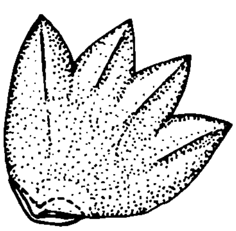
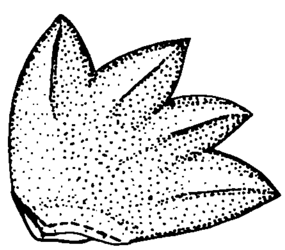
OKLAHOMA GEOLOGICAL SURVEY
Charles J. Mankin, *Director*

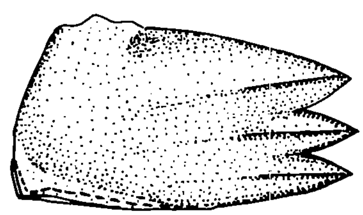
BULLETIN 141 ISSN 0078-4397

CONODONTS AND CONODONT BIOSTRATIGRAPHY OF THE McLISH AND TULIP CREEK FORMATIONS (MIDDLE ORDOVICIAN) OF SOUTH-CENTRAL OKLAHOMA

JEFFREY A. BAUER







The University of Oklahoma
Norman
1987

Title Page Illustration
Skeletal apparatus of *Leptochirognathus quadratus* Branson and Mehl.

This publication, printed by Hirschfeld Press, Inc., Denver, Colorado, is issued by the Oklahoma Geological Survey as authorized by Title 70, Oklahoma Statutes, 1981, Section 3310, and Title 74, Oklahoma Statutes, 1981, Sections 231–238. 1,000 copies have been prepared for distribution at a cost of $4,201 to the taxpayers of the State of Oklahoma. Copies have been deposited with the Publications Clearinghouse of the Oklahoma Department of Libraries.

CONTENTS

TABLES

ILLUSTRATIONS

Text–Figures

Plates

CONODONTS AND CONODONT BIOSTRATIGRAPHY OF THE McLISH AND TULIP CREEK FORMATIONS (MIDDLE ORDOVICIAN) OF SOUTH-CENTRAL OKLAHOMA

JEFFREY A. BAUER[1]

Abstract—Samples from the McLish and Tulip Creek Formations of south-central Oklahoma yielded 12,890 identifiable conodont elements referable to 25 genera. The conodont fauna is dominated by *Phragmodus flexuosus,* which is divided into two distinct, biostratigraphically useful morphotypes. Species of *Cahabagnathus* and *Eoplacognathus* allow correlation of the McLish and Tulip Creek with the *Pygodus serra* Zone of the North Atlantic Province. The conodont fauna, accordingly, is representative of the upper Whiterockian Series (Chazyan). Continuity of the fauna through the McLish–Tulip Creek boundary beds indicates no significant break in sedimentation.

Samples just above the basal sandstone of the McLish yielded conodonts different from those in the remainder of the formation and in the overlying Tulip Creek. *Neomultioistodus, Paraprioniodus,* and *Scandodus*? are representatives of this lower McLish association. Conodonts of this *Neomultioistodus* association are considered reworked.

INTRODUCTION

The thick intracratonic succession of Middle Ordovician rocks exposed in the Arbuckle Mountains of south-central Oklahoma is critical to the understanding of North American Middle Ordovician biostratigraphy. Many previous biostratigraphic studies of that interval lack the detail necessary for positive correlations. This paper describes conodonts from the Middle Ordovician McLish and Tulip Creek Formations. These two units are exposed in thick, continuous, generally well-exposed sections in the Arbuckles and provide excellent targets for conodont research. The conodont succession of the McLish and Tulip Creek Formations is compared with presently used conodont faunal and zonal schemes and is fit into accepted chronostratigraphic frameworks.

STRATIGRAPHY AND STRUCTURE

The McLish and Tulip Creek Formations make up the middle portion of the Simpson Group, which is underlain by the Cambrian–lower Middle Ordovician Arbuckle Group and overlain by the Middle and Upper Ordovician Viola Group. The Simpson was introduced initially as a formation by Taff (1902,1904), who published early descriptions (1904, p. 23) of the interval. Ulrich (1930, p. 76–77) treated the Simpson as a group composed of seven formations.

Decker and Merritt (1931, p. 11–12) recognized the five presently accepted formations in their summary of the Simpson Group. Those five formations are (from oldest to youngest) the Joins, Oil Creek, McLish, Tulip Creek, and Bromide. Cooper (1956, p. 120–121) divided the Bromide into the Mountain Lake and Pooleville Members.

Harris (1957, p. 10–53) gave a detailed account of important stratigraphic studies published before 1957. Other summaries of previous Simpson studies were given by Schramm (1964, p. 1167–1168; 1965, p. 26–34), Shaw (1974, p. 2), and Longman (1981, p. 2–3).

The studied rocks are part of the thick Paleozoic sequence of south-central Oklahoma exposed in the Arbuckle Mountains, which comprise a series of NW-trending anticlinal uplifts formed during Pennsylvanian orogenic episodes (Text-fig. 1; Ham and Wilson, 1967, p. 398; Ham, 1969, p. 17–19).

Samples were collected from a section of the McLish and Tulip Creek Formations exposed along Interstate Highway 35 (Text-fig. 1; Murray County, Oklahoma; sec. 30, T1S, R2E; Turner

[1]The Ohio State University, Columbus, Ohio.

Falls 7.5′ quadrangle). These exposures have been described by Fay (1969, p. 73–75). This sampled section bears the Ohio State University (OSU) locality designation 82JA. The section is situated in the overturned north limb of the Arbuckle anticline. Beds in the section strike N. 50° W. and dip 65–75° SW.

The basal part of the McLish Formation is exposed in a valley east of the highway, about 500 ft north of milepost 50. The sampled portion of the formation is 405 ft (~123 m) thick and consists of a basal quartzose sandstone succeeded by a series of alternating carbonate rocks and shales. Much of the upper part of the McLish is covered; according to descriptions by Fay (1969, p. 74), this covered interval is shale. The contact between the McLish and the subjacent Oil Creek Formation is covered, but is estimated to be 20 ft below the base of the exposed section (Fay, 1969, p. 75). The McLish appears to be conformable with the younger Tulip Creek Formation, as indicated by the absence of an identifiable erosional surface and the continuity of the conodont fauna across the contact.

The Tulip Creek comprises a basal calcareous, quartzose sandstone succeeded by beds of limestone, calcareous sandstone, and shale. The upper part of the sequence is mostly covered and is presumed to be mostly shale (Fay, 1969, p. 73). Total thickness of the Tulip Creek is 304 ft (~93 m). The contact with the overlying Bromide Formation is covered, but is assumed to be at the intersection of a subtle ledge (basal Bromide sandstone) and the slope formed by the upper Tulip Creek shale.

Additional collections used in this research are from a McLish–Tulip Creek section sampled in 1972 by W. C. Sweet, S. M. Bergström, and V. Jaanusson (OSU localities 72SE and 72SF). That section is along the west side of U.S. Highway 77, north of Ardmore, Carter County, Oklahoma, on the south flank of the Arbuckle anticline (Text-fig. 1). Although no detailed lithologic descriptions of the section were made by the collectors, the McLish portion (locality 72SE) had been described before by Decker and Merritt (1931, Table IV, p. 62–67), and the Tulip Creek portion (locality 72SF) had been described by Fay (1969, p. 31).

DEPOSITIONAL ENVIRONMENTS

Ham and Wilson (1967, p. 393–396) summarized two principal depositional sequences in the Paleozoic of southern Oklahoma. The first (Late Cambrian–Early Devonian) consists of 11,000 ft of dominantly carbonate rocks and includes the Arbuckle, Simpson, and Viola Groups, the Sylvan Shale, and the Hunton Group. The second sequence primarily comprises Upper Devonian through Pennsylvanian terrigenous rocks.

Although carbonate rocks dominate the early Paleozoic sequence, terrigenous rocks are a significant component in the Simpson Group. Except for the Joins, all Simpson formations have a relatively thick basal sandstone. Shale is also common in the Simpson.

Schramm (1964, p. 1172–1191) constructed lithofacies maps of the Simpson Group. According to his model, terrigenous material in Simpson formations was derived from the east and northeast from sourcelands in the Canadian Shield (p. 1192).

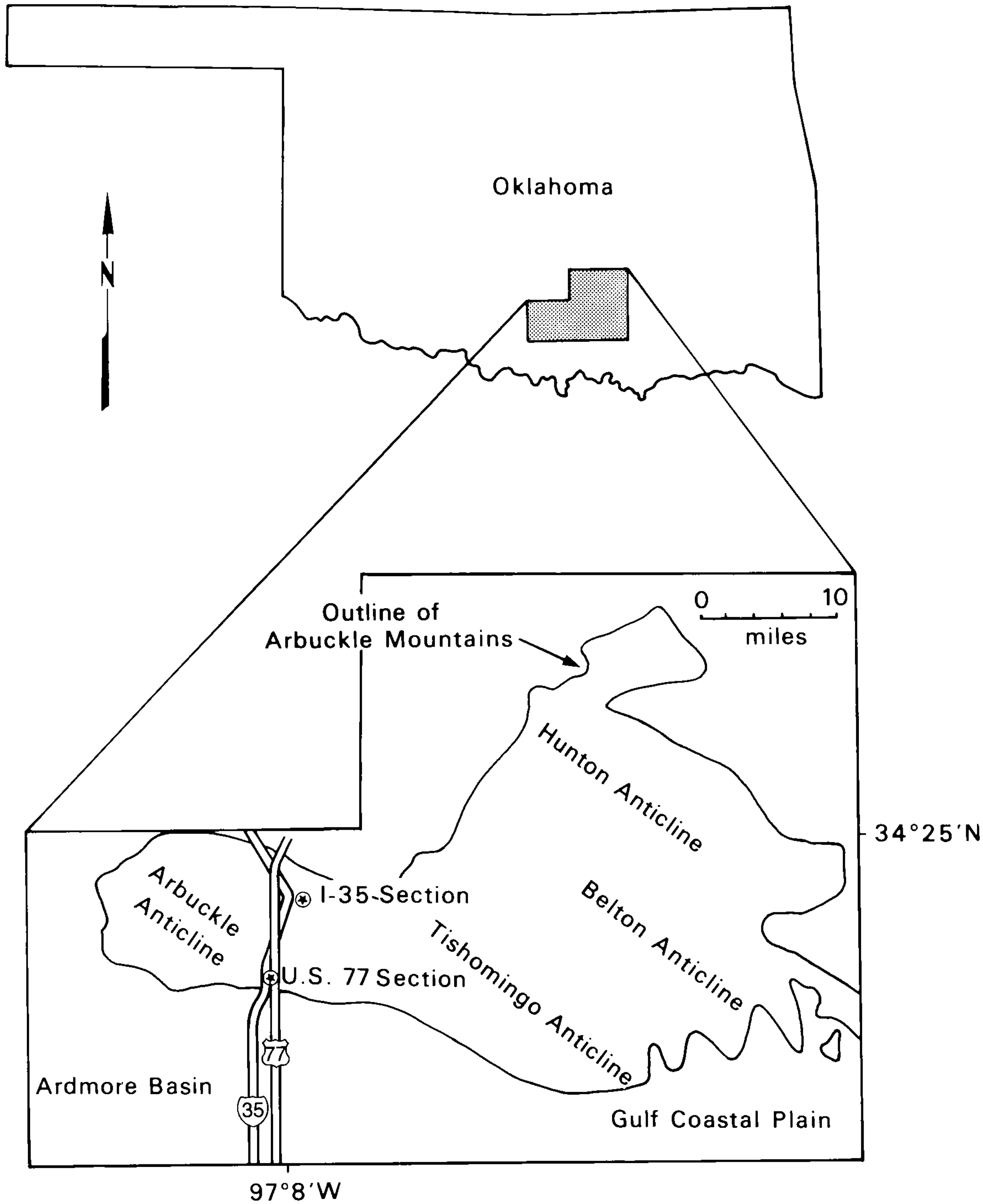
Shaw (1974, p. 2–5) believed that the Joins and Oil Creek represent tidal to subtidal depositional environments. He concluded that the McLish was deposited in environments of very shallow water and high energy, which is indicated by birdseye limestone in eastern facies (Ham, 1954; Illing, 1959; Perkins, 1963; Laporte, 1967; Shinn, 1968), and by a fauna of highly fragmented shelly fossils in western facies. Shaw further concluded that, among Simpson Group formations, the Bromide was deposited in the deepest water. He wrote little about Tulip Creek depositional environments.

Longman (1981, p. 1) recognized four episodes, or pulses, of subsidence in southern Oklahoma during Simpson deposition. During periods of quiescence, quartz sands were transported from bordering sourcelands to all parts of the depositional basin. As the basin subsided, marine shales and carbonates succeeded the sands.

The I-35 section of the McLish Formation has a basal sandstone (60 ft exposed) which represents Longman's (1981, p. 1) quiescent period during which quartzose sands extended into many parts of the southern Oklahoma basin. Biostratigraphic data show a significant hiatus at the top of the Oil Creek (Cooper, 1956, chart 1; Harris, 1957, p. 66; Sweet and Bergström, 1976, p. 147; Ross and others, 1982, correlation chart; Sweet, 1984, p. 31) and indicate that the basal McLish sandstone is transgressive, rather than regressive as implied by Longman (1981, p. 1).

The basal McLish sandstone is succeeded upward by mostly calcarenitic limestones (cross-bedded in places) and interbedded shales. Shelly fossils in the limestones are mostly fragmented. This interval represents a shallow-water (subtidal to intertidal) environment and intermittent periods of sustained influx of terrigenous sediment.

Cross-bedded, quartzose sandstones appear in the uppermost McLish and are common in the lower 120 ft of the Tulip Creek. The conodont faunal succession across the McLish–Tulip Creek boundary is continuous; this faunal continuity and the lack of physical evidence for a hiatus support the idea of a regressive sandstone unit. Shale is the most common constituent throughout the remainder of the Tulip Creek and records a shallow-water subtidal depositional environment. The persistent deposition of fine-grained clastic sedi-



Text-figure 1. Locations of sampled sections of the McLish and Tulip Creek Formations along Interstate Highway 35 and U.S. Highway 77.

ments during Tulip Creek time resulted in a significantly lower proportion of limestone in the Tulip Creek than in the McLish.

CONODONT SAMPLES

Samples of 1 kg were collected at 5-ft intervals from the McLish and Tulip Creek Formations in the I-35 section. Limestone and calcareous sandstone are well exposed in the section and presented no sampling problems. The upper portion of each formation is mostly shale that forms covered slopes; these intervals were sampled by digging through the cover into the weathered, shale-rich layers beneath. Some intervals could not be sampled, because of thick soil cover.

Initially, 500 g of each sample of calcareous sandstone and limestone was processed. Additional material was processed if the sample was not productive (in general, fewer than 10 conodont elements) or if elements critical to conodont analysis were not recovered. All available shale material was processed.

A 100-mesh sieve was used to separate residues from finer material. A 120-mesh sieve was used for two samples (82JA-350, 82JA-360) in order to recover elements that were generally too small to be caught on larger sieve openings. Magnetic separation and heavy liquids (tetrabromoethane) were used to concentrate residues further.

On the average, 130 conodont elements were recovered per kilogram of shale (22 samples total), 154 per kilogram of limestone (55 samples), and 520 per kilogram of calcareous sandstone (20 samples). A few beds from which large numbers of conodont elements were recovered are responsible for the high productivity of the quartzose sandstone samples. Most sandstone samples gave very low yields.

CONODONT FAUNAS

A collection of 12,890 identifiable conodont elements referable to 25 genera was recovered from the I-35 section. Also studied were 4,723 elements from the section along U.S. Highway 77. All conodont elements have a color alteration index of 1 (Epstein and others, 1977). Conodonts from both sections are listed in Table 1, and their sample-by-sample occurrence is given in Appendix 1.

Ordovician conodont provincialism has been discussed in a number of reports (Sweet and others, 1959, p. 1034–1038; Sweet and Bergström, 1962, p. 1216, 1974, 1984; Bergström and Sweet, 1966, p. 282–285; Schopf, 1966, p. 21–22; Bergström, 1973a, 1973c, p. 265–267, 1977; Barnes and Fåhraeus, 1975; Lindström, 1976), in which two provinces are recognized. Midcontinent provincial forms dominate the conodont collections from the McLish–Tulip Creek sections. *Phragmodus flexuosus* Moskalenko, representing 78% of the total conodont elements collected from the I-35 section and 75% of those from the U.S. 77 section, is by far the most abundant of the Midcontinent species. Conodonts recognized as North Atlantic provincial forms are represented in very small numbers and include the genera *Eoplacognathus* Hamar and *Cahabagnathus* Bergström.

In this report, *Phragmodus flexuosus* is differentiated into two morphotypes, A and B, based on the character of elements in the P position of the skeletal apparatus. Two species of *Belodella* Ethington, *B. robusta* Ethington and Clark and *B.* sp. cf. *B. jemtlandica* Löfgren, are represented in both sections. Ranges of those two species overlap to a large degree. The ratio of elements of *B. robusta* to those of *B.* sp. cf. *B. jemtlandica* is higher in the U.S. 77 section than in the I-35 section, which suggests environmental controls on the lateral distribution of the two species, although there are no apparent lithologic differences between the two sections.

Conodonts from the lowest three samples of the McLish Formation (82JA-66, -67, -71) in the I-35 section make up a fauna distinctly different from that recognized in the remainder of the interval. This fauna, discussed below under "Biostratigraphy and Chronostratigraphy," includes *Neomultioistodus compressus, Scandodus? sinuosus, Paraprioniodus* sp. cf. *P. costatus,* and *Histiodella* n. sp. 2.

DISTRIBUTION OF CONODONTS

The conodonts of the McLish Formation appear to be considerably more diverse than those of the Tulip Creek Formation. However, this change in diversity probably is an artifact of sampling difficulties in the middle and upper Tulip Creek. Ranges of conodont species in the I-35 section are plotted in Text-figure 2.

The lower three samples of the McLish yielded the *Neomultioistodus* association, but the remainder of the lower and middle parts of the McLish is dominated by *Phragmodus flexuosus* morphotype B and also includes relatively abundant representatives of *Belodella* sp. cf. *B. jemtlandica* and *Protopanderodus varicostatus*. The latter is present through the lower Tulip Creek.

Other, more sparsely represented forms in the lower and middle McLish include *Eoplacognathus foliaceus* (Fåhraeus)–*E. reclinatus* Fåhraeus transition (= *E.* sp. of this report), *Erismodus arbucklensis* n. sp., *Erraticodon* sp. cf. *E. balticus, Staufferella* sp., and *Cahabagnathus* sp. The *E. foliaceus–E. reclinatus* transition is of particular importance in correlation.

Most of the conodont species in the upper McLish range upward into the Tulip Creek. Representatives of *Phragmodus flexuosus* morphotype A, *Belodina monitorensis,* and *Cahaba-*

TABLE 1.—OCCURRENCE OF CONODONTS IN THE MCLISH AND TULIP CREEK FORMATIONS IN THE I-35 AND U.S. 77 SECTIONS

Species	Recovered elements	
	I-35 section	U.S. 77 section
1. *Belodella* sp. cf. *B. jemtlandica* Löfgren	158	88
2. *Belodella robusta* Ethington and Clark	33	51
3. *Belodina monitorensis* Ethington and Schumacher	47	18
4. *"Bryantodina"* sp.	22	—
5. *Cahabagnathus chazyensis* Bergström	1	—
6. *Cahabagnathus friendsvillensis* (Bergström)	40	34
7. *Cahabagnathus directus* n. sp.	77	6
8. *Cahabagnathus* sp.	45	61
9. *Coleodus?* sp.	1	1
10. *Dapsilodus? nevadensis* (Ethington and Schumacher)	3	1
11. *Drepanoistodus angulensis* (Harris)	66	—
12. *Drepanoistodus suberectus* (Branson and Mehl)	825	530
13. *Eoplacognathus* sp.	15	20
14. *Erismodus arbucklensis* n. sp.	98	17
15. *Erraticodon* sp. cf. *E. balticus* Dzik	42	82
16. *Histiodella* n. sp. 2 Harris and others	1	—
17. *Leptochirognathus quadratus* Branson and Mehl	18	—
18. *Neomultioistodus compressus* Harris and Harris	695	—
19. *Oneotodus? ovatus* (Stauffer)	1	—
20. *Panderodus panderi* (Stauffer)	5	—
21. *Panderodus* sp.	24	39
22. *Paraprioniodus* sp. cf. *P. costatus* (Mound)	194	—
23. *Phragmodus flexuosus* morphotype A	8,007	2,291
24. *Phragmodus flexuosus* morphotype B	2,028	1,254
25. *Plectodina* sp. cf. *P. aculeata* (Stauffer)	6	—
26. *Plectodina* sp.	13	—
27. *Plectodina?* sp.	47	6
28. *Protopanderodus varicostatus* (Sweet and Bergström)	79	74
29. *Pteracontiodus?* sp.	40	—
30. *Scandodus? sinuosus* Mound	117	—
31. *Staufferella* sp.	28	21
32. *"Tetraprioniodus"* sp.	1	—
33. *Thrincodus palaris* n. gen., n. sp.	1	1
34. *Triangulodus alatus* Dzik	64	126
35. Genus indeterminate, sp. A	37	2
36. Genus indeterminate, sp. B	11	—
Total	12,890	4,723

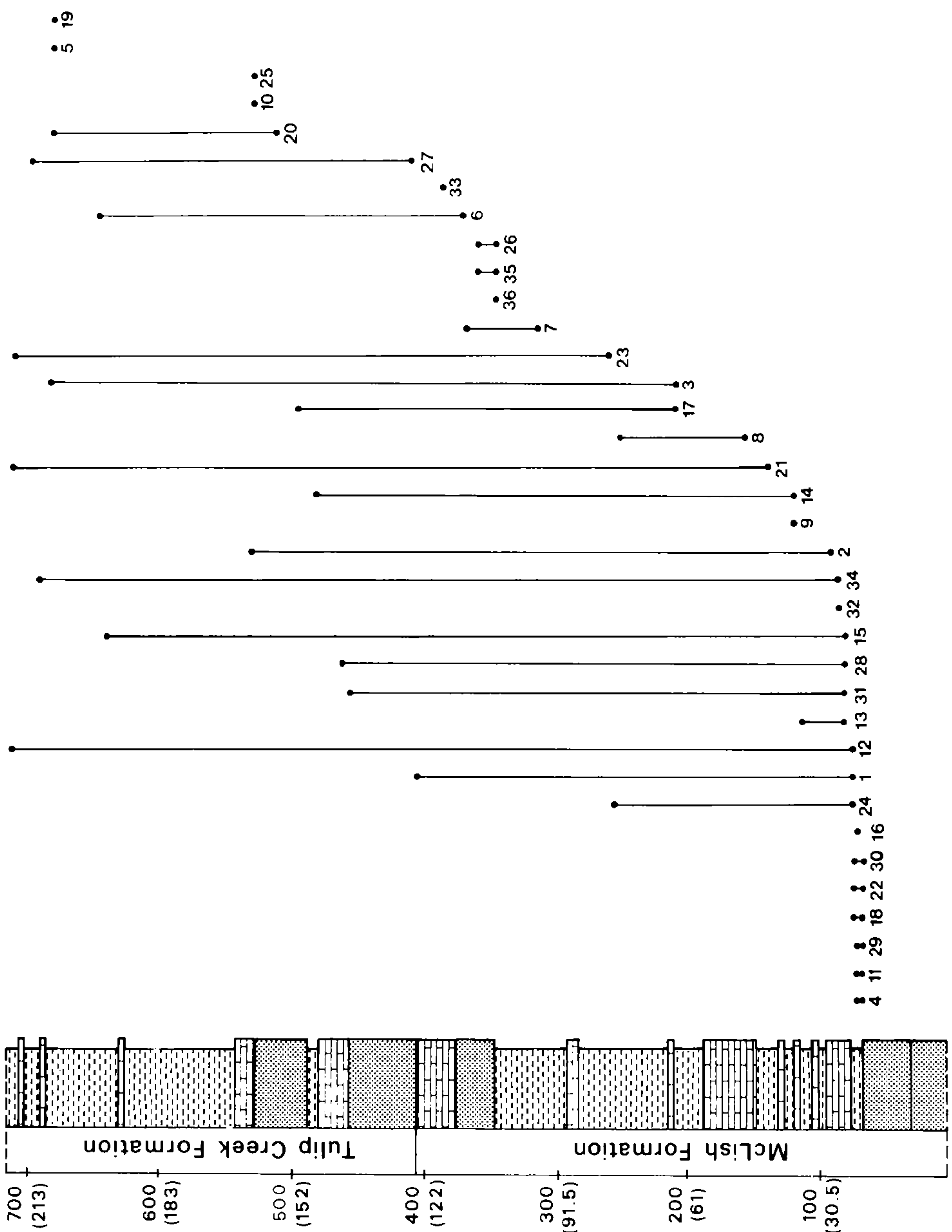
gnathus friendsvillensis are notable constituents of strata adjacent to the McLish–Tulip Creek contact.

