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LOWER SILURIAN CONODONTS FROM NORTHERN MICHIGAN AND ONTARIO

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ABSTRACT—Conodonts representing 50 species, 8 new, from 19 genera, one new, were collected from 15 outcrop sections and a core of lower Silurian rocks in the northern peninsula of Michigan and in Ontario. New taxa include the genus *Exochognathus* and the following species: *Ambalodus anapetus, Aphelognathus siluricus, Exochognathus keislognathoides, Icriodella discreta, Spathognathodus comptus, S. elibatus, S. hassi,* and *S. manitoulinensis.* The conodont zone between the top of the Ordovician and the base of the *Icriodina irregularis* Assemblage Zone is named the *Panderodus simplex* Assemblage Zone.

INTRODUCTION

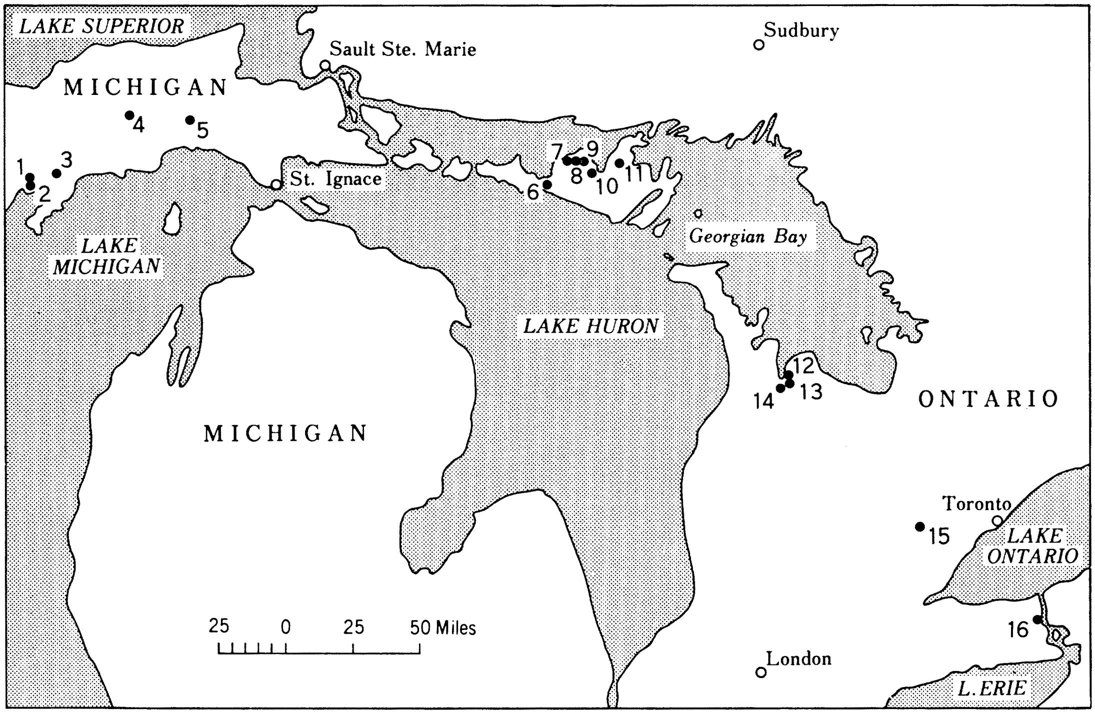
Studies of Silurian conodont biostratigraphy by members of the Indiana Geological Survey have established conodont zones for the lower and lower middle parts of the Silurian System in the Cincinnati Arch outcrop area (Rexroad, 1967; Nicoll & Rexroad, 1968). Work is being continued on Silurian strata of the southern part of the Michigan Basin as part of a larger study on the middle Paleozoic geology of that area. The two earlier studies in conjunction with a report on the conodont sequence in the Niagara Gorge (Rexroad & Rickard, 1965) showed that faunal provincialism must be recognized and understood before complete interpretations of conodont sequences are possible. For this reason and because much of the stratigraphic terminology of the Silurian strata in the subsurface of the Michigan Basin is derived from outcrops of the northern part of the basin, representative material was collected from the northern peninsula of Michigan, Manitoulin Island, Ontario, and western Ontario (Text-fig. 1). The purpose of this paper, then, is to describe from that area the conodonts from the *Icriodina irregularis* Assemblage Zone and from older Silurian strata.

We are grateful to A. E. Slaughter, Michigan Geological Survey, for allowing us to examine and sample the Cleveland-Cliffs Iron Company core and to W. J. Kilgour for suggesting collecting sites on Manitoulin Island and for comments on stratigraphic relationships in the area. Critical reading of the manuscript by F. H. T. Rhodes, University of Michigan, is also greatly appreciated. The study was supported by a National Science Foundation grant (GP-5629) as part of a larger project undertaken at Indiana University. Publication is authorized by the State Geologist, Indiana Geological Survey, and by Amoco Canada Petroleum Company.

STRATIGRAPHY

Both lower and middle Silurian sections were sampled, but conodonts described in this paper are essentially limited to lower Silurian strata. Samples from the northern peninsula of Michigan came from the Manitoulin Dolomite (including the Moss Lake Formation of Ehlers & Kesling, 1957), Cabot Head Shale, and Hendricks Dolomite (Text-fig. 2). From Manitoulin Island and peninsular Ontario the formations sampled include the Manitoulin Dolomite and Cabot Head Shale, and the Dyer Bay, Wingfield, Mindemoya, and Fossil Hill Formations. Conodonts from the Neahga Shale of the Niagara Gorge were reexamined. Fifteen outcrop sections (Text-fig. 3) and one core were examined. Because all but two of the sections studied have been described in previous publications, the sections are not elaborated on here. One of the two sections not previously described (loc. 2) is in the Manitoulin Dolomite one-half mile south of stop 3 of Ehlers & Kesling (1957) in Delta County, Michigan, and the second (loc. 11) is in the Manitoulin Dolomite along the road at the south edge of Perch Lake, Manitoulin Island, Ontario. Precise locations and pertinent references are given in the section "Collecting localities".

Stratigraphic interpretation is not the primary purpose of this paper, but some inconsistencies in previous interpretations are shown by the conodonts. Strata in Delta County, Michigan, at stop 2 of Ehlers & Kesling (1957) were referred by them to the Cabot Head Shale, but the section contains Ordovician conodonts. Only a few miles south of this section is the type section of the Moss Lake Formation (stop 3, Ehlers & Kesling, 1957). Here the Moss Lake was distinguished from the Manitoulin Dolomite because it was presumed to overlie the Cabot Head which in turn is above the Manitoulin.



TEXT-FIG. *1*—Map showing locations of collecting sites. See list of collecting localities in text for precise locations.

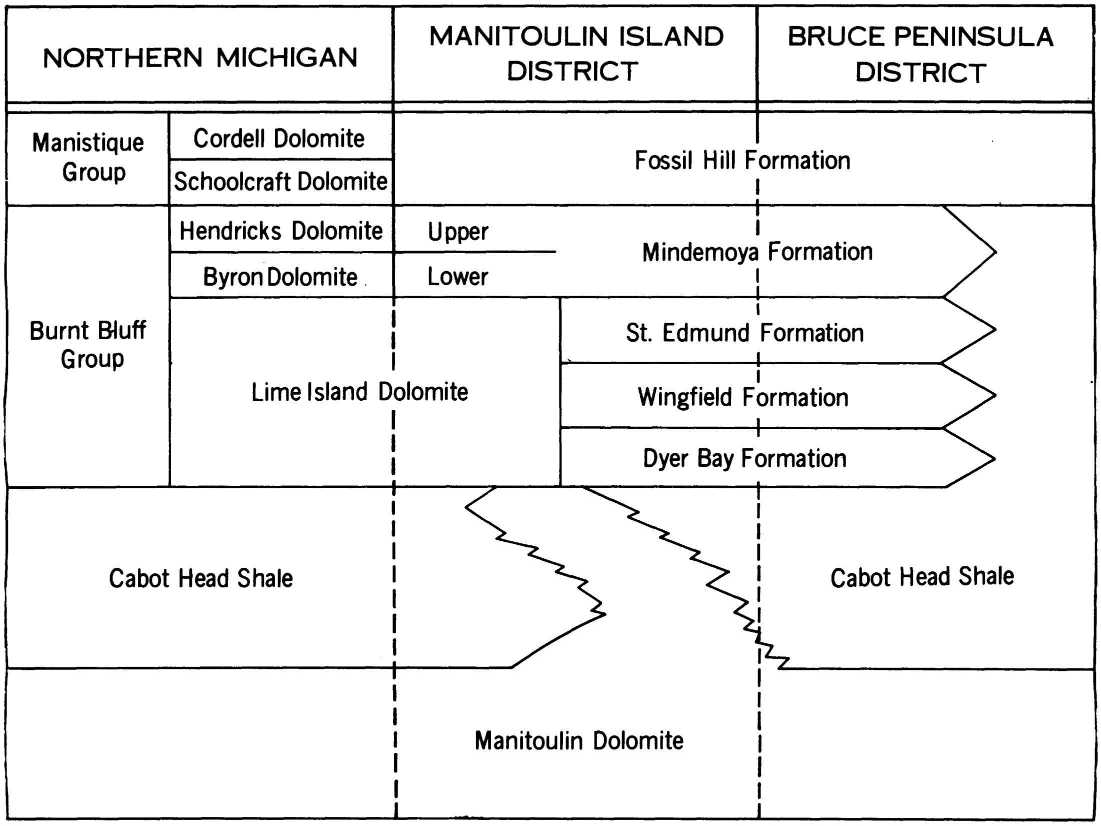
The type section of the Moss Lake, however, overlies Ordovician rather than Cabot Head strata and occupies the same stratigraphic position as does the Manitoulin. For this reason and because the lithology and conodonts of the type section of the Moss Lake and the Manitoulin are the same, the Moss Lake is not regarded as a valid unit.

The same stratigraphic relationship is shown by conodonts from the cored section (loc. 3) in Schoolcraft County, Michigan, drilled by the Cleveland-Cliffs Iron Company and described by Ehlers, Kesling & Slaughter (1967). Ordovician conodonts are found below 228.3 feet and Silurian foraminifers above. The boundary between Ordovician and Silurian strata should be placed at this depth, even though Silurian conodonts were not found in the seven feet immediately above the contact. Thus, beds referred to the Manitoulin Dolomite and Cabot Head Shale (Ehlers, Kesling & Slaughter, 1967, p. 223–224) are Ordovician in age. The Manitoulin Dolomite most probably occurs between 182.0 and 228.3 feet, and the Cabot Head Shale between 118.2 and 182.0 feet.

At locality 14 north of Georgetown, Ontario, (stop 3, Michigan Geological Society, 1955) 7.7 feet of the Reynales Limestone were recorded above the Cabot Head Shale. These beds contain conodonts characterizing the *Pterospathodus amorphognathoides–Spathognathodus ranuliformis* Assemblage Zone, whereas in the Niagara Gorge these fossils are found in the Rockway Dolomite Member of the Irondequoit Limestone, and the Reynales Limestone contains conodonts indicative of the lower part of the *Neospathognathodus celloni* Assemblage Zone. The Reynales then is either time transgressive or has been misidentified at this section.

THE CONODONT FAUNA

Faunal analysis is based on specimens from 139 samples (Text-fig. 2 and list of collecting localities). Fifty species from 19 genera, one new, are represented in the collection. Included are 43 named species, eight of which are new, and seven unnamed species. The new genus is *Exochognathus* and the new species are *Ambalodus anapetus, Aphelognathus siluricus, Exochognathus keislognathoides, Icriodella discreta, Spathognathodus comptus, S. elibatus, S. hassi,* and *S. manitoulinensis.* The unnamed species are represented by an insufficient number of specimens for adequate understanding and description but are illustrated to help show the fauna that is representative of the zone.



TEXT-FIGS 2—Chart showing stratigraphic relations of Silurian units studied in Michigan and Ontario. Modified from Liberty (1968, fig. 10).

The genus *Panderodus* dominates the fauna and constitutes about two-thirds of the specimens. *Acodus* is next in abundance, but specimens are only about one-tenth as numerous as those of *Panderodus*. In order of decreasing abundance the remaining genera are *Spathognathodus, Paltodus, Exochognathus, Ozarkodina, Ambalodus, Synprioniodina, Sagittodontus, Drepanodus, Neoprioniodus, Ligonodina, Distomodus, Trichonodella, Aphelognathus, Icriodella, Lonchodina, Plectospathodus,* and *Carniodus*. *Aphelognathus* previously has been recorded only from strata of Ordovician age, and the generic name *Sagittodontus* has not been applied to specimens from Silurian rocks. One of the species of *Sagittodontus* described herein, however, was described from Silurian rocks under the name *Trichonodella? edentata* as discussed in the systematic paleontology.

The difference in faunal province between these conodonts and those described from correlative rocks of the Cincinnati Arch area was suggested by Nicoll & Rexroad (1968, p. 6), and this study shows that there are appreciable differences in conodonts from the *Icriodina irregularis* Assemblage Zone from each area. Supplemental collections from younger rocks in Ontario and northern Michigan suggest that provincialism does not affect conodonts from the *N. celloni* and the *P. amorphognathoides–S. ranuliformis* Zones.

In spite of provincial differences, the upper limit of the *I. irregularis* Zone is well established in the Niagara Gorge and the Cincinnati Arch area. In the Niagara Gorge area it lies at the base of the Hickory Corners Limestone Member of the Reynales Limestone and in southeastern Indiana approximately at the base of the Lee Creek Member of the Brassfield Limestone. In both areas this is just below the first occurrence of guide fossils characterizing the overlying *N. celloni* Zone. Additionally, in both areas the platform genera characteristic of the *I. irregularis* Zone, *Icriodina* in the midwest and *Icriodella* in the northern area, are also present in small numbers in the lower part of the *N. celloni* Zone but not higher in the section. The termination of the ranges of both

Icriodina and *Icriodella* therefore must be in the lower part of the *N. celloni* Zone.

