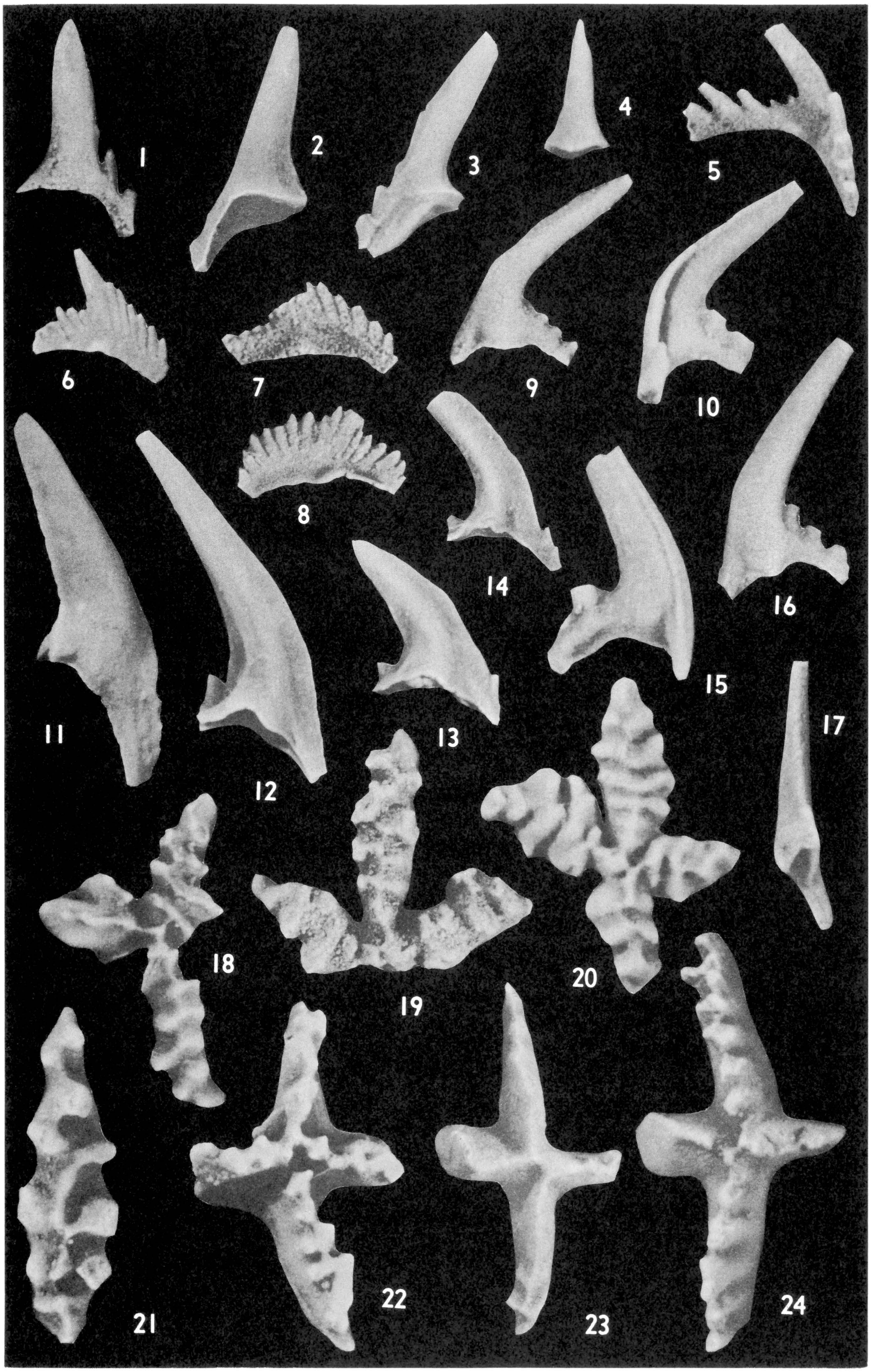
7, 8 *Ozarkodina typica* Branson and Mehl (p. 39).
Outer lateral view 10038 (10-9) and inner lateral view 10039 (9-9).