The conodont fauna of the middle and upper Tulip Creek consists of *Phragmodus flexuosus* morphotype A, *Erraticodon* sp. cf. *E. balticus*, *Belodina monitorensis*, and *Panderodus panderi*. Long-ranging *Drepanoistodus suberectus* and *Triangulodus alatus* are sporadically represented throughout the section.

BIOSTRATIGRAPHY AND CHRONOSTRATIGRAPHY

Previous research on the biostratigraphy of the McLish and Tulip Creek Formations includes reports on trilobites (Ulrich, 1930, p. 77; Shaw, 1974, p. 6–8), brachiopods (Cooper, 1956, p. 119–120), ostracodes (Harris, 1957, p. 77,83), bryozoans (Loeblich, 1938; Farmer, 1975), chitinozoans (Wilson and Dolly, 1964), and conodonts (Branson and Mehl, 1943; Sweet and others, 1971, p. 174; Sweet and Bergström, 1976, p. 146–147; Sweet, 1984, figs. 3,11). In addition, Taff (1904) and Decker and Merritt (1931, p. 30–40) published early reports on a variety of invertebrate groups. Amsden (1957) gave a summary of fossils described from the McLish and Tulip Creek prior to 1957.

Chronostratigraphic relationships of the McLish and Tulip Creek Formations proposed by



Text-figure 2. Ranges of conodont species in the I-35 section of the McLish and Tulip Creek Formations. See Table 1 and Appendix 1.

previous investigators are summarized in Table 2.

Sweet and others (1971) established a succession of 12 conodont faunas for the Middle and Upper Ordovician rocks of the Midcontinent Province. Those conodont faunas still provide a general biostratigraphic framework, although several faunal ranges have been shown to overlap chronologically.

Conodonts from the McLish Formation (except those from samples 82JA-66, -67, and -71) and Tulip Creek Formation are representative of faunas 5 and 6 of Sweet and others (1971). Harris and others (1979, p. 10) noted uncertainty in differentiating fauna 5 from fauna 6, and consequently chose to group the two. *Phragmodus flexuosus,* represented in great numbers in the McLish–Tulip Creek section, is a member of both faunas and therefore offers little help in faunal determination. *Multioistodus subdentatus* Cullison is present only in fauna 5 and appears to be the only form that can be used to distinguish the two faunas. *M. subdentatus,* described from the Dutchtown Formation of Missouri (Cullison, 1938, p. 226; Youngquist and Cullison, 1946, p. 586), is not represented in the McLish–Tulip Creek samples. However, in consideration of the somewhat uncertain relationship between faunas 5 and 6, it is probably best to describe the conodont assemblage as fauna 5–6. *P. flexuosus, Leptochirognathus quadratus, Belodina monitorensis,* and *Cahabagnathus friendsvillensis* support assignment to fauna 5–6.

Belodina compressa Branson and Mehl, *Plectodina aculeata* (Stauffer), and *Phragmodus inflexus* Stauffer characterize fauna 7 (Sweet and others, 1971, p. 175; Sweet, 1984, p. 25). Those species are not represented in either the McLish or Tulip Creek. *P. inflexus* has been reported from the lower Bromide Formation (Sweet and Bergström, 1973; Sweet and Bergström, 1976, p. 128; Sweet and others, 1973).

Ethington and Clark (1982, p. 5–14), in their study of Lower and Middle Ordovician conodonts from the Ibex area of western Utah, introduced local conodont intervals to replace some of the Midcontinent faunal assemblages of Sweet and others (1971). The youngest interval listed in their report (p. 14), the ?*Phragmodus flexuosus* interval, contains some forms in common with the McLish–Tulip Creek section, including *Belodella robusta, Erraticodon* aff. *E. balticus,* and *Dapsilodus? nevadensis.* However, the *Phragmodus* described from that interval has a geniculate coniform element in the M position. *P. flexuosus,* as interpreted in this report, has a dolabrate element in the M position and appears to represent younger strata, as concluded by Harris and others (1979, p. 23).

North Atlantic-type conodonts in the McLish and Tulip Creek Formations allow some comparisons between the Midcontinent successions and the North Atlantic provincial zonation introduced

TABLE 2.—MCLISH–TULIP CREEK CHRONOSTRATIGRAPHIC RELATIONSHIPS ACCORDING TO PREVIOUS INVESTIGATORS

Reference	Fossil group	Lithostratigraphic unit	Chronostratigraphic unit
Taff (1904)	(several)	Lower Simpson	Chazyan
Ulrich	Trilobites	McLish–Tulip Creek	Chazyan
Decker and Merritt (1931)	Gastropods, conodonts, bryozoans, etc.	McLish	Middle Chazyan
		Tulip Creek	Upper Chazyan or Blackriveran
Cooper (1956)	Brachiopods	McLish	Marmorian
		Tulip Creek	Ashbyan
Harris (1957)	Ostracodes	McLish–Tulip Creek	Blackriveran
Bergström (1971)	Conodonts	McLish	Marmorian
Shaw (1974)	Trilobites	McLish–Tulip Creek	Chazyan
Sweet and Bergström (1976)	Conodonts	McLish	Lower Chazyan
		Tulip Creek	Upper Chazyan
Ross and others (1982)	—	McLish–Tulip Creek	Upper Whiterockian

by Bergström (1971, p. 91–104). The *Eoplacognathus foliaceus–E. reclinatus* transition occurs with *Phragmodus flexuosus* morphotype B. The *Phragmodus* species with a geniculate coniform element in the apparatus described from the Crystal Peak Dolomite of Utah (Ethington and Clark, 1982, p. 79–82) and the Antelope Valley Limestone of Nevada (Harris and others, 1979, p. 23) is associated with an older form of *Eoplacognathus* (*E. suecicus* Bergström); this offers further evidence that the ?*P. flexuosus* interval of Ethington and Clark (1982, p. 14) is older than that with the normal conodont assemblage of the McLish.

Eoplacognathus is succeeded in the McLish by species of *Cahabagnathus,* which range through the remainder of the McLish and Tulip Creek. *Cahabagnathus chazyensis* (= *Polyplacognathus friendsvillensis–P. sweeti* transition of earlier reports) is represented in one sample near the top of the Tulip Creek. The succession of North Atlantic-type conodonts indicates that the McLish–Tulip Creek section falls primarily within the *Pygodus serra* Zone, based on Bergström's (1971, p. 91,94; 1973b, p. 12; 1977, p. 91; 1983, p. 42) correlations of the *Eoplacognathus* and *Cahabagnathus* lineages with the *Pygodus* lineage. The *P. serra* zonal correlation is given with some reservation, because no representatives of that species occur in the section, and because the biostratigraphic control in the upper part of the Tulip Creek is poor.

In previous studies, the McLish and Tulip Creek Formations generally have been assigned to the Chazyan and/or Blackriveran Stages of the Middle Ordovician (Champlainian) Series. Conodonts of the Chazy Group (Raring, 1972) include representatives of *Phragmodus flexuosus* (= *P. tortus* Sweet of Raring, 1972, p. 101–104), *Eoplacognathus foliaceous–E. reclinatus* transition (= *E.* n. sp. of Raring, p. 77–80), *Cahabagnathus friendsvillensis,* and *C. chazyensis* (*Polyplacognathus sweeti* of Raring, pl. 2, figs. 18,19). The McLish–Tulip Creek interval appears to be within the biostratigraphic boundaries of the Chazy sequence according to conodont faunal comparisons; therefore, these formations are assigned to the Chazyan Stage.

Harris and others (1979, p. 29–31), using conodont biostratigraphy, summarized some of the relationships between Cooper's (1956) Middle Ordovician stages based on brachiopods and other stadial divisions. Cooper's assignment of the McLish to the Marmorian Stage (see Cooper's correlation chart) is substantiated by the conodont assemblage (as noted by Bergström, 1971, p. 125). Harris and others (1979, p. 29) stated that the type Marmorian contains *Pygodus serra* (reported first by Bergström, 1971, p. 125) and the *Eoplacognathus foliaceus–E. reclinatus* transition, which is present in the lower McLish.

Cooper's (1956) assignment of the Tulip Creek to the Ashbyan Stage is not substantiated by the conodont assemblage. The conodont fauna indicates a Chazyan age for that formation. The Ashbyan Stage, on the other hand, was described by Cooper (1956, p. 8) as having a younger brachiopod fauna than that of the uppermost Chazy Group. Conodont studies of Ashbyan reference sections also have indicated that the Ashbyan is younger than the Chazyan (Carnes and Bergström, 1973; Carnes, 1975, p. 90–95). Cooper (1956, p. 120) relied heavily on the brachiopod *Valcourea* to correlate the Tulip Creek with the Elway Formation (part of the type Ashbyan). Although Cooper reported that genus from the Tulip Creek, there is no reference to its presence in the Elway. Based on the conodont fauna, the Tulip Creek appears to be more closely associated with Cooper's Marmorian Stage.

Ross and others (1982) presented new series divisions of the Ordovician System: Ibexian (lowermost), Whiterockian, Mohawkian, and Cincinnatian (uppermost). The base of the Mohawkian coincides with the base of the *Prioniodus gerdae* conodont subzone (Ross and others, 1982, p. 12). Sweet and Bergström (1973; 1976, p. 128) and Sweet and others (1973) noted the occurrence of *P. gerdae* in the Mountain Lake Member of the Bromide Formation. The conodont fauna characteristic of the upper part of the Whiterockian Series includes conodont fauna 5–6 of Sweet and others (1971) and the *Pygodus serra* and *P. anserinus* Zones of Bergström (1971). The McLish and Tulip Creek are therefore interpreted to represent the upper Whiterockian as shown in the correlation chart of Ross and others (1982) and Sweet (1984, p. 31).

Sweet (1984, p. 31)—using graphic correlation of the ranges of key species, including *Cahabagnathus friendsvillensis, C. sweeti,* and the *Eoplacognathus foliaceus–E. reclinatus* transition—placed the McLish and Tulip Creek approximately between 685 and 790 m in his composite standard section (CSS). (See Amsden and Sweet, 1983, p. 26, for a discussion of graphic methods.) That level corresponds to the *C. friendsvillensis* chronozone and a portion of the *C. sweeti* chronozone (p. 25–26). Considering that *C. sweeti* was not found in the sampled McLish–Tulip Creek sections, and that taxonomic revisions have been made in the *Cahabagnathus* lineage by Bergström (1983, p. 41–43), correlations of the McLish and Tulip Creek presented by Sweet are in need of revision. Graphic analysis based on ranges given in this report (not including ranges of species in the lowermost three samples of the I-35 section) indicates that the McLish–Tulip Creek interval lies entirely within the *C. friendsvillensis* Zone, approximately between 695 and 755 m in the CSS (Text-fig. 3). Further revisions will probably be necessary in the graphic correlation of the

McLish–Tulip Creek once conodont ranges in both that section and the CSS are more clearly known. For instance, bases of the ranges of species 19 and 20 (*Oneotodus*? *ovatus* and *Panderodus panderi*) plot anomalously to the right of the line of correlation (LOC) shown in Text-figure 3. This inconsistency results either from an error in placement of the LOC or, more likely, from an extension of the lowermost occurrence of the two species in the McLish–Tulip Creek section in relation to the CSS.

Strata of the Lower McLish

Samples 82JA-66, -67, -71, taken just above the basal McLish sandstone in the I-35 section, produced conodonts distinctly different from those in succeeding samples. Conodonts referable to *Neomultioistodus, Paraprioniodus, Scandodus*?, and *Histiodella* were recovered from that interval; these conodonts indicate fauna 4 of Sweet and others (1971, p. 169) and the *Histiodella sinuosa* and *Paraprioniodus costatus–Chosonodina rigbyi–Histiodella holodentata* interval of Ethington and Clark (1982, p. 13–14). A sample just above that interval (82JA-76) yielded representatives of fauna 5–6, dominated by *Phragmodus flexuosus*.

The striking difference between conodont faunas over such a short stratigraphic interval can be explained in several ways. The interval may contain a significant hiatus or a fault separating the two faunal associations. The interval may represent a time of great faunal replacement due to competition or to a change in environmental parameters. The interval may also include reworked sediment and fossils.

The hiatus or fault-contact explanations are not consistent with field observations.

If faunal replacement took place through competition or environmental change, one would expect the two faunas, where both are present, to be closely associated in other stratigraphic intervals. The *Neomultiostodus* association has been reported from the Pogonip Group of Utah by Ethington and Clark (1982) and is characteristic of Simpson strata (Joins and Oil Creek Formations) just below the McLish in Oklahoma. Although *Phragmodus flexuosus* is not known in the Pogonip or lower Simpson, a species of *Phragmodus* has been recognized in the Crystal Peak Dolomite of Utah, above the Pogonip; that species, as previously mentioned, also has been reported from the Antelope Valley Limestone of Nevada and is there characteristic of strata older than units containing *P. flexuosus* (Harris and others, 1979, p. 23). It appears, therefore, that the *P. flexuosus* and *Neomultioistodus* associations are separated in some of the Great Basin sequences by strata containing the "pre-*flexuosus*" form of *Phragmodus*. If this is also true in southern Oklahoma, the case for faunal replacement due to competition seems to be very weak.

The lithologies of samples containing the *Neomultioistodus* and *P. flexuosus* associations in the lower McLish are nearly identical; this close lithologic similarity would not be expected among samples representing significantly different environments.

Alternatively, the lower McLish interval could be composed of reworked sediment and fossils. The interval consists of alternating shales and thin dolomitic limestones with gradational contacts; there is no conclusive physical evidence of reworking. A possible mixed association in sample 82JA-71 of the *Phragmodus flexuosus* and *Neomultioistodus* associations along with the apparent admixture of conodonts representing two of Ethington and Clark's (1982) conodont intervals within the *Neomultioistodus* association lends support to the hypothesis of reworked sediment.

The problem of the conodont succession in the lower McLish cannot be resolved with the data at hand. Pending further study, the conodonts of this interval are herein considered reworked.

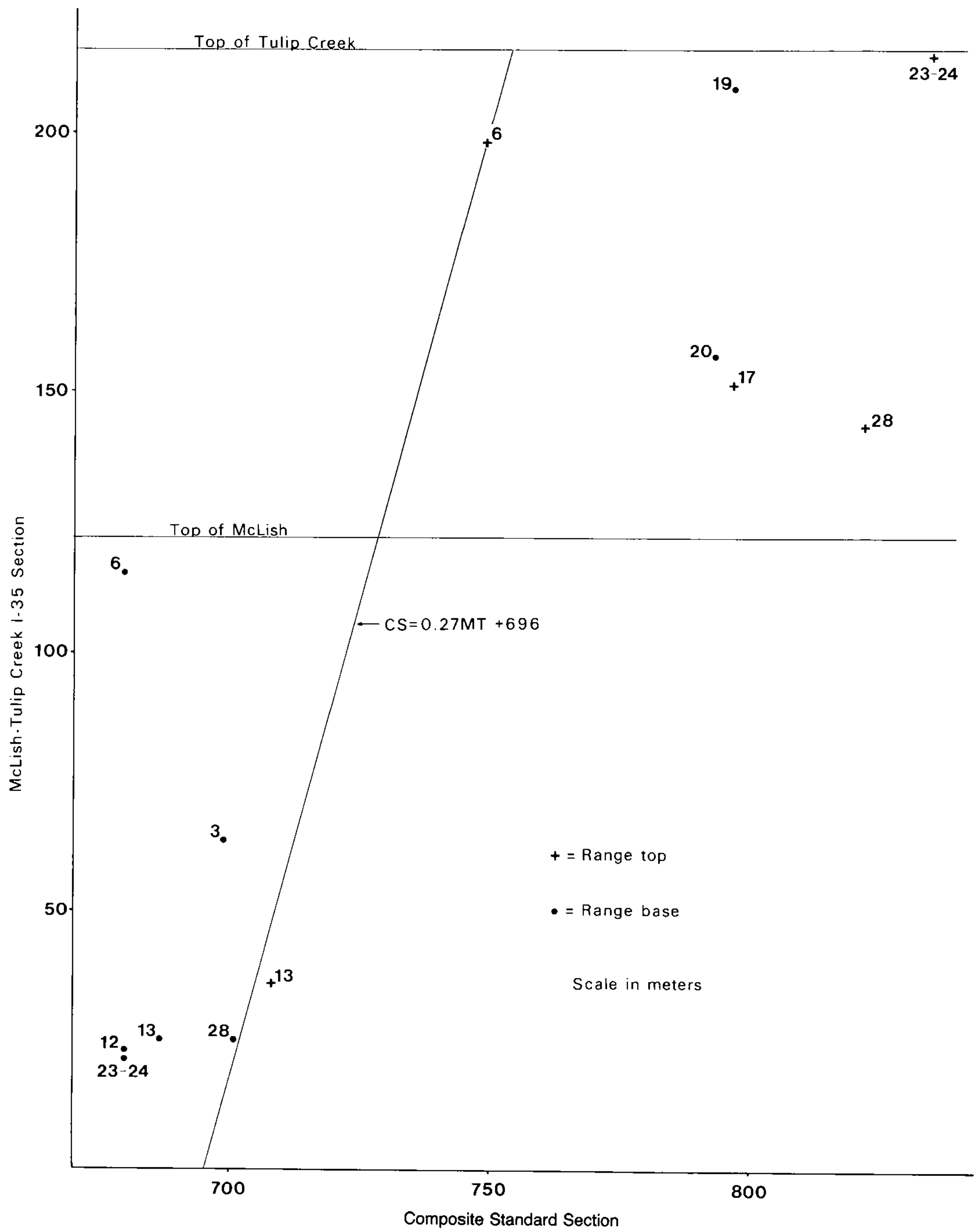
Correlation of the McLish–Tulip Creek interval is shown in Text-figure 4.

ACKNOWLEDGMENTS

Dr. Walter C. Sweet suggested and supervised this research project and reviewed the manuscript. Many ideas and concepts fostered throughout the study and included herein are the result of discussions with Sweet. Dr. Stig M. Bergström contributed many valuable ideas concerning research problems. Assistance by Maureen Lorenz on SEM photomicrographs, Mike Roberts on sample collection, and Karen Tyler on drafting of figures is greatly appreciated. Grants from "Friends of Orton" and an Amoco fellowship (1982–83) helped with financial considerations.

SYSTEMATIC PALEONTOLOGY

Conodont specimens recovered from the McLish and Tulip Creek Formations are described in the following section. "Occurrences" and "Collection" sections of each species description refer to specimens collected from the I-35 section. Distribution of conodonts in the U.S. 77 interval (collected by Sweet, Bergström, and Jaanusson) is given in Appendix 1. Table 1 lists species and total recovered elements from the U.S. 77 section. All illustrated specimens are in the collections of the Orton Geological Museum, The Ohio State University.



Text-figure 3. Graphic correlation of the McLish–Tulip Creek I-35 section with the Composite Standard Section of Sweet (1984). Species identification numbers correspond to those in Table 1 and Appendix 1. Note that *Phragmodus flexuosus* morphotypes A and B are combined (23–24), because they are not differentiated in the CSS.

Formation		I.U.G.S. N. American Series	Stage	N. Atlantic Conodont Zones	Conodont Fauna
Bromide	Mountain Lake	Mohawkian	Blackriveran	*A. tvaerensis*	7
		Whiterockian	Chazyan	*Pygodus anserinus*	5-6
Tulip Creek				*Pygodus serra*	
McLish					
Oil Creek					4

Text-figure 4. Correlation of the McLish–Tulip Creek interval and adjacent units. I.U.G.S. North American series from Ross and others (1982). North Atlantic conodont zones from Bergström (1971). Numbered conodont faunas from Sweet and others (1971). Correlation of Bromide and Oil Creek Formations is based on reports by Sweet and others (1971), Sweet and Bergström (1973,1976), and Sweet and others (1973), and on undescribed conodont collections stored at The Ohio State University. Boundaries of the Chazyan are somewhat uncertain.

Genus **Belodella** Ethington, 1959

Type species.—Belodus devonicus Stauffer, 1940.

Belodella sp. cf. **B. jemtlandica** Löfgren, 1978
Pl. 1, Figs. 2–4,9; Text-fig. 5B

cf. *Belodella jemtlandica* Löfgren, 1978, p. 46–49, pl. 15, figs. 1–8, text-figs. 24A–D; Cooper, 1981, pl. 26, fig. 14; An Tai-xiang and others, 1983, p. 77, pl. XXV, figs. 8–12; Stouge, 1984, p. 60, pl. 6, figs. 13–23, pl. 7, figs. 1–4.
cf. *Belodella erecta* (Rhodes and Dineley). Barnes and Poplawski, 1973, p. 769, pl. 4, figs. 19–20.
cf. *Belodella* n. sp. s.f. Barnes and Poplawski, 1973, p. 769, pl. 4, figs. 5,9,10,18,18a, text-fig. 2F.
cf. *"Belodella" jemtlandica* Löfgren. Dzik, 1983, figs. 6–18.

Description.—Apparatus quadrimembrate, composed of geniculate coniform and three types of rastrate elements distinguished by their cross section and termed biconvex, planoconvex, and triangular by Löfgren (1978, p. 46–48). Biconvex rastrate element subtriangular in cross section, keeled anteriorly and posteriorly. Posterior margin sharp, adenticulate; one side expanded slightly more than the other. Expanded side has broad, anterolateral carina.

Planoconvex rastrate element keeled anteriorly and slightly twisted. Posterior margin has series of denticles inclined toward cusp apex.

Triangular rastrate element keeled anterolaterally; posterior margin variably denticulated. In most specimens, large denticles alternate with smaller ones.

Geniculate coniform element laterally bowed; base expanded; cusp keeled anteriorly and posteriorly. Side of cusp toward which element is bowed bears broad carina; other side smoothly convex.

Discussion.—Belodella was discussed in detail by Löfgren (1978, p. 46–49), who distinguished three species based on characters of their biconvex rastrate element. That element in the apparatus of *B. jemtlandica* differs from those in the other two species, *B. erecta* and *B. nevadensis* (Ethington and Schumacher), by having an undenticulated posterior margin.

Ethington and Clark (1982, p. 25–27) described an additional species of *Belodella, B. robusta,* from the Lehman Formation and Crystal Peak Dolomite of Utah. That species has an undenticulated biconvex rastrate element distinguished from that of *B. jemtlandica* by having longitudinal ridges on the lateral surfaces. Ethington and Clark (1982, p. 26) also observed that *B. robusta* has coarse, variable denticles on the triangular element and coarse, erect denticles on the planoconvex element. Figures of *B. jemtlandica* (Löfgren, 1978, pl. 15, figs. 1–4) show finer, more-uniform denticles on triangular and planoconvex elements. Furthermore, denticles on the planoconvex element are inclined toward the cusp.