The greatest difference in composition between the two provinces is at the species level, except that *Icriodella* is the platform element in the northern area and *Icriodina* in the midwestern area. Because of similarities of some fragments of the two genera, possibly a few specimens of each genus are represented in collections from the area where they were not identified. *Aphelognathus,* although not abundant, is present in a number of northern samples, but was not found in the Brassfield or Noland Formations in the Cincinnati Arch area. *Ambalodus* is extremely rare in the south but is common in the north, and the species of the two areas differ. *Spathognathodus* is represented in this study by a greater diversity of species and larger number of individuals than in the Cincinnati Arch area.

Fewer species have been reported from the Brassfield Formation in the Cincinnati Arch area than from the present study, 40 species from the Brassfield and 50 from the northern area. Of these species 28 are common to both areas, although three of the species found in both areas are so rare in the Brassfield that it was questioned as to whether they are indigenous (Table 1). Twenty-two species were found only in the northern area and 12 only in the southern area. These numbers include uncommon, rare, or questionable species, and so about half of the species occurring at least in moderate numbers are found in both areas. The fact that relatively few species are common to time-equivalent units in both areas must be attributed to provincialism.

The definition of Walliser's (1964) *celloni*-Zone was modified (Nicoll & Rexroad, 1968) to allow for the overlap of species thought by Walliser to represent separate zones. For this reason and because of the recognition of provincialism, it is necessary to shift the position of the zone boundary in the Niagara Gorge from the base of the Thorold Sandstone as provisionally recognized by Rexroad & Rickard (1965) to the top of the Neahga Shale. The faunas of the Hickory Corners and the underlying Neahga Shale were found to be similar except for the absence of *celloni*-Zone guide fossils in the Neahga. Because of the similarity to the Hickory Corners fauna and the differences from the Brassfield and Noland faunas, the Neahga was considered to belong in Walliser's *celloni*-Zone. The similarity to the Hickory Corners is now known to result from the continuation of many of the earlier species upward into the lower part of the *N. celloni* Zone, and the differences from the Brassfield result from provincialism. The fauna of the Neahga belongs in the *I. irregularis* Zone and is similar to that of the Manitoulin Dolomite.

Recognition of the base of the *Icriodina irregularis* Assemblage Zone is less certain. Nonetheless, an interval below the *I. irregularis* Zone is recognized in this study in the oldest part of the Manitoulin and seems to correspond with the pre-*Icriodina* Zone in the Midwest (Rexroad, 1967) and with the lower part of Walliser's (1964) Bereich I. Because of the wide distribution of this zone and the need for a convenient designation, we here apply the name, the *Panderodus simplex* Assemblage Zone, to this interval. The top of the zone is immediately below the lowest occurrence of the genus *Icriodina* or of *Icriodella discreta* or *I.* n. sp. of this report. The base is directly above the highest occurrence of conodonts considered to be characteristic of Ordovician faunas as represented by such Ordovician genera as *Oistodus, Phragmodus, Rhipidognathus, Scandodus,* and *Zygognathus.* One of the characteristic features of the zone in the areas studied is its general paucity of conodonts. Only *Panderodus simplex* and *P. unicostatus* are common, and except for these two species, the conodonts found in the overlying zone are absent or rare.

COLLECTING LOCALITIES

1. Strata exposed in ditch on north side of road about 1.5 miles west of Isabella, SE¼SE¼ sec. 35, T.41N., R.19W., Delta County, Michigan (type section Moss Lake Formation); stop 3, Ehlers & Kesling, 1957.
2. Small quarry near Moss Lake along U.S. Highway 2 about 1.5 miles west southwest of Isabella, SW¼ sec. 2, T.40N., R.19E., Delta County, Michigan.
3. The Cleveland-Cliffs Iron Company core, about one mile northwest of the village of Cooks, SW¼ sec. 19, T.41N., R.17W., Schoolcraft County, Michigan.
4. Abandoned quarry on Michigan Highway 98, about 4 miles east of Germfask, SW¼ sec. 20, T.45N., R.12W., Luce County, Michigan; stop 12, Ehlers & Kesling, 1957.
5. Abandoned Hendricks quarry northwest of Rexton and 4 miles south of McLeods Corner, NW¼ sec. 6, T.44N., R.8W., and NE¼ sec. 1, T.44N., R.9W., Mackinac County, Michigan (type section Hendricks Dolomite); stop 14, Michigan Geological Society guidebook 1957.
6. Roadside exposure on a road south of Ontario Highway 540 near the south end of the

TABLE 1—COMPARISON OF SPECIES FROM THE NORTHERN MICHIGAN-ONTARIO AREA (N) WITH THOSE FROM THE CINCINNATI ARCH AREA (S). NAMES IN PARENTHESES ARE THOSE USED IN THE EARLIER STUDY (REXROAD, 1967) THAT HAVE SUBSEQUENTLY BEEN CHANGED

	N	S		N	S
Acodus curvatus	c	a	*Neoprioniodus costatus*	—	?
A. unicostatus	a	va	*Neoprioniodus* cf. *N. excavatus*	r	c
Ambalodus anapetus	a	—	(*Euprioniodina* cf. *P. excavatus*)		
A. triangularis	—	?	(*N. planus*)		
A. spp.	—	r	*N. planus*	c	—
Aphelognathus siluricus	r	—	*N. subcarnulus*	—	?
Carniodus n. sp.	r	—	*Ozarkodina typica*	r	r
Distomodus kentuckyensis	r	a	*O.* cf. *O. edithae* (*O. edithae*)	c	?
D. triangularis triangularis	c	?	*O.* aff. *O. media*	r	—
(*Neoprioniodus triangularis*)			*O* n sp. A	c	—
D. cf. *N. triangularis tenuirameus*	r	—	*O.* n. sp. B	c	—
Drepanodus? arrectus	r	c	*Paltodus costulatus*	a	a
D. suberectus	c	c	*P. debolti*	r	va
Exochognathus brassfieldensis	r	c	*P. dyscritus*	c	va
(*Trichonodella brassfieldensis*)			*P. migratus*	r	c
E. brevialatus	c	r	*Panderodus simplex*	va	va
(*Roundya truncialata*)			*P. unicostatus*	va	va
E. caudatus	r	c	*Plectospathodus flexuosus*	r	—
(*Roundya caudata*)			*P. irregularis*	—	r
E. keislognathoides	c	r	*Sagittodontus edentatus*	c	c
(*Keislognathus?* sp.)			(*Trichonodella? edentata*)		
E. [*Rhynchognathodus?*] n. sp.	—	r	*S. robustus*	c	—
Icriodella discreta	r	—	*Spathognathodus comptus*	c	—
I. n. sp.	r	—	*S. elibatus*	c	—
Icriodina irregularis	—	a	*S. hassi*	r	r
I. stenolophata	—	c	*S. manitoulinensis*	r	—
Ligonodina kentuckyensis	r	c	*S. oldhamensis*	c	r
L. cf. *L. silurica*	r	—	*Synprioniodina bicurvata*	r	r
L.? extrorsa	—	c	(*S.* cf. *Prioniodus bicurvatus*)		
L.? variabilis	c	r	*S. silurica*	c	—
L. n. sp.	r	—	*Trichonodella inconstans*	r	?
Lonchodina spp.	r	r	(*T.* cf. *T. inconstans*)		
L. walliseri	r	r	*T. symmetrica*	r	—
L. greilingi	r	—	*T.* n. sp. (*T.* sp. B)	c	r
L. detorta	r	—	*T.* sp. A	—	c
L.? sp.	—	r	*T.?* n. sp.	—	c

va—Greater than 4 specimens per kilogram of sample
a—1–4 specimens per kilogram
c—$\frac{1}{4}$–1 specimen per kilogram
r—0–$\frac{1}{4}$ specimens per kilogram

Lake Woolsey Causeway, Manitoulin Island, Ontario; stop 5, Alguire & Liberty, 1968.

7. Abandoned quarry southeast of village of Gore Bay, Manitoulin Island, Ontario; stop 22, Bolton & Liberty, 1954.

8. Section exposed in ditch on north side of Ontario Highway 540, northwest of Ice Lake, Manitoulin Island, Ontario; stop 21, Bolton & Liberty, 1954.

9. Abandoned quarry and road cut on Ontario Highway 540 west of village of Kagawong, Manitoulin Island, Ontario; stop 20, Bolton & Liberty, 1954, and stop 2, Alguire & Liberty, 1968.

10. Section exposed in ditch on south side Ontario Highway 540 about 1 mile west of village of Excellison, Manitoulin Island, Ontario; stop 18, Bolton & Liberty, 1954, and stop 13, Alguire & Liberty, 1968.

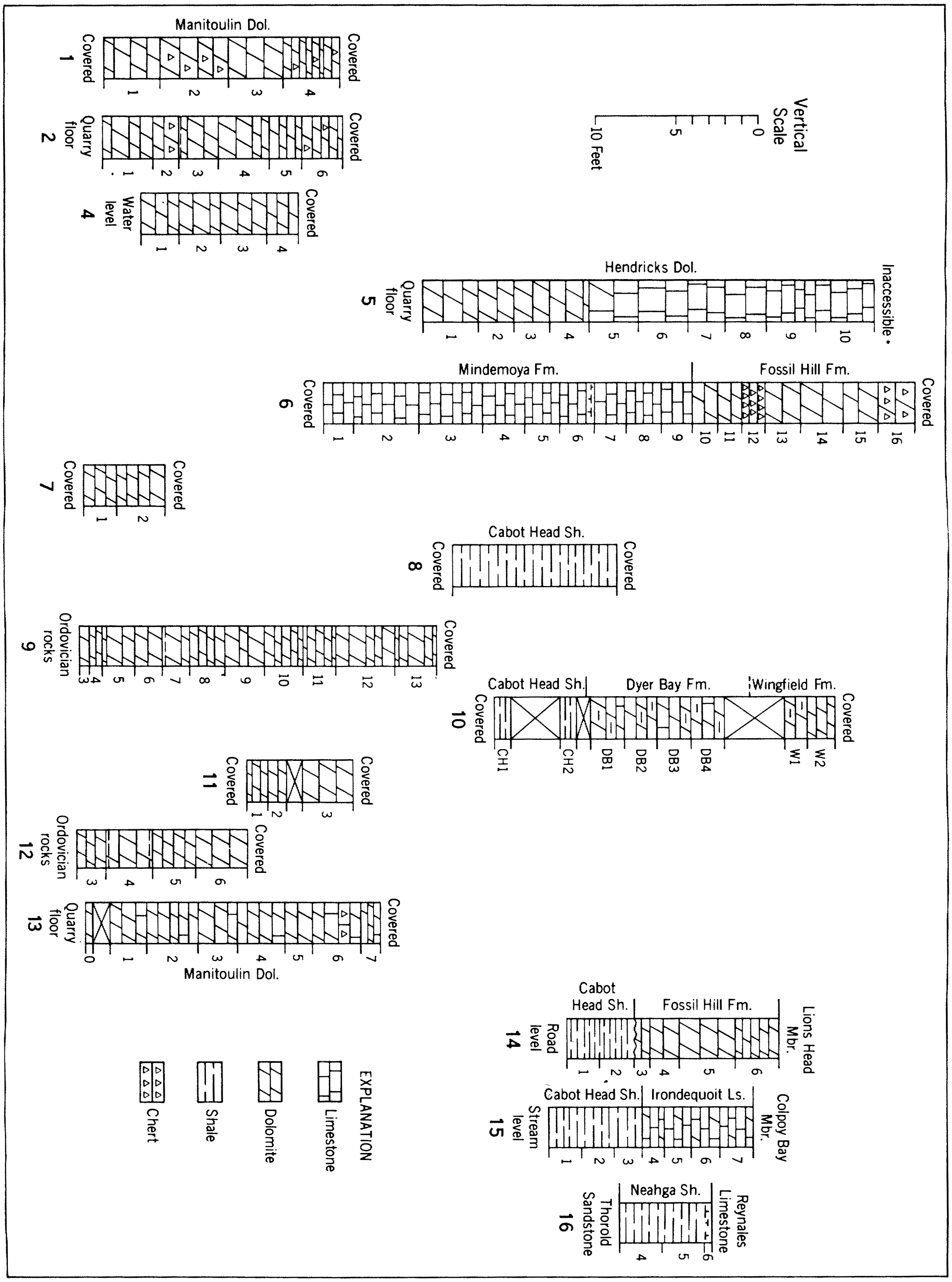
11. Road exposure along road south of Perch Lake, Manitoulin Island, Ontario.

12. Cliff exposure along Shore Road on east side of Owen Sound Bay, Owen Sound, Grey County, Ontario; stop 6, Michigan Geological Society guidebook 1955.

13. Easterly quarries, east side of Owen Sound; Grey County, Ontario; stop 7, Michigan Geological Society guidebook 1955.

14. Inglis Falls road cut about 2 miles south of Owen Sound, Grey County, Ontario; stop 8, Michigan Geological Society guidebook 1955.

15. Creek section about 5 miles north of Georgetown, Halton County, Ontario; stop 3, Michigan Geological Society guidebook 1955.



TEXT-FIG. *3*—Measured sections showing stratigraphic units and sample intervals for outcrop sections. See Text-fig. 1 and list of collecting localities in text for locations of sections.

16. Road cut on access road to the Sir Adam Beck-Niagara Generating Station No. 2, Niagara Falls, Welland County, Ontario; stop, Anderson, 1953; section 1, Bolton, 1964; Text-fig. 1, Rexroad & Rickard, 1965.

SYSTEMATIC PALEONTOLOGY

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. Sample intervals are shown by Text-figure 2 except for locality 3. Sample numbers for that locality give hole depth in feet. Under the heading "Material studied" only the specimens from the present collection are listed.

Genus Acodus Pander, 1856

Type species.—*Acodus erectus* Pander, 1856.