9, 10 *Ligonodina? extrorsa* Rexroad, n. sp. (p. 36).
15-17 9, Outer lateral view of holotype 10011 (33-3).
10, Inner lateral view of ligonodinid specimen 10016 (2-7).
15, Inner lateral view of paratype 10014 (33-3).
16, Outer lateral view of paratype 10012 (28-bulk).
17, Posterior view of paratype 10015 (47-5).

11-14 *Distomodus kentuckyensis* Branson and Branson (p. 28).
Outer lateral view of 10017 (20-4) and inner lateral views of 10020 (5-7), 10018 (11-3), and 10019 (22-5).

18-21 *Icriodina irregularis* Branson and Branson (p. 33).
Oral views 10027 (28-bulk), 10028 (28-bulk), 10097 (Dog Falls, Jefferson County, Ind.), and 10029 (31-2).

22-24 *Icriodina stenolophata* Rexroad, n. sp. (p. 34).
22, Oral view of specimen transitional with *I. irregularis* 10034 (28-bulk).
23, 24, Oral views of paratype 10032 (28-bulk) and holotype 10031 (31-2).



BRASSFIELD CONODONTS

PLATE 3

All figures are × 40

Numbers in parentheses refer to locality and sample numbers; for example, (14-11) refers to locality 14, sample 11.

1, 2 *Spathognathodus oldhamensis* Rexroad, n. sp. (p. 49).
1, Outer lateral view of paratype 10069 (14-11).
2, Inner lateral view of holotype 10068 (8-15).

3 *Spathognathodus* cf. *S. oldhamensis* Rexroad (p. 49).
Inner lateral view 10070 (3-10).

4 *Ambalodus* sp. (p. 27).
Oral view 10009 (11-4).

5 *Lonchodina?* sp. (p. 38).
Lateral view 10037 (12-7).

6 *Lonchodina walliseri* Ziegler (p. 37).
Lateral view 10036 (11-2).

7, 8 *Euprioniodina* cf. *Prioniodus excavatus* Branson and Mehl (p. 31).
Inner lateral views 10025 (9-11) and 10026 (18-2).

9, 10 *Synprioniodina* cf. *Prioniodus bicurvatus* Branson and Mehl (p. 50).
Inner lateral views 10071 (12-9) and 10072 (11-4).

11 *Neoprioniodus planus* Walliser (p. 39).
Inner lateral view 10099 (11-4).

12 *Neoprioniodus triangularis* Walliser.
Posterior view 10101 (53-4).

13 *Neoprioniodus costatus* Walliser.
Outer lateral view 10098 (11-4).

14 *Neoprioniodus subcarnulus* Walliser.
Inner lateral view 10100 (12-9).

15 *Plectospathodus irregularis* Branson and Branson (p. 48).
Lateral view 10067 (13-1).

16 *Trichonodella* cf. *T. excavata* (Branson and Mehl) (p. 52, 53).
Posterior view 10078 (14-6).

17 *Trichonodella* sp. B (p. 53).
Posterior view 10079 (9-9).

18 *Trichonodella* sp. A (p. 52).
Posterior view 10077 (28-1).

19 *Trichonodella* cf. *T. inconstans* Walliser (p. 54).
Posterior view 10080 (18-12).

20, 21 *Keislognathus?* n. sp. (p. 59).
Posterior views 10091 (34-3) and 10092 (22-6).

22 *Roundya truncialata* Walliser (p. 58).
Posterior view 10090 (3-7).