Specimens of *Belodella* recovered from the McLish–Tulip Creek section have undenticulated biconvex rastrate elements. I have referred most of those forms to *B.* sp. cf. *B. jemtlandica* because their biconvex elements do not exhibit the pronounced longitudinal ridges described in *B. robusta* by Ethington and Clark (1982, p. 26). However, some of the forms assigned to *B.* sp. cf. *B. jemtlandica* display the coarse, variable denticulation of *B. robusta.* Size and arrangement of denticles in *Belodella* vary markedly both within samples and vertically in the sequence and, consequently, may not be of use in distinguishing species. (See Text-fig. 5.)

Occurrence.—Belodella sp. cf. *B. jemtlandica* is represented in the McLish Formation 76–400 ft above the base of the section. Specimens that may represent the same species have been reported from the Mystic Formation of Quebec (Barnes and Poplawski, 1973, p. 769); from the Horn Valley Siltstone of Australia (Cooper, 1981, pl. 26, fig. 14); and from the Table Head Formation of Newfoundland (Stouge, 1984). Löfgren (1978, p. 46–49) described *B. jemtlandica* from the Lunne quarry in Sweden.

Collection.—158 specimens (38 biconvex elements, 28 planoconvex elements, 65 triangular elements, 27 geniculate coniform elements).

Figured specimens.—OSU 37191–37194, inclusive.

Belodella robusta Ethington and Clark, 1982
Pl. 1, Figs. 1,5,8; Text-fig. 5C

Paltodus? sp. ETHINGTON AND SCHUMACHER, 1969, p. 468, pl. 69, fig. 13.
Roundya sp. B ETHINGTON AND SCHUMACHER, 1969, p. 475–476, pl. 67, fig. 24.
Belodella robusta ETHINGTON AND CLARK, 1982, p. 25–27, pl. 2, figs. 1–4.
Belodella rigida n. sp. AN TAI-XIANG AND OTHERS, 1983, p. 77–79, pl. XVIII, figs. 12–18, text-fig. 12 (24–27).
?*Belodella sinuosa* n. sp. STOUGE, 1984, p. 60–61, pl. 7, figs. 5–14.

Discussion.—The apparatus of *Belodella robusta,* which is described in detail by Ethington and Clark (1982, p. 26), differs from that of *B. jemtlandica* by having a biconvex rastrate element with longitudinal ridges on each side. Distinctions between the two species based on denticulation of the triangular and planoconvex elements (Ethington and Clark, 1982, p. 26) are not recognized in specimens recovered from the McLish–Tulip Creek section.

The apparatus of *Belodella robusta* differs from that of *B. nevadensis* by having an undenticulated biconvex rastrate element. The biconvex element of *B. nevadensis* has lateral costae much like those of *B. robusta,* but the "posterior margin is broken by well-developed denticles" (Ethington and Clark, 1982, p. 26).

Occurrence.—Between 97 and 534 ft in the section. Other occurrences include those mentioned by Ethington and Clark (1982, p. 27) in the Crystal Peak Dolomite and the Lehman Formation of Utah; also found in the Copenhagen Formation of Nevada (Ethington and Schumacher, 1969), and the Womble Shale of Arkansas (Repetski and Ethington, 1977).

Collection.—33 specimens (11 biconvex elements, 7 planoconvex elements, 13 triangular elements, 2 geniculate coniform elements).

Figured specimens.—OSU 37195–37197, inclusive.

Genus **Belodina** Ethington, 1959

Belodina ETHINGTON, 1959, p. 271.
Eobelodina SWEET AND OTHERS, 1959, p. 1050.

Type species.—Belodus compressus Branson and Mehl, 1933b.

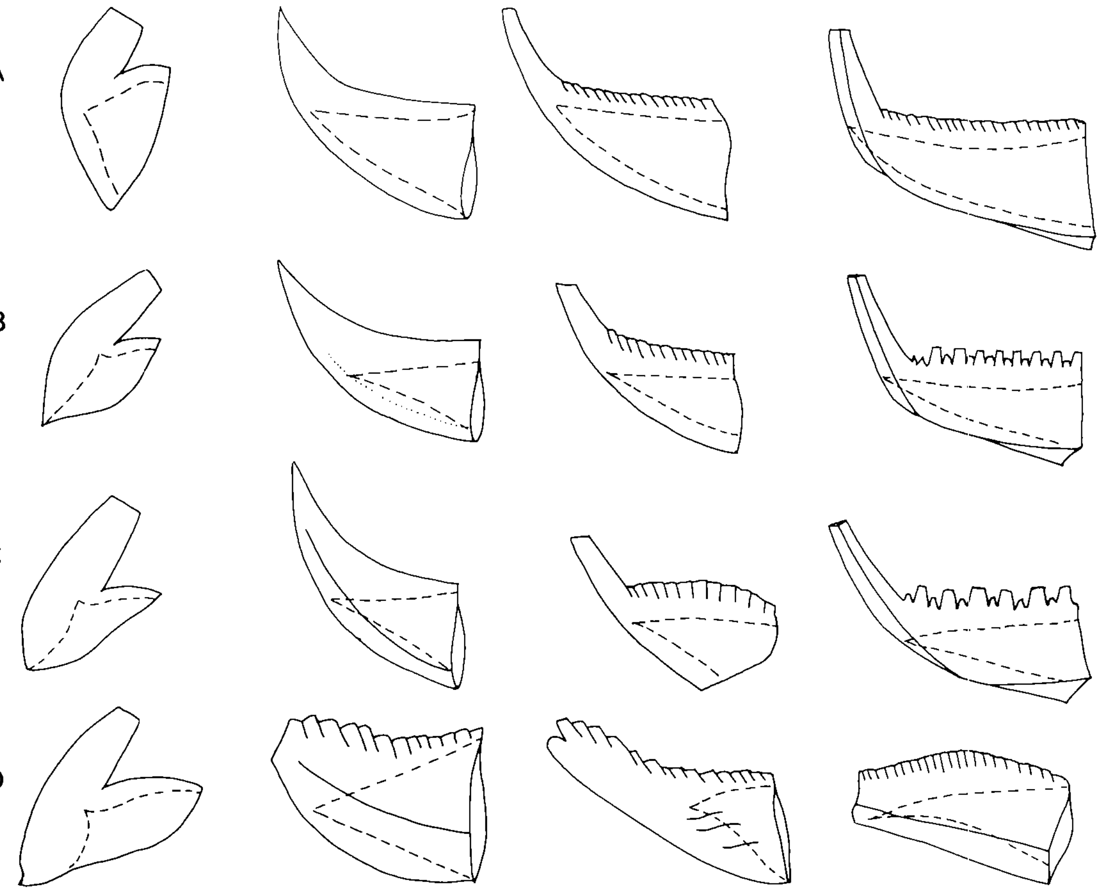
Belodina monitorensis Ethington and Schumacher, 1969
Pl. 1, Figs. 10,13,14

Belodina monitorensis ETHINGTON AND SCHUMACHER, 1969, p. 455–456; BERGSTRÖM, 1978, p. 736, pl. 79, figs. 18,19; SWEET, 1981, p. 79–81, pl. 1, figs. 10,11, pl. 2, figs. 5–7 (synonymy through 1981); DZIK, 1983, figs. 3-17, 3-18.

Description.—Apparatus trimembrate; consists of geniculate coniform (eobelodiniform) and two types of rastrate (belodiniform) elements described as grandiform and compressiform.

Remarks.—Belodina monitorensis was introduced in form taxonomy by Ethington and Schumacher (1969, p. 455–456) and has been described in multielement taxonomy by Carnes (1975, p. 117–120) and Sweet (1981, p. 79–81). Specimens recovered in this study are consistent with those detailed descriptions.

Belodina monitorensis is sparsely represented in the McLish and Tulip Creek Formations.



Text-figure 5. Comparison of corresponding skeletal elements of *Belodella*. Elements of a single apparatus are arranged horizontally (from left to right: geniculate coniform, biconvex, planoconvex, and triangular elements). *A*, apparatus of *B. jemtlandica* (after Löfgren, 1978). *B*, apparatus of *B.* sp. cf. *B. jemtlandica* (this report). *C*, apparatus of *B. robusta* Ethington and Clark. *D*, apparatus of *B. nevadensis* (after Ethington and Schumacher, 1969).

Among the 47 recovered elements, grandiform elements are most common; nearly all exhibit marked asymmetry.

Occurrence.—Belodina monitorensis was found from a level near the middle of the McLish Formation (210 ft above the base of the section) to a level near the top of the Tulip Creek Formation. Other North American occurrences are in the Copenhagen Formation of central Nevada (Ethington and Schumacher, 1969, p. 455–456); the Pratt Ferry Formation of Alabama (Sweet and Bergström, 1962, p. 1224 [= *B. grandis*]); the Holston Formation, Lenoir Limestone, Sevier Shale, and Chota Formation of Tennessee (Carnes, 1975; Bergström and Carnes, 1976, p. 48–49); the Woods Hollow Shale of Texas (Bergström, 1978); the Antelope Valley Limestone of Nevada (Harris and others, 1979, p. 10); and the Chickamauga Limestone of Georgia and Alabama (Schmidt, 1982, p. 119–120).

Collection.—47 specimens (9 geniculate coniform, 11 compressiform, 26 asymmetrical grandiform, 1 symmetrical grandiform).

Figured specimens.—OSU 37198–37200, inclusive.

Genus **Bryantodina** Stauffer, 1935

Type species.—Bryantodina typicalis Stauffer, 1935.

"Bryantodina" sp.
Pl. 1, Fig. 6

Description.—From a small number of recovered specimens, apparatus appears to be unimembrate, composed of a carminate pectiniform element. Basal cavity narrow, shallow, and expands variably near midlength; base hyaline; denticles erect and fused through most of their length.

White matter within individual denticles discrete from that of other denticles.

Remarks.—If the skeletal apparatus is unimembrate, consisting only of bladelike elements, it may be related to that of *Jumudontus gananda* Cooper (1981, p. 170–172), a widely distributed Lower Ordovician conodont. The element of "*Bryantodina*" sp. differs most notably from that of *J. gananda* by having erect rather than anteriorly inclined denticles.

"*Bryantodina*" sp. is similar to *Histiodella* n. sp. 2 Harris and others (1979, pl. 4, figs. 12,13) in overall morphology. The skeletal apparatus of both species appears to consist of a bladelike element with fused denticles and a basal expansion near midlength. However, elements of "*B.*" sp. differ from those of *Histiodella* by having white matter restricted to individual denticles and separate from that of adjacent denticles. Blades of *Histiodella* skeletal elements are entirely albid.

The assignment of forms discussed here to "*Bryantodina*" is based strictly on morphology of the single skeletal element. *Bryantodina* has a multimembrate apparatus, as suggested by Webers (1966, p. 49–52), and therefore probably is not closely related to "*B.*" sp.

"*Bryantodina*" sp. occurs in strata containing elements referable to *Neomultioistodus, Paraprioniodus,* and *Histiodella* n. sp. 2. That interval is assumed to contain reworked fossils. Specimens of "*B.*" sp. are fragmentary.

Occurrence.—"*Bryantodina*" sp. is represented at horizons 66 and 67 ft above the base of the section.

Collection.—22 specimens.

Figured specimen.—OSU 37201.

Genus **Cahabagnathus** Bergström, 1983

Petalognathus Drygant, 1974.

Type species.—*Polyplacognathus sweeti* Bergström, 1971.

Remarks.—The following species belonging to *Cahabagnathus* are described according to process designations in Bergström (1983, p. 51). However, illustrated pastiniplanate elements have not been reoriented. Consequently, the anterior process is directed horizontally and the posterior downward in all illustrations of pastiniplanate elements of *Cahabagnathus.*

Cahabagnathus chazyensis Bergström, 1983
Pl. 4, Fig. 15

Cahabagnathus chazyensis Bergström, 1983, p. 54, fig. 6M–P (includes synonymy to date).

Remarks.—One pastiniplanate (ambalodontiform) element from near the top of the Tulip Creek (sample 82JA-684) shows a gap in the main denticle row formed at the proximal part of the anterior process. That character is indicative of *Cahabagnathus chazyensis.* No stelliplanate element was found in association with the pastiniplanate element.

Collection.—One specimen.

Figured specimen.—OSU 37268.

Cahabagnathus friendsvillensis
(Bergström, 1971)
Pl. 4, Figs. 7,11

Polyplacognathus friendsvillensis Bergström, 1971, p. 142–143, pl. 1, figs. 3,4, text-fig. 14; Tipnis and others, 1978, pl. IX, figs. 1,3,5; Harris and others, 1979, pl. 2, figs. 16,17; Dzik, 1983, fig. 8-4.

Remarks.—Bergström's (1971) description of *Cahabagnathus friendsvillensis* (= *Polyplacognathus friendsvillensis* of that report) is adequate for specimens recovered from the McLish and Tulip Creek.

Occurrence.—*Cahabagnathus friendsvillensis* was found between 377 and 649 ft above the base of the section. *C. friendsvillensis* also has been reported from the Lenoir Limestone of eastern Tennessee (Bergström, 1971,1973c; Bergström and Carnes, 1976, p. 48); Day Point Formation of the Chazy Group of New York and Vermont (Raring, 1972, p. 113–116); St. Dominique Limestone of Quebec (Roscoe, 1973, p. 90–91); Row Park Limestone and Pinesburg Station Dolomite of West Virginia (Boger, 1976, p. 106–107); Road River Formation, southern District of Mackenzie, Canada (Tipnis and others, 1978); Antelope Valley Limestone of Nevada (Harris and others, 1979); and Lenoir Limestone of Georgia and Alabama (Schmidt, 1982, p. 169–170).

Collection.—40 specimens (13 stelliplanate, 27 pastiniplanate)

Figured specimens.—OSU 37266 and 37267.

Cahabagnathus directus n. sp.
Pl. 4, Figs. 6,10,13

Cahabagnathus n. sp. A, Bergström, 1983, p. 53, fig. 6Q,R.

Diagnosis.—The pastiniplanate (ambalodontiform) element of *Cahabagnathus directus* differs from that of other closely related forms by having a combination of a straight denticle row on the anterior process and a relatively wide, rounded posterior process.

Description.—Apparatus bimembrate, composed of pastiniplanate and stelliplanate (polyplacognathiform) pectiniform elements. Pastiniplanate element has wide, rounded posterior process with centrally located row of short denticles extending to a point near the distal margin; anterior process triangular in outline with row of denticles straight and continuous with that of the posterior process; lateral process short with curved row of few short denticles.

Stelliplanate element similar to that of *Cahabagnathus friendsvillensis*. Posterior process relatively long and wide; posterolateral process short, wide, triangular to rhomboidal in outline, bears relatively large denticles; anterolateral process bifid with short anterior lobe and long posterior lobe equal in length to the posterior process.

Remarks.—The pastiniplanate element of *Cahabagnathus directus* differs from that of *C. friendsvillensis* in having a wide, rounded posterior process and a straight denticle row on the anterior process. The general outline of the element is similar to that of comparable elements of *C. sweeti*, but the denticulation patterns are quite different. Most notably, the main denticle row of pastiniplanate elements of *C. directus* is continuous, whereas that of similar elements of *C. sweeti* has a gap near the proximal part of the anterior process (Bergström, 1971, p. 143). The stelliplanate element of *C. directus* is very similar to that of *C. friendsvillensis*.

Derivation of name.—Specific name is from the Latin *directus* (straight) and refers to the character of the denticle row on the anterior process.

Occurrence.—*Cahabagnathus directus* was found 321–375 ft above the base of the section (upper McLish).

Collection.—77 specimens (48 pastiniplanate, 29 stelliplanate).

Figured specimens.—OSU 37270 (holotype), OSU 37269, 37271 (paratypes).

Cahabagnathus sp.
Pl. 4, Figs. 8,9

Description.—Apparatus consists of pastiniplanate and stelliplanate pectiniform elements. Pastiniplanate element has subequal anterior and posterior processes. Main denticle row extends continuously from the anterior to posterior process. Lateral process short. Element lacks conspicuous nodes and ridges.

Stelliplanate element has anterior, posterior, posterolateral, and anterolateral processes. Element similar to corresponding element of *Cahabagnathus friendsvillensis* but lacks bifid anterolateral process.

Remarks.—Available specimens of *Cahabagnathus* sp. are few and small and most are broken. Examined forms appear to represent either a species closely related to or a developmental stage of *C. friendsvillensis*, although they lack the distinct node and ridge ornamentation (*C.* sp. does have a reticulated pattern of ornamentation) and the bifid anterolateral process characteristic of the stelliplanate element of *C. friendsvillensis*.

Occurrence.—Between 158 and 260 ft in the section (middle McLish).

Collection.—45 specimens (39 pastiniplanate, 6 stelliplanate).

Figured specimens.—OSU 37272 and 37273.

Genus **Coleodus** Branson and Mehl, 1933a

Type species.—*Coleodus simplex* Branson and Mehl, 1933a.

Coleodus? sp.
Pl. 1, Fig. 7

Remarks.—One fragment of a hyaline bladelike form was recovered. Generic determination cannot be confidently made.

Occurrence.—*Coleodus*? sp. was found in a sample 123 ft above the base of section.

Collection.—One specimen.

Figured specimen.—OSU 37202.

Genus **Dapsilodus** Cooper, 1976

Type species.—*Distacodus obliquicostatus* Branson and Mehl, 1933.

Dapsilodus? nevadensis
(Ethington and Schumacher, 1969)
Pl. 1, Figs. 11,12

Acontiodus nevadensis ETHINGTON AND SCHUMACHER, 1969, p. 450,452, pl. 67, figs. 21,22, text-fig. 4C.
Dapsilodus? *nevadensis* (Ethington and Schumacher). ETHINGTON AND CLARK, 1982, p. 35, pl. 3, fig. 1 (includes synonymy).
Dapsilodus compressus n. sp. AN TAI-XIANG AND OTHERS, 1983, p. 90, pl. XXVI, figs. 10–14, text-fig. 12 (nos. 13–15).
Besselodus sp. DZIK, 1983, fig. 4-8.
?*Distacodus variabilis* WEBERS, 1966, p. 28, pl. 2, figs. 15–17.

Description.—Three specimens recovered from the Tulip Creek Formation appear to be representatives of *Dapsilodus*? *nevadensis*. Those specimens are nongeniculate coniform elements that are laterally compressed and sharply keeled posteriorly. The basal cavity is deep and triangular in lateral profile.

Two of the specimens are distacodontiform and bear symmetrically disposed lateral costae. The third specimen is scandodontiform and has a slightly twisted cusp and no observable lateral costae.

Remarks.—Cooper (1976, p. 211) described the skeletal apparatus of *Dapsilodus*, which consists of acodontiform elements and a series of distacodontiform elements. Scandodontiform and distacodontiform elements are represented in the apparatus of *D.*? *nevadensis*. The presence of a lateral costa on the scandodontiform element would make the apparatus of *D.*? *nevadensis* (as presently known) conform to Cooper's (1976) definition of *Dapsilodus*.

Aldridge (1982, p. 425–430) reported a fused cluster of Upper Ordovician conodont elements including elements identified as *Dapsilodus*. He referred those elements to a new genus, *Besselodus*. From the material described herein, it cannot be resolved whether the Middle Ordovician apparatus is similar to Aldridge's *Besselodus*.

Dapsilodus? *nevadensis* was recognized from the Copenhagen Formation of Nevada (*Acontiodus nevadensis* and *Distacodus* aff. *D. bigdoeyensis* of Ethington and Schumacher, 1969, p. 450,452,460–461). Ethington and Clark (1982) later reported *D.*? *nevadensis* from the Crystal Peak Dolomite of Utah and noted the equivalence of that species with the one from the Copenhagen Formation. Dzik (1983, p. 68) reported *D.*? *nevadensis* (= *Besselodus* sp.) from the Mountain Lake Member of the Bromide Formation.

Carnes (1975, p. 104–106) and Schmidt (1982, 100–106) reported specimens in their collections that appear to be the same as *D.*? *nevadensis*. Both authors referred their specimens to "*Acodus*" *variabilis,* citing Webers's (1966) *Distacodus variabilis* as an identical form. If Carnes and Schmidt are correct in their comparisons with *D. variabilis,* then the specific designation given here is in error.

Occurrence.—This species is represented at 534 ft above the base of the section, approximately 175 ft below the Tulip Creek–Bromide contact.

Collection.—3 specimens (2 distacodontiform, 1 scandodontiform).

Figured specimens.—OSU 37203 and 37204.

Genus **Drepanoistodus** Lindström, 1971

Type species.—*Oistodus forceps* Lindström, 1955.

Drepanoistodus angulensis (Harris, 1962)
Pl. 1, Figs. 18–21

Oistodus angulensis HARRIS, 1962, p. 199–201, pl. 1, figs. 1a–c.

Drepanoistodus angulensis (Harris). ETHINGTON AND CLARK, 1982, p. 41–42, pl. 3, figs. 18–21 (includes synonymy through 1981); DZIK, 1983, fig. 4-12.

Remarks.—As noted by Ethington and Clark (1982), the most diagnostic element of *Drepanoistodus angulensis* is the geniculate coniform element. It differs from the corresponding elements of *D. forceps* (Lindström) and *D. basiovalis* (Sergeeva) by having a "relatively short posterior base" (Ethington and Clark, 1982, p. 42). The differences between the geniculate coniform element of *D. angulensis* and that of *D. suberectus* are much more subtle. The angle enclosed by the posterior margin of the cusp and the upper basal surface is generally smaller in the geniculate coniform element of *D. angulensis* than in that of *D. suberectus,* as noted by Ethington and Clark (1982).

Occurrence.—*Drepanoistodus angulensis* was found at 66 and 67 ft above the base of the section. That interval contains representatives of *Neomultioistodus compressus* and associated species. Ethington and Clark (1982) reported occurrences of *D. angulensis* in the Lehman Formation, Kanosh Formation, and lower Watson Ranch Quartzite of Utah. Other occurrences include the Joins (Harris, 1962; Mound, 1965b) and Oil Creek (Dzik, 1983) Formations of Oklahoma; and the Fort Peña Formation of Texas (Graves and Ellison, 1941; Bradshaw, 1969).

Collection.—66 specimens (16 geniculate coniform, 14 homocurvatiform, 20 suberectiform, 16 scandodontiform).

Figured specimens.—OSU 37205–37208, inclusive.

Drepanoistodus suberectus
(Branson and Mehl)
Pl. 1, Figs. 15–17,22

Oistodus suberectus BRANSON AND MEHL, 1933b, p. 111, pl. 9, fig. 7.

Drepanodus suberectus (Branson and Mehl). BERGSTRÖM AND SWEET, 1966, p. 330–333, pl. 35, figs. 22–27; OBERG, 1966, p. 137–138, pl. 16, fig. 1; GLOBENSKY AND JAUFFRED, 1971, p. 55, pl. IV, figs. 3–6 (synonymy through 1969); UYENO, 1974, p. 14, pl. 1, figs. 5–9 (synonymy through 1973).

Drepanodus homocurvatus Lindström. OBERG, 1966, p. 137, pl. 16, fig. 13; ANDREWS, 1967, p. 889, pl. 113, fig. 16, pl. 114, figs. 8,15.

Oistodus inclinatus Branson and Mehl. OBERG, 1966, p. 139, pl. 15, fig. 3; ANDREWS, 1967, p. 895, pl. 114, fig. 19; ETHINGTON AND SCHUMACHER, 1969, p. 467, pl. 68, fig. 7.

Oistodus excelsus Stauffer. OBERG, 1966, p. 139, pl. 15, fig. 2.

Drepanoistodus suberectus (Branson and Mehl). BARNES, 1977, p. 106, pl. 3, figs. 18–20; TIPNIS AND OTHERS, 1978, pl. I, figs. 25–27; BOLTON AND NOWLAN, 1979, p. 18, pl. 7, figs. 11,15,16; SWEET, 1979, fig. 7, nos. 21,23,30; NOWLAN AND BARNES, 1981, p. 12–13, pl. 4, figs. 17–19 (includes synonymy) SWEET, 1982, pl. 1, figs. 7,8,11,18,19; DZIK, 1983, figs. 4-10, 4-11.