Acodus curvatus Branson & Branson
Pl. 114, fig. 35

Acodus curvatus Branson & Branson, 1947, p. 554, Pl. 81, fig. 20; Rexroad, 1967, p. 25, Pl. 4, figs. 9–12, Text-fig. 4; Nicoll & Rexroad, 1968, p. 23, Pl. 7, figs. 19,20.
Acodus cfr. *mutatus* (Branson & Mehl), Serpagli & Greco, 1964, p. 196, Pl. 34, figs. 2a,b.

Material studied.—Forty-three specimens.
Repository.—Figured specimen, 12501 (7–4).

Acodus unicostatus Branson & Branson
Pl. 114, figs. 36,37

Acodus unicostatus Branson & Branson, 1947, p. 554, Pl. 82, figs. 9,10,41,43; Rexroad, 1967, p. 26, Pl. 7, figs. 34–36.
Paltodus acostatus Branson & Branson (part), 1947, p. 554, Pl. 82, figs. 23,24 only.

Material studied.—433 specimens.
Repository.—Figured specimens, 12502 (12–3) and 12503 (7–3).

Genus Ambalodus Branson & Mehl, 1933

Type species.—*Ambalodus triangularis* Branson & Mehl, 1933.

Ambalodus anapetus n. sp.
Pl. 112, figs. 9–15

Derivation of name.—*anapetes,* Gr., wide open, expanded, in reference to the totally excavated aboral surface.

Diagnosis.—This species has a completely excavated base that is essentially triangular in shape and has thin walls. The apical denticle is short, stout, and triangular in section.

Description.—Three merging processes form a nearly pyramidal, completely excavated base, which is surmounted by a stout denticle. In aboral view the base would be triangular except that the lateral faces are slightly concave. The lateral faces of each process are steep and unite orally in a sharp margin. The anterior and posterior processes are inclined inward a few degrees. Their oral edges either bear small denticles or are serrate. Generally, the oral edge of the short outer process, which is directed slightly anteriorly as well as outward, lacks denticles, but on a few specimens it is serrated. The height of the base is almost equal to but is slightly less than its length. The apical denticle is short, stout, and approximately triangular in shape near its base but is more rounded distally. Its edges are a continuation of the oral edges of the processes and its faces of the lateral faces of the base. A few specimens have a slight expansion or protoprocess on the inner face of the posterior process near its posterior end.

Remarks.—This species is similar to *Ambalodus triangularis* and several other species of the genus, and on a morphologic basis there can be no hesitation in the generic placement. On the other hand, the totally excavated base closely resembles the base of several associated species herein referred to *Sagittodontus,* particularly the denticulate forms of *S. edentatus.* The major difference is in the large size of the cusp of *Sagittodontus* and its small size in *Ambalodus.* Its aboral outline is similar to those of *Aphelognathus* and *Icriodella.* A phylogenetic or functional relationship is possible, but more data will be necessary to establish the phylogenies of these genera. Because the lineage of *Ambalodus* has not been traced continuously from the Ordovician species to those of the Silurian, which occur well above the oldest Silurian conodonts, the possibility must be considered that Silurian forms referred to *Ambalodus* are homeomorphic, even though Walliser's specific identification of *A. triangularis* strongly suggests a gap in our knowledge of the range of the genus. The species is present in larger numbers in the Neahga Shale than in any of the other units studied.

Material studied.—166 specimens.
Repository.—Holotype, 12504 (16–6); paratypes, 12505, 12506, 12507, 12508, 12509, and 12510 (all 16–6).

Genus Aphelognathus Branson, Mehl & Branson, 1951

Type species.—*Aphelognathus grandis* Branson, Mehl & Branson, 1951.

Aphelognathus siluricus n. sp.
Pl. 114, figs. 1–4

Derivation of name.—In reference to the first record of the genus in rocks of Silurian age.

Diagnosis.—An *Aphelognathus* with about 14 short denticles, whose oral margin forms an arc that generally is highest above and immediately anterior to the laterally expanded lips over the basal excavation near the midpoint of the blade.

Description.—The unit is very slightly arched and bowed. From the narrow denticulate oral margin the sides expand or diverge aborally, but the totally excavated base in aboral view is also relatively narrow except near the midpoint where each side flares out to form slightly offset expansions in the form of half cones on each lateral face. The oral margin as viewed laterally is an arc that generally is highest above and immediately anterior to the expansions. The unit commonly bears 14 short, subround denticles that are nearly equal in size except that a few near the posterior tend to be smaller, and the apical denticle in some specimens is very slightly larger than adjacent denticles.

Remarks.—The species is similar to *Aphelognathus grandis* but differs in having smaller and finer denticles and in being straighter. Also, in *A. grandis* the anterior denticles tend to point anteriorly and the posterior denticles posteriorly, a condition which caused Branson, Mehl & Branson to designate the short end as posterior. The slight, but nearly uniform, recurvature of the denticles of *A. siluricus* shows their orientation to be correct.

Aphelognathus has not been recorded previously from rocks younger than Late Ordovician. The abundance and distribution of specimens in this study suggest that it is indigenous in the Silurian strata. It has not yet been recorded in other rocks of the same age, and it apparently is a provincial element. There are a number of apparent gaps in the stratigraphic ranges of several Silurian conodont taxa. Some gaps may eventually be explained on the basis of provincialism, others on the basis of homeomorphy. *Aphelognathus* is one of several possible ancestors to the forms which are referred to *Icriodella* in this paper, but only if the *Icriodella* of this study is a homeomorph of the Ordovician representatives of the genus rather than a local recurrence of a lineage that displays continuity in another area.

Material studied.—Twenty-five specimens.

Repository.—Holotype, 12511 (16–6); paratypes, 12512 (16–6), 12513 (16–6), and 12514 (16–7).

Genus CARNIODUS Walliser, 1964

Type species.—*Carniodus carnulus* Walliser, 1964.

CARNIODUS n. sp.
Pl. 113, fig. 12

Description.—The unit bears three or four compressed denticles, and the largest is about two times the size of the others. Specimens with three denticles have a large central denticle and a smaller denticle on each side of it; those with four denticles have one denticle on one side and two on the other side of the large denticle. The basal cavity underlies the entire conodont and appears to extend upward into all of the denticles. The cavity is oval in aboral view.

Material studied.—Five specimens.

Repository.—Figured specimens, 12515 (3–219–222).

Genus DISTOMODUS Branson & Branson, 1947

Type species.—*Distomodus kentuckyensis* Branson & Branson, 1947.

DISTOMODUS KENTUCKYENSIS
Pl. 112, figs. 7,8

Distomodus kentuckyensis BRANSON & BRANSON, 1947, p. 553, Pl. 81, figs. 21–23,29–33,36–41; REXROAD, 1967, p. 28, Pl. 2, figs. 11–14; NICOLL & REXROAD, 1968, p. 34, Pl. 5, figs. 24,25.

Material studied.—Seven specimens.

Repository.—Figured specimens, 12516 (3–49,50) and 12517 (16–6).

DISTOMODUS TRIANGULARIS TRIANGULARIS
(Walliser)
Pl. 112, figs. 2–6

Neoprioniodus triangularis triangularis WALLISER, 1964, p. 53, Pl. 6, fig. 13; Pl. 28, figs. 25–30, Text-fig. 6*d–f*.

Neoprioniodus triangularis Walliser, NICOLL & REXROAD, 1968, p. 42, Pl. 5, fig. 17.

Remarks.—The same line of evolution that led from *Sagittodontus* to *Distomodus kentuckyensis,* type species of *Distomodus,* apparently also resulted in the species referred by Walliser to *Neoprioniodus triangularis.* Because of the close evolutionary relationship we refer *N. triangularis triangularis* to *Distomodus,* and probably *N. triangularis tenuirameus* Walliser also should be reassigned. The three processes arising from the three edges of *Sagittodontus* are approximately equally developed, but during evolution the orientation of the cusp changed and one process did not evolve. In *D. triangularis triangularis* the triangular shape of the inner face of the cusp reflects the position of the lost process, but even this reflection is missing on *N. triangularis tenuirameus* and on *D. kentuckyensis.* The degree of denticulation on the processes of *Sagittodontus* and *Distomodus* varies, and this is one factor to evaluate in distinguishing species.

Material studied.—Forty-two specimens.

Repository.—Figured specimen, 12518 (3-113–115), 12519 (16–6), 12520 (16–6), 12521 (16–6), and 12523 (16–6).

DISTOMODUS cf. NEOPRIONIODUS TRIANGULARIS TENUIRAMEUS Walliser
Pl. 112, fig. 1

cf. *Neoprioniodus triangularis tenuirameus* WALLISER, 1964, p. 53, Pl. 28, figs. 21–24.

Remarks.—The specimens of this study have the general form of *N. triangularis tenuirameus,* but the basal cavity is less excavated and the posterior bar is not inclined downward quite as much. Whereas Walliser's two subspecies intergrade, this group does not seem to intergrade with *N. triangularis triangularis,* although the number of specimens is too few to be certain. It is primarily because of the small number of specimens that more adequate placement of the material cannot be made.

Material studied.—Sixteen specimens.

Repository.—Figured specimen, 12523 (16–5).

Genus DREPANODUS Pander, 1856

Type species.—*Drepanodus arcuatus* Pander, 1856.

DREPANODUS? ARRECTUS Rexroad
Pl. 114, fig. 22

Drepanodus? arrectus REXROAD, 1967, p. 29, Pl. 2, figs. 1–3; NICOLL & REXROAD, 1969, p. 35, Pl. 4, fig. 11.

Drepanodus simplex BRANSON & BRANSON, 1947, p. 522, Pl. 81, figs. 24–26, Pl. 82, fig. 38 (=lectotype, Rexroad, 1967).

Remarks.—The few specimens found in this study are not adequate to resolve the generic status, and it seems best to retain the original generic designation with a question until additional phylogenetic information is obtained.

Material studied.—Twenty-seven specimens.

Repository.—Figured specimen, 12524 (9–7).

DREPANODUS SUBERECTUS (Branson & Mehl)
Pl. 114, fig. 21

Oistodus suberectus BRANSON & MEHL, 1933, p. 111, Pl. 9, fig. 7; STAUFFER, 1935, p. 147, Pl. 12, figs. 14,19,28,31,35; BRANSON, MEHL & BRANSON, 1951, p. 8, Pl. 2, fig. 1–4; RHODES, 1953, p. 229, Pl. 21, figs. 93, 94; GLENISTER, 1957, p. 726, Pl. 86, figs. 12,14.

Drepanodus suberectus (Branson & Mehl), LINDSTRÖM, 1954, p. 568, Pl. 2, figs. 21,22; SANNEMANN, 1955, p. 27, Pl. 1, fig. 22, Pl. 2, fig. 1; ETHINGTON, 1959, p. 276, Pl. 39, fig. 17; STONE & FURNISH, 1959, p. 222, Pl. 31, fig. 7; SWEET, ET AL., 1959, p. 1049, Pl. 130, fig. 4; PULSE & SWEET, 1960, p. 253, Pl. 35, figs. 2,7; CARLSON, 1960, Pl. 2, fig. 10; BERGSTRÖM, 1961, p. 41, Pl. 5, fig. 7, Text-figs. 3K,4B; WOLSKA, 1961, p. 349, Pl. 1, figs. 8a,b; SWEET & BERGSTRÖM, 1962, p. 1226, Pl. 169, fig. 8; ETHINGTON & CLARK, 1964, p. 689, Pl. 113, fig. 18; BARNETT, 1965, p. 70, Pl. 1, fig. 29; Pl. 2, fig. 22; MERRILL, 1965, p. 376, Pl. 1, fig. 8; WINDER, 1966, Pl. 9, fig. 6; ÖBERG, 1966, p. 137, Pl. 16, fig. 1; WEBERS (part), 1966, p. 29, Pl. 6, fig. 9 (only); HAMAR, 1966, p. 58, Pl. 1, figs. 8,9; SCHOPF, 1966, p. 54, Pl. 5, fig. 25; BERGSTRÖM & SWEET, 1966, p. 330, Pl. 35, figs. 22,23; FÅHRAEUS, 1966, p. 23, Pl. 2, fig. 10, Text-fig. 20; REXROAD, 1967, p. 30, Pl. 2, fig. 4.

Material studied.—Eighty specimens.

Repository.—Figured specimen, 12525 (11–1).

Genus EXOCHOGNATHUS n. gen.

Type species.—*Trichonodella brassfieldensis* Branson & Branson, 1947.

Derivation of name.—*exochos,* Gr., projecting, jutting out, prominent; *gnathos,* Gr., jaw, named in reference to the three variable projecting processes or bars.

Diagnosis.—Specimens assigned to *Exochognathus* consist of a single prominent cusp with three processes, at least one denticulate, arising from its lower edges. The whole unit is asymmetrical, although some species include individuals that are very nearly symmetrical. One bar tends to be posterior, one outer anterior, and one inner, but differences in symmetry modify positions of the processes. The basal cavity is of moderate to considerable depth.

Description.—The single main cusp commonly is stout. It varies from erect to recurved, and the cross-sectional shape ranges from nearly triangular to oval. It is totally excavated by a cavity of moderate to great depth, and the excavation commonly extends at least a short distance under the processes. In species with the more nearly triangular cusp the three processes tend to be in line with the three edges of the cusp. Costae may be present on the cusp, usually in line with the processes. One process is posterior and is denticulate in all presently known examples of the genus. Another process tends to be in an outer anterior position, and commonly this process is directed sharply downward but only slightly posteriorly. This process may lack denticles. The third process is inner lateral and generally is denticulate. It commonly is directed strongly posteriorly as well as in and down. In the more nearly symmetrical specimens, it and the outer process form an arch corresponding to that of *Hibbardella.*

Remarks.—We consider the following to be valid species and refer them to *Exochognathus: Trichonodella brassfieldensis* Branson & Branson, *Roundya brevialata* Walliser, *R. caudata* Walliser, *R. detorta* Walliser, *R. latialata* Walliser, and *Exochognathus keislognathoides* n. sp. Also, *Rhynchognathodus?* n. sp. of Rexroad (1967) belongs here. *Roundya brevialata, R. latialata,* and *Exochognathus keislognathoides* differ somewhat from the remaining species, but we have found many transitional specimens that cannot be placed with certainty in either group, and therefore, we consider all to belong within a single genus.