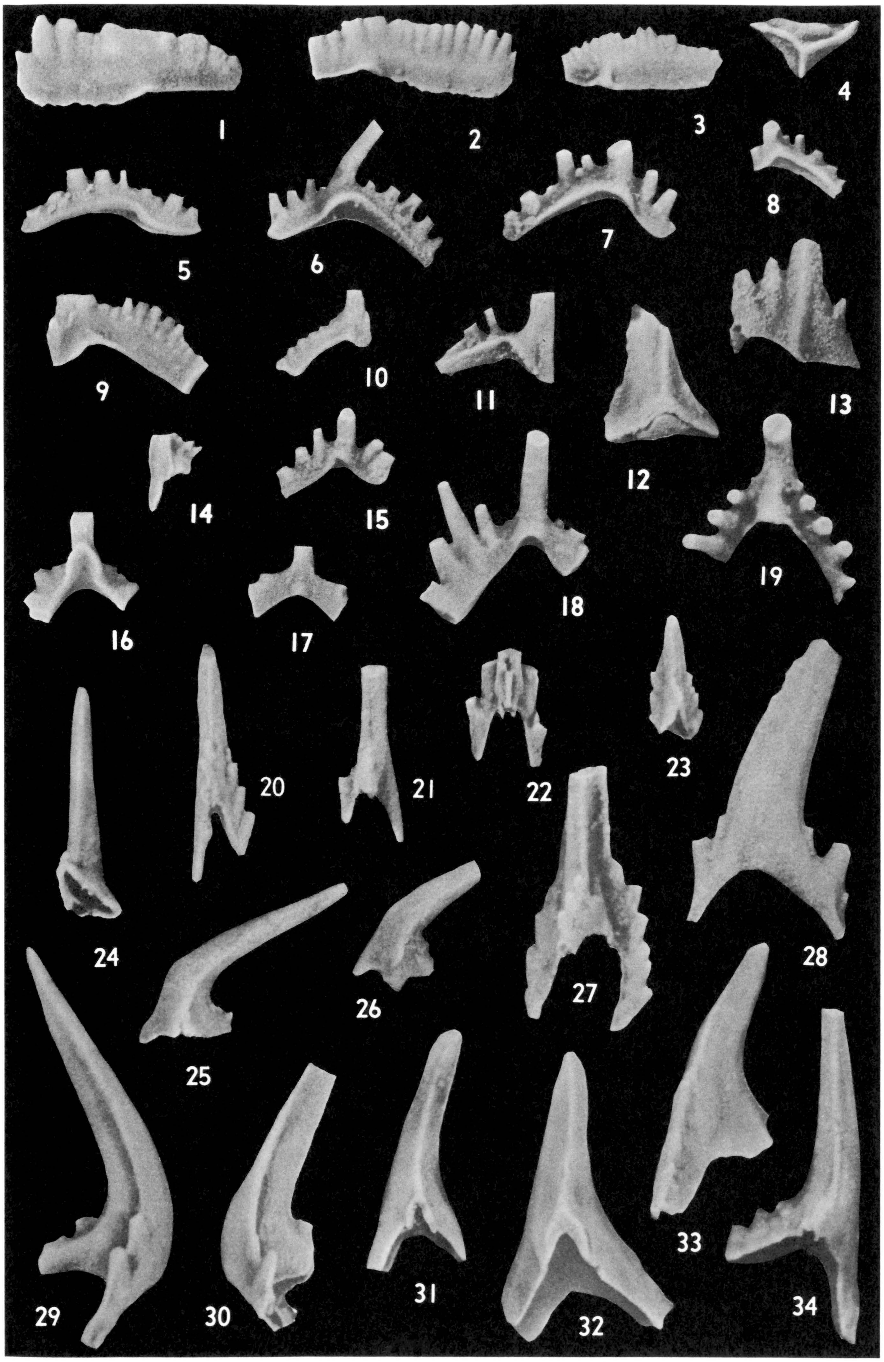
23 *Rhynchognathodus?* n. sp. (p. 60).
Posterior view 10093 (9-10).

24-26 *Trichonodella?* n. sp. (p. 57).
Posterior view 10094 (31-2) and inner lateral views 10095 (38-2) and 10096 (37-5).

27, 28 *Trichonodella brassfieldensis* Branson and Branson (p. 56).
Posterior view 10086 (22-5) and anterior view 10087 (22-5).

29, 30 *Roundya caudata* Walliser (p. 58).
Lateral views 10088 (3-2) and 10089 (25-5).

31-34 *Trichonodella? edentata* Branson and Branson (p. 55).
Posterior views 10081 (28-bulk) and 10082 (28-2), lateral view 10083 (12-10), and posterior view 10084 (28-2).



BRASSFIELD CONODONTS

PLATE 4

All figures are × 40

Numbers in parentheses refer to locality and sample numbers; for example, (31-2) refers to locality 31, sample 2.