Remarks.—The skeletal apparatus of *Drepanoistodus suberectus* consists of inclinatiform, suberectiform, and homocurvatiform elements according to Bergström and Sweet (1966). Carnes (1975, p. 129–132) divided homocurvatiform elements into three distinct, intergradational forms based on the character of the base.

Occurrence.—Elements of *Drepanoistodus suberectus* are common throughout the McLish and Tulip Creek.

Collection.—825 specimens (554 homocurvatiform, 111 suberectiform, 114 inclinatiform, 46 indeterminate).

Figured specimens.—OSU 37209–37212, inclusive.

Genus **Eoplacognathus** Hamar, 1966

Type species.—*Ambalodus lindstroemi* Hamar, 1964.

Eoplacognathus sp.
Pl. 2, Figs. 1,2,4

Eoplacognathus foliaceus (Fåhraeus)–*E. reclinatus* Fåhraeus transition HARRIS AND OTHERS, 1979, pl. 2, figs. 6,7; BERGSTRÖM, 1983, p. 42, fig. 2.

Description.—Skeletal apparatus composed of stelliplanate (polyplacognathiform) and pastiniplanate (ambalodontiform) pectiniform elements. Stelliplanate element has wide, distally pointed posterior process; short, triangularly shaped anterior process; and bifid anterolateral process with long, sinuous posterior lobe and short anterior lobe.

Dextral pastiniplanate element has relatively long, distally pointed anterior process; wide, subrounded posterior process; and relatively narrow, distally pointed lateral process; angle between margins of posterior and lateral processes is ~ 90°. Sinistral form like dextral form, except angle between margins of posterior and lateral processes approaches 180°.

Discussion.—Elements of *Eoplacognathus* sp. are very similar to the forms figured by Harris and others (1979), which they termed typical of the *E. foliaceus–E. reclinatus* transition. The stelliplanate element of *E.* sp. differs from those of *E. foliaceus* and *E. reclinatus* in the character of the posterolateral and anterolateral processes.

In *Eoplacognathus* sp., the denticle row on the posterolateral process of the stelliplanate element is directed posteriorly at an acute angle to the denticle row on the posterior process. The corresponding denticle row on the stelliplanate element of *E. foliaceus* and *E. reclinatus* is directed laterally, and in *E. reclinatus* the row is shortened.

The posterior lobe of the bifid anterolateral process observed in the stelliplanate element of *Eoplacognathus* sp. has an anterior curved row of denticles. The corresponding lobe in *E. foliaceus* and *E. reclinatus* has a nearly straight denticle row. There is also a slight difference between *E.* sp. and the other two forms in the curvature of the main denticle row.

The pastiniplanate elements of *Eoplacognathus* sp. are similar to those of *E. foliaceus*. The sinistral pastiniplanate element of the *E. foliaceus–E. reclinatus* transition has a slightly more sinuous row of denticles on the anterior process than in *E.* sp. The sinistral pastiniplanate element of *E.* sp. figured in this report appears to represent a morphotype more closely associated to *E. foliaceus*.

Remarks.—Harris and others (1979, p. 29) noted that the *Eoplacognathus foliaceus–E. reclinatus* transition may be a very significant guide to the lower Chazyan.

Occurrence.—*Eoplacognathus* sp. was found in the McLish Formation between 81 and 117 ft above the base of the section. Harris and others (1979) noted occurrences of the *E. foliaceus–E. reclinatus* transition in a 5-m interval above the McLish sandstone of Oklahoma and in the upper 15 m of the Antelope Valley Limestone of Nevada. Other occurrences of the transition are in the lower Day Point Formation (Chazy Group) of New York (Raring, 1972, p. 77–80 [= *E.* n. sp.]), and the Lenoir Limestone of Tennessee (*E. foliaceus* of Bergström, 1973c as noted by Harris and others, 1979, p. 29).

Collection.—15 specimens (7 stelliplanate, 8 pastiniplanate).

Figured specimens.—OSU 37213–37215, inclusive.

Genus **Erismodus** Branson and Mehl, 1933a

Erismodus BRANSON AND MEHL, 1933a, p. 25.
Microcoelodus Branson and Mehl, 1933b, p. 89.
Pteroconus BRANSON AND MEHL, 1933a, p. 99.
Ptiloconus SWEET, 1955, p. 245–246.

Type species.—*Erismodus typus* Branson and Mehl, 1933a.

Discussion.—Carnes (1975, p. 138–141) and Sweet (1982, p. 1040) recognized seven elements in the reconstructed skeletal apparatus of *Erismodus*. Those seven elements included digyrate (prioniodiniform) Pa, digyrate (oulodontiform) Pb, bipennate (modified falodontiform) M with an adenticulate posterior process, alate (trichonodelliform) Sa, tertiopedate (asymmetrical trichonodelliform) Sba, digyrate (zygognathiform) Sbb, and bipennate (eoligonodiniform) Sc elements. Sweet (1982) concluded that the M element was probably most characteristic of the apparatus.

Chirognathus Branson and Mehl, *Oulodus* Branson and Mehl, and *Erraticodon* Dzik have skeletal apparatuses that are very similar to that of *Erismodus*. Sweet (1982, p. 1039–1040) discussed similarities and differences between *Erismodus* and *Chirognathus*.

The skeletal elements of *Erismodus*, despite being hyaline and fibrous, are very similar to those of *Oulodus*, as noted by Sweet and Schönlaub (1975, p. 44). The *Oulodus* apparatus consists of six elements, compared to seven in the *Erismodus* apparatus. Division of the Sb position of the latter into Sba and Sbb positions accounts for that difference. Distinction between the two apparatuses based on the number of elements may be somewhat artificial, because the S elements are a series of gradational forms subject to arbitrary classification. The focus, therefore, probably should be directed to the M position, as suggested by Sweet (1982).

The M element of *Oulodus* is dolabrate or bipennate and has a well-developed posterior process. The M element of *Erismodus* is bipennate, yet only the anterior process of described species is developed and denticulate. Other corresponding elements of *Oulodus* and *Erismodus,* including the characteristic digyrate Pb element, are very similar.

Dzik (1978, p. 64–66) described the skeletal apparatus of *Erraticodon* and included five elements in his reconstruction. That apparatus does not appear to be complete, as elements referable to the P position are missing. Cooper (1981, p. 164–166) emended the diagnosis of *Erraticodon,* including pastinate-like Pa and digyrate Pb elements and excluding one element from the symmetry-transition series (Sbb). The apparatus of *Erraticodon* as interpreted in this report has seven elements including the Sbb element.

The symmetry-transition series of *Erraticodon* is similar to that of *Erismodus* and *Oulodus*. However, the Sa element of *Erraticodon* has a well-developed, denticulate posterior process, whereas the other two genera have no observable development of that process. The M element of *Erraticodon* is similar to that of *Oulodus,* but differs from that of *Erismodus* in having a developed posterior process. The Pa element of *Erraticodon* is pastinate-like with three processes, whereas Pa elements of *Oulodus* and *Erismodus* are digyrate with two processes. Pb elements are similar in all three genera.

Erismodus arbucklensis n. sp.
Pl. 2, Figs. 3,5,7–9,11,12

Diagnosis.—Species distinguished from congeneric taxa by having an Sa element with a markedly compressed cusp and S elements with widely spaced, marginally costate denticles compressed anteroposteriorly.

Description.—Apparatus composed of seven types of hyaline elements. Sa element alate; cusp long, recurved, compressed laterally, bearing anterior and anterolateral costae and posterior keel which extends to basal margin. Anterolateral costae produced into symmetrically disposed processes bearing a few widely spaced denticles of variable length. Processes and denticles compressed anteroposteriorly. Sba element like Sa, but processes not symmetrically disposed and posterior keel does not extend to basal margin.

Sbb element digyrate; cusp smooth posteriorly and anteriorly, costate laterally. One lateral process directed posteriorly, the other anteriorly and downward. Denticulation on processes like that of Sa element.

Sc element bipennate; cusp keeled anteriorly and posteriorly. Posterior process has short, widely spaced denticles; anterior process short, weakly denticulate, and laterally deflected.

Pa element digyrate; cusp costate laterally. Lateral processes turned slightly posteriorly; each bears long, thin, closely spaced, keeled denticles. Pb element digyrate; cusp erect; lateral processes twisted in opposite directions, one directed downward. M element bipennate; anterior process short, bearing small, closely spaced denticles; posterior process short and adenticulate.

Remarks.—Elements of this species are small and delicate; consequently, they are difficult to compare to the more robust forms of *E. quadridactylus* (Stauffer). As noted by Sweet (1982, p. 1041), the skeletal elements of *E. quadridactylus* are distinguishable from those of other *Erismodus* species by having "slender, marginally costate denticles, which are compressed in the planes of the processes that bear them."

The skeletal apparatus of *Erismodus arbucklensis* is similar to that of *E. quadridactylus.* However, the Sa element of *E. arbucklensis* differs by having a more compressed cusp. Futhermore, S elements of *E. arbucklensis* have more widely spaced, generally shorter denticles than those of *E. quadridactylus.*

Comparison of *Erismodus arbucklensis* with *E. asymmetricus* (Branson and Mehl) is difficult because descriptions of the latter by Branson and Mehl (1933), Andrews (1967), and Ethington and Clark (1982, p. 43–44) do not include all corresponding elements described in this report. However, Andrews (1967, p. 893–894) observed that the denticles of form-species *E. asymmetricus* (Sb? element) and *E. symmetricus* (Sa element) are round in cross section. By comparison, the denticles of corresponding elements of *E. arbucklensis* are compressed and laterally costate.

M elements of *Erismodus arbucklensis* are rare in the present material. The element is a small, conical form and may have been lost during sieving.

Derivation of name.—Specific name refers to the Arbuckle Mountains of south-central Oklahoma.

Occurrence.—Erismodus arbucklensis was found between 123 and 484 ft above the base of the section.

Collection.—98 specimens (12 Pa, 14 Pb, 2 M, 6 Sa, 13 Sba, 22 Sbb, 29 Sc).

Figured specimens.—OSU 37218 (holotype), 37216, 37217, 37219, 37220, 37221, 37222 (paratypes).

Genus **Erraticodon** Dzik, 1978

Type species.—Erraticodon balticus Dzik, 1978.
Remarks.—The discussion of *Erismodus* includes a comparison of *Erraticodon* with *Erismodus* and *Oulodus*.

Erraticodon sp. cf. **E. balticus** Dzik, 1978
Pl. 2, Figs. 10,13–18; Text-fig. 6A–B

cf. *Erraticodon balticus* Dzik, 1978, p. 66, pl. 15, figs. 1–3,5,6, text-fig. 6.
cf. "Fibrous" conodont-elements Sweet and Bergström, 1962, p. 1249–1250, pl. 169, figs. 2,5,10,13,15,16 (*not* fig. 1).
cf. *Phragmodus*? sp. n. Fåhraeus, 1966, pl. 3, figs. 12a,b.
cf. "Fibrous conodont" Fåhraeus, 1966, pl. 4, figs. 6a–8b.
cf. *"Chirognathus"* sp. Viira, 1974, pl. 11, figs. 15,21,22.
cf. *"Cordylodus"* sp. Sweet and Bergström. Repetski and Ethington, 1977, p. 99.
cf. *"Tvaerenognathus"* sp. Repetski and Ethington, 1977, p. 100, pl. 2, fig. 6.
cf. *Ptiloconus strachanognathoides* s.f. Moskalenko. Tipnis and others, 1978, pl. V, figs. 16,19.
cf. *Erraticodon* sp. Harris and others, 1979, pl. 3, figs. 1–5.
cf. *Erraticodon* aff. *E. balticus* Dzik. Ethington and Clark, 1982, p. 45, pl. 4, figs. 15,17,23,24.
cf. ?*Erraticodon balticus* Dzik. Stouge, 1984, p. 84–85, pl. 17, figs. 9–19.

Description.—Apparatus septimembrate. Sa element alate; cusp long, gently recurved, with faint lateral and posterior costae. Lateral costae produced into short, slightly anteriorly directed processes bearing one long, anteroposteriorly compressed denticle. Posterior costa produced into a process bearing a number of discrete denticles.

Sba elements tertiopedate. One lateral process extends from a point near anterior margin of cusp and is gently arched downward; other lateral process extends from more medial position on cusp and is directed downward much more conspicuously; each process has a series of long slender denticles. Posterior process long, arched, bearing long, posteriorly inclined denticles.

Sbb elements bipennate; cusp has faint anterior and posterior costae. Anterior costa produced into short denticulate process directed anteriorly and downward; posterior process short, bears slender discrete denticles and, in at least one specimen, has prominent denticle nearly as large as cusp. Sc elements like Sbb, except anterior process reduced to short, laterally deflected, adenticulate knob.

M elements dolabrate; cusp keeled anteriorly and posteriorly. Anterior keel straight or flexed slightly inward; posterior keel produced as short process bearing discrete, laterally compressed denticles. Cusp and denticles bent slightly to one side and smoothly curved posteriorly.

Pa elements pastinate-like; posterior process(?) long, denticulate, and inwardly deflected; anterior process short, with one or two small denticles. Lateral process very short, adenticulate, and located on inner side of element.

Pb element digyrate; basal cavity very shallow; cusp erect, with circular cross section. Lateral processes deflected in opposite directions, one shorter and more weakly denticulated than the other. All elements are hyaline.

Remarks.—The apparatus of *Erraticodon balticus* was described by Dzik (1978). In his reconstruction, he recognized trichonodelliform, plectospathodontiform, ozarkodiniform, hindeodelliform, and neoprioniodontiform elements, which correspond to the Sa, Sba, Sbb, Sc, and M elements, respectively, of this report. Although the P elements of *E. balticus* were not figured by Dzik, the similarity of those described here to remaining elements of the *E. balticus* apparatus indicates that they are very closely associated to other forms of *Erraticodon* in my samples. The large posterior denticle of Sa, Sbb, and Sc elements of typical *E. balticus* was recognized in only one specimen of *Erraticodon* from the McLish and Tulip Creek.

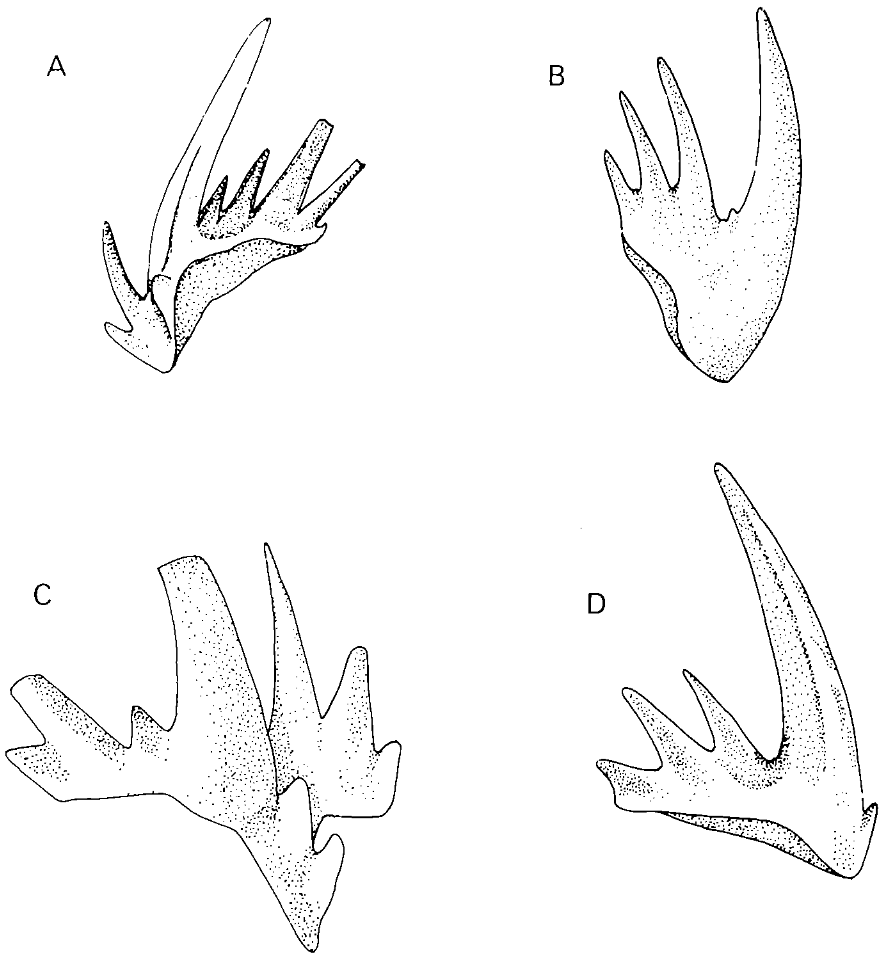
Cooper (1981, p. 166–168) described *Erraticodon patu* from the Horn Valley Siltstone of Australia. The apparatus of *E. patu* differs from that of *E.* sp. cf. *E. balticus* by having a Pa element with three well-developed, denticulated processes and an M element with a small denticle anterior to the cusp (Text-fig. 6). Cooper's (1981) description of *E. patu* also excludes the Sbb element described in this report.

The collection of *Erraticodon* from the McLish and Tulip Creek is small and scattered. Reconstruction of the apparatus was facilitated by examining *Erraticodon* from samples collected from the McLish and Tulip Creek by Sweet, Bergström, and Jaanusson in 1972. Some of those specimens are figured in this report because of their better preservation.

Occurrence.—Erraticodon sp. cf. *E. balticus* is represented throughout the McLish and Tulip Creek section (81–639 ft above the base). Similar forms have been reported from the Womble Shale of Arkansas (Repetski and Ethington, 1977); the Pratt Ferry Formation of Alabama (Sweet and Bergström, 1962); the Eureka Quartzite and Copenhagen Formation of Nevada (Harris and others, 1979); the Sunblood Formation of the southern District of Mackenzie (Tipnis and others, 1978); the Lehman Formation, Watson Ranch Quartzite, and Crystal Peak Dolomite of Utah (Ethington and Clark, 1982); and the Table Head Formation of Newfoundland (Stouge, 1984).

Collection.—42 specimens (5 Pa, 6 Pb, 7 M, 1 Sa, 7 Sba, 8 Sbb, 8 Sc).

Figured specimens.—OSU 37223–37229, inclusive.



Text-figure 6. Comparison of Pa and M elements of *Erraticodon* sp. cf. *E. balticus* (*A* and *B*, respectively) and *E. patu* (*C* and *D*, respectively), after Cooper (1981).

Genus **Histiodella** Harris, 1962

Type species.—Histiodella altifrons Harris, 1962.

Histiodella n. sp. 2 Harris and others, 1979
Pl. 2, Fig. 6

Histiodella n. sp. 2 HARRIS AND OTHERS, 1979, pl. 4, figs. 12,13.

Description.—Element bears five denticles anterior to and six posterior to relatively large, bladelike cusp. Cusp and denticles fused for most of their length and inclined posteriorly except for three anteriormost denticles.

Discussion.—Ontogeny, phylogeny, and apparatus reconstruction of *Histiodella* have been discussed in depth by McHargue (1982, p. 1410–1433). In his reconstruction, six elements are included in the apparatus. The bryantodontiform (= carminate pectiniform) element is most diagnostic.

Ethington and Clark (1982, p. 47–48) described *Histiodella holodentata* from the Pogonip Group of Utah. In their remarks, they compared *H. holodentata* to *H.* n. sp. 2. The carminate element of the unnamed species differs from that of *H. holodentata* in "having a strongly developed basal shoulder along the length of the blade" and "a laterally directed knob or lip that projects from the lateral shoulder at midlength" (Ethington and Clark, 1982, p. 48). McHargue (1982, p. 1412) included a geniculate coniform element in his reconstruction of *Histiodella,* but Ethington and Clark (1982) asserted that no geniculate coniform element is associated with *H. holodentata* or *H.* n. sp. 2.

The carminate pectiniform element of *Histiodella* n. sp. 2 recovered from the McLish has a pronounced shoulder but does not have the strongly developed, laterally projecting lip characteristic of carminate elements of *H.* n. sp. 2. Consequently, I assign this element to *H.* n. sp. 2 with some reservation. The presence of only one element in my collection increases the uncertainty of the assignment.

Occurrence.—*Histiodella* n. sp. 2 occurs 67 ft above the base of the section along with elements of *Neomultioistodus, Paraprioniodus,* and *Scandodus*? Harris and others (1979) reported *H.* n. sp. 2 from the Antelope Valley Limestone of Nevada.

Collection.—One specimen.

Figured specimen.—OSU 37230.

Genus **Leptochirognathus** Branson and Mehl, 1943

Type species.—*Leptochirognathus quadrata* Branson and Mehl, 1943.

Remarks.—Branson and Mehl (1943, p. 377) described elements of *Leptochirognathus* as palmate, fibrous conodonts with thin, sharp-edged denticles. Eight form-species were recognized on the basis of differences in denticulation and symmetry.

Elements of *Leptochirognathus* recovered from the McLish–Tulip Creek section are few and fragmentary. However, one sample (82JA-260) yielded forms that appear to be part of a symmetry-transition series of at least three elements.

In this report, elements of *Leptochirognathus* are oriented as suggested by Branson and Mehl (1943), with one exception. The inclined denticles are herein considered to be directed posteriorly rather than anteriorly.

Leptochirognathus quadratus Branson and Mehl, 1943
Pl. 2, Figs. 19–21; Text-fig. 7A–C

Leptochirognathus quadrata Branson and Mehl, 1943, p. 378–379, pl. 63, figs. 23–28.
Leptochirognathus prima Branson and Mehl, 1943, p. 378, pl. 63, figs. 29–35.
Leptochirognathus gracilis Branson and Mehl, 1943, p. 377, pl. 63, figs. 39,40.
Leptochirognathus quadratus Branson and Mehl. Bergström, 1978, pl. 79, fig. 11.
Leptochirognathus cf. *L. gracilis* s.f. Branson and Mehl. Tipnis and others, 1978, pl. V, fig. 26.
Leptochirognathus cf. *L. tridactylus* Branson and Mehl. Tipnis and others, 1978, pl. V, fig. 27.

Emended diagnosis.—A species of *Leptochirognathus* with a skeletal apparatus consisting of at least three types of morphologically gradational elements, each having four denticles. Elements are distinguished by their degree of symmetry about a plane perpendicular to the plane bearing the denticles.

Description.—Apparatus trimembrate, consisting of nearly symmetrical (quadratiform), asymmetrical (primadontiform), and markedly asymmetrical (graciliform) palmate elements with four compressed denticles. Quadratiform element has slightly flaring, shallowly excavated base; denticles subequal, sharp-edged, with carinate inner side and smooth outer side. Anterior and posterior denticles form right angle; remaining two denticles inclined at about 30° and 60° to anterior denticle. Primadontiform element like quadratiform element, except two intermediate denticles are inclined posteriorly at greater angles. Graciliform element has posteriorly elongated basal cavity extending nearly the length of posteriormost denticle; three posterior denticles are long and subparallel to basal margin (Text-fig. 7).

Remarks.—The three skeletal elements of *Leptochirognathus quadratus* described in this report resemble form species *L. quadratus, L. prima,* and *L. gracilis* described by Branson and Mehl (1943, p. 377–379)—hence the terms quadratiform, primadontiform, and graciliform. The figured specimens are small, delicate forms. More-robust elements which appear to be representative of the same species show greater variability and distortion of features.

The basal cavity of the quadratiform element of *Leptochirognathus quadratus* is similar to that of forms described as *L. semiflorealis* Branson and Mehl. However, *L. semiflorealis* has five denticles, compared to four in quadratiform elements.

The skeletal apparatus of *Leptochirognathus* n. sp. Harris and others (1979, pl. 1, figs. 16–18) consists of three elements homologous with those of *L. quadratus.* Elements of that species, however, have only three denticles.