Several of the above species were initially referred to *Roundya* Hass, but that genus was placed in synonymy with *Hibbardella* Bassler by Huddle (1968) after restudy of type material showed that the type species has a large basal cavity in contrast with earlier interpretations. Although we agree with the synonymy, we do not believe that initial referral of the Silurian specimens to *Roundya* was correct nor that the species belong within the same evolutionary lineage as *Hibbardella*. The morphology of the Silurian specimens is not the same as that of Devonian and Mississippian types. The Silurian specimens are slightly to appreciably asymmetrical. Similarly *Trichonodella brassfieldensis* is far more asymmetrical than typical representatives of *Trichonodella,* and we believe that it has a lineage unrelated to other trichonodellids. Despite generalized morphologic similarity, we have erected a new genus because we believe the above group of specimens to be distinct in morphology and in evolution from other named genera.

Limited evidence presently available suggests that *Sagittodontus* Rhodes is ancestral to several different Silurian genera, and that one trend involving increase in dentition of the processes led through *S. edentatus* (Branson & Branson) to the group of species in question. Rexroad (1967) recognized that *Trichonodella edentata* Branson & Branson did not belong in *Trichonodella,* and he included it in a group that is essentially the same as our new genus. Subsequent study has shown that it apparently is transitional between more typical species of *Sagittodontus* and species of *Exochognathus,*

EXPLANATION OF PLATE 111

All figures are ×40. Indiana University-Indiana Geological Survey repository numbers are followed by locality and sample numbers in parentheses.

FIGS. *1–7*—*Spathognathodus comptus* n. sp. *1–3,* Lateral, lower, and upper views of paratypes 12599 (7–1), 12600 (9–4), and 12601 (7–1); *4a–c,* lateral, lower, and upper views of holotype 12598 (7–2); *5a,b,* upper and lower views of paratype 12602 (9–4); *6,7,* upper views of paratypes 12603 (9–5) and 12604 (9–4).

8–12—*Spathognathodus hassi* n. sp. *8,* Lateral view of paratype 12611 (9–10); *9,* lateral view of holotype 12610 (7–2); *10–12,* lateral, lateral and upper views of paratypes 12612 (9–6), 12613 (10–DB1), and 12614 (7–2).

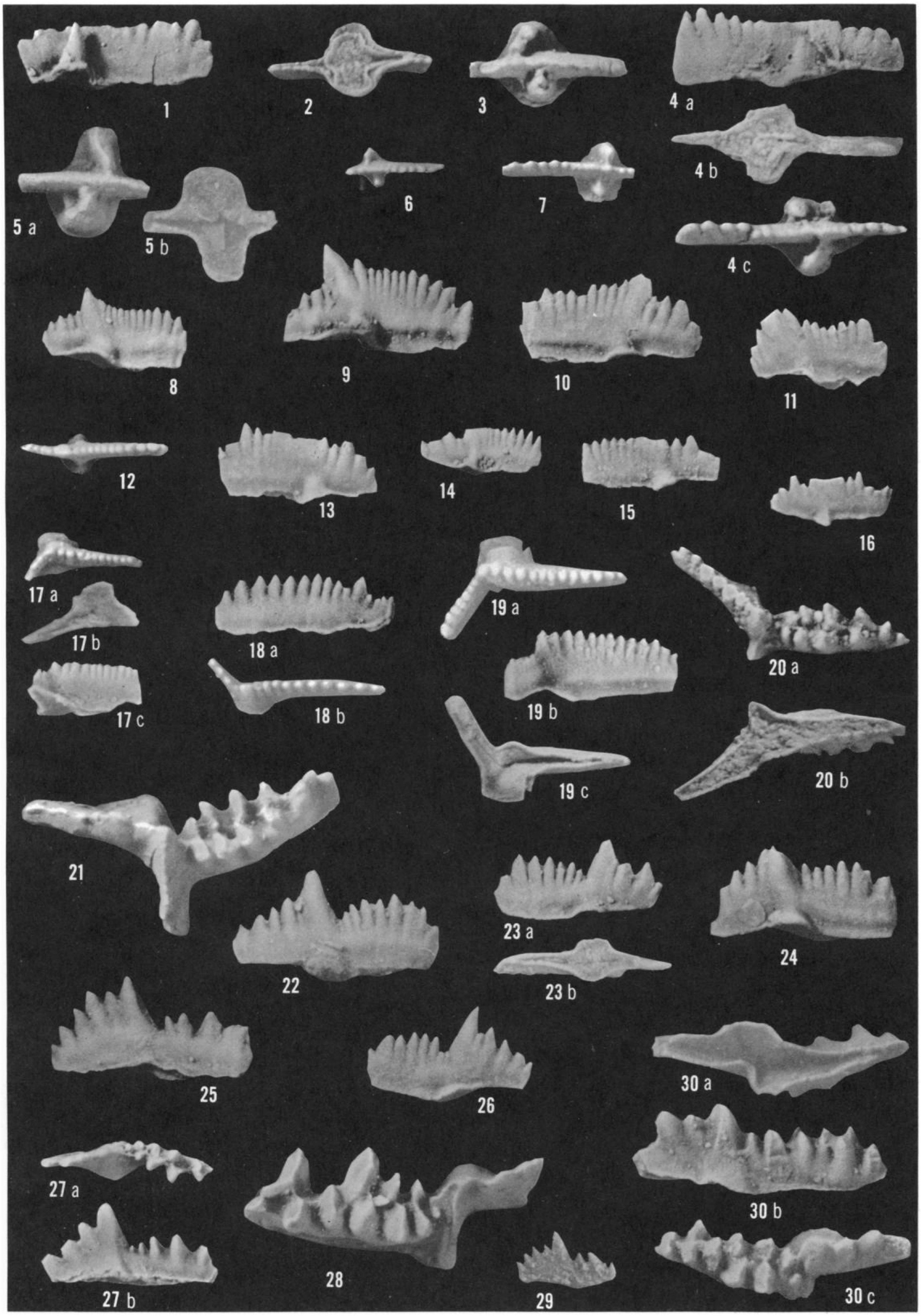
13–16—*Spathognathodus oldhamensis* Rexroad. Lateral views of 12618 (9–3), 12619 (4–1), 12620 (8–219–222), and 12621 (3–12–37).

17–19—*Spathognathodus manitoulinensis* n. sp. *17a–c,* Upper, lower, and inner lateral views of paratype 12616 (6–8); *18a,b,* upper and inner lateral views of paratype 12617 (9–4); *19a–c,* upper, inner lateral and lower views of holotype (5–1).

20,21—*Icriodella* n. sp. *20a,b,* Upper and lower views of 12540 (3–49,50); *21,* upper view of 12541 (9–4).

22–26—*Spathognathodus elibatus* n. sp. *22,* lateral view of holotype 12605 (9–7); *23a,b,* lateral and lower views of paratype 12606 (9–7); *24–6,* lateral views of paratypes 12607 (3–219–222), 12608 (3–215–218), and 12609 (3–219–222).

27–30—*Icriodella discreta* n. sp. *27a,b,* Upper and outer lateral views of holotype 12536 (16–6); *28,29,* inner lateral and upper views of paratypes 12537 (9–4) and 12538 (3–51,52); *30a–c,* lower, inner lateral, and upper views of paratype 12539 (3–12–37).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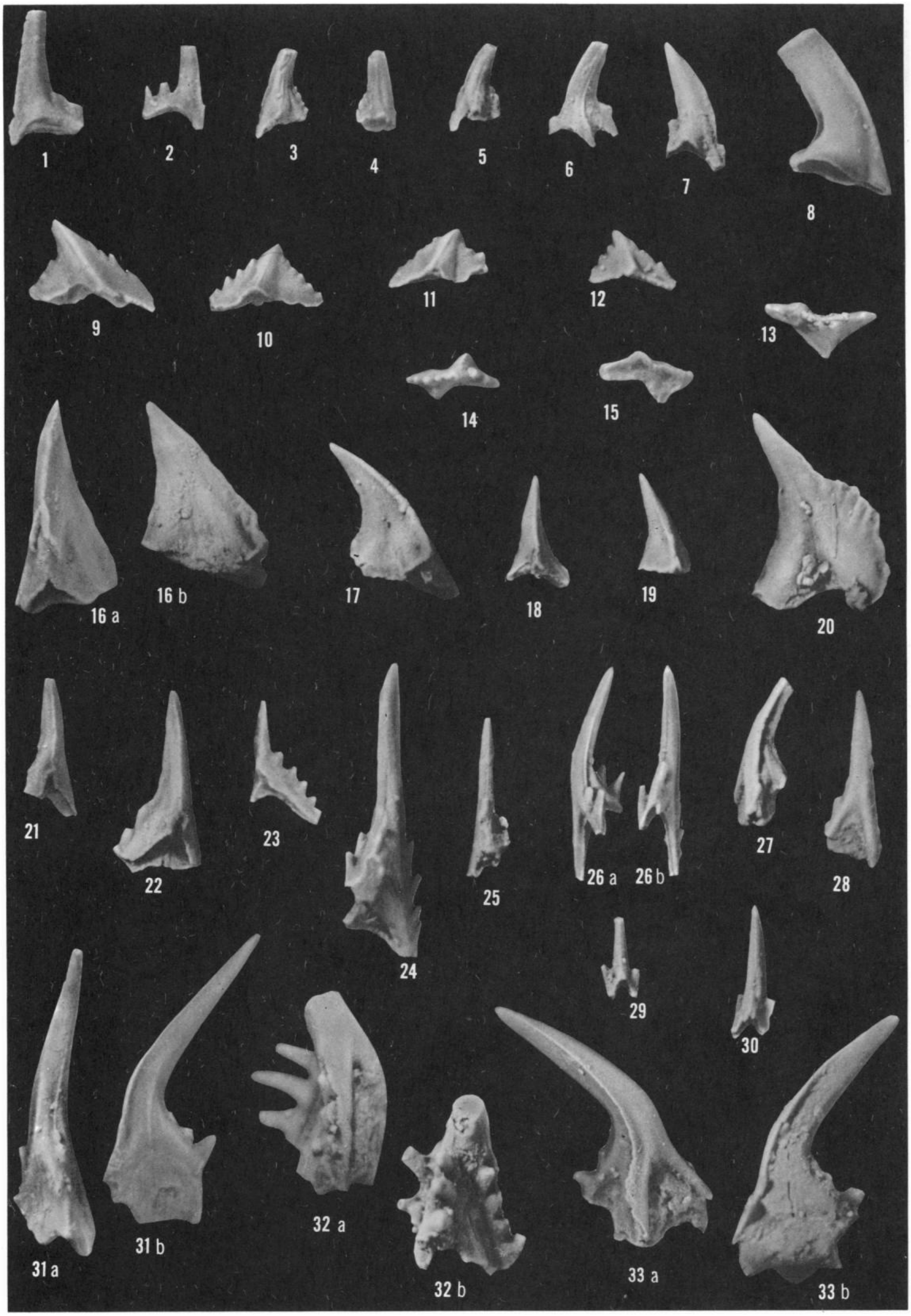
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and in this transitional position it could be placed with either group. We believe it closer to *Sagittodontus* and make that assignment.

EXOCHOGNATHUS BRASSFIELDENSIS (Branson & Branson)
Pl. 112, fig. 24

Trichonodella brassfieldensis BRANSON & BRANSON (part), 1947, p. 551, Pl. 82, fig. 47 (holotype); Pl. 81, fig. 12; REXROAD, 1967, p. 56, Pl. 3, figs. 27,28; NICOLL & REXROAD, 1968, p. 62, Pl. 5, figs. 13,14.

Material studied.—Eleven specimens.

Repository.—Figured specimen, 12526 (9–10).

EXOCHOGNATHUS BREVIALATUS (Walliser)
Pl. 112, figs. 29,30

Roundya brevialata WALLISER, 1964, p. 69, Pl. 4, fig. 16; Pl. 31, figs. 8–10; NICOLL & REXROAD, 1968, p. 57.

Roundya truncialata WALLISER, 1964, p. 72, Pl. 4, fig. 7; Pl. 31, figs. 3–6; REXROAD, 1967, p. 58, Pl. 3, fig. 22.

Remarks.—Walliser separated *Roundya brevialata* from *R. truncialata* because the former has only one or two denticles on the lateral processes. In addition to specimens which readily can be placed in one or the other, we have numerous specimens with lateral processes intermediate in length and dentition, and we believe that the two names have been applied to variants of a single species. We recognized the trivial name *brevialata* on the basis of page precedence.

Material studied.—Ninety-one specimens.

Repository.—Figured specimens, 12527 (3–46–48), 12528 (3–135).

EXOCHOGNATHUS CAUDATUS (Walliser)
Pl. 112, figs. 31–33

Roundya caudata WALLISER, 1964, p. 70, Pl. 31, figs. 18,19; REXROAD, 1967, p. 58, Pl. 3, figs. 29,30; NICOLL & REXROAD, 1968, p. 58.

Material studied.—Ten specimens.

Repository.—Figured specimens, 12529 (9–7), 12530 (7–1), and 12531 (9–7).

EXOCHOGNATHUS KEISLOGNATHOIDES n. sp.
Pl. 112, figs. 25–28

Keislognathus? n. sp. REXROAD, 1967, p. 59, Pl. 3, figs. 20,21.

EXPLANATION OF PLATE 112

All figures are ×40. Indiana University-Indiana Geological Survey repository numbers are followed by locality and sample numbers in parentheses.

FIG. *1*—*Distomodus* cf. *D. triangularis tenuirameus* (Walliser). Inner lateral view of 12523 (16–5).

2–5—*Distomodus triangularis triangularis* (Walliser). Inner lateral views of 12518 (3–113–115), 12519 (16–6), 12520 (16–6), and 12521 (16–6).