1, 2 *Panderodus unicostatus unicostatus* (Branson and Mehl) (p. 46).
Lateral views 10061 (31-2) and 10062 (13-5).

3, 4 *Panderodus unicostatus serratus* Rexroad, n. subsp. (p. 47).
Lateral views of holotype 10063 (3-10) and of paratype 10064 (3-10).

5, 6 *Panderodus* cf. *P. unicostatus* (Branson and Mehl) (p. 46).
Lateral views 10065 (9-11) and 10066 (11-2).

7, 8 *Panderodus simplex* (Branson and Mehl) (p. 45).
Lateral views 10059 (28-2) and 10060 (28-2).

9-12 *Acodus curvatus* Branson and Branson (p. 25).
9, 12, Outer lateral views 10001 (12-9) and 10004 (26-1).
10, 11, Inner lateral views 10002 (12-11) and 10003 (24-2).

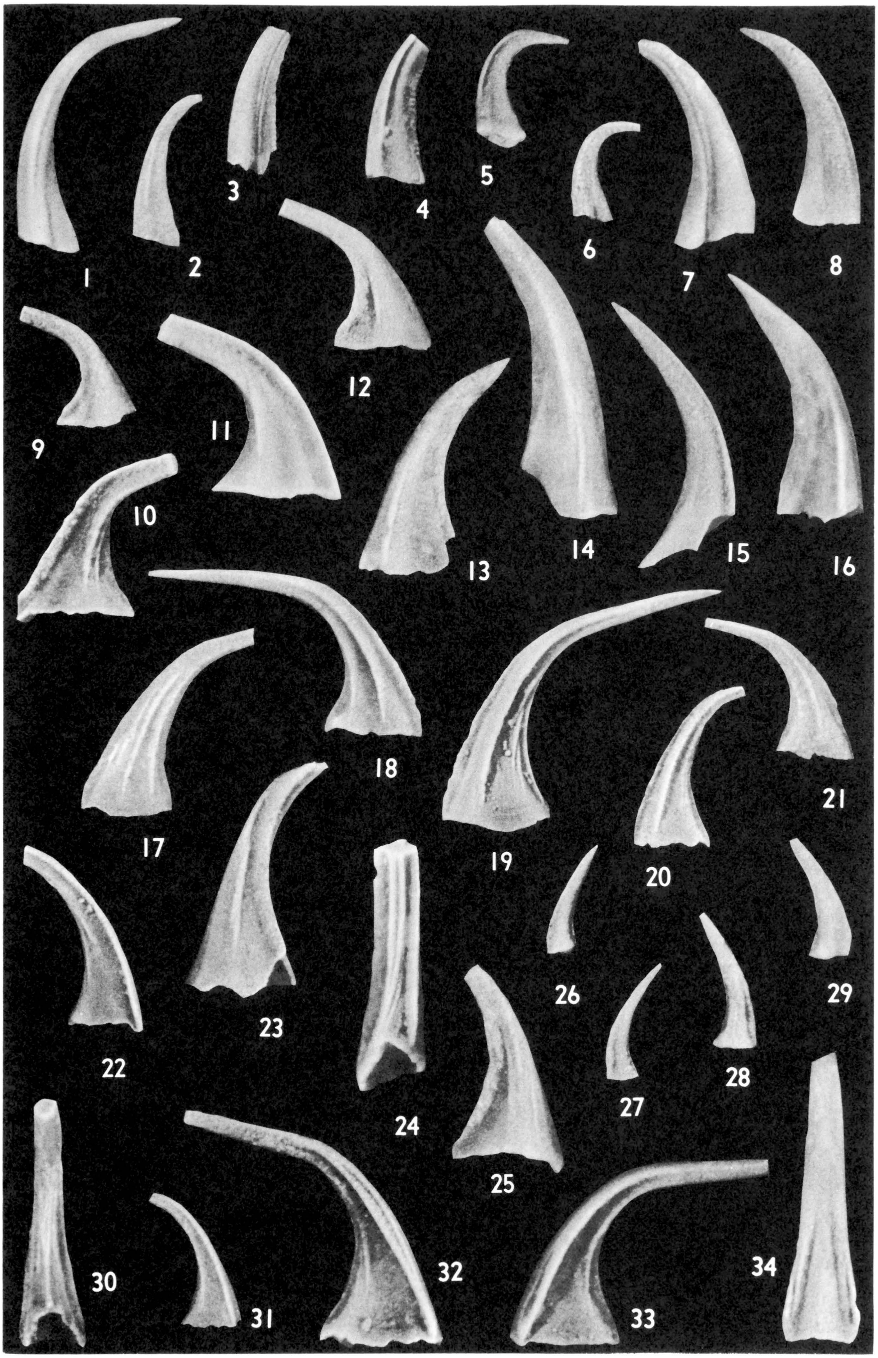
13-16 *Acodus unicostatus* Branson and Branson (p. 26).
Lateral views 10005 (22-5), 10006 (26-2), 10007 (U. S. Highway 150 at Clear Creek, Ky.), and 10008 (27-3).