Rexroad and others (1982, p. 8) reported *Leptochirognathus quadratus* from the Everton Dolomite of southwestern Indiana. Figures of elements in that skeletal apparatus show from three to five denticles. It cannot be postulated from the few examined specimens from the McLish–Tulip Creek section whether the number of denticles is significant in species determination.

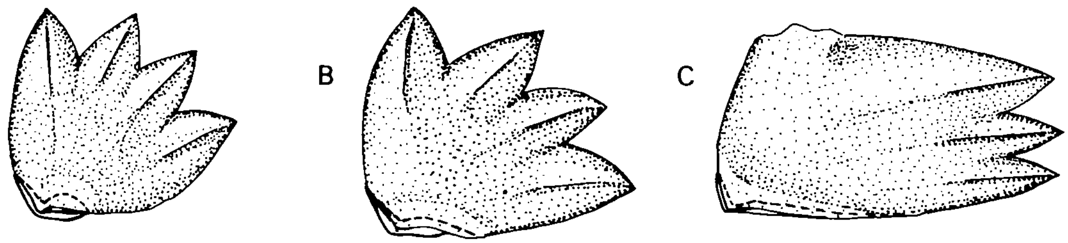
Occurrence.—*Leptochirognathus quadratus* was found between 210 and 499 ft in the section. Other reported occurrences include the Dutchtown Formation of Missouri (Branson and Mehl, 1943); Woods Hollow Shale of Texas (Bergström, 1978); Pinesburg Station Dolomite and Row Park Limestone of West Virginia and Maryland (Boger, 1976, p. 81–82); and Everton Dolomite of the Indiana subsurface (Rexroad and others, 1982).

Collection.—18 specimens (8 quadratiform, 4 primadontiform, 3 graciliform, 3 indeterminate).

Figured specimens.—OSU 37231–37233, inclusive.

Genus **Neomultioistodus** Harris and Harris, 1965

Multioistodus (Neomultioistodus) Harris and Harris, 1965, p. 43.
Tricladiodus Mound, 1965a, p. 198.



Text-figure 7. Skeletal apparatus of *Leptochirognathus quadratus* Branson and Mehl. *A–C,* quadratiform, primadontiform, and graciliform elements, respectively.

Type species.—Neomultioistodus compressus Harris and Harris, 1965.

Diagnosis.—Skeletal apparatus is quinquimembrate or seximembrate, consisting of one or two pastinate elements, a geniculate coniform element, and a symmetry-transition series of alate through dolabrate elements. Genus is distinguished from *Multioistodus* by having a geniculate coniform element in the M position.

Discussion.—Cullison (1938, p. 226) erected *Multioistodus* to include three form-species with stout, peglike denticles that project directly from the base. Cullison's three species were interpreted as a symmetry-transition series (Lindström, 1964, fig. 48 l,m; Sweet and Bergström, 1972, p. 33, fig. 2B) and subsequently were assigned to the multielement species *M. subdentatus*.

Harris and Harris (1965) described specimens from the West Spring Creek Formation of Oklahoma as the form-taxon *Multioistodus (Neomultioistodus) compressus*. Those specimens differ most notably from elements of *M. subdentatus* in having a prominent, laterally flattened posterior denticle, rather than a stout, peglike denticle.

Elements similar to the type of *Neomultioistodus compressus* have since been assigned to the multielement apparatus of *Multioistodus compressus* (Bradshaw, 1969, p. 1153–1155; Sweet and others, 1971, p. 169, pl. 1, figs. 36,40; Barnes, 1974, p. 230, pl. 1, fig. 12; Ethington and Clark, 1982, p. 58–59). However, *M. subdentatus,* the type species of *Multioistodus,* differs from *M. compressus* by lacking a geniculate coniform element in its skeletal apparatus. This evidence indicates that these two forms have general similarities; nevertheless, it seems that they should be separated at the generic level. Therefore, I have assigned forms previously described as *M. compressus* to *Neomultioistodus compressus.*

Mound (1965a) based *Tricladiodus* on material from the Joins Formation. The element figured in his report appears to be a pastinate element of a species very similar to *Neomultioistodus compressus*. Furthermore, examined specimens of *Tricladiodus* from the Oil Creek Formation (Ohio State conodont collections, 72SC) have a geniculate coniform element in the M position. Accordingly, I include *Tricladiodus* as a junior subjective synonym of *Neomultioistodus.*

Neomultioistodus compressus
Harris and Harris
Pl. 3, Figs. 1–5,7,9

Multioistodus (Neomultioistodus) compressus HARRIS AND HARRIS, 1965, p. 43–44, pl. 1, figs. 7a–c.
Multioistodus compressus Harris and Harris. MOUND, 1965b, p. 24, pl. 3, figs. 12,13; SWEET AND OTHERS, 1971, p. 169, pl. 1, figs. 36,40; BARNES, 1974, p. 230, pl. 1, fig. 12; ETHINGTON AND CLARK, 1982, p. 58–59, pl. 6, figs. 8–11,16 (includes synonymy).
"*Multioistodus*" *compressus* Harris and Harris. DZIK, 1983, fig. 6-5.

Description.—Apparatus seximembrate. P elements pastinate; Pa is basally expanded with prominent posterior denticle; M element geniculate coniform. Symmetry-transition series consists of alate Sa elements with stubby, symmetrically or nearly symmetrically disposed lateral processes; tertiopedate Sb elements; and dolabrate Sc elements. All elements hyaline.

Occurrences.—Specimens of *Neomultioistodus compressus* were recovered from samples taken 66, 67, and 71 ft above the base of the section (just above the basal sandstone). *N. compressus* has been reported from the West Spring Creek Formation (Harris and Harris, 1965); the Joins Formation (Mound, 1965b); the Kanosh and Lehman Formations of Utah (Sweet and others, 1971; Ethington and Clark, 1982); the Bay Fiord Formation of Arctic Canada (Barnes, 1974, p. 230); and the Sunblood Formation of the southern Mackenzie Mountains, Canada (Tipnis and others, 1978, p. 73, pl. IV, figs. 1,4,6).

Collection.—695 specimens (134 Pa, 57 Pb, 170 M, 50 Sa, 118 Sb, 166 Sc).

Figured specimens.—OSU 37234–37240, inclusive.

Genus **Oneotodus** Lindström, 1955

Type species.—Distacodus? *simplex* Furnish, 1938.

Oneotodus? ovatus (Stauffer, 1935)
Pl. 3, Fig. 25

Oistodus ovatus STAUFFER, 1935, p. 147, pl. 12, fig. 34.
Oneotodus ovatus (Stauffer). WEBERS, 1966, p. 67, pl. 2, fig. 7.

Remarks.—Ethington and Brand (1981, p. 239–247) revised Lindström's (1955, p. 581) original diagnosis of *Oneotodus*. Included in their definition of the genus were coniform elements with an albid cusp of subcircular cross section; a hyaline base; and a low basal cavity that is triangular in lateral profile. Ethington and Brand (1981, p. 245) indicated that *O. ovatus* would require further reassignment because of their emendation.

The form I have assigned to *Oneotodus*? *ovatus* appears to be identical to the one described as *O. ovatus* by Webers (1966). *O. ovatus* conforms to all the criteria set forth by Ethington and Brand (1981, p. 245) in their definition of *Oneotodus* except for a shallow, flattened basal cavity. If that character is suitable for generic differentiation, then *O. ovatus* should then be assigned to another genus. The basal cavity of the specimen identified as *O.*? *ovatus* in this study is flat except for a small, shallow excavated area near the anterobasal margin.

Occurrence.—Oneotodus? *ovatus* is represented near the top of the Tulip Creek Formation, 684 ft above the base of the section. *O.*? *ovatus* also occurs in the Glenwood Formation of Minnesota (Stauffer, 1935; Webers, 1966).

Collection.—One specimen.

Figured specimen.—OSU 37241.

Genus **Panderodus** Ethington, 1959

Remarks.—Elements assignable to the skeletal apparatus of *Panderodus* are represented in very small numbers throughout the McLish–Tulip Creek section. Two groups can be distinguished by the character of the basal margin. One group comprises elements with prominently in-turned basal margins and appears to represent the skeletal apparatus of *P. panderi* (Stauffer).

The other group comprises relatively small elements with straight basal margins. Some of those elements may represent the apparatus of *Panderodus gracilis* (Branson and Mehl). The elements show wide variability and may also represent several distinct species.

Panderodus panderi (Stauffer, 1940)
Pl. 4, Fig. 14

Paltodus panderi STAUFFER, 1940, p. 427, pl. 60, figs. 8,9.
Panderodus panderi (Stauffer). SWEET, 1979, p. 64, fig. 7 (2–6,10) (includes synonymy).

Remarks.—Sweet (1979) described the multielement apparatus of *Panderodus panderi*. Specimens assigned to *P. panderi* in this report have the prominently in-turned basal margin characteristic of that species.

Occurrence.—Panderodus panderi is represented in samples taken 514 and 684 ft above the base of the section.

Collection.—5 specimens.

Figured specimen.—OSU 37242.

Panderodus sp.
Pl. 4, Fig. 12

Remarks.—Elements with relatively straight basal margins are here included in *Panderodus* sp. Although those elements may represent several species, the majority of them are comparable to *Panderodus gracilis* (Branson and Mehl).

Occurrence.—Elements assigned to *Panderodus* sp. were found between 143 and 704 ft in the section.

Collection.—24 specimens.

Figured specimen.—OSU 37243.

Genus **Paraprioniodus**
Ethington and Clark, 1982

Type species.—Tetraprioniodus costatus Mound, 1965b.

Remarks.—The conclusions reached by Ethington and Clark (1982, p. 77) in their discussion of *Paraprioniodus* are adhered to in this report.

Paraprioniodus sp. cf. **P. costatus**
(Mound, 1965b)
Pl. 3, Figs. 6,8,11–13,16

cf. *Tetraprioniodus costatus* MOUND, 1965b, p. 34–35, pl. 4, figs. 19,25,31, text-fig. 1K.
cf. *Paraprioniodus costatus* (Mound). ETHINGTON AND CLARK, 1982, p. 77–79, pl. 8, figs. 20–26 (includes synonymy through 1981). DZIK, 1983, fig. 6-2.
cf. *Eoneoprioniodus*? sp. 1 STOUGE, 1984, p. 78–79, pl. 15, figs. 7–13,15,16.

Diagnosis.—A species of *Paraprioniodus* similar to *P. costatus,* but having elements with very weakly developed processes and denticulation.

Description.—Apparatus seximembrate. P elements pastinate with very weak denticulation on lateral and posterior processes which extend horizontally on Pa element; lateral process of Pb element extends downward. M element dolabrate; cusp swollen on one side, keeled anteriorly and posteriorly. Posterior process weakly denticulate or adenticulate.

Sa element alate; cusp slender, rounded anteriorly, keeled posteriorly, and laterally costate. Posterior process has one or two small denticles or is adenticulate. Lateral processes adenticulate.

Sb element quadriramate; cusp keeled anteriorly, costate posteriorly and laterally. Denticulation as on Sa element. Sc element dolabrate and distinguished from M element by its greater lateral compression and stronger posterior denticulation.

Remarks.—The elements assigned in this report to *Paraprioniodus* sp. cf. *P. costatus* are similar to those of *P. costatus* described by Ethington and Clark (1982, p. 77–79). Prioniodontiform, cyrtoniodontiform, trichonodelliform, tetraprionioodontiform, and cordylodontiform elements reported by Ethington and Clark correspond to P, M, Sa, Sb, and Sc elements, respectively.

However, there are marked differences between specimens recovered from the McLish Formation and the specimens described by Ethington and Clark (1982). The most notable difference is the degree of development and denticulation of the processes. Despite observed differences, overall agreement of the two forms indicates that they represent either different morphotypes of the same species or closely related species.

Occurrences.—*Paraprioniodus* sp. cf. *P. costatus* is represented in samples taken 66, 67, and 71 ft above the base of the section. This interval also contains specimens of other genera (e.g., *Neomultioistodus, Scandodus*?) characteristic of strata older than the McLish and may represent reworked sediment.

Specimens of *Paraprioniodus costatus* occur in the Joins Formation of Oklahoma (Mound, 1965b; McHargue, 1975, p. 85–89, [= *Prioniodus costatus*]); Oil Creek Formation of Oklahoma (McHargue, 1975, p. 88); upper part of the Antelope Valley Formation of Nevada (Harris and others, 1979, pl. 1, figs. 13–15); Sunblood Formation of the southern Mackenzie Mountains, Canada (Tipnis and others, 1978); Lehman Formation and Watson Ranch Quartzite of Utah (Ethington and Clark, 1982); Everton Dolomite of the Indiana subsurface (Rexroad and others, 1982); and Table Head Formation of Newfoundland (Stouge, 1984).

Collection.—194 specimens (39 Pa, 59 Pb, 48 M, 9 Sa, 15 Sb, 24 Sc).

Figured specimens.—OSU 37244–37249, inclusive.

Genus **Phragmodus** Branson and Mehl, 1933b

Type species.—*Phragmodus primus* Branson and Mehl, 1933b.

Phragmodus flexuosus Moskalenko, 1973

Phragmodus flexuosus, n. sp. Moskalenko, 1973, p. 73–74, pl. XI, figs. 4–6.

Remarks.—Ethington and Clark (1982, p. 79–82) extensively discussed the taxonomic development of *Phragmodus flexuosus*. In their report, they recognized two distinctly different North American species that can be interpreted as *P. flexuosus*. In the apparatus of one species, the M position is occupied by a dolabrate (cyrtoniodontiform) element. That species traditionally has been referred to *P. flexuosus* and was described in detail by Carnes (1975, p. 178–181) and Sweet (1981, p. 255–257). The second species has a geniculate coniform (oistodontiform) element in the M position. It was first recognized in North America by Harris and others (1979, p. 23) and subsequently was described by Ethington and Clark (1982, p. 79–82) as ?*P. flexuosus*.

It is difficult to determine which form Moskalenko (1973) was describing when she first introduced the form-taxon *Phragmodus flexuosus*. As noted by Ethington and Clark (1982, p. 81), Moskalenko's samples contain elements that can be referred to as dolabrate and as geniculate coniform. To avoid confusion, forms referred in this report to *P. flexuosus* match the traditional reconstruction of Carnes (1975) and Sweet (1981); that is, they have a dolabrate element in the M position.

Phragmodus flexuosus recovered from samples of the McLish and Tulip Creek can be separated into two forms on the basis of P element development. They are presented in this report as *P. flexuosus* morphotype A and morphotype B. Unfortunately, the character that distinguishes those forms is gradational and often difficult to categorize with confidence. For this reason, both forms are referred to *P. flexuosus*, and no new species or subspecies is recognized.

Morphotypes A and B are of general biostratigraphic use in the study section. For simplicity, ranges of those two forms are shown in Text-figure 2 to be disjunct, although it should be emphasized that transitional forms in the upper McLish are problematic in classification.

Phragmodus flexuosus morphotype A
Pl. 3, Figs. 10,14,15,18,20,24; Text-fig. 8A

Phragmodus flexuosus Moskalenko. Harris and others, 1979, pl. 2, figs. 1–4; Sweet, 1981, p. 255–259, pl. 2, figs. 1–6. Dzik, 1983, fig. 6-3.

Phragmodus sp. A Sweet and others, 1971, p. 173–174, pl. 2, figs. 3–6.

Phragmodus sp. nov. Moskalenko, 1972, p. 48–50, fig. 1, nos. 1–12, (not fig. 1, nos. 13–15).

Phragmodus flexuosus flexuosus Moskalenko. Tipnis and others, 1978, p. 60–61, pl. V, figs. 1,2,4.

Description.—Apparatus seximembrate. Sa element alate with adenticulate, symmetrically disposed lateral processes; cusp rounded anteriorly, keeled laterally and posteriorly. Posterior process long, arched, and laterally twisted, with discrete, laterally compressed denticles. Sb element tertiopedate, but otherwise similar to the Sa element.

Sc element bipennate or dolabrate. Bipennate forms exhibit laterally deflected anterior process (adenticulate) and straight or very slightly twisted posterior process with denticles more delicate than those on the posterior process of Sa and Sb elements; dolabrate forms have straight anterior keel. M element dolabrate; posterior process arched and denticulate.

P elements pastinate; Pa and Pb positions distinguished by angle between lateral process and adenticulate anterior keel or process. Processes of Pa element enclose a 10–20° angle, whereas those of Pb element enclose a 70–80° angle.

Remarks.—Phragmodus flexuosus morphotype A corresponds to the species discussed in detail by Carnes (1975, p. 178–182) and Sweet (1981, p. 255–257). Morphotype A is clearly different from the species described by Ethington and Clark (1982, p. 79–82) as ?*P. flexuosus*. The most notable differences are the appearance of a dolabrate rather than a geniculate coniform element in the M position and the differentiated P elements (Ethington and Clark recognized only one type of P element in their reconstruction).

Phragmodus flexuosus flexuosus (Tipnis and others, 1978) is described as having a dolabrate element and two distinguishable P elements, so it has tentatively been listed under morphotype A.

Occurrence.—Morphotype A dominates the conodont fauna from 260 ft above the base of the sampled section to the top of the section. Sweet and others (1973) reported that *Phragmodus flexuosus* can be recognized from the McLish, Tulip Creek, and lower Bromide. Other occurrences of morphotype A in North America include the Lenoir Limestone, Holston Formation, and associated strata of Tennessee (Carnes, 1975; Bergström and Carnes, 1976); the Chazy Group of New York and Vermont (Raring, 1972, p. 101–104, [= *P. tortus*]); Pinesburg Station Dolomite, Row Park Limestone, and New Market Formation of West Virginia and Maryland (Boger, 1976, p. 101); Antelope Valley Limestone of Nevada (Harris and others, 1979); and Chickamauga Limestone of Alabama and Georgia (Schmidt, 1982, p. 160–161).

Collection.—8,007 specimens (726 Pa, 1,017 Pb, 1,702 M, 415 Sa, 2,015 Sb, 2,132 Sc).

Figured specimen.—OSU 37250–37255, inclusive.

Phragmodus flexuosus morphotype B
Pl. 3, Fig. 17; Text-fig. 8B

?*Phragmodus flexuosus*, n. sp. MOSKALENKO, 1973, p. 73–74, pl. XI, figs. 4–6.

?*Gothodus evenkiensis*, n. sp. MOSKALENKO, 1973, p. 67–68, pl. XI, figs. 1–3.

Plectodina glenwoodensis Stauffer. MOSKALENKO, 1973, p. 76, pl. XI, figs. 7–9.

?*Subcordylodus sinuatus* Stauffer. MOSKALENKO, 1973, p. 80–81, pl. XII, figs. 7–9.

?*Dichognathus decipiens* Branson and Mehl. MOSKALENKO, 1973, p. 66–67, pl. XV, figs. 7–12.

Diagnosis.—Apparatus differs from that of *Phragmodus flexuosus* morphotype A only in that the P elements are pastinate but are not divisible into Pa and Pb categories based on the angle between their lateral and anterior processes.

Remarks.—Phragmodus flexuosus morphotype B occurs stratigraphically lower than *P. flexuosus* morphotype A. Its apparatus differs from that of *P. flexuosus* morphotype A in having undifferentiated P elements. Other elements of the apparatus, including the dolabrate M element, are nearly identical to those of *P. flexuosus* morphotype A.

As noted previously, Ethington and Clark (1982, p. 80) recognized only one type of P element in their description of *Phragmodus* from the Crystal Peak Dolomite of Utah, and examined specimens of *Phragmodus* with geniculate coniform M elements from the Antelope Valley Limestone also have undifferentiated P elements (Text-fig. 8). This interval of the Antelope Valley also contains *Eoplacognathus suecicus* (Harris and others, 1979, p. 23).

Phragmodus flexuosus morphotype B occurs in an interval containing the *Eoplacognathus foliaceus–E. reclinatus* transition (= *E.* sp. of this report), which indicates that it is younger than the forms from the Antelope Valley Limestone. This evidence appears to indicate that *P. flexuosus* morphotype B may be intermediate between the species of *Phragmodus* whose apparatus has geniculate coniform M elements and *P. flexuosus* morphotype A. However *P. flexuosus* morphotype B is very closely associated with *P. flexuosus* morphotype A, and often difficult to distinguish.

Moskalenko's (1973) *Phragmodus flexuosus* (and associated elements) is tentatively included in the synonymy of *P. flexuosus* morphotype B. The basis for this assignment is the presence of only one type of P element (discussed by Ethington and Clark, 1982, p. 81) and the presence of a dolabrate M element (*Plectodina glenwoodensis* of Moskalenko, 1973).

Occurrence.—Elements of morphotype B can be recognized confidently in the lower part of the McLish Formation.

Collection.—2,028 specimens (398 P, 455 M, 133 Sa, 470 Sb, 572 Sc).

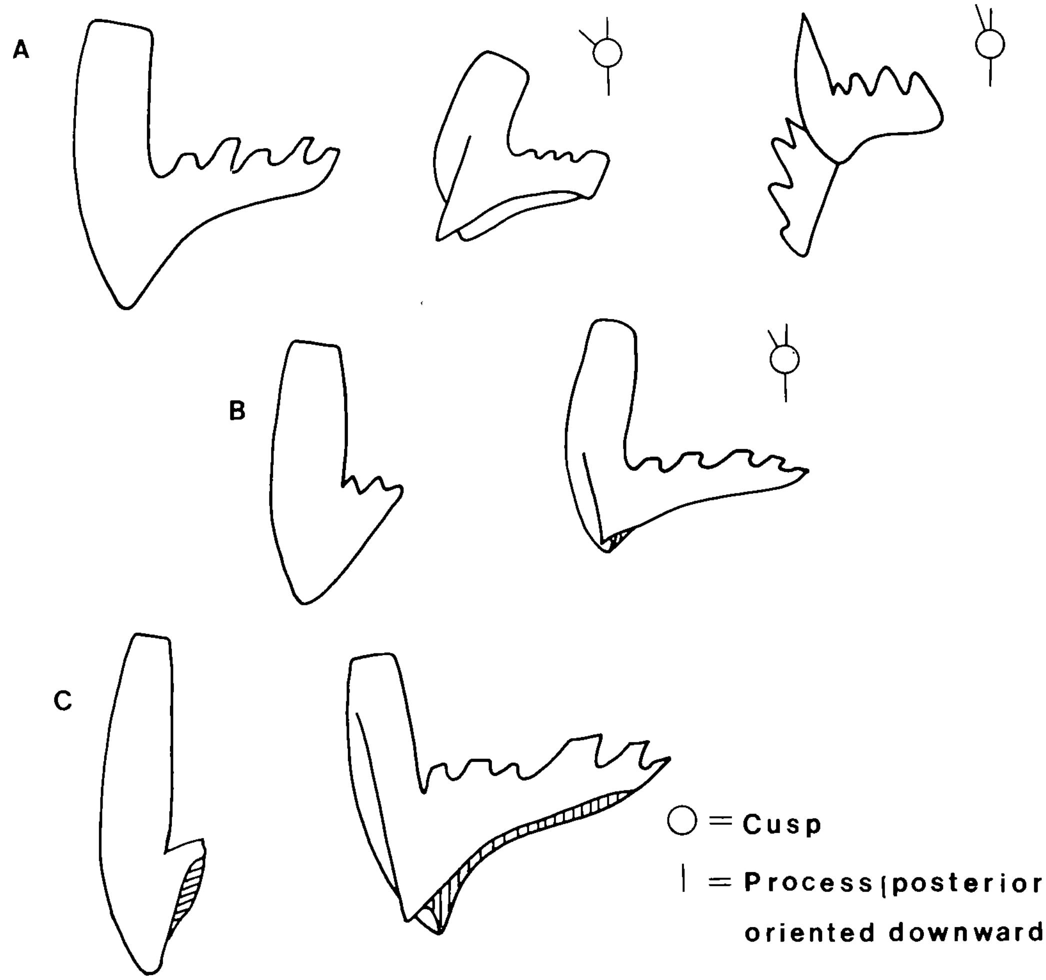
Figured specimens.—OSU 37256.