6—*Distomodus* cf. *D. triagularis triangularis* (Walliser). Inner lateral view of 12522 (16–6).

7,8—*Distomodus kentuckyensis* Branson & Branson. Inner lateral views of 12516 (3–49,50), and 12517 (16–6).

9–15—*Ambalodus anapetus* n. sp. *9,* Outer lateral view of holotype 12504 (16–6); *10–15,* three outer lateral, two upper, and a lower view of paratypes 12505, 12506, 12507, 12508, 12509, and 12510 (all 16–6).

16–20—*Sagittodontus robustus* Rhodes. *16a,b,* Posterior and inner lateral views of 12593 (9–5); *17–20,* inner lateral, posterior, outer lateral, and inner lateral views of 12594 (9–7), 12595 (16–6), 12596 (8), and 12597 (12–5).

21–23—*Sagittodontus edentatus* (Branson & Branson). Posterior views of 12590 (3–129,130), 12591 (4–1), and an atypical specimen, 12592 (3–51,52).

24—*Exochognathus brassfieldensis* (Branson & Branson). Posterior view of 12526 (9–10).

25–28—*Exochognathus keislognathoides* n. sp. *25,* Posterior view of paratype 12533 (9–7); *26a,b,* oblique lateral and posterior views of holotype 12532 (3–12–37); *27,28,* outer lateral and anterior views of paratypes 12534 (9–8) and 12535 (9–5).

29,30—*Exochognathus brevialatus* (Walliser). Posterior views of 12527 (3–46–48) and 12528 (3–135).

31–33—*Exochognathus caudatus* (Walliser), *31a,b,* Posterior and outer lateral views of 12529 (9–7); *32a,b,* oblique lateral and oblique posterior views of 12530 (7–1); *33a,b,* oblique outer anterior and inner lateral views of 12531 (9–7).

Derivation of name.—Genus *Keislognathus* Rhodes and suffix *oides,* resembling, having the form of, in reference to the similarity of the morphologies of this species and *Keislognathus.*

Diagnosis.—The unit consists of a stout costate recurved cusp roughly triangular in cross section, a long, commonly nondenticulate anticusplike process, and denticulate inner lateral and posterior bars. The aboral surface is excavated.

Description.—The cusp is asymmetrical, recurved, and nearly triangular except that the anterior face is convex. A long anticusplike bar extends downward from the inner anterior part of the cusp. This bar may have either fine denticles or a costa that is continuous with the one on the inner anterior edge of the cusp. The posterior process is directed somewhat downward and has sharp subround discrete denticles. The outer lateral bar is inclined posteriorly out and down and bears denticles similar to those of the posterior bar. The denticles are in line with a costa that extends along the outer anterior edge of the cusp. There is also a weak costa extending along the posterior edge of the cusp. The deep basal cavity extends upward into the main denticle and beneath the inner anterior, lateral, and posterior bars.

Material studied.—Ninety-four specimens.

Repository.—Holotype, 12532 (3–12–17); paratypes 12533 (9–7), 12534 (7–8), 12535 (9–5).

Genus Icriodella Rhodes, 1953

Type species.—*Icriodella superba* Rhodes, 1953.

Remarks.—*Icriodella* is similar in general morphology to *Scyphiodus* Stauffer, but the former has a more deeply excavated aboral surface and does not have three distinct rows of denticles on the platform surface. Rexroad & Rickard (1965) considered the two as congeneric on the basis that platform configuration is not a significant difference. We now consider the characteristics of the aboral surface to be different and both genera to be valid. Webers (1966) indicated that juvenile specimens of *Scyphiodus* are like *Ozarkodina,* and he believed that *Scyphiodus* evolved from *Ozarkodina;* Rhodes suggested a relationship of *Icriodella* to *Aphelognathus,* and both have similar basal excavations that differ from those of *Ozarkodina* and *Scyphiodus.* Several specimens of *Ambalodus anapetus* show variations that suggest a close relationship with Silurian specimens referred to *Icriodella,* and this must be considered as a possible lineage.

At present a continuous lineage has not been recognized between the Ordovician species of *Icriodella* and those of this study. Although we tentatively consider our material to represent an extension of the stratigraphic range of *Icriodella,* it is possible that the Silurian forms are homeomorphs of those of the Ordovician. *Icriodella* is a provincial form, for only questionably are specimens of *Icriodella* and *Icriodina* Branson & Branson associated.

Rhodes (1953, p. 285) oriented *Icriodella* with the blade anterior and the platform posterior, but examination of our specimens shows the denticles of the blade to be inclined away from the platform. This suggests that the blade is posterior and the platform anterior, or just the reverse of the orientation ascribed to most platform elements. This interpretation of the orientation is strengthened by comparison of *I. discreta* with *Spathognathodus elibatus,* a form almost identical in lateral view, and *Ambalodus anapetus,* which may be the precursor of *I. discreta.*

Icriodella discreta n. sp.
Pl. 111, figs. 27–30

Derivation of name.—*discreta,* L., separated, in reference to the distinct separation of the platform from the blade which is further emphasized by the lateral offset of the blade.

Diagnosis.—The platform has two rows of denticles, and the denticles of the blade decrease abruptly in height posteriorly from a large denticle at or slightly posterior to the midpoint.

Description.—The platform has two rows of denticles, one row along each margin, although on many specimens the rows are interrupted by a single median denticle. Denticles on the platform of juvenile forms are small, round, sharp pointed, and discrete, but during growth they tend to widen to form transverse ridgelike nodes along the margins. On some specimens nodes on opposite margins coalesce irregularly.

Typically the blade is slightly less than half the length of the specimen, but in immature specimens it is proportionally longer. The blade bears three or four denticles fused nearly to their apices. The anteriormost denticle of the blade, or apical denticle, is the highest and rises far above the platform. Posteriorly from it, the denticles decrease abruptly, but regularly, in height.

The entire aboral surface is excavated except that in some specimens the posterior part of the blade and anterior part of the platform narrow, and here the aboral surface is marked only by a groove. The basal cavity is deepest near the point of union of the blade and platform and below the apical denticle. The basal cavity flares asymmetrically to form an antero-outer lateral flange mostly on the platform and a postero-inner lateral flange mostly on the blade as described by Rhodes. The whole unit is bowed.

Remarks.—The species differs from *Icriodella superba* in that the rows of nodes do not coalesce transversely to form ridges across the entire width of the platform and in having a blade composed of prominent denticles. Similarity in gross morphology with *Spathognathodus elibatus* is discussed briefly under remarks for that species.

Material studied.—Fifteen specimens.

Repository.—Holotype, 12536 (16–6); paratypes, 12537 (3–51, 52), 12538 (9–4), and 12539 (3–12–17).

ICRIODELLA n. sp.
Pl. 111, figs. 20,21

Description.—Specimens have two rows of nodelike denticles along the margins of the platform which is relatively narrow. On the posterior blade the denticles number about seven and decrease gradually in height to the posterior end. The platform and blade are about equal in length and form an angle of about 135° with each other. The entire aboral surface is excavated, but a lateral flange about the basal cavity is present only in the outer side.

Remarks.—Specimens are too few in number to warrant naming.

Material studied.—Nine specimens.

Repository.—Figured specimens, 12540 (3–49, 50) and 12541 (9–4).

Genus LIGONODINA Bassler, 1925

Type species.—*Ligonodina pectinata* Ulrich & Bassler, 1926.

LIGONODINA KENTUCKYENSIS Branson & Branson
Pl. 114, figs. 9,10

Ligonodina kentuckyensis BRANSON & BRANSON, 1947, p. 555, Pl. 82, figs. 28,35; REXROAD, 1967, p. 35,36, Pl. 2, fig. 5.

Material studied.—Seven specimens.

Repository.—Figured specimens, 12542 (3–42–45) and 12543 (11–2).

LIGONODINA cf. L. SILURICA Branson & Mehl
Pl. 114, figs. 7,8

cf. *Ligonodina silurica* BRANSON & MEHL, 1933, p. 48, Pl. 3, figs. 18–20.

Material studied.—Ten specimens.

Repository.—Figured specimens, 12544 and 12545 (both 3–46–48).

LIGONODINA? VARIABILIS Nicoll & Rexroad
Pl. 114, figs. 11,12

Ligonodina? variabilis NICOLL & REXROAD, 1968, p. 39, Pl. 4, figs. 12–14.

Remarks.—The species is highly variable, particularly in the degree of flexure and the number of denticles on the anterior bar.

Material studied.—Forty-one specimens.

Repository.—Figured specimens, 12546 (6–10) and 12547 (3–46–48).

LIGONODINA n. sp.
Pl. 114, figs. 5,6

Description.—The posterior bar is directed slightly downward and bears subround discrete denticles. The bar is broken in all specimens studied, but it apparently is excavated under much of its length. The terminal cusp is oval in cross-section and is recurved, more sharply near the base. The base is slightly expanded on each side around the basal cavity. The form of the base resembles sheath lamellae connecting the cusp, posterior bar, and inner lateral process on the inner side and the first two of these on the outer side. The inner lateral process is inclined down, in, and slightly to the anterior. It bears discrete denticles somewhat compressed in the plane of the process. The deep large basal cavity rises to a terminal point almost at the anterior margin of the cusp at the same height at which the top of the posterior bar joins the cusp.

Remarks.—Most specimens are from the Neahga Shale.

Material studied.—Eight specimens.

Repository.—Figured specimens, 12548 (16–6) and 12549 (16–7).

Genus LONCHODINA Bassler, 1925

Type species.—*Lonchodina typicalis* Ulrich & Bassler, 1926.

LONCHODINA spp.
Pl. 113, figs. 25,28–30

Remarks.—The genus *Lonchodina* is represented in our collection by less than 25 specimens. These few specimens are diverse and are not readily categorized in species. Several individuals resemble *L. detorta* Walliser (1964), and one is tentatively referred to that species; a few specimens are the same as those from the Brassfield Limestone referred by Rexroad (1967) and Nicoll & Rexroad (1968) to *L. walliseri* Ziegler (1960); several specimens appear to be at the *L. greilingi* end of the *L. greilingi*-*Trichonodella inconstans* intergradational series; and additional species are represented but mostly by fragmental material. The limited number of complete specimens does not allow evaluation of intraspecific or ontogenetic variation, and so speciation is not attempted. If *L. detorta* and *L. walliseri* are truly indigenous, both of their stratigraphic ranges would be extended downward, that of *L. detorta* from Walliser's (1964) *siluricus*-Zone of middle Ludlow (Late Silurian) age and that of *L. walliseri* from rocks of early Ludlow age.

Material studied.—Twenty-two specimens.

Repository.—Figured specimens, 12550 (10-DB1), 12551 (3–49, 50), 12552 (3–46–48), and 12553 (9–13).

Genus NEOPRIONIODUS Rhodes & Müller, 1956

Type species.—*Prioniodus conjunctus* Gunnell, 1933.

NEOPRIONIODUS cf. N. EXCAVATUS (Branson & Mehl)
Pl. 114, figs. 18–20

cf. *Prioniodus excavatus* BRANSON & MEHL, 1933, p. 45, p. 3, figs. 7,8.

Remarks.—Two varieties of *Neoprioniodus* found in this study correspond in a general way to two variants of *Neoprioniodus* present in the Bainbridge Formation at Lithium, Missouri, from which Branson & Mehl described *Neoprioniodus excavatus.* Whether both variants belong in *N. excavatus* is not yet settled, and the answer to the speciation of the present varieties depends in part on the interpretation of *N. excavatus.* One of the forms from the lower Silurian rocks is considered to be the same species as specimens from the Brassfield Limestone represented by figure 8, Plate 3, of Rexroad (1967) and identified as *Euprioniodina* cf. *Prioniodus excavatus.* The other form is probably a robust variation of the species misidentified by Rexroad (1967, p. 39, Pl. 3, fig. 11) as *Neoprioniodus planus* Walliser. Only three specimens of the latter were found in this study. They are closely similar to one of the variants found in the beds at Lithium that may belong in *N. excavatus,* but they have a more broadly flaring flange on the inner lateral basal part of the cusp. These specimens are also nearly the same as *N. latidentatus* Walliser. The cusp of *N. latidentatus* is recurved to a greater degree, but the two may be conspecific. Both variants found in the present study are illustrated.

Material studied.—Sixteen specimens.

Repository.—Figured specimens, 12554 (3–227–229), 12555 (11–1), and 12556 (16–7).

NEOPRIONIODUS PLANUS Walliser
Pl. 114, figs. 13,14

Neoprioniodus planus, WALLISER, 1964, p. 51, Pl. 29, figs. 12,13,15; NICOLL & REXROAD, 1968, p. 41, Pl. 5, figs. 11,12.

Remarks.—Bergström & Sweet (1966, p. 324) considered that *N. planus* is a *Cyrtoniodus.* They also suspected that the rocks from which Walliser collected the species were Late Ordovician rather than Early Silurian in age. The present specimens came from strata of unquestionable Silurian age. The basal cavity of *N. planus* is not deeply excavated and extends only a short distance under the posterior bar, and so the species is retained in *Neoprioniodus.* With only slight modification, primarily involving increase in flare of the lip above the inner lateral part of the cavity, it gives rise to *N. excavatus.*

Material studied.—Forty-eight specimens.

Repository.—Figured specimens, 12557 (3–46–48) and 12558 (16–7).

Genus OZARKODINA Branson & Mehl, 1933

Type species.—*Ozarkodina typica* Branson & Mehl, 1933.

OZARKODINA cf. O. EDITHAE Walliser
Pl. 113, figs. 1–4

cf. *Ozarkodina edithae* WALLISER, 1964, p. 55, Pl. 26, figs. 12–18.

Remarks.—Specimens recovered in our study are nearly the same as those tentatively assigned to *Ozarkodina edithae* by Rexroad (1967, p. 40, Pl. 2, fig. 6) and are similar to Walliser's type material. They differ from the latter in being slightly shorter, in being a bit more arched and bowed, and in having a less angular oral outline as viewed laterally. Walliser recorded *O. edithae* only from his *sagittus*-Zone, and so if the specimens from the *Icriodina irregularis* Assemblage Zone belong in the species, the range of *O. edithae* must be extended downward.