17-21 *Paltodus migratus* Rexroad, n. sp. (p. 44).
Lateral views of paratypes 10055 (12-1) and 10056 (11-4), holotype 10054 (9-11), and paratypes 10057 (12-9) and 10058 (11-2).

22-25 *Paltodus debolti* Rexroad, n. sp. (p. 41).
22, Inner lateral view of paratype 10046 (3-9).
23, Outer lateral view of paratype 10047 (22-4).
24, Posterior view of holotype 10045 (25-6).
25, Outer lateral view of paratype 10048 (25-4).

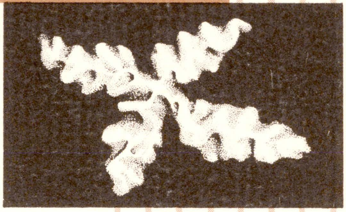
26-29 *Paltodus costulatus* Rexroad, n. sp. (p. 40).
Lateral views of paratype 10042 (9-11), holotype 10041 (9-11), and paratypes 10043 (11-5) and 10044 (12-1).

30-34 *Paltodus dyscritus* Rexroad, n. sp. (p. 42).
30, Posterior view of paratype 10050 (17-2).
31, Lateral view of immature paratype 10051 (14-6).
32, Lateral view of paratype 10052 (26-2).
33, Lateral view of holotype 10049 (26-2).
34, Anterior view of paratype 10053 (27-3).