Genus **Plectodina** Stauffer, 1935

Type species.—Prioniodus aculeatus Stauffer, 1930.

Plectodina sp. cf. **P. aculeata** (Stauffer, 1930)
Pl. 4, Figs. 17,18,22

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



Text-figure 8. Comparison of critical elements of *Phragmodus* skeletal apparatus. *A.*—M, Pb, and Pa elements (left to right) of *P. flexuosus* morphotype A. *B.*—M and P elements of *P. flexuosus* morphotype B. *C.*—M and P elements of *Phragmodus* from the Crystal Peak Dolomite (after Ethington and Clark, 1982).

cf. *Plectodina aculeata* (Stauffer). BARNES, 1977, p. 107, pl. 4, figs. 19,23; TIPNIS AND OTHERS, 1978, pl. VI, figs. 1–4; SWEET, 1981, p. 277–280, pl. 1, figs. 1–9 (includes synonymy).

Remarks.—Sweet (1981) distinguished *Plectodina aculeata* from congeneric species by the combination of pastinate (dichognathiform) Pa elements and angulate (prioniodiniform) M elements. Although elements assignable to *Plectodina* are represented throughout the Tulip Creek Formation, only one sample (82JA-534) contained both Pa and M elements of that genus. In that sample, the Pa element is pastinate and the M element is angulate, with a very weakly developed unidenticulate anterior process. Elements in that sample were also very small and fragile.

Occurrence.—*Plectodina* sp. cf. *P. aculeata* is represented at 534 ft above the base of the section. *P. aculeata* is a widespread Middle Ordovician Midcontinent form. Sweet (1981, p. 279–280) has listed many of the reported occurrences of *P. aculeata*.

Collection.—6 specimens (1 Pa, 1 M, 1 alate Sa, 3 bipennate Sc).

Figured specimens.—OSU 37257–37259, inclusive.

Plectodina sp.
Pl. 4, Figs. 16,19,20,23,24

Remarks.—Elements of the skeletal apparatus are very small and appear to represent an apparatus similar to that of *Plectodina aculeata*. The apparatus is sparsely represented in two samples (82JA-350, 82JA-360).

Occurrence.—This species was found in the upper part of the McLish Formation.

Collection.—13 specimens (3 pastinate Pa, 4 angulate Pb, 2 digyrate M, 1 digyrate Sb, 3 bipennate Sc).

Figured specimens.—OSU 37260–37264, inclusive.

Plectodina? sp.
Pl. 4, Fig. 21

?*Plectodina* sp. n. DZIK, 1983, fig. 5-9.

Remarks.—As noted in the remarks on *Plectodina* sp. cf. *P. aculeata,* elements similar to those of *Plectodina* occur throughout the Tulip Creek Formation. Because those elements do not appear to be characteristic of a particular known species, I have included them in *P.*? sp.

The elements recovered include alate Sa and tertiopedate Sb elements. They occur in samples dominated by representatives of *Phragmodus flexuosus* morphotype A. Elements in the P and Sc positions of the apparatus of this species of *Plectodina* probably are so much like their counterparts in *Phragmodus* (pastinate and dolabrate, respectively) that they are very difficult to distinguish.

Occurrence.—*Plectodina*? sp. was found between 403 and 699 ft above the base of the McLish–Tulip Creek section.

Collection.—47 specimens.

Figured specimen.—OSU 37265.

Genus **Protopanderodus** Lindström, 1971

Type species.—*Acontiodus rectus* Lindström, 1955.

Protopanderodus varicostatus
(Sweet and Bergström, 1962)
Pl. 3, Figs. 19,21–23

Scolopodus varicostatus SWEET AND BERGSTRÖM, 1962, p. 1247–1248, pl. 168, figs. 4–9, text-fig. 1A,C,K; HAMAR, 1964, p. 284, pl. 1, figs. 1,2, text-fig. 4, no. 7a,b; BRADSHAW, 1969, p. 1163, pl. 132, fig. 10, pl. 134, figs. 12,13; VIIRA, 1974, p. 123, fig. 160.

Scandodus unistriatus SWEET AND BERGSTRÖM, 1962, p. 1245, pl. 168, fig. 12, text-fig. 1E; BRADSHAW, 1969, p. 1161, pl. 135, figs. 5,6.

"*Scolopodus*" *varicostatus* Sweet and Bergström. BERGSTRÖM, 1971, p. 92–93, figs. 4,5.

Protopanderodus varicostatus (Sweet and Bergström). BERGSTRÖM, 1973b, p. 13; BERGSTRÖM, 1973c, p. 272–280, figs. 5–9; BERGSTRÖM AND OTHERS, 1974, pl. I, figs. 9,10; BERGSTRÖM, 1978, pl. 79, figs. 6,7; TIPNIS AND OTHERS, 1978, pl. VIII, figs. 8,12; SIMES, 1980, pl. 1, fig. 6; DZIK, 1983, fig. 3-29.

?*Protopanderodus* cf. *varicostatus* (Sweet and Bergström). LÖFGREN, 1978, p. 91–93, pl. 3, figs. 26–31.

Discussion.—Sweet and Bergström (1962) recognized elements included in *Protopanderodus varicostatus* from the Pratt Ferry Formation of Alabama. Those elements were assigned to *Scandodus unistriatus* and *Scolopodus varicostatus. S. varicostatus* included three distinct, intergradational forms based on the disposition and number of costae (Sweet and Bergström, 1962).

Carnes (1975, p. 208–209) included a short discussion of *Protopanderodus varicostatus* in his report on Middle Ordovician rocks of northeastern Tennessee. In that discussion, he recognized varicostatiform and unistriatiform elements. Both symmetrical and asymmetrical varicostatiform elements are illustrated in his plate 2 (figs. 11,12). Löfgren (1978) also recognized symmetrical and asymmetrical elements in her specimens of *P.* cf. *varicostatus* from Sweden, although the symmetrical elements were scarce.

Elements representative of *Protopanderodus varicostatus* are rare in the McLish–Tulip Creek samples. In this small collection, at least three distinct forms can be recognized, corresponding to unistriatiform, symmetrical varicostatiform, and asymmetrical varicostatiform elements of Carnes (1975). Furthermore, it appears that two other elements may be differentiated in the apparatus. One is a variation of the unistriatiform type, with greater development of the posteriormost costa on the furrowed side. The other element is intermediate between the symmetrical and asymmetrical varicostatiform types (= intermediate form of *Scolopodus varicostatus,* Sweet and Bergström, 1962).

Occurrence.—*Protopanderodus varicostatus* is represented primarily in the McLish Formation of the sampled interval. It ranges from 81 to 469 ft above the base of the section (to 64 ft above the base of the Tulip Creek).

Collection.—79 specimens (14 unistriatiform, 10 unistriatiform with pronounced lateral costae, 8 symmetrical varicostatiform, 12 nearly symmetrical varicostatiform, 35 asymmetrical varicostatiform).

Figured specimens.—OSU 37274–37277, inclusive.

Genus **Pteracontiodus** Harris and Harris, 1965

Pteracontiodus HARRIS AND HARRIS, 1965, p. 41.
Eoneoprioniodus MOUND, 1965a, p. 195.

Type species.—*Pteracontiodus aquilatus* Harris and Harris, 1965.

Pteracontiodus? sp.
Pl. 4, Figs. 1–5

Description.—Skeletal apparatus consists of keeled coniform elements assignable to acontiodontiform, distacodontiform, drepanodontiform, acodontiform, and oistodontiform shape categories. Acontiodontiform (Sa) element has posterior keel produced into a stubby basal projection and symmetrically disposed lateral costae; cusp erect or slightly recurved.

Distacodontiform (Sb) element keeled anteriorly and posteriorly; lateral surfaces have pronounced costae, one located medially on the cusp and the other located posteriorly. Costae form variably shaped, albid knobs near basal margin.

Drepanodontiform (Sc) element has anterior keel and faint posterior costa; lateral surfaces smooth; cusp recurved.

Acodontiform (P) element keeled anteriorly and posteriorly; one lateral surface bears pronounced costa, whereas the other is smooth and rounded. Lateral costa and posterior keel projected basally into short, albid, adenticulate processes; cusp erect. Oistodontiform (M) element has slightly recurved cusp with anterior and posterior keels produced basally into thin, adenticulate projections; lateral surfaces smooth.

Remarks.—The skeletal apparatus of *Pteracontiodus*? sp. resembles that of *Paraprioniodus costatus* (Mound), but differs in having elements with poorly developed, generally adenticulate processes. Elements of *Paraprioniodus* sp. cf. *P. costatus* (this report) also have poorly developed processes. However, denticulation in those forms is more distinct than in *Pteracontiodus*? sp.

In their description of *Pteracontiodus,* Ethington and Clark (1982, p. 88) included five hyaline, coniform elements with keels produced into stubby, commonly albid, generally adenticulate, basal projections. The elements of *Pteracontiodus*? sp. basically conform to that description. Similarities between *Pteracontiodus*? sp. and *Paraprioniodus* also exist; consequently, the generic assignment is uncertain.

Occurrence.—*Pteracontiodus*? sp. was found in samples 66 and 67 ft above the base of the section.

Collection.—40 specimens (17 P, 9 M, 3 Sa, 7 Sb, 4 Sc).

Figured specimens.—OSU 37278–37282, inclusive.

Genus **Scandodus** Lindström, 1955

Type species.—*Scandodus furnishi* Lindström, 1955.

Scandodus? sinuosus Mound, 1965b
Pl. 5, Figs. 1,2,5,7,8

Scandodus sinuosus Mound, 1965b, p. 33–34, pl. 4, figs. 21,22,24, text-fig. 1J; Ethington and Clark, 1982, p. 94–96, pl. 11, figs. 1–4 (not fig. 5).
Acodus campanula Mound, 1965b, p. 8–9, pl. 1, figs. 4–6.
Acontiodus curvatus Mound, 1965b, p. 11–12, figs. 19–21, text-fig. 1D; Sweet and others, 1971, p. 168, pl. 2, fig. 34.

Description.—Skeletal apparatus consists of at least five distinct nongeniculate coniform elements assignable to acodontiform, scandodontiform, drepanodontiform, and acontiodontiform categories; all elements hyaline. Acodontiform elements keeled anteriorly and posteriorly; one side bears medial to posterior costa; the other side is smoothly convex.

Scandodontiform elements noncostate; anterior and posterior keels twisted slightly toward the same side. Anterior keel extends to basal margin; cusp slightly twisted.

Drepanodontiform elements divisible into two forms. In one, cusp is conspicuously twisted; in the other, cusp is straight. Anterior and posterior keels in both forms reduced in comparison with scandodontiform elements.

Acontiodontiform elements are posteriorly keeled and have symmetrically disposed anterolateral costae; anterior margin smooth.

Discussion.—Ethington and Clark's (1982) interpretation of *Scandodus* is based on Lindström's (1971, p. 39–40) description of *S. brevibasis. S. furnishi,* the type species of *Scandodus,* does not appear, in Lindström's (1971) reconstruction, to have as many distinct elements as *S. brevibasis* and lacks costate elements. The generic assignment of *Scandodus* suggested by Ethington and Clark (1982) is therefore suspect, pending better information on *S. furnishi.*

Remarks.—The reconstruction of *Scandodus*? *sinuosus* adopted here differs from that described by Ethington and Clark (1982) in that no geniculate coniform (oistodontiform) or distacodontiform elements are included in the apparatus. It appears that all geniculate coniform elements in my samples are part of *Neomultioistodus compressus,* which occurs with *S.*? *sinuosus.* Ethington and Clark (1982) do not include a geniculate coniform element in *Multioistodus compressus* (= *N. compressus*), which probably explains the disparity in reconstructions.

The absence of distacodontiform elements may be due to the small number of specimens recovered from my samples. However, Ethington and Clark (1982) note that distacodontiform elements are not present in the upper part of the range of *S. sinuosus* in the Ibex area. McHargue (1975, p. 92–93) also reported the absence of distacodontiform elements in some of his samples containing elements of *S. sinuosus.*

Occurrence.—*Scandodus*? *sinuosus* was found in samples taken 66, 67, and 71 ft above the base of the section (lower McLish). *S. sinuosus* has been reported from the Joins Formation of Oklahoma (Mound, 1965b; McHargue, 1975), and from the Kanosh Shale and Watson Ranch Quartzite of Utah (Ethington and Clark, 1982).

Collection.—117 specimens (30 acodontiform, 39 scandodontiform, 10 acontiodontiform, 13 twisted drepanodontiform, 25 straight drepanodontiform).

Figured specimens.—OSU 37283–37287, inclusive.

Genus **Staufferella** Sweet and others, 1975

Type species.—*Distacodus falcatus* Stauffer, 1935.

Staufferella sp.
Pl. 5, Figs. 12–14

Semiacontiodus sp. n. Dzik, 1983, fig. 3-3.

Description.—Bilaterally symmetrical coniform and two types of asymmetrical coniform elements of *Staufferella* are represented in the McLish–Tulip Creek collections. All elements have the faint longitudinal striae characteristic of the genus.

Bilaterally symmetrical elements have broadly rounded anterolateral costae that taper toward basal margin and tip of cusp. Posterior face rounded and marked by pronounced longitudinal groove; anterior face flat; basal margin outline subcircular.

Two types of asymmetrical elements distinguished by length of base relative to cusp, as suggested by Carnes (1975). Long-based asymmetrical element bears faint lateral carinae; anterior face rounded, posterior face rounded, with variable longitudinal costa. Short-based asymmetrical element has anterolateral carina on one side and sharp posterolateral costa on opposite side; anterolateral and posterolateral faces rounded; cusp variably twisted.

Discussion.—Sweet and others (1975, p. 45) recognized that the symmetrical element of *Staufferella* is diagnostic in species determination. Symmetrical elements of *S.* sp. and *S. falcata* (Stauffer) have a midposterior groove. That character distinguishes those two species from other species of *Staufferella.* The two species differ from each other in the development of lateral costae. In *S. falcata,* the costae of the symmetrical element are projected as prominent "wings" near the basal margin. Costae of *S.* sp. are greatly reduced near the basal margin. The symmetrical element of *S.* sp. is also much less compressed anteroposteriorly than is that of *S. falcata.*

Remarks.—*Staufferella* sp. is sparsely represented in samples from the McLish and Tulip Creek. For this reason, I have not given a specific identification to recovered specimens. However, it would appear that elements referred here to *Staufferella* represent an important link between later forms (e.g., *S. falcata*) and an ancestral lineage. The characteristics of the symmetrical elements of *Staufferella* sp. may be of some significance in interpreting the *Staufferella* lineage. Only *S. falcata* has been described as having a posterior groove on the symmetrical element like *S.* sp. Later forms of *Staufferella* developed a sharp, midposterior costa. Sweet (1982, p. 1046–1047) discussed trends in later forms of *Staufferella.*

Löfgren (1978, p. 105–108) reported on *Scolopodus cornuformis* Sergeeva and *S. bulbosus* n. sp., species that she believed may be referable to *Staufferella* based on surface striations. She noted (p. 105) also that some cornuform (symmetrical) elements of *Scolopodus cornuformis* have a central posterior groove.

Occurrence.—*Staufferella* sp. was found between 81 and 454 ft above the base of the section.

Collection.—28 specimens (4 symmetrical, 14 long-based asymmetrical, 10 short-based asymmetrical).

Figured specimens.—OSU 37288–37290, inclusive.

Genus **Tetraprioniodus** Lindström, 1955

Type species.—*Tetraprioniodus robustus* Lindström, 1955.

"**Tetraprioniodus**" sp.
Pl. 5, Fig. 11

Description.—Skeletal element similar to those described by Sweet and Bergström (1962, p. 1248–1249) as *Tetraprioniodus lindstroemi,* but differs in having more pronounced lateral processes that occupy position nearer to the posterior process than to the anterior process; lateral processes bear distinct denticulation; anterior process laterally deflected and denticulate; cusp and base turned slightly toward same side.

Remarks.—Bergström (1971, p. 148) suspected that *Tetraprioniodus lindstroemi* belongs to the *Pygodus* skeletal apparatus. Only one element of "*Tetraprioniodus*" sp. was recovered in the present study, from the McLish. That element is similar in general form to those described as *T. lindstroemi* from the Pratt Ferry Formation of Alabama (Sweet and Bergström, 1962). Elements referable to haddingodontiform or pygodontiform elements of *Pygodus* were not found in this study.

Occurrence.—Specimen found 86 ft above the base of the section.

Collection.—One specimen.

Figured specimen.—OSU 37291.

Genus **Thrincodus** n. gen.

Type species.—*Thrincodus palaris* n. sp.

Diagnosis.—Conodont with unimembrate apparatus consisting of carminate pectiniform elements distinguished by combination of a long, bladelike anterior process with short, fused denticles, and a very short, denticulate, posterior process.

Discussion.—*Thrincodus* is established for a single new species, *T. palaris,* represented in Middle Ordovician rocks of the Appalachians (Carnes, 1975; Boger, 1976), the Great Basin (Harris and others, 1979), Texas (Bergström, 1978), New York (Raring, 1972), and Oklahoma. The genus was originally proposed in an unpublished dissertation on the conodonts of the Chazy Group by Raring (1972), who included a species having a single type of skeletal element. Subsequent reports have confirmed the unimembrate nature of the apparatus.

Thrincodus is morphologically similar to the segminate (spathognathodontiform) element of *Appalachignathus* Bergström and others and *Bergstroemognathus* Serpagli. However, it differs in having a posterior process and a very distinctive, laterally flaring base beneath the cusp. Furthermore, both *Appalachignathus* and *Bergstroemognathus* have a multielement apparatus.

Several species currently assigned to *Histiodella* Harris, such as *H. holodentata* and *H.* n. sp. 2, have a single type of carminate pectiniform element. However, those forms of *Histiodella* can be distinguished from *Thrincodus* by more extensive development of the posterior process and greater denticle length with respect to the base. The type species of *Histiodella, H. altifrons* Harris, is multimembrate.

Thrincodus palaris n. sp.
Pl. 5, Fig. 15

New genus, new species Raring. BERGSTRÖM, 1978, pl. 79, fig. 8; HARRIS, AND OTHERS, 1979, pl. 3, fig. 8.

Diagnosis and description.—Apparatus unimembrate, consisting of carminate pectiniform elements. Cusp reclined, compressed, and may be slightly bowed toward the inner side.

Anterior process long, bladelike, inwardly bowed, and slightly twisted. Denticles short (less than half the height of the blade), erect, subequal, fused for most of their length, and apically discrete. Posterior process limited to a denticulate keel along the posterior portion of the cusp. Denticles reclined at a significantly greater angle than the cusp.

Basal cavity shallow, expanded beneath cusp, and extends as a narrow slit along the entire length of the anterior process. Base beneath cusp flares posteriorly and laterally toward the inner side. Basal margin along inner side is turned slightly inward, forming a subtle ledge. Outer side is smoothly convex.

Derivation of name.—The generic and specific names were proposed by Dr. Andrew M. Raring (1972) in an unpublished doctoral dissertation. Although Raring's report has not been published, he has graciously given his consent to establish *Thrincodus palaris* herein. Raring's conodont collection of the Chazy Group has recently been transferred to the Ohio State University. Figured specimens are catalogued in the collections of the Orton Geological Museum.

Occurrence.—*Thrincodus palaris* was found in a sample taken 15 ft below the top of the McLish Formation. *T. palaris* also has been reported from the Chazy Group of New York (Raring, 1972); Copenhagen Formation and Antelope Valley Limestone of Nevada (Harris and others, 1979); Holston Formation of Tennessee (Carnes, 1975); Woods Hollow Shale of Texas (Bergström, 1978); and Row Park Limestone of Maryland and West Virginia (Boger, 1976).

Figured specimen.—OSU 37292 (holotype).

Nonfigured paratypes.—OSU 31771, 31772 (illustrated in Carnes, 1975, pl. 2, figs. 6,7), 38701 (illustrated in Raring, 1972, pl. 2, fig. 8).

Genus **Triangulodus** van Wamel, 1974

Type species.—*Scandodus brevibasis* (Sergeeva), sensu Lindström, 1971.

Discussion.—Much confusion has arisen concerning the relationship of *Trigonodus* Nieper, *Triangulodus, Scandodus* Lindström, and *Tripodus* Bradshaw. Ethington and Clark (1982, p. 109) and Cooper (1981, p. 179) discussed the problems associated with interpretation of those four genera. Ethington and Clark (1982) contended that *Triangulodus* is a junior subjective synonym of *Tripodus* and that *Scandodus* is morphologically similar but composed of hyaline rather than albid elements.

The apparatus of *Scandodus* based on the type species, *S. furnishi,* appears to be represented by three hyaline coniform elements corresponding to three form-species (Lindström, 1971, p. 39). *Tripodus,* established by Bradshaw (1969), was reevaluated by Ethington and Clark (1982), who described five distinct, costate, coniform elements with albid cusps.

Original reference to *Trigonodus* by Nieper (1969) is inconclusive regarding important characteristics (e.g., unimembrate vs. multimembrate apparatus). Emended *Trigonodus* (Cooper, 1981) includes multielement species composed of costate, coniform elements. Cooper's reconstruction of *Trigonodus* is similar to that of *Tripodus,* but includes hyaline elements.

Triangulodus, as described by van Wamel (1974), is composed of five elements comparable to those of *Tripodus* and *Trigonodus*. Van Wamel assigned two species to *Triangulodus, T. brevibasis* (Sergeeva) and *T. subtilis* n. sp. The former is composed entirely of hyaline elements, whereas the latter is composed of albid elements.

Ethington and Clark (1982) stated that *Triangulodus* cannot be used for species characterized by albid elements because *Tripodus* has priority by five years. Conversely, species consisting of hyaline elements should not be included in *Tripodus* (assuming that that characteristic is of taxonomic significance at the generic level). Consequently, the following species are here included in *Triangulodus,* because it has a quinquimembrate apparatus and hyaline elements, which distinguish it from *Scandodus* and *Tripodus,* respectively. *Trigonodus* has priority over *Triangulo-*

dus, but was established on a single morphologic form (*T. triangularis* Nieper) with uncertain multimembrate status.

Van Wamel (1974) established *Paltodus volchovensis* Sergeeva, a form-species, as the type species of *Triangulodus. P. volchovensis* was included by the original reviser (Lindström, 1971) in the multielement species *Scandodus brevibasis.* Van Wamel (1974, p. 96) agreed with Lindström's (1971) synonymy of *S. brevibasis* and retained the specific name. Consequently, *Scandodus brevibasis* should have been regarded as the type species of the newly erected multielement genus.

Triangulodus alatus Dzik, 1976
Pl. 5, Figs. 3,4,6,9,10

Triangulodus (?) *alatus* sp. n. Dzik, 1976, p. 422, text-fig. 20f–k, pl. XLI, fig. 2-5.
Eoneoprioniodus alatus (Dzik). Dzik, 1983, fig. 6 (nos. 12,13).

Description.—Apparatus consists of five coniform elements corresponding to oistodontiform, paltodontiform, acontiodontiform, acodontiform, and erect scandodontiform elements of van Wamel (1974, p. 96–97) with strongly developed costae that are basally elongated (Dzik, 1976, p. 422); all elements hyaline.

Remarks.—*Triangulodus alatus* is sparsely represented in the McLish–Tulip Creek section. No sample contains the complete apparatus, although each element is represented in the section.

Dzik (1983) reassigned *T. alatus* to *Eoneoprioniodus* Mound. Ethington and Clark (1982, p. 88) listed *Eoneoprioniodus* as a junior synonym of *Pteracontiodus,* noting apparatus similarity. Species of *Pteracontiodus* are composed of hyaline elements comparable to those of *Triangulodus;* therefore, that genus may prove to be a more suitable generic assignment for *T. alatus.*

Occurrence.—*Triangulodus alatus* was found between 86 and 694 ft above the base of the section. It was described by Dzik (1976) from upper Llanvirn erratic boulders in Estonia. *T. alatus* is also known from the Holston Formation and associated strata of eastern Tennessee (= *T.* sp. cf. *T. brevibasis* of Carnes, 1975, p. 215).