Within the group of specimens assigned to *Ozarkodina* cf. *O. edithae* are a number of specimens that consistently are shorter, and have a less pronounced apical denticle and a more rounded oral outline in lateral view than do the remainder of the specimens. One specimen is figured as *O.* cf. *O. edithae* variety A in order to illustrate this variation.

Material studied.—Fifty-five specimens.

Repository.—Figured specimens, 12559 (3–219–222), 12560 (9–10), 12561 (9–10), and *O.* cf. *O. edithae* var. A 12562 (9–7).

OZARKODINA? aff. O. MEDIA Walliser
Pl. 113, figs. 13,14

aff. *Ozarkodina media* WALLISER, 1957, p. 40, Pl. 1, figs. 21–25.

Description.—The unit is arched, slightly bowed, and thickened along the sides near the base. The amount of arching varies but is not great. A prominent apical denticle normally is lacking, and all denticles are short, subround to compressed, and fused through at least half of their length. They generally number about 16 or 17. Almost the entire aboral surface is shallowly excavated, but the lips flare prominently only around the central cavity and taper from there to points near the ends of the specimen.

Remarks.—Specimens are much closer morphologically to *Bryantodus* than to *Ozarkodina* in the thickening of the blade and length of the basal cavity, but they differ from both in lacking an apical denticle. The arching and bowing and basal cavity do not fit well with *Spathognathodus,* another genus into which the species might be placed. A single specimen in our collection shows a probable relationship to our *O.* aff. *O. media* and also to *O. media.* It is figured as *O.* cf. *O. media* (Pl. 113, fig. 15). Because its apparent intermediate position suggests a relationship, we relate the described species to *O. media.*

Material studied.—Fourteen specimens.

Repository.—Figured specimens, 12563 (3–219–222), 12564 (3–219–222), and *O.* cf. *O. media* 12565 (3–46–48).

OZARKODINA TYPICA Branson & Mehl
Pl. 113, figs. 16–18

Ozarkodina typica BRANSON & MEHL, 1933, p. 51, Pl. 3, figs. 43–45; RHODES, 1953, p. 320, Pl. 23, figs. 251,261,262; REXROAD, 1967, p. 39, Pl. 2, figs. 7,8.

Ozarkodina typica typica Branson & Mehl, WALLISER, 1964, p. 61, Pl. 25, figs. 20,21, Pl. 26, figs. 1,2.

Remarks.—Most of the specimens of *Ozarkodina typica* found in Lower Silurian beds are shorter than the primary and topotype specimens of the species. Possibly the Lower Silurian specimens should be placed in a separate species, but because some specimens do not vary significantly from the types, we prefer to assign all specimens to *O. typica.*

Material studied.—Seven specimens.

Repository.—Figured specimens, 12566 (3–46–48), 12567 (3–46–48), and 12568 (3–51, 52).

OZARKODINA n. sp. A
Pl. 113, figs. 5–8

Description.—The blade is angularly arched and is nearly straight. It bears partially fused, laterally compressed, sharp pointed denticles numbering about nine on the anterior part and about six on the posterior part of the blade. The apical denticle is not much larger than the adjacent denticles. The lower part of the blade is thickened just above the base for the length of the specimen. The basal cavity is below the apical denticle just posterior to midlength and is extremely shallow. It is marked by slightly expanded lips, the greater expansion on the outer side, and by a longitudinal groove that continues along the aboral surface nearly to the anterior and posterior tips.

Remarks.—This species is similar to *Ozarkodina* n. sp. B of this paper but has a more prominent apical denticle and a thickened blade. The thickening of the blade is also characteristic of *Prioniodella inclinata* Rhodes, but that species normally lacks an apical denticle. The phylogenetic relationships of *O.* n. sp. A and *O.* n. sp. B are not clear from the present study, but their similarity to each other and to *Prioniodella inclinata* suggest a relationship among the three.

Material studied.—Thirty-one specimens.

Repository.—Figured specimens, 12569 (3–49, 50), 12570 (3–49, 50), 12571 (3–46–48), and 12572 (3–46–48).

OZARKODINA n. sp. B
Pl. 113, figs. 9–11

Description.—The blade is slightly arched and bowed and bears deeply inserted, laterally compressed, sharp pointed denticles that are fused nearly to their apices. The length of the blade and the number of denticles increase during ontogeny. As few as five denticles are found on very young specimens and as many as 18 on adults. The denticles tend to be larger in the middle third of the blade, and on some specimens one denticle above the basal cavity is conspicuously larger than the others. The basal cavity is deepest somewhat posterior to midlength. Laterally flared lips are present in the area of greatest depth from which the cavity tapers anteriorly and posteriorly to points near each tip of the blade. Aboral grooves continue to the tips.

Remarks.—The larger denticle on some specimens in combination with the moderate arching and bowing is the reason for assignment to *Ozarkdina.* Except for the lack of thickening of the blade the longer specimens are very closely similar to *Prioniodella inclinata* Rhodes.

Material studied.—Sixty-one specimens.

Repository.—Figured specimens, 12573 (3-12-37), 12574 (3-12-37), and 12575 (3-42-45).

Genus PALTODUS Pander, 1856

Type species.—*Paltodus subaequalis* Pander, 1856.

PALTODUS COSTULATUS Rexroad
Pl. 114, figs. 29,30

Paltodus costulatus REXROAD, 1967, p. 40, Pl. 4, figs.

26–29; NICOLL & REXROAD, 1968, p. 51, Pl. 7, figs. 16–18.

Remarks.—Some specimens are shorter, more recurved, and have more elongate bases than do the majority of specimens. An example of this variation is illustrated by figure 30 of Plate 114.

Material studied.—149 specimens.

Repository.—Figured specimens, 12576 (9–4) and 12577 (13–6).

PALTODUS DEBOLTI Rexroad
Pl. 114, figs. 32,33

Paltodus debolti REXROAD, 1967, p. 41, Pl. 4, figs. 22–25; NICOLL & REXROAD, 1968, p. 52, Pl. 7, fig. 26.
Paltodus unicostatus Branson & Mehl, BRANSON & BRANSON (part), 1947, p. 554, Pl. 82, figs. 20–22 only.

Material studied.—Forty specimens.

Repository.—Figured specimens, 12578 (9–11) and 12579 (12–4).

PALTODUS DYSCRITUS Rexroad
Pl. 114, fig. 31

Paltodus dyscritus REXROAD, 1967, p. 42, Pl. 4, figs. 30–34; NICOLL & REXROAD, 1968, p. 52, Pl. 7, figs. 31–33.
Paltodus unicostatus Branson & Mehl, BRANSON & BRANSON (part), 1947, p. 554 Pl. 82, figs. 16–19,6? only.

Material studied.—Sixty-seven specimens.

Repository.—Figured specimen, 12580 (9–11).

PALTODUS MIGRATUS Rexroad

Paltodus migratus REXROAD, 1967, p. 44, Pl. 4, figs. 17–21; NICOLL & REXROAD, 1968, p. 52, Pl. 7, fig. 27.

Material studied.—Nine specimens.

Repository.—Figured specimen, 12581 (13–5).

Genus PANDERODUS Ethington, 1959

Type species.—*Paltodus unicostatus* Branson & Mehl, 1933.

PANDERODUS SIMPLEX (Branson & Mehl)
Pl. 114, figs. 23–25

Paltodus simplex BRANSON & MEHL, 1933, p. 42, Pl. 3, fig. 4.
Panderodus simplex (Branson & Mehl), CLARK & ETHINGTON, 1966, p. 682, Pl. 82, figs. 10,14; REXROAD, 1967, p. 45, Pl. 4, figs. 7,8; NICOLL & REXROAD, 1968, p. 54, Pl. 7, fig. 28.
Paltodus acostatus BRANSON & BRANSON (part), 1947, p. 554, Pl. 82, figs. 1–5 (only); RHODES, 1953, p. 296, Pl. 21, figs. 111,112; Pl. 22, figs. 163, 164; Pl. 23, figs. 212,213; RHODES, 1955, p. 127, Pl. 10, figs. 11,12; BERGSTRÖM, 1961, p. 48, Pl. 1, figs. 13,14; PHILIP, 1965, p. 108, Pl. 8, figs. 10?, 23,43?.
Paltodus? acostatus Branson & Branson, GLENISTER, 1957, p. 727, Pl. 85, fig. 7.
Paltodus cf. *P. acostatus* Branson & Branson, WALLISER, 1960, p. 31, Pl. 7, fig. 10.
Panderodus acostatus (Branson & Branson), SERPAGLI & GRECO, 1964, p. 204, Pl. 36, figs. 4a,b; PHILIP, 1966, p. 447, Pl. 1, figs. 13,18.
Panderodus sp. 2, SPASOV & GANEV, 1966, p. 55, Pl. 3, fig. 16.

Material studied.—1,323 specimens.

Repository.—Figured specimens, 12582 (9–5), 12583 (9–12), and 12584 (3–46–48).

PANDERODUS UNICOSTATUS UNICOSTATUS
(Branson & Mehl)
Pl. 114, figs. 26–28

Paltodus unicostatus BRANSON & MEHL, 1933, p. 42, Pl. 3, fig. 3; BRANSON & BRANSON, 1947, p. 554, Pl. 82, figs. 6–8,11–22; RHODES, 1953, p. 298, Pl. 21, figs. 84–88; Pl. 22, figs. 155,156; Pl. 23, figs. 214–216; WALLISER, 1957, p. 43, Pl. 2, fig. 10; PHILIP, 1965, p. 109, Pl. 8, fig. 9, text-fig. 2g; MOSKALENKO, 1966, p. 82, Pl. 11, figs. 1–3.
Paltodus cf. *P. unicostatus* Branson & Mehl, RHODES, 1955, p. 127, Pl. 10, figs. 1,3.
Paltodus? unicostatus Branson & Mehl, GLENISTER, 1957, p. 729, Pl. 85, fig. 1.
Panderodus unicostatus (Branson & Mehl), SWEET ET AL., 1959, p. 1057, Pl. 131, fig. 3; WOLSKA, 1961, p. 353, Pl. 4, figs. 3a,b; KOCKEL & STOPPEL, 1962, p. 161, Pl. 1, fig. 2; SWEET & BERGSTRÖM, 1962, p. 1234, Text-fig. 1d; BERGSTRÖM, 1964, p. 31, Text-fig. 14; SERPAGLI & GRECO, 1964, p. 206, Pl. 36, fig. 7; Pl. 37, figs. 1a,b; BROOKS & DRUCE, 1965, p. 376, Pl. 12, fig. 8; MERRILL, 1965, p. 390, Pl. 2, fig. 8; WINDER, 1966, Pl. 9, fig. 27; CLARK & ETHINGTON, 1966, p. 683, Pl. 82, figs. 17,19; HAMAR, 1966, p. 67, Pl. 1, fig. 6; SPASOV & GANEV, 1966, p. 55, Pl. 3, figs. 13,14; PHILIP, 1966, p. 447, Pl. 1, figs. 10–12,19.
Panderodus cf. *unicostatus* (Branson & Mehl), HAMAR, 1964, p. 272, Pl. 1, figs. 28,29, Text-fig. 6 (1a–b).
Panderodus unicostatus unicostatus (Branson & Mehl), REXROAD, 1967, p. 46, Pl. 4, figs. 1,2; NICOLL & REXROAD, 1968, p. 54, Pl. 7, figs. 29,30.

Material studied.—3,225 specimens.

Repository.—Figured specimens, 12585 (9–5), 12586 (9–7), and 12587 (9–3).

Genus PLECTOSPATHODUS Branson & Mehl, 1933

Type species.—*Plectospathodus flexuosus* Branson & Mehl, 1933.

PLECTOSPATHODUS FLEXUOSUS Branson & Mehl
Pl. 113, figs. 19,20

Plectospathodus flexuosus BRANSON & MEHL, 1933, p. 47, Pl. 3, figs. 31,32; WALLISER, 1964, p. 65, Pl. 9, fig. 10; Pl. 30, figs. 15,16.
Plectospathodus elegans RHODES, 1953, p. 323, Pl. 23, figs. 255,263,264.

Material studied.—Eight specimens.

Repository.—Figured specimens, 12588 (16–6) and 12589 (6–9).

Genus SAGITTODONTUS Rhodes, 1953

Type species.—*Sagittodontus robustus* Rhodes, 1953.

SAGITTODONTUS EDENTATUS (Branson & Branson)
Pl. 112, figs. 21–23

Trichonodella? edentata BRANSON & BRANSON, 1947, p. 552, Pl. 81, figs. 28; Pl. 82, figs. 40,44,48; REXROAD, 1967, p. 55, Pl. 3, figs. 31–34; NICOLL & REXROAD, 1968, p. 63, Pl. 4, figs. 16–18.
Trichonodella brassfieldensis BRANSON & BRANSON (part), 1947, p. 551, Pl. 82, fig. 49 only.
Trichonodella carinata BRANSON & BRANSON (part), 1947, p. 552, Pl. 82, figs. 27,34 only.

Remarks.—Branson & Branson (1947) described the species as lacking denticles, and most specimens do not have secondary dentition. Rexroad (1967), however, described specimens from the Brassfield Limestone which have denticles on the processes. Branson & Branson also stated that "the discovery of more specimens may make the creation of a new genus for this species desirable." Subsequently, Rhodes (1953) proposed the genus *Sagittodontus,* which superficially resembles *Trichonodella* but differs in the general lack of dentition and in symmetry. Species of *Sagittodontus* suggest a barblike unit consisting of a large main denticle whose three edges are extended as short processes. Although the genus appears to be characterized by lack of denticles, one of Rhodes' specimens shows irregular indentations on one of the bars, and Ethington (1959) described an upper Ordovician species that has short denticles on the anterior edge. Because our species is similar to *S. robustus,* type species of *Sagittodontus,* and to other species of the genus, we have changed Branson & Branson's generic assignment of *T.? edentata.*

Material studied.—Seventy-four specimens.