BRASSFIELD CONODONTS

THIS PAGE INTENTIONALLY LEFT BLANK



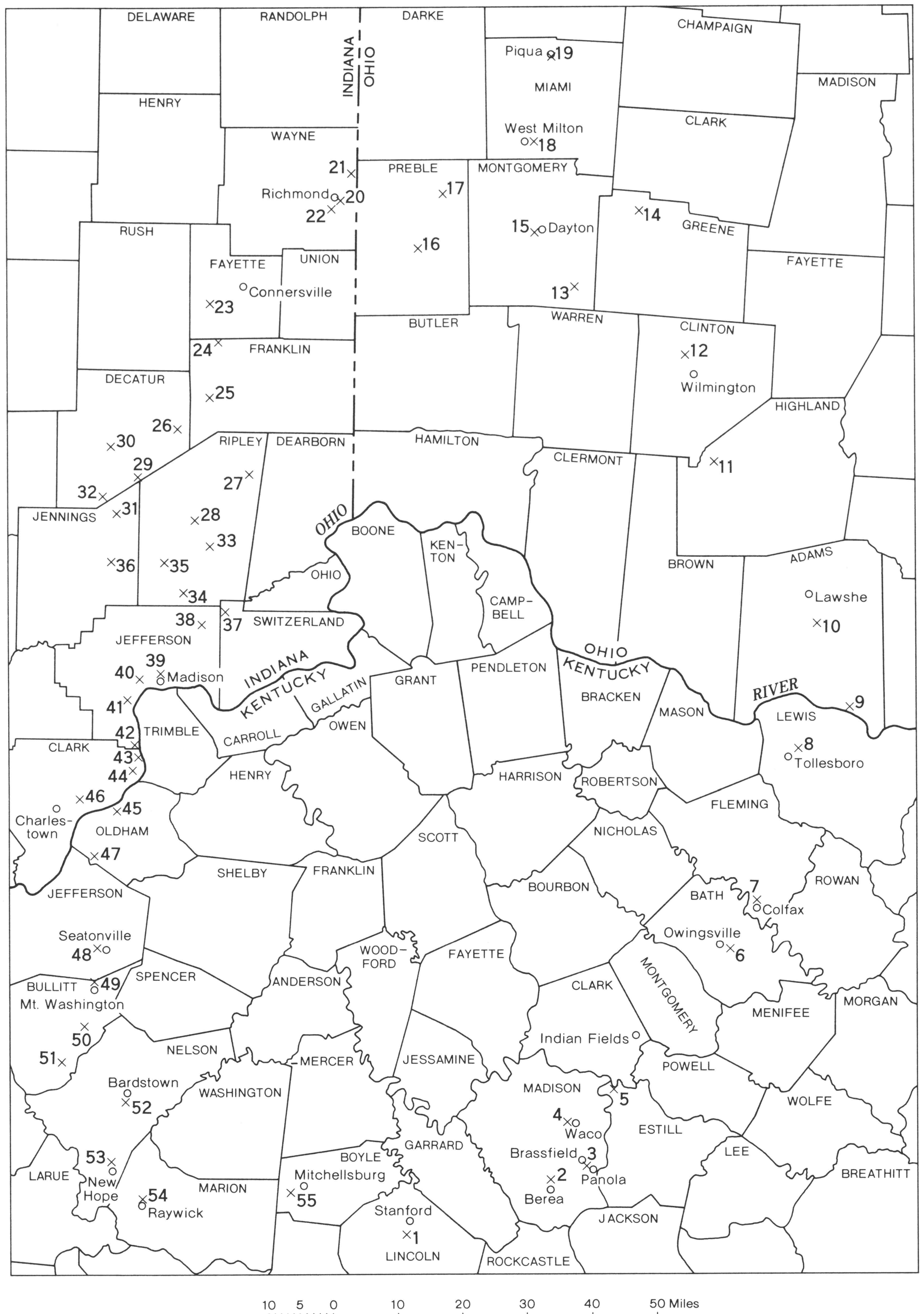
OVERSIZED DOCUMENT

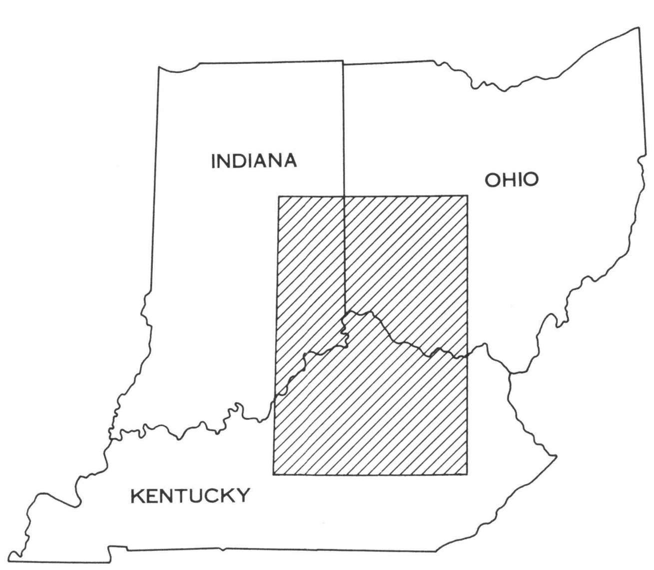
The following pages are oversized and need to be printed in correct format.