Collection.—64 specimens (25 oistodontiform, 3 paltodontiform, 17 erect scandodontiform, 13 acodontiform, 6 acontiodontiform).

Figured specimens.—OSU 37293–37297, inclusive.

Genus **indeterminate**, species A
Pl. 5, Figs. 16,17,20–23

Description.—Skeletal apparatus consists of six types of very small elements. Sa element alate, with relatively long, denticulate posterior process and short lateral processes, each with one recurved denticle. Sb element like Sa, but lateral processes not symmetrically disposed. Sc element bipennate, the anterior process turned to one side. M? element pastinate, with subequal processes; anterior and lateral processes weakly denticulate; posterior process strongly denticulate and slightly arched.

P elements pastiniscaphate; anterior and posterior processes of Pa element (dextral) subequal, forming arched bar in lateral profile. Bifid posterolateral process extends from cusp at angle of 50–60° with respect to posterior process; side opposite primary posterolateral process may have one or two secondary processes. Pb element has very long, strongly denticulate anterior and posterior processes; lateral process short and adenticulate.

Remarks.—The apparatus of genus indeterminate, species A is comparable to that of *Amorphognathus,* as suggested by Sweet (personal communication). The elements of genus indeterminate, species A are very small and few. Consequently, it cannot be concluded from the specimens recovered whether the entire apparatus is represented.

Occurrence.—This species was found near the top of the McLish Formation (samples 82JA-350, 82JA-360).

Collection.—37 specimens (10 Pa, 12 Pb, 7 M, 2 Sa, 3 Sb, 3 Sc).

Figured specimens.—OSU 37298–37303, inclusive.

Genus **indeterminate**, species B
Pl. 5, Figs. 18,19

Description.—Apparatus consists of a series of small, irregularly denticulate, cap-shaped elements.

Remarks.—Elements are so small that only two specimens were recovered on a 100-mesh sieve. On a 120-mesh sieve, the number of recovered specimens increased to nine. Generic affinities could not be postulated from recovered specimens.

Occurrence.—This species was found 350 ft above the base of the section.

Collection.—11 specimens.

Figured specimens.—OSU 37304 and 37305.

PLATES

Plate 1

Conodont genera *Belodella, Belodina, "Bryantodina," Coleodus?, Dapsilodus?, and Drepanoistodus*

Scanning electron micrographs of specimens coated with gold. Sample numbers prefixed 82JA represent the I-35 sections (see text). OSU catalog numbers are those of the Orton Museum of Geology, The Ohio State University.

Figs. 2–4,9.—*Belodella* sp. cf. *B. jemtlandica* Löfgren. *2,* geniculate coniform element (82JA-81), ×110. *3,* biconvex rastrate element (82JA-76), ×90. *4,* planoconvex rastrate element (82JA-81), ×110. *9,* triangular rastrate element (82JA-163). OSU 37191–37194, inclusive.

Figs. 1,5,8.—*Belodella robusta* Ethington and Clark. *1,* triangular rastrate element (82JA-403), ×90. *5,* biconvex rastrate element (82JA-403), ×100. *8,* planoconvex rastrate element (82JA-534), ×130. OSU 37195–37197, inclusive.

Figs. 10,13,14.—*Belodina monitorensis* Ethington and Schumacher. *10,* grandiform rastrate element (82JA-360), ×100. *13,* geniculate coniform element (82JA-360), ×100. *14,* compressiform rastrate element (82JA-245), ×100. OSU 37198–37200, inclusive.

Fig. 6.—*"Bryantodina"* sp. (82JA-66), ×100. OSU 37201.

Fig. 7.—*Coleodus?* sp. (82JA-123), ×82.5. OSU 37202.

Figs. 11,12.—*Dapsilodus? nevadensis* (Ethington and Schumacher). *11,* distacodontiform element (82JA-534), ×130. *12,* scandodontiform element (82JA-534), ×115. OSU 37203, 37204.

Figs. 18–21.—*Drepanoistodus angulensis* (Harris). *18,* suberectiform element (82JA-66), ×95. *19,* homocurvatiform element (82JA-67), ×75. *20,* scandodontiform element (82JA-66), ×100. *21,* geniculate coniform element (82JA-66), ×70. OSU 37205–37208, inclusive.

Figs. 15–17,22.—*Drepanoistodus suberectus* (Branson and Mehl). *15,* homocurvatiform element (82JA-623), ×60. *16,* geniculate coniform element (82JA-623), ×70. *17,* homocurvatiform (scandodontiform) element (82JA-623), ×60. *22,* suberectiform element (82JA-623), ×80. OSU 37209–37212, inclusive.


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22

Plate 2

Conodont genera *Eoplacognathus, Erismodus, Erraticodon, Histiodella,* and *Leptochirognathus*

Scanning electron micrographs of specimens coated with gold. Sample numbers prefixed 82JA represent the I-35 section (see text); sample numbers prefixed 72SE represent the U.S. 77 section (see text). OSU catalog numbers are those of the Orton Museum of Geology, The Ohio State University.

Figs. 1,2,4.—*Eoplacognathus* sp. *1,* dextral pastiniplanate pectiniform element (82JA-81), ×80. *2,* stelliplanate pectiniform element (82JA-97), ×80. *4,* sinistral pastiniplanate pectiniform element (82JA-97), ×65. OSU 37213–37215, inclusive.

Figs. 3,5,7–9,11,12.—*Erismodus arbucklensis* n. sp. *3,* Pb element (82JA-350), ×120. *5,* Pa element (82JA-360), ×110. *7,* Sa element, posterior view (82JA-350), ×90. *8,* Sba element (82JA-360), ×110. *9,* M element, basal lateral view (82JA-484), ×85. *11,* Sc element (82JA-260), ×100. *12,* Sbb element, inner lateral view (82JA-360), ×85. OSU 37216–37222, inclusive.

Figs. 10,13–18.—*Erraticodon* sp. cf. *E. balticus* Dzik. *10,* Sba element (82JA-163), ×50. *13,* Pb element (72SE-125), ×55. *14,* Sa element (72SE-125), ×70. *15,* Sbb element (82JA-623), ×75. *16,* Sc element (72SE-125), ×75. *17,* M element (82JA-163), ×65. *18,* Pa element (82JA-290), ×65. OSU 37223–37229, inclusive.

Fig. 6.—*Histiodella* n. sp. 2 Harris and others (82JA-67), ×100. OSU 37230.

Figs. 19–21.—*Leptochirognathus quadratus* Branson and Mehl. *19,* quadratiform element (82JA-210), ×140. *20,* primadontiform element (82JA-260), ×115. *21,* graciliform element (82JA-260), ×120. OSU 37231–37233, inclusive.

Plate 3

Conodont genera *Neomultioistodus, Oneotodus?, Paraprioniodus, Phragmodus,* and *Protopanderodus*

Scanning electron micrographs of specimens coated with gold. Sample numbers prefixed 82JA represent the I-35 section (see text). OSU catalog numbers are those of the Orton Museum of Geology, The Ohio State University.

Figs. 1–5,7,9.—*Neomultioistodus compressus* Harris and Harris. *1,* Pa element (82JA-66), ×60. *2,* Sa element (82JA-66), ×110. *3,* Sa element, posterior view (82JA-66), ×60. *4,* Sb element (82JA-66), ×40. *5,* M element (82JA-66), ×57.5. *7,* Pb element (82JA-67), ×57.5. *9,* Sc element (82JA-66), ×75. OSU 37234–37240, inclusive.

Fig. 25.—*Oneotodus? ovatus* (Stauffer). (82JA-684), ×140. OSU 37241.

Figs. 6,8,11–13,16.—*Paraprioniodus* sp. cf. *P. costatus* (Mound). *6,* Pa element, anterolateral view (82JA-66), ×80. *8,* Pb element (82JA-66), ×100. *11,* Sa element (82JA-66), ×65. *12,* M element (82JA-66), ×70. *13,* Sb element (82JA-66), ×100. *16,* Sc element (82JA-66), ×100. OSU 37244–37249, inclusive.

Figs. 10,14,15,18,20,24.—*Phragmodus flexuosus* morphotype A. *10,* Sc element (82JA-360), ×70. *14,* Pa element (82JA-360), ×70. *15,* Sa element (82JA-360), ×62.5. *18,* Sb element (82JA-350), ×90. *20,* Pb element (82JA-360), ×75. *24,* M element (82JA-360), ×60. OSU 37250–37255, inclusive.

Fig. 17.—*Phragmodus flexuosus* morphotype B. P element (82JA-123), ×65. OSU 37256.

Figs. 19,21–23.—*Protopanderodus varicostatus* (Sweet and Bergström). *19,* unistriatiform, with pronounced lateral costa (82JA-97), ×70. *21,* symmetrical varicostatiform element, posterior view (82JA-97), ×75. *22,* unistriatiform element (82JA-81), ×50. *23,* asymmetrical varicostatiform element (82JA-81), ×100. OSU 37274–37277, inclusive.


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25

Plate 4

Conodont genera *Pteracontiodus*?, *Cahabagnathus, Panderodus,* and *Plectodina*

Scanning electron micrographs of specimens coated with gold. Sample numbers prefixed 82JA represent the I-35 section (see text). OSU catalog numbers are those of the Orton Museum of Geology, The Ohio State University.

Figs. 1–5.—*Pteracontiodus*? sp. *1,* Sb element (82JA-66), ×50. *2,* M element (82JA-66), ×55. *3,* Sa element (82JA-66), ×60. *4,* P element (82JA-66), ×60. *5,* Sc element (82JA-66), ×70. OSU 37278–37282, inclusive.

Figs. 6,10,13.—*Cahabagnathus directus* n. sp. *6,* stelliplanate pectiniform element showing bifid anterolateral process (82JA-360), ×80. *10,* sinistral pastiniplanate pectiniform element (82JA-360), ×70. *13,* stelliplanate pectiniform element showing posterior process (82JA-360), ×100. OSU 37269–37271, inclusive.

Figs. 7,11.—*Cahabagnathus friendsvillensis* (Bergström). *7,* sinistral pastiniplanate element (82JA-385), ×100. *11,* stelliplanate element (82JA-385), ×100. OSU 37266, 37267.

Figs. 8,9.—*Cahabagnathus sp. 8,* stelliplanate pectiniform element (82JA-163), ×60. *9,* sinistral pastiniplanate pectiniform element (82JA-178), ×70. OSU 37272, 37273.

Fig. 12.—*Panderodus* sp. (82JA-285), ×100. OSU 37243.

Fig. 14.—*Panderodus panderi* (Stauffer). (82JA-684), ×70. OSU 37242.

Fig. 15.—*Cahabagnathus chazyensis* Bergström. Sinistral pastiniplanate pectiniform element (82JA-684), ×100. OSU 37268.

Figs. 16,19,20,23,24.—*Plectodina* sp. *16,* angulate Pb element (82JA-350), ×140. *19,* digyrate M element (82JA-360), ×130. *20,* bipennate Sc element (82JA-350), ×160. *23,* digyrate Sb element, posterior view (82JA-350), ×175. *24,* pastinate Pa element (82JA-360), ×140. OSU 37260–37264, inclusive.

Figs. 17,18,22.—*Plectodina* sp. cf. *P. aculeata* (Stauffer). *17,* alate Sa element, posterior view (82JA-534), ×150. *18,* pastinate Pa element (82JA-534), ×135. *22,* angulate M element (82JA-534), ×100. OSU 37257–37259, inclusive.

Fig. 21.—*Plectodina*? sp., digyrate element, posterior view (82JA-699), ×95. OSU 37265.


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24

Plate 5

Conodont genera *Scandodus*?, *Staufferella*, "*Tetraprioniodus*," *Thrincodus*, *Triangulodus*, and indeterminate

Scanning electron micrographs of specimens coated with gold. Sample numbers prefixed 82JA represent the I-35 section (see text). OSU catalog numbers are those of the Orton Museum of Geology, The Ohio State University.

Figs. 1,2,5,7,8.—*Scandodus*? *sinuosus* Mound. *1,* acontiodontiform element (82JA-66), ×80. *2,* acodontiform element (82JA-66), ×57.5. *5,* twisted drepanodontiform element (82JA-66), ×55. *7,* straight drepanodontiform element (82JA-66), ×55. *8,* scandodontiform element (82JA-66), ×50. OSU 37283–37287, inclusive.

Figs. 12–14.—*Staufferella* sp. *12,* asymmetrical element, short base (82JA-102), ×90. *13,* asymmetrical element, long base (82JA-97), ×70. *14,* symmetrical element, posterior view (82JA-81), ×100. OSU 37288–37290, inclusive.

Fig. 11.—"*Tetraprioniodus*" sp. (82JA-86), ×100. OSU 37291.

Fig. 15.—*Thrincodus palaris* n. gen., n. sp. (82JA-390), ×80. OSU 37292.

Figs. 3,4,6,9,10.—*Triangulodus alatus* Dzik. *3,* paltodontiform element (82JA-350), ×100. *4,* acodontiform element (82JA-609), ×100. *6,* acontiodontiform element, posterior view (82JA-484), ×100. *9,* erect scandodontiform element (82JA-375), ×100. *10,* oistodontiform element (82JA-519), ×80. OSU 37293–37297, inclusive.

Figs. 16,17,20–23.—Genus indeterminate, sp. A. *16,* Pb element (82JA-350), ×95. *17,* Pa element (82JA-350), ×190. *20,* M? element (82JA-350), ×160. *21,* Sb element (82JA-350), ×200. *22,* Sc element (82JA-350), ×170. *23,* Sa element (82JA-350), ×185. OSU 37298–37303, inclusive.

Figs. 18,19.—Genus indeterminate, sp. B. *18,* upper view (82JA-350), ×210. *19,* upper view (82JA-350), ×250. OSU 37304, 37305.


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23

REFERENCES CITED

Aldridge, R. J., 1982, A fused cluster of coniform conodont elements from the Late Ordovician of Washington Land, western north Greenland: Palaeontology, v. 25, pt. 2, p. 425–430.

Amsden, T. W., 1957, Catalogue of fossils from the Middle and Upper Ordovician of Oklahoma: Oklahoma Geological Survey Circular 43, 41 p.

Amsden, T. W.; and Sweet, W. C., 1983, Upper Bromide Formation and Viola Group (Middle and Upper Ordovician) in eastern Oklahoma: Oklahoma Geological Survey Bulletin 132, 76 p.

Andrews, H. E., 1967, Middle Ordovician conodonts from the Joachim Dolomite of eastern Missouri: Journal of Paleontology, v. 41, no. 4, p. 881–901.

An Tai-xiang; Zhang Fang; Xiang Weida; Zhang Youqiu; Xu Wenhao; Zhang Huijuan; Jiang Debiao; Yang Changsheng; Lin Liandi; Cui Zhantang; and Yang Xinchang, 1983, The conodonts of North China and the adjacent regions: Science Press of China, 223 p.

Barnes, C. R., 1974, Ordovician conodont biostratigraphy of the Canadian Arctic, *in* Aitken, J. D.; and Glass, D. G. (eds.), Symposium on the geology of the Canadian Arctic: Geological Association of Canada and Canadian Society of Petroleum Geologists, Toronto, p. 211–240.

———1977, Ordovician conodonts from the Ship Point and Bad Cache Rapids Formations, Melville Peninsula, southeastern District of Franklin: Geological Survey of Canada Bulletin 269, p. 99–119.

Barnes, C. R.; and Fåhraeus, L. E., 1975, Provinces, communities, and the proposed nektobenthic habit of Ordovician conodontophorids: Lethaia, v. 8, p. 133–149.

Barnes, C. R.; and Poplawski, M. L. S., 1973, Lower and Middle Ordovician conodonts from the Mystic Formation, Quebec, Canada: Journal of Paleontology, v. 47, no. 4, p. 760–790.

Bergström, S. M., 1971, Conodont biostratigraphy of the Middle and Upper Ordovician of Europe and eastern North America: Geological Society of America Memoir 127, p. 83–161.

———1973a, Ordovician conodonts, *in* Hallam, A. (ed.), Atlas of palaeobiogeography: Elsevier, Amsterdam, p. 47–58.

———1973b, Correlation of the late Lasnamägian Stage (Middle Ordovician) with the graptolite succession: Geologiska Föreningens i Stockholm Förhandlingar, v. 95, pt. 1, p. 9–18.

———1973c, Biostratigraphy and facies relations in the lower Middle Ordovician of easternmost Tennessee: American Journal of Science, v. 273-A, p. 261–293.

———1977, Early Paleozoic conodont biostratigraphy in the Atlantic Borderlands, *in* Swain, F. M. (ed.), Stratigraphic micropaleontology of Atlantic Basin and Borderlands: Elsevier, Amsterdam, p. 85–110.

———1978, Middle and Upper Ordovician conodont and graptolite biostratigraphy of the Marathon, Texas, graptolite zone reference standard: Palaeontology, v. 21, pt. 4, p. 723–758.

———1983, Biogeography, evolutionary relationships, and biostratigraphic significance of Ordovician platform conodonts: Fossils and Strata, no. 15, p. 35–58.

Bergström, S. M.; and Carnes, J. B., 1976, Conodont biostratigraphy and paleoecology of the Holston Formation (Middle Ordovician) and associated strata in eastern Tennessee, *in* Barnes, C. R. (ed.), Conodont paleoecology: Geological Association of Canada Special Paper, no. 15, p. 27–57.

Bergström, S. M.; Riva, J.; and Kay, M., 1974, Significance of conodonts, graptolites and shelly faunas from the Ordovician of western and north-central Newfoundland: Canadian Journal of Earth Science, v. 11, p. 1625–1660.

Bergström, S. M.; and Sweet, W. C., 1966, Conodonts from the Lexington Limestone (Middle Ordovician) of Kentucky, and its lateral equivalents in Ohio and Indiana: Bulletins of American Paleontology, v. 50, no. 229, p. 271–441.

Boger, J., 1976, Conodont biostratigraphy of the Upper Beekmantown Group and the St. Paul Group (Middle Ordovician) of Maryland and West Virginia: The Ohio State University unpublished M.S.thesis, 180 p.

Bolton, T. E.; and Nowlan, G. S., 1979, A Late Ordovician fossil assemblage from an outlier north of Aberdeen Lake, District of Keewatin: Geological Survey of Canada Bulletin 321, p. 1–26.

Bradshaw, L. E., 1969, Conodonts from the Fort Peña Formation (Middle Ordovician), Marathon Basin, Texas: Journal of Paleontology, v. 43, no. 5, p. 1137–1168.

Branson, E. B.; and Mehl, M. G., 1933a, Conodont studies no. 1; conodonts from Harding sandstone of Colorado; from the Bainbridge (Silurian) of Missouri; from the Jefferson City (Lower Ordovician) of Missouri: Missouri University Studies, v. 8, no. 1, p. 1–72.

———1933b, Conodont studies no. 2; conodonts from Joachim (Middle Ordovician) of Missouri; from the Plattin (Middle Ordovician) of Missouri; from the Maquoketa–Thebes (Upper Ordovician) of Missouri; a study of Hinde's types of conodonts preserved in the British Museum: Missouri University Studies, v. 8, no. 2, p. 77–167.

———1943, Ordovician conodont faunas from Oklahoma: Journal of Paleontology, v. 17, no. 4, p. 374–387.

Carnes, J. B., 1975, Conodont biostratigraphy in the lower Middle Ordovician of the western Appalachian thrust-belts in northeastern Tennessee: The Ohio State University unpublished Ph.D. dissertation, 291 p.

Carnes, J. B.; and Bergström, S. M., 1973, On the stage subdivision of the North American lower Middle Ordovician: biostratigraphy and correlation of the Ashby Stage: Geological Society of America Abstracts with Programs, v. 5, no. 4, p. 307.

Cooper, B. J., 1976, Multielement conodonts from the St. Clair Limestone (Silurian) of southern Illinois: Journal of Paleontology, v. 50, p. 205–217.

———1981, Early Ordovician conodonts from the Horn Valley Siltstone, central Australia: Palaeontology, v. 24, pt. 1, p. 147–183.

Cooper, G. A., 1956, Chazyan and related brachiopods: Smithsonian Institution Miscellaneous Collection, v. 127, pt. 1 (p. 1–1024) and pt. 2 (p. 1025–1045).

Cullison, J. S., 1938, Dutchtown fauna of southeastern Missouri: Journal of Paleontology, v. 12, no. 3, p. 219–228.

Decker, C. E.; and Merritt, C. A., 1931, The stratigraphy and physical characteristics of the Simpson Group: Oklahoma Geological Survey Bulletin 55, 112 p.

Drygant, D. M., 1974, New Middle Ordovician conodonts from northwestern Volyn: Paleontologicheskii Sbornik, no. 11, p. 54–58.

Dzik, J., 1976, Remarks on the evolution of Ordovician conodonts: Acta Palaeontologica Polonica, v. 21, no. 4, p. 395–455.

———1978, Conodont biostratigraphy and paleogeographical relations of the Ordovician Mójcza Limestone (Holy Cross Mountains, Poland): Acta Palaeontologica Polonica, v. 23, no. 1, p. 51–72.

———1983, Relationships between Ordovician Baltic and North American Midcontinent conodont faunas: Fossils and Strata, no. 15, p. 59–85.

Epstein, A. G.; Epstein, J. B.; and Harris, L. D., 1977, Conodont color alteration—an index to organic metamorphism: U.S. Geological Survey Professional Paper 995, p. 1–27.

Ethington, R. L., 1959, Conodonts of the Ordovician Galena Formation: Journal of Paleontology, v. 33, no. 2, p. 257–292.

Ethington, R. L.; and Brand, U., 1981, *Oneotodus simplex* (Furnish) and the genus *Oneotodus* (Conodonta): Journal of Paleontology, v. 55, no. 1, p. 239–247.

Ethington, R. L.; and Clark, D. L., 1982, Lower and Middle Ordovician conodonts from the Ibex area, western Millard County, Utah: Brigham Young University Geology Studies, v. 28, pt. 2, 155 p.

Ethington, R. L.; and Schumacher, D., 1969, Conodonts of the Copenhagen Formation (Middle Ordovician) in central Nevada: Journal of Paleontology, v. 43, no. 2, p. 440–484.

Fåhraeus, L. E., 1966, Lower Viruan (Middle Ordovician) conodonts from the Gullhögen quarry, southern central Sweden: Sveriges Geologiska Undersökning, Avhandlingar och Uppsatser, Series C, no. 610, Arsbok 60, no. 5, 40 p.

Farmer, G. T., Jr., 1975, New bifoliate tubular bryozoan genera from the Simpson Group (Middle Ordovician), Arbuckle Mountains, Oklahoma: Bulletins of American Paleontology, v. 67, no. 287, p. 123–138.

Fay, R. O., 1969, Geology of the Arbuckle Mountains along Interstate-35, Carter and Murray Counties, Oklahoma—Guidebook, 1969: Ardmore Geological Society, Ardmore, Oklahoma, 75 p.

Furnish, W. M., 1938, Conodonts from the Prairie du Chien (Lower Ordovician) beds of the upper Mississippi Valley: Journal of Paleontology, v. 12, no. 4, p. 318–340.

Globensky, Y.; and Jauffred, J., 1971, Stratigraphic distribution of conodonts in the Middle Ordovician Neuville section of Quebec: Proceedings, Geological Association of Canada, v. 23, p. 43–68.

Graves, R. W., Jr.; and Ellison, S. P., Jr., 1941, Ordovician conodonts of the Marathon basin, Texas: University of Missouri School of Mines and Metallurgy Bulletin, Technical Series, v. 14, no. 2, 26 p.