Repository.—Figured specimens, 12590 (3-129, 130), 12591 (4–1), and 12592 (3–51,52).

SAGITTODONTUS ROBUSTUS Rhodes
Pl. 112, figs. 16–20

Sagittodontus robustus, RHODES, 1953, p. 311, Pl. 21, figs. 141,142; ETHINGTON, 1959, p. 287, Pl. 39, fig. 12; ?BARNETT, 1965, p. 73, Pl. 2, figs. 24,27; ?HAMAR, 1966, p. 72, Pl. 6, fig. 7, Text-fig. 4, no. 14; SCHOPF, 1966, p. 78, Pl. 5, fig. 31.
Acodus robustus (Rhodes), LINDSTRÖM, 1959, p. 433, Pl. 4, figs. 22–27.
?*Icriodella superba* Rhodes, BERGSTRÖM & SWEET (part), 1966, p. 337, Pl. 29, figs. 4,5 only (=*Sagittodontus robustus*).

Material studied.—Sixty-five specimens.

Repository.—Figured specimens, 12593 (9-5), 12594 (9–7), 12595 (16–6), 12596 (8), and 12597 (12–5).

Genus SPATHOGNATHODUS Branson & Mehl, 1941

Type species.—*Spathodus primus* Branson & Mehl, 1933.

SPATHOGNATHODUS COMPTUS n. sp.
Pl. 111, figs. 1–7

Derivation of name.—*comptus,* L., ornamented, adorned, in reference to the surface sculpture on the upper surface of the cup.

Diagnosis.—The unit consists of a nearly straight blade, decreasing in height posteriorly and bearing about 15 denticles, underlain slightly posterior to midlength by a shallow broad basal cavity. The cup has one or several denticles on each side.

Description.—The blade is nearly straight and bears about 15 laterally compressed denticles, those in the middle commonly being completely fused, those near either end being fused nearly to their apices. The anterior three or four denticles are the highest, and the height of the blade decreases fairly regularly from them to the posterior. The aboral margin in lateral view appears to be very slightly arched except that the margin of the cup is below the remainder. The cup is posterior to midlength but generally is within the middle third of the blade. The height of the cup including denticles varies from about two-thirds the height of the blade to a height slightly greater than that of the blade. On each side the cup bears one or a few node-like denticles that tend to fuse into transverse ridges inclined obliquely away from the blade. The cup is approximately oval, and its greatest dimension is transverse to the blade. The outer side generally is the widest, the inner side the longest. The basal cavity is very shallow. From it a groove extends along the sharp aboral margin to the posterior tip and part way to the anterior end.

Remarks.—This species is much like some specimens of *Spathognathodus steinhornensis eosteinhornensis,* for example, the specimens illustrated by figures 21 and 22, Plate 20, of Walliser (1964). The stratigraphic interval separating the two species is long, and collections are sufficiently extensive to indicate that the two are homeomorphs.

Material studied.—Forty-eight specimens.

Repository.—Holotype, 12598 (11–2); paratypes 12599 (11–1), 12600 (9–4), 12601 (11-1), 12602 (9–4), 12603 (9–5), and 12604 (9-4).

SPATHOGNATHODUS ELIBATUS n. sp.
Pl. 111, figs. 22–26

Derivation of name.—*elibatus,* Gr., high, steep, in reference to the high apical denticle from which the denticles decrease steeply toward the posterior.

Diagnosis.—Above the oval basal cavity is a large main denticle from which the denticles decrease in height posteriorly. The anterior denticles are lower. In some specimens they are fairly uniform in height; in others they are highest near the middle of the anterior part of the blade.

Description.—Near or somewhat posterior to the midpoint of the blade is a large posteriorly inclined main denticle. It is about twice as large as the other anterior denticles. Posterior to it are three to five slightly laterally compressed denticles that decrease in size posteriorly. The anterior denticles, four to nine in number, are either more or less uniform in height or in lateral view form a low arch. The basal cavity is oval, fairly shallow but deepest below the main denticle, and commonly has slightly flared lips about it. Thin grooves extend a short distance anteriorly and posteriorly from the basal cavity.

Remarks.—In lateral view the outlines of this species and of *Icriodella discreta* are nearly identical. Both have a high main denticle behind which are four or five denticles that decrease abruptly in height to the posterior. Both have a low silhouette anterior to the main denticle. Similarity in gross morphology between another *Icriodella-Spathognathodus* pair, *I.* n. sp. and *S. manitoulinensis,* is noted and commented on, and no additional information has been gained from study of *I. discreta* and *S. elibatus.*

Material studied.—Seventy-six specimens.

Repository.—Holotype, 12605 (9–7); paratypes 12606 (9–7), 12607 (3–219–222), 12608 (3–215–218), and 12609 (3–219–222).

SPATHOGNATHODUS HASSI n. sp.
Pl. 111, figs. 8–12

Spathognathodus cf. *S. oldhamensis* REXROAD, 1967, Pl. 3, fig. 3.

Derivation of Name.—Named in honor of Wilbert H. Hass, whose years of careful study of conodonts added greatly to our knowledge of these fossils.

Diagnosis.—The denticle about one-third the distance from the posterior is larger and longer than the other denticles, and the denticles posterior to it are shorter than those to the anterior. The basal cavity below the large denticle has broadly flaring lips.

Description.—The blade is nearly straight and bears about 16 long laterally compressed denticles fused nearly to their apices. The apical denticle, located above the basal cavity and about one-third of the length of the specimen

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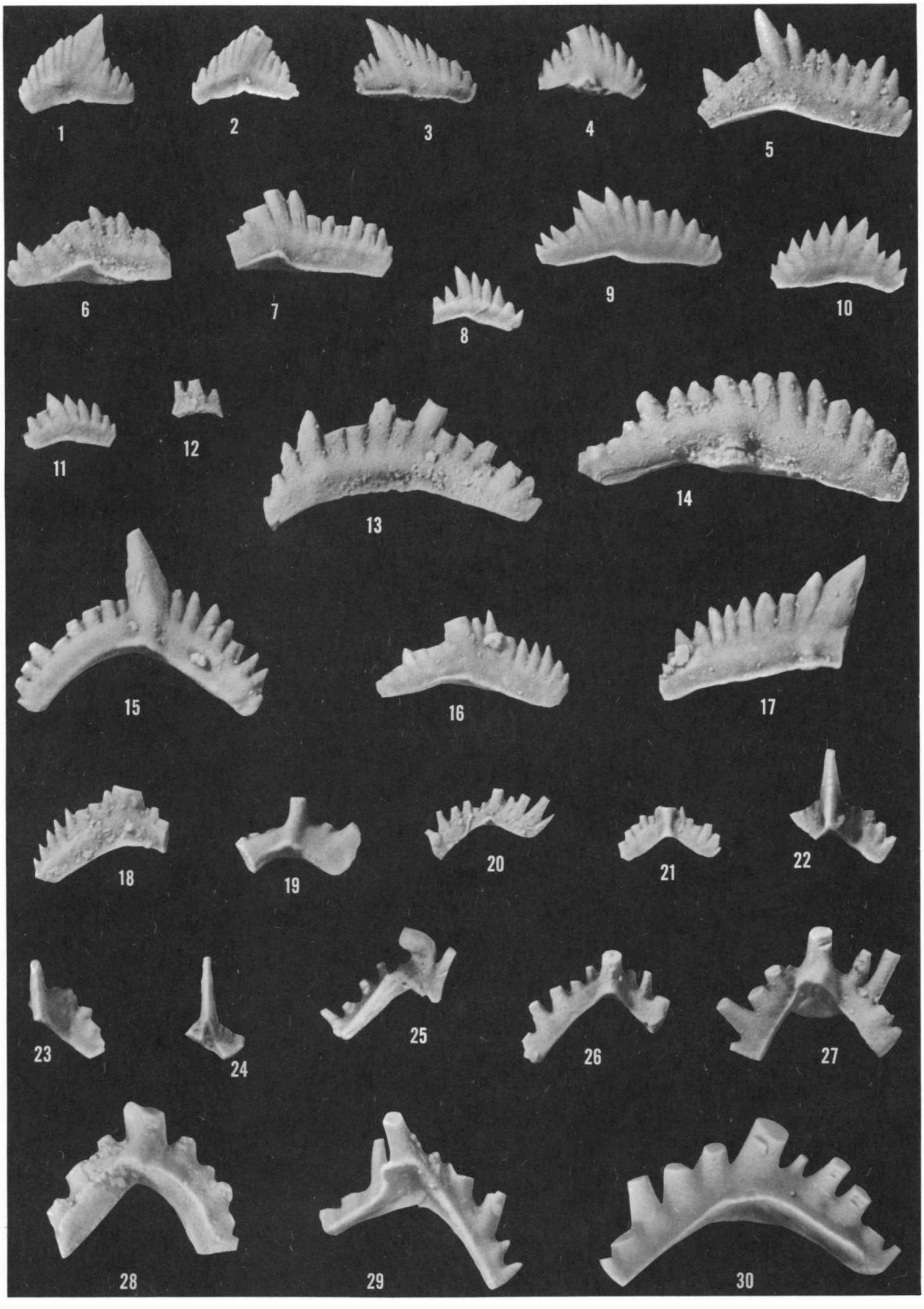
EXPLANATION OF PLATE. 113

All figures are ×40. Indiana University-Indiana Geological Survey repository numbers are followed by locality and sample numbers in parenthesis.

FIGS. *1–4*—*Ozarkodina* cf. *O. edithae* Walliser. Three inner lateral and an outer lateral view of 12559 (3–219–222), 12560 (9–10), 12561 (9–10), and *O.* cf. *O. edithae* var. A, 12562 (9–7).
5–8—*Ozarkodina* n. sp. A. Outer lateral views of 12569 (3–49,50), 12570 (3–49,50), 12571 (3–46–48), and 12572 (3–46–48).
9–11—*Ozarkodina* n. sp. B. Two inner lateral and one outer lateral view of 12573 (3–12–37), 12574 (3–12–37), and 12575 (3–42–45).
12—*Carniodus* n. sp. Posterior? view of 12515 (3–51,52).
13,14—*Ozarkodina* aff. *O. media* Walliser. Inner and outer lateral views of 12563 and 12564 (both 3–219–222).
15—*Ozarkodina* cf. *O. media* Walliser. Inner lateral view of 12565 (3–46–48).
16–18—*Ozarkodina typica* Branson & Mehl. Lateral views of 12566 (3–46–48), 12567 (3–46–48), and 12568 (3–51,52).
19,20—*Plectospathodus flexuosus* Branson & Mehl. Inner lateral views of 12588 (16–6) and 12589 (6–9).
21—*Trichonodella* n. sp. Posterior view of 12630 (9–11).
22–24—*Trichonodella symmetrica* Branson & Mehl variety A. Posterior views of 12627 (3–96–98), 12628 (3–46–48), and 12639 (3–49,50).
25—*Lonchodina* n. sp. Inner lateral view of 12550 (10–DB1).
26,27—*Trichonodella inconstans* Walliser. Posterior views of 12625 (13–5) and of 12626 (7–1), a specimen transitional with *Lonchodina greilingi* Walliser.
28—*Lonchodina greilingi* Walliser. Inner lateral view of 12551 (3–49,50).
29—*Lonchodina detorta* Walliser. Inner lateral view of 12552 (3–46–48).
30—*Lonchodina walliseri* Ziegler. Inner lateral view of 12553 (9–13).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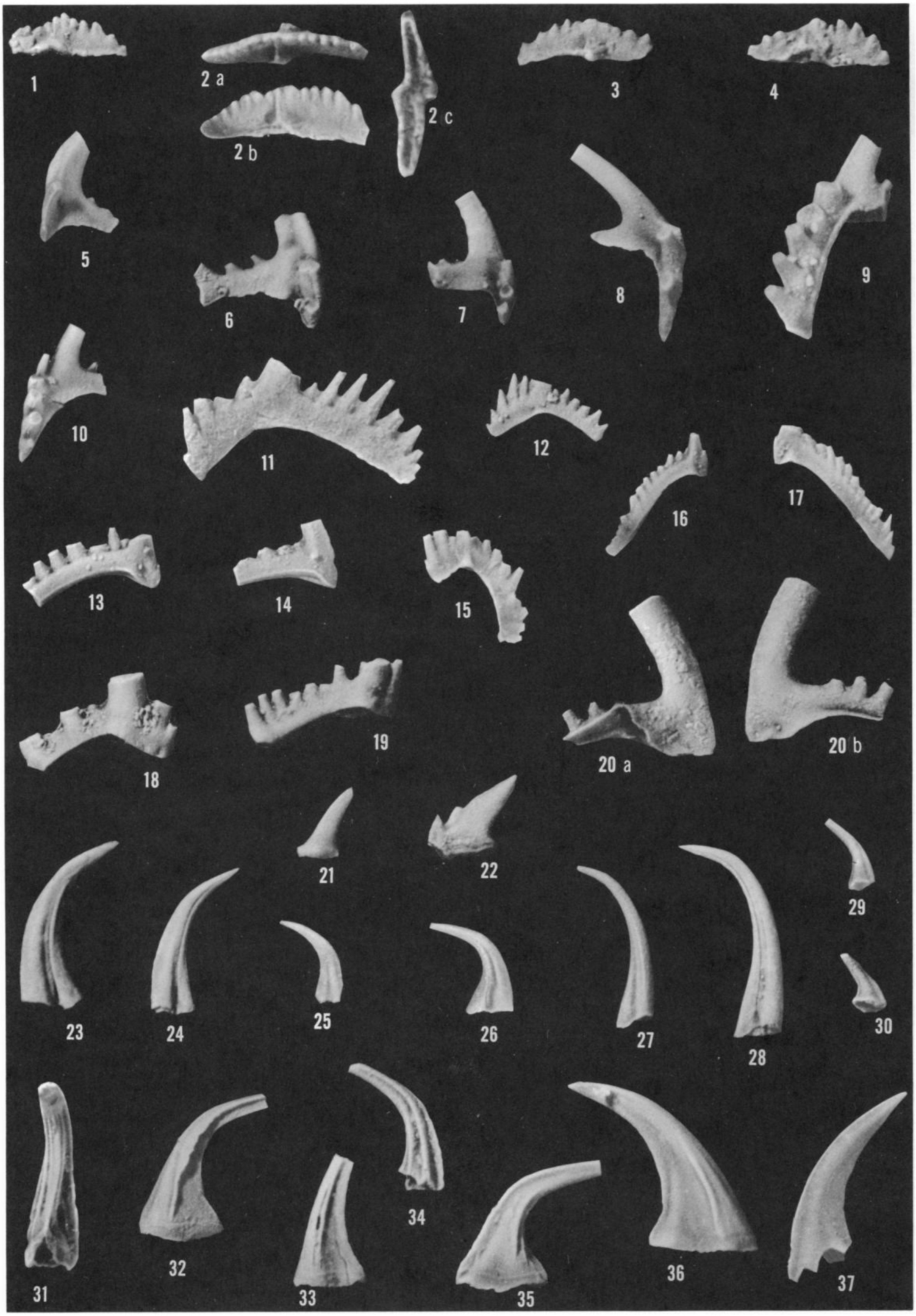
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from the posterior, is several times larger than the adjacent denticles and imparts to the species a strong resemblance to *Ozarkodina*. The oral margin forms an arc in lateral view. The anterior denticles are longer and thinner than the posterior ones, generally number about ten, and tend to incline slightly anteriorly near the anterior end. The blade is slighty thickened along the base of the denticles but is sharp edged aborally except for the broadly flaring lips about the basal cavity. The basal cavity is moderately deep, slightly asymmetrical, and rounded except that in aboral view it is pointed anteriorly and posteriorly where it narrows to join the margins of the blade. This is most obvious in immature specimens.