PRINTED BY AUTHORITY OF THE STATE OF INDIANA
ROGER D. BRANIGIN, GOVERNOR

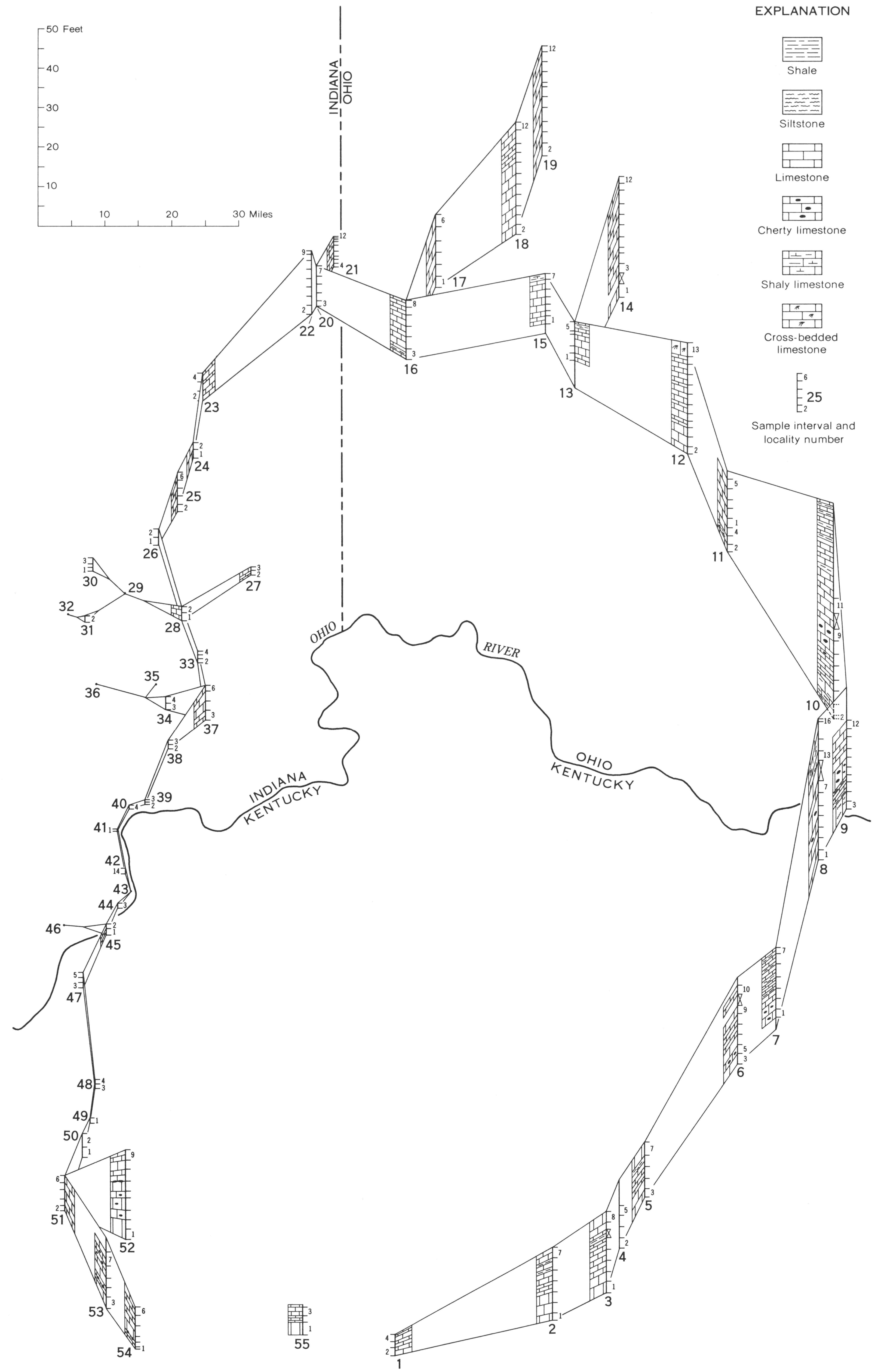
GEOLOGICAL SURVEY
JOHN B. PATTON, STATE GEOLOGIST

DEPARTMENT OF NATURAL RESOURCES
JOHN E. MITCHELL, DIRECTOR





INDEX MAP



Drafted by James R. Tolen

LOCATION MAP AND FENCE DIAGRAM SHOWING COLLECTING LOCALITIES AND STRATIGRAPHIC SECTIONS OF THE BRASSFIELD

(SEE TEXT FOR PRECISE LOCATIONS)

By Carl B. Rexroad

1967