Ham, W. E., 1954, Algal origin of the "birdseye" limestone in McLish formation: Oklahoma Academy of Science, Proceedings 1952, v. 33, p. 200–203.

Ham, W. E.; and others, 1969, Regional geology of the Arbuckle Mountains, Oklahoma: Oklahoma Geological Survey Guidebook 17, p. 1–52.

Ham, W. E.; and Wilson, J. L., 1967, Paleozoic epeirogeny and orogeny in the central United States, *in* Symposium on the chronology of tectonic movements in the United States: American Journal of Science, v. 265, no. 5, p. 332–407.

Hamar, G., 1964, The Middle Ordovician of the Oslo region, Norway. 17. Conodonts from the lower Middle Ordovician of Ringerike: Norsk Geologisk Tidsskrift, v. 44, p. 243–292.

———1966, The Middle Ordovician of the Oslo region, Norway. 22. Preliminary report on conodonts from the Oslo–Asker and Ringerike districts: Norsk Geologisk Tidsskrift, v. 46, p. 27–83.

Harris, A. G.; Bergström, S. M.; Ethington, R. L.; and Ross, R. J., Jr., 1979, Aspects of Middle and Upper Ordovician conodont biostratigraphy of carbonate facies in Nevada and southeast California and comparison with some Appalachian successions: Brigham Young University Geology Studies, v. 26, pt. 3, p. 7–44.

Harris, R. W., 1957, Ostracoda of the Simpson Group of Oklahoma: Oklahoma Geological Survey Bulletin 75, 333 p.

———1962, New conodonts from the Joins (Ordovician) Formation of Oklahoma: Oklahoma Geology Notes, v. 22, p. 199–211.

Harris, R. W.; and Harris, B., 1965, Some West Spring Creek (Ordovician Arbuckle) conodonts from Oklahoma: Oklahoma Geology Notes, v. 25, p. 34–47.

Illing, L. V., 1959, Deposition and diagenesis of some upper Palaeozoic carbonate sediments in western Canada: Fifth World Petroleum Congress Proceedings, Section 1, Paper 2, p. 23–52.

Laporte, L. F., 1967, Carbonate deposition near mean sea-level and resultant facies mosaic: Manlius Formation (Lower Devonian) of New York State: American Association of Petroleum Geologists Bulletin, v. 51, no. 1, p. 73–101.

Lindström, M., 1955, Conodonts from the lowermost Ordovician strata of south central Sweden: Geologiska Föreningens i Stockholm Förhandlingar, v. 76, p. 517–614.

———1960, A Lower-Middle Ordovician succession of conodont faunas: International Geological Congress, 21st session, Norden, pt. 7, p. 88–96.

———1964, Conodonts: Elsevier, Amsterdam, 196 p.

———1971, Lower Ordovician conodonts of Europe: Geological Society of America Memoir 127, p. 21–61.

———1976, Conodont paleogeography of the Ordovician, *in* Bassett, M. G. (ed.), The Ordovician System; proceedings of a Palaeontological Association Symposium, Birmingham, September 1974: University of Wales Press and National Museum of Wales, Cardiff, p. 501–522.

Loeblich, A. R., 1938, A study of McLish (Middle Ordovician) Bryozoa of the Arbuckle Mountains, Oklahoma: University of Oklahoma unpublished M.S. thesis, 55 p.

Löfgren, A., 1978, Arenigian and Llanvirn conodonts from Jämtland, northern Sweden: Fossils and Strata, no. 13, 129 p.

Longman, M. W., 1981, Deposition of the Bromide Formation, Arbuckle Mountains, Oklahoma: ontogeny of an ancient carbonate shelf: Shale Shaker, v. 32, no. 2, p. 1–18.

McHargue, T. R., 1975, Conodonts of the Joins Formation (Ordovician), Arbuckle Mountains, Oklahoma: University of Missouri–Columbia unpublished M.S. thesis, 151 p.

———1982, Ontogeny, phylogeny, and apparatus reconstruction of the conodont genus *Histiodella*, Joins Formation, Arbuckle Mountains, Oklahoma:

Journal of Paleontology, v. 56, no. 6, p. 1410–1433.

Moskalenko, T. A., 1972, Ordovician conodonts of the Siberian Platform and their bearing on multielement taxonomy: Geologica et Palaeontologica, Sonderband 1, p. 47–56.

———1973, Conodonts of the Middle and Upper Ordovician of the Siberian Platform: Akademiya Nauk SSSR, Sibirskoe Otdelenie, Instituta Geologii i Geofiziki Trudy, vyp. 137, p. 1–143.

Mound, M. C., 1965a, Two new conodont genera from the Joins Formation (lower Middle Ordovician) of Oklahoma: Biological Society of Washington Proceedings, v. 78, art. 24, p. 193–200.

———1965b, A conodont fauna from the Joins Formation (Ordovician), Oklahoma: Tulane Studies in Geology, v. 4, no. 1, p. 1–46.

Nieper, C., 1969, Conodonts, *in* Hill, D.; Playford, C.; and Woods, J. T. (eds.), Ordovician and Silurian fossils of Queensland: Queensland Palaeontological Society, Brisbane, Australia, p. o.12–o.15.

Nowlan, G. S.; and Barnes, C. R., 1981, Late Ordovician conodonts from the Vauréal Formation, Anticosti Island, Quebec: Geological Survey of Canada Bulletin 329, pt. 1, p. 1–49.

Oberg, R., 1966, Winnipeg conodonts from Manitoba: Journal of Paleontology, v. 40, no. 1, p. 130–147.

Perkins, R. D., 1963, Petrology of the Jeffersonville Limestone (Middle Devonian) of southeastern Indiana: Geological Society of America Bulletin, v. 74, no. 11, p. 1335–1354.

Raring, A. M., 1972, Conodont biostratigraphy of the Chazy Group (lower Middle Ordovician), Champlain Valley, New York and Vermont: Lehigh University unpublished Ph.D. dissertation, 152 p.

Repetski, J. E.; and Ethington, R. L., 1977, Conodonts from graptolite facies in the Ouachita Mountains, Arkansas and Oklahoma, *in* Stone, C. G. (ed.), Symposium on the geology of the Ouachita Mountains: Arkansas Geological Commission, v. 1, p. 92–106.

Rexroad, C. B.; Droste, J. B.; and Ethington, R. L., 1982, Conodonts from the Everton Dolomite and the St. Peter Sandstone (lower Middle Ordovician) in a core from southwestern Indiana: Indiana Department of Natural Resources Geological Survey Occasional Paper 39, p. 1–13.

Roscoe, M., 1973, Conodont biostratigraphy and facies relationships of the lower Middle Ordovician strata in the Upper Lake Champlain Valley: The Ohio State University unpublished M.S. thesis, 125 p.

Ross, R. J., Jr.; and others, 1982, The Ordovician System in the United States: International Union of Geological Sciences Publication 12, 73 p.

Schmidt, M. A., 1982, Conodont biostratigraphy and facies relations of the Chickamauga Limestone (Middle Ordovician) of the southern Appalachians, Alabama and Georgia: The Ohio State University unpublished M.S. thesis, 270 p.

Schopf, T. J. M., 1966, Conodonts of the Trenton Group (Ordovician) in New York, southern Ontario, and Quebec: New York State Museum and Science Service Bulletin 405, 105 p.

Schramm, M. W., Jr., 1964, Paleogeologic and quantitative lithofacies analysis, Simpson Group, Oklahoma: American Association of Petroleum Geologists Bulletin, v. 48, no. 7, p. 1164–1195.

———1965, Resume of Simpson (Ordovician) stratigraphy, *in* Herndon, T. (ed.), Symposium on the Simpson: Tulsa Geological Society Digest, v. 33, p. 26–34.

Sergeeva, S. P., 1963, Conodonts from the Lower Ordovician of the Leningrad region: Paleontologicheskii Zhurnal, no. 2, p. 93–108.

Shaw, F. C., 1974, Simpson Group (Middle Ordovician) trilobites of Oklahoma: Journal of Paleontology Memoir 6 (supplement to v. 48), p. 1–54.

Shinn, E. A., 1968, Practical significance of birdseye structures in carbonate rocks: Journal of Sedimentary Petrology, v. 38, no. 1, p. 215–223.

Simes, J. E., 1980, Age of the Arthur Marble: conodont evidence from Mount Owen, northwest Nelson: New Zealand Journal of Geology and Geophysics, v. 23, no. 4, p. 529–532.

Stauffer, C. R., 1930, Conodonts from Decorah Shale: Journal of Paleontology, v. 4, no. 2, p. 121–128.

———1935, Conodonts of the Glenwood beds: Geological Society of America Bulletin, v. 46, no. 1, p. 125–168.

———1940, Conodonts from the Devonian and associated clays of Minnesota: Journal of Paleontology, v. 14, no. 5, p. 417–435.

Stouge, S. S., 1984, Conodonts of the Middle Ordovician Table Head Formation, western Newfoundland: Fossils and Strata, no. 16, 145 p.

Sweet, W. C., 1955, Conodonts from the Harding Formation (Middle Ordovician) of Colorado: Journal of Paleontology, v. 29, no. 2, p. 226–262.

———1979, Late Ordovician conodonts and biostratigraphy of the western Midcontinent province: Brigham Young University Geology Studies, v. 26, pt. 3, p. 45–86.

———1981, *Belodina monitorensis, Phragmodus flexuosus, Plectodina aculeata, in* Ziegler, W. (ed.), Catalogue of conodonts: E. Schweizerbart'sche Verlag, Stuttgart, v. IV, p. 79–81, 255–259, 277–280.

———1982, Conodonts from the Winnipeg Formation (Middle Ordovician) of the northern Black Hills, South Dakota: Journal of Paleontology, v. 56, no. 5, p. 1029–1049.

———1984, Graphic correlation of upper Middle and Upper Ordovician rocks, North American Midcontinent Province, U.S.A., *in* Bruton, D. L. (ed.), Aspects of the Ordovician System: Palaeontological Contributions from the University of Oslo, no. 295, Universitetsforlaget, p. 23–35.

Sweet, W. C.; and Bergström, S. M., 1962, Conodonts from the Pratt Ferry Formation (Middle Ordovician) of Alabama: Journal of Paleontology, v. 36, no. 6, p. 1214–1252.

———1972, Multielement taxonomy and Ordovician conodonts: Geologica et Palaeontologica, Sonderband 1, p. 29–42.

———1973, Biostratigraphic potential of the Arbuckle Mountains sequence as a reference standard for the Midcontinent Middle and Upper Ordovician [abstract]: Geological Society of America Abstracts with Programs, v. 5, p. 355.

———1974, Provincialism exhibited by Ordovician conodont faunas, *in* Ross, C. A. (ed.), Paleogeographic provinces and provinciality: Society of Economic Paleontologists and Mineralogists Special Publication 21, p. 189–202.

———1976, Conodont biostratigraphy of the Middle and Upper Ordovician of the United States Midcontinent, *in* Bassett, M. G. (ed.), The Ordovician System, Proceedings of a Palaeontological Association Symposium, Birmingham, September 1974: University of Wales Press and National Museum of Wales, Cardiff, p. 121–151.

———1984, Conodont provinces and biofacies of the Late Ordovician, *in* Clark, D. L. (ed.), Conodont biofacies and provincialism: Geological Society of America Special Paper 196, p. 69–87.

Sweet, W. C.; Bergström, S. M.; and Carnes, J. B., 1973, Lower Middle Ordovician biostratigraphy in the North American Midcontinent, relations between sequences in Oklahoma, the Cincinnati Region and the western Appalachians [abstract]: Geological Society of America Abstracts with Programs, v. 5, p. 832–833.

Sweet, W. C.; Ethington, R. L.; and Barnes, C. R., 1971, North American Middle and Upper Ordovician conodont faunas: Geological Society of America Memoir 127, p. 163–193.

Sweet, W. C.; and Schönlaub, H. P., 1975, Conodonts of the genus *Oulodus* Branson and Mehl, 1933: Geologica et Palaeontologica, v. 9, p. 41–59.

Sweet, W. C.; Thompson, T. L.; and Satterfield, I. R., 1975, Conodont stratigraphy of the Cape Limestone (Maysvillian) of eastern Missouri, *in* Five studies in stratigraphy: Missouri Department of Natural Resources, Division of Research and Technical Information, Geological Survey, Report of Investigations 57, p. 1–60.

Sweet, W. C.; Turco, C. A.; Warner, E.; and Wilkie, L. C., 1959, Eden conodonts from the Cincinnati Region of Ohio and Kentucky, *pt. 1 of* The American Upper Ordovician standard: Journal of Paleontology, v. 33, no. 6, p. 1029–1068.

Taff, J. A., 1902, Description of the Atoka Quadrangle [Indian Territory]: U.S. Geological Survey Geologic Atlas, Atoka Folio (no. 79), 8 p.

———1904, Preliminary report on the geology of the Arbuckle and Wichita Mountains in Indian Territory and Oklahoma: U.S. Geological Survey Professional Paper 31, p. 1–81.

Tipnis, R. S.; Chatterton, B. D. E.; and Ludvigsen, R., 1978, Ordovician conodont biostratigraphy of the southern District of Mackenzie, Canada, *in* Stelck, C. R.; and Chatterton, B. D. E. (eds.), Western and Arctic Canadian biostratigraphy: Geological Association of Canada Special Paper 18, p. 39–91.

Ulrich, E. O., 1930, Ordovician trilobites of the family Telephidae and concerned stratigraphic correlations: U.S. National Museum Proceedings, v. 76, art. 21, 101 p.

Uyeno, T. T., 1974, Conodonts of the Hull Formation, Ottawa Group (Middle Ordovician), of the Ottawa–Hull area, Ontario and Quebec: Geological Survey of Canada Bulletin 248, 31 p.

van Wamel, W. A., 1974, Conodont biostratigraphy of the Upper Cambrian and Lower Ordovician of northwestern Öland, southeastern Sweden: Utrecht Micropaleontology Bulletin 10, p. 1–126.

Viira, V., 1974, Ordovician conodonts of the east Baltic: Institut Geologii Akademii Nauk Estonskoi SSR, Tallin, 142 p.

Webers, G. F., 1966, The Middle and Upper Ordovician conodont faunas of Minnesota: Minnesota Geological Survey Special Publication Series SP-4, 123 p.

Wilson, L. R.; and Dolly, E. D., 1964, Chitinozoa in the Tulip Creek Formation, Simpson Group (Ordovician), of Oklahoma: Oklahoma Geology Notes, v. 24, p. 224–230.

Youngquist, W. L.; and Cullison, J. S., 1946, The conodont fauna of the Ordovician Dutchtown Formation of Missouri: Journal of Paleontology, v. 20, no. 6, p. 579–590.

APPENDIX 1

Distribution and Abundance of Conodonts in the I-35 and U.S. 77 Sections

Distribution and abundance of conodonts in the I-35 and U.S. 77 sections are given in Tables A1-1 and A1-2.

Specimens are stored with The Ohio State University conodont collections under OSU 82JA, OSU 72SE, and OSU 72SF.

Table A1-1.–Distribution and Frequency of McLish and Tulip Creek Conodonts in the I-35 Section (OSU Locality 82JA)

Sample*

McLish Formation

Species	66	67	71	76	81	86	91	97	102	107	112	117	123	128	133	138	143	148	153	158	163	168
1. *Belodella* sp. cf. *B. jemtlandica*				4	6	8	6	10	2	1	4		1				4	7	2		23	4
2. *Belodella robusta*								1														
3. *Belodina monitorensis*																						
4. "*Bryantodina*" sp.	19	3																				
5. *Cahabagnathus chazyensis*																						
6. *Cahabagnathus friendsvillensis*																						
7. *Cahabagnathus directus* n. sp.																						
8. *Cahabagnathus* sp.																				1	7	1
9. *Coleodus*? sp.													1									
10. *Dapsilodus*? *nevadensis*																						
11. *Drepanoistodus angulensis*	45	21																				
12. *Drepanoistodus suberectus*				3	4	4	2	5	11	3	4	5	13	5		2	5	2	5		14	
13. *Eoplacognathus* sp.					6	1		5		2		1										
14. *Erismodus arbucklensis* n. sp.													3									
15. *Erraticodon* sp. cf. *E. balticus*					1		1	1	1	2	1	2						3			1	
16. *Histiodella* n. sp. 2		1																				
17. *Leptochirognathus quadratus*																						
18. *Neomultioistodus compressus*	389	297	9																			
19. *Oneotodus*? *ovatus*																						
20. *Panderodus panderi*																						
21. *Panderodus* sp.																	1	2				
22. *Paraprioniodus* sp. cf. *P. costatus*	126	65	3																			
23. *Phragmodus flexuosus* morphotype A																						
24. *Phragmodus flexuosus* morphotype B			6	15	9	11	6	8	2	6	47	18	330	46	4	7	165	72	158	1	4	2
25. *Plectodina* sp. cf. *P. aculeata*																						
26. *Plectodina* sp.																						
27. *Plectodina*? sp.																						
28. *Protopanderodus varicostatus*					15	2	1	29	7		3											1
29. *Pteracontiodus*? sp.	34	6																				
30. *Scandodus*? *sinuosus*	102	13	2																			
31. *Staufferella* sp.					3	2		5	3									2	1			
32. "*Tetraprioniodus*" sp.						1																
33. *Thrincodus palaris* n. gen., n. sp.																						
34. *Triangulodus alatus*						1		1					3				2	1				
35. Genus indeterminate, sp. A																						
36. Genus indeterminate, sp. B																						
Total	**715**	**406**	**20**	**22**	**44**	**30**	**16**	**65**	**26**	**14**	**59**	**26**	**351**	**51**	**4**	**9**	**177**	**89**	**166**	**2**	**49**	**8**

*All samples prefixed OSU 82JA; sample numbers represent distance in feet above the base of the section.

Table A1-1.–(*Continued*)

Sample*
McLish Formation

Species	173	178	183	188	198	208	210	211	215	219	222	245	247	250	255	260	285	290	321	329	350	355
1. *Belodella* sp. cf. *B. jemtlandica*	2	2	1	1	3	4		13					2	3			1		7		2	
2. *Belodella robusta*																						
3. *Belodina monitorensis*							1					1	1					3	9	6	2	
4. "*Bryantodina*" sp.																						
5. *Cahabagnathus chazyensis*																						
6. *Cahabagnathus friendsvillensis*																						
7. *Cahabagnathus directus* n. sp.																			5	12	14	4
8. *Cahabagnathus* sp.	6	12	2	2	2	3		3				3				3						
9. *Coleodus*? sp.																						
10. *Dapsilodus*? *nevadensis*																						
11. *Drepanoistodus angulensis*																						
12. *Drepanoistodus suberectus*	3	1	1		7	3	6	4	7			32	8	5	8	47	6	12	7	17	69	6
13. *Eoplacognathus* sp.																						
14. *Erismodus arbucklensis* n. sp.												1	2		1	17	1				26	1
15. *Erraticodon* sp. cf. *E. balticus*	1			1				1										2	3			
16. *Histiodella* n. sp. 2																						
17. *Leptochirognathus quadratus*							1							1		8					1	1
18. *Neomultioistodus compressus*																						
19. *Oneotodus*? *ovatus*																						
20. *Panderodus panderi*																						
21. *Panderodus* sp.	2																3		1	1	1	
22. *Paraprioniodus* sp. cf. *P. costatus*																						
23. *Phragmodus flexuosus* morphotype A																663	53	7	92	262	736	129
24. *Phragmodus flexuosus* morphotype B		7	5	3	22	17	149	7	69	3	1	436	216	79	97							
25. *Plectodina* sp. cf. *P. aculeata*																						
26. *Plectodina* sp.																					5	
27. *Plectodina*? sp.																						
28. *Protopanderodus varicostatus*	2		1		1	1	1	1										1	1		4	
29. *Pteracontiodus*? sp.																						
30. *Scandodus*? *sinuosus*																						
31. *Staufferella* sp.	1				1		1	1												1		
32. "*Tetraprioniodus*" sp.																						
33. *Thrincodus palaris* n. gen., n. sp.																						
34. *Triangulodus alatus*									2			2		1	1	7		1	1		4	
35. Genus indeterminate, sp. A																					24	
36. Genus indeterminate, sp. B																					11	
Total	**17**	**22**	**10**	**7**	**36**	**28**	**159**	**30**	**78**	**3**	**1**	**475**	**229**	**89**	**107**	**745**	**64**	**26**	**126**	**299**	**899**	**141**

*All samples prefixed OSU 82JA; sample numbers represent distance in feet above the base of the section.

Table A1-1.–(*Continued*)

	Sample*																					
	McLish Formation												Tulip Creek Formation									
Species	360	365	370	375	377	380	385	390	395	400	403	409	414	419	424	434	439	444	449	454	459	464
1. *Belodella* sp. cf. *B. jemtlandica*	9			1		3	13			9												
2. *Belodella robusta*					4						7			5								
3. *Belodina monitorensis*	3	1		1			1			3				4			1				1	
4. "*Bryantodina*" sp.																						
5. *Cahabagnathus chazyensis*																						
6. *Cahabagnathus friendsvillensis*					3		6	3						2							1	
7. *Cahabagnathus directus* n. sp.	39			3																		
8. *Cahabagnathus* sp.																						
9. *Coleodus*? sp.																						
10. *Dapsilodus*? *nevadensis*																						
11. *Drepanoistodus angulensis*																						
12. *Drepanoistodus suberectus*	203	1	1	14	8	7	26	1	2	10	4		1	13	1	1	9	3	1	1	3	
13. *Eoplacognathus* sp.																						
14. *Erismodus arbucklensis* n. sp.	24																					
15. *Erraticodon* sp. cf. *E. balticus*					2		1											1				
16. *Histiodella* n. sp. 2																						
17. *Leptochirognathus quadratus*																	2	1			1	
18. *Neomultioistodus compressus*																						
19. *Oneotodus*? *ovatus*																						
20. *Panderodus panderi*																						
21. *Panderodus* sp.	3									2	1			1								
22. *Paraprioniodus* sp. cf. *P. costatus*																						
23. *Phragmodus flexuosus* morphotype A	2,086	7	6	174	92	79	248	25	16	176	165	19	7	103	18	16	197	57	14	52	71	46
24. *Phragmodus flexuosus* morphotype B																						
25. *Plectodina* sp. cf. *P. aculeata*																						
26. *Plectodina* sp.	8																					
27. *Plectodina*? sp.											1									6	3	
28. *Protopanderodus varicostatus*				1	1		2			1			1	1								
29. *Pteracontiodus*? sp.																						
30. *Scandodus*? *sinuosus*																						
31. *Staufferella* sp.				1										2			2		1	1		
32. "*Tetraprioniodus*" sp.																						
33. *Thrincodus palaris* n. gen., n. sp.								1														
34. *Triangulodus alatus*				3					2				1									
35. Genus indeterminate, sp. A	13																					
36. Genus indeterminate, sp. B																						
Total	**2,388**	**9**	**7**	**198**	**110**	**89**	**297**	**30**	**20**	**201**	**178**	**19**	**9**	**132**	**19**	**17**	**211**	**62**	**16**	**60**	**80**	**46**

*All samples prefixed OSU 82JA; sample numbers represent distance in feet above the base of the section.

Table A1-1.–(Continued)

Sample*
Tulip Creek Formation

Species	469	474	478	484	499	506	514	519	534	609	614	619	623	624	639	649	684	694	699	704	Total
1. *Belodella* sp. cf. *B. jemtlandica*																					**158**
2. *Belodella robusta*									16												**33**
3. *Belodina monitorensis*				1					3				1				4				**47**
4. "*Bryantodina*" sp.																					**22**
5. *Cahabagnathus chazyensis*																	1				**1**
6. *Cahabagnathus friendsvillensis*										3	9		7			6					**40**
7. *Cahabagnathus directus* n. sp.																					**77**
8. *Cahabagnathus* sp.																					**45**
9. *Coleodus*? sp.																					**1**
10. *Dapsilodus*? *nevadensis*									3												**3**
11. *Drepanoistodus