Remarks.—Specimens are similar to *Ozarkodina* in the presence of an apical denticle and in the arched appearance of the oral margin. The species, however, is not truly arched, and for this reason and because of its apparent close relationship to *Spathognathodus oldhamensis*, we refer it to *Spathognathodus*. It is also much like *S. fundamentatus* Walliser but differs in having a smaller basal cavity and in having relatively narrow and numerous denticles on the anterior part of the blade. The present species has an apical denticle that is lacking in *S. oldhamensis*, and the denticles are uniformly spaced whereas on most specimens of *S. oldhamensis* there is a gap in dentition.

Material studied.—114 specimens.

Repository.—Holotype, 12610 (7–2); paratypes, 12611 (9–10), 12612 (9–6), 12613 (10-DB1), and 12614 (7–2).

SPATHOGNATHODUS MANITOULINENSIS n. sp.
Pl. 111, figs. 17–19

Derivation of name.—The species is named for Manitoulin Island, Ontario, Canada, where well-preserved specimens are found in the Manitoulin Dolomite.

EXPLANATION OF PLATE 114

All figures are ×40. Indiana University-Indiana Geological Survey repository numbers are followed by locality and sample numbers in parenthesis.

FIGS. *1–4*—*Aphelognathus siluricus* n. sp. *1*, inner lateral view of paratype 12512 (16–6); *2a–c*, Upper, inner lateral, and lower views of holotype 12511 (16–6); *3,4*, outer and inner lateral views of paratypes 12513 (16–6) and 12514 (16–7).

5,6—*Ligonodina* n. sp. Inner lateral views of 12548 (16–6) and 12547 (16–7).

7,8—*Ligonodina* cf. *L. silurica* Branson & Mehl. Inner lateral views of 12544 and 12545 (both 3–46–48).

9,10—*Ligonodina kentuckyensis* Branson & Branson. Inner lateral views of 12542 (3–42–45) and 12543 (11–2).

11,12—*Ligonodina? variabilis* Nicoll & Rexroad. Inner lateral views of 12546 (6–10) and 12547 (3–46–48).

13,14—*Neoprioniodus planus* Walliser. Inner lateral views of 12557 (3–46–48) and 12558 (16–7).

15—*Synprioniodina silurica* Walliser. Inner lateral? view of 12624 (9–4).

16,17—*Synprioniodina bicurvata* (Branson & Mehl). Inner lateral views of 12622 (9–4) and 12623 (2–6).

18–20—*Neoprioniodus* cf. *N. excavatus* (Branson & Mehl). *18,19*, Inner lateral views of 12554 (3-227–229) and 12555 (11–1); *20a,b*, inner and outer lateral views of a variant, 12556 (16–7), resembling *N. latidentatus* Walliser.

21—*Drepanodus suberectus* (Branson & Mehl). Outer lateral view of 12525 (11–1).

22—*Drepanodus? arrectus* Rexroad. Lateral view of 12524 (9–7).

23–25—*Panderodus simplex* (Branson & Mehl). Lateral views of 12582 (9–5), 12583 (9–12), and 12584 (3–46–48).

26–28—*Panderodus unicostatus unicostatus* (Branson & Mehl). Lateral views of 12585 (9–5), a variant, 12586 (9–7), and 12587 (9–3).

29,30—*Paltodus costulatus* Rexroad. Inner lateral views of 12576 (9–4) and 12577 (13–6), a variant.

31—*Paltodus dyscritus* Rexroad. Posterior view of 12580 (9–10).

32,33—*Paltodus debolti* Rexroad. Outer lateral views of 12578 (9–11) and 12579 (12–4).

34—*Paltodus migratus* Rexroad. Lateral view of 12581 (13–5).

35—*Acodus curvatus* Branson & Branson. Inner lateral view of 12501 (9–4).

36,37—*Acodus unicostatus* Branson & Branson. Outer and inner lateral views of 12502 (12–3) and 12503 (9–3).

Diagnosis.—The posterior part of the blade is directed laterally about 60° from the line of the anterior part. At the juncture of the anterior and posterior parts of the blade, lips flare prominently outwardly but only slightly so inwardly. The cavity extends the entire length of the blade.

Description.—At a point about one-third of the length of the specimen from the posterior tip, the blade angles sharply so that in oral view there is an angle of approximately 120° between the anterior and posterior parts. The anterior part of the blade commonly bears 10 to 13 round, partly fused denticles, which are uniform in size; the posterior part bears one to seven similar, but smaller, denticles. The anterior denticles are about twice as high as the posterior ones. The denticle directly above the basal cavity is conspicuously larger than any of the others. The basal cavity is deep at the point of flexure where a lip flares markedly on the outer side but only slightly on the inner side, thus forming an asymmetrical cup. The cavity narrows and becomes shallower from here toward the ends of the blade.

Remarks.—The very sharp bend in the blade of this species is duplicated in *Icriodella* n. sp. found associated in the same strata in our study. Specimens are too few to work out the evolution and detailed stratigraphic relationships of *S. manitoulinensis* and *I.* n. sp., and so we do not know whether this similarity in gross morphology indicates evolution from common or closely related forms, whether it is the result of similar function in different animals, or whether another explanation is called for. The general morphology of *S. manitoulinensis* is nearly duplicated in the genus *Bactrognathus,* which is found in Mississippian rocks and which evolved from *Spathognathodus.* This homeomorph suggests that the elements represent homologous structures related to their function in the animal. Another slight similarity of form is found in those few specimens of *S. ranuliformis* that have one or two denticles on the cup in a line suggestive of the flexed posterior part of the blade of *S. manitoulinensis.*

Material studied.—Ten specimens.

Repository.—Holotype, 12615 (5–1); paratypes, 12616 (6–8), and 12617 (9–4).

SPATHOGNATHODUS OLDHAMENSIS Rexroad
Pl. 111, figs. 13–16

Spathognathodus oldhamensis REXROAD, 1967, p. 49, Pl. 3, figs. 1,2.

Remarks.—Denticles tend to be fused and flattened immediately above the basal cavity, and this might be a function of the age of the specimen. The fusion may have served as a protective measure to prevent damage to the denticles.

Material studied.—109 specimens.

Repository.—Figured specimens, 12618 (9–3), 12619 (4–1), 12620 (3–219–222), and 12621 (3–13–17).

Genus SYNPRIONIODINA Bassler, 1925

Type species.—*Synprioniodina alternata* Ulrich & Bassler, 1926.

SYNPRIONIODINA BICURVATA (Branson & Mehl)
Pl. 114, figs. 16,17

Prioniodus bicurvatus, BRANSON & MEHL, 1933, p. 44, Pl. 3, figs. 9–12.
Prioniodina bicurvata (Branson & Mehl), ?WALLISER, 1957, p. 46, Pl. 2, figs. 18,19; BISCHOFF & SANNEMANN, 1958, p. 102, Pl. 15, figs. 6,12; ?SERPAGLI & GRECO, 1964, p. 207, Pl. 37, fig. 11.
Prioniodina bicurvata pronoides WALLISER, 1960, p. 33, Pl. 8, figs. 8–10; ZIEGLER, 1960, p. 193, Pl. 15, figs. 8,9; JENTZSCH, 1962, p. 971, Pl. 2, fig. 13.
Neoprioniodus bicurvatus (Branson & Mehl), WALLISER, 1964, p. 46, Pl. 29, figs. 27–30,31–33?, Text-fig. 5d; PHILIP, 1965, p. 105, Pl. 9, figs. 13,18,20; BARNETT ET AL., 1966, Pl. 58, fig. 22; SPASOV & GANEV, 1966, p. 52, Pl. 3, fig. 9; PHILIP, 1966, p. 446, Pl. 3, figs. 12–16.
Synprioniodina bicurvata pronoides (Walliser), MOSKALENKO, 1966, p. 89, Pl. 11, figs. 16,17?,18?
Prioniodina tropa (Stauffer), ZIEGLER, 1956, p. 104, Pl. 6, fig. 29; Pl. 7, fig. 29.

Material studied.—Seventeen specimens.

Repository.—Figured specimens, 12622 (9–4) and 12623 (2–6).

SYNPRIONIODINA SILURICA Walliser
Pl. 114, fig. 15

Synprioniodina silurica WALLISER, 1964, p. 88, Pl. 6, fig. 12; Pl. 8, fig. 18; Pl. 29, figs. 38–41; Pl. 30, figs. 1–4,6; NICOLL & REXROAD, 1968, p. 61, Pl. 4, fig. 10.

Material studied.—134 specimens.

Repository.—Figured specimen, 12624 (9–10).

Genus TRICHONODELLA Branson & Mehl, 1948

Type species.—*Trichognathus prima* Branson & Mehl, 1933.

TRICHONODELLA INCONSTANS Walliser
Pl. 113, figs. 26,27

Trichonodella inconstans WALLISER, 1957, p. 50, Pl. 3, figs. 10–17; ?WALLISER, 1960, p. 35, Pl. 7, figs. 11,12; BISCHOFF & SANNEMANN, 1958, p. 109, Pl. 15, figs. 20,21; ETHINGTON & FURNISH, 1962, p. 1287, Pl. 173, fig. 7; WALLISER, 1964, p. 90, Pl. 8, fig. 8; Pl. 30, figs. 10–12; PHILIP (part), 1965, p. 112, Pl. 9, fig. 15 only; PHILIP, 1966, p. 451, Pl. 3, fig. 23, Pl. 4, figs. 21,23,27,30; NICOLL & REXROAD, 1968, p. 64, Pl. 4, fig. 1.
Trichonodella aff. *T. inconstans* Walliser, BROOKS & DRUCE, 1965, p. 378, Pl. 12, fig. 4.

Trichonodella cf. *T. inconstans* Walliser, REXROAD, 1967, p. 54, Pl. 3, fig. 19.

Remarks.—Walliser (1957, p. 50, 51, fig. 3) showed that *Trichonodella inconstans* and *Lonchodina greilingi* are transitional. Many of our specimens seem to fall within the transitional interval. Although a few end members referred to each species are readily recognizable, so many specimens are not that we treat both species under *T. inconstans,* the dominant form, as a single group.

Material studied.—Twenty specimens.

Repository.—Figured specimens, 12625 (13–6) and 12626 (7–1).

TRICHONODELLA SYMMETRICA
(Branson & Mehl)
Pl. 113, figs. 22–24

Trichognathus symmetrica BRANSON & MEHL, 1933, p. 50, Pl. 3, fig. 33,34.
Trichonodella symmetrica (Branson & Mehl), RHODES (part), 1953, p. 315, Pl. 23, fig. 246 only; PHILIP, 1965, p. 112, Pl. 9, figs. 19,21.

Remarks.—Branson & Mehl distinguished *Trichonodella symmetrica* from *T. excavata* primarily on the cross-section of the cusp which is triangular with a relatively sharp posterior edge in *T. symmetrica* and which is nearly subcircular in *T. excavata.* Also, the posterior margin is more expanded posteriorly in *T. excavata,* and the cusp is angled posteriorly. One variety of *Trichonodella* found in the present study combines elements of both species. The lower part of the cusp is very narrow, but it extends back even farther than is typical of *T. excavata.* The posterior margin is sharp edged, and we retain the variation in *T. symmetrica.* It is figured as *T. symmetrica* variety A.

Material studied. Eleven specimens.

Repository.—Figured specimens, 12627 (3–96–98), 12628 (3–46–48), and 12629 (3–49, 50).

TRICHONODELLA n. sp
Pl. 113, fig. 21

Trichonodella sp. *B.* REXROAD, 1967, p. 53, Pl. 3, fig. 17.

Remarks.—As was true of specimens from the Brassfield Limestone, the present specimens are too fragmentary to reconstruct the overall morphology. Slightly asymmetrical incomplete specimens are nearly impossible to distinguish from specimens of *Synprioniodina silurica* on which the longer limb has been broken, resulting in a fragment that appears virtually symmetrical.

Material studied.—Twenty-six specimens.

Repository.—Figured specimen, 12630 (9–11).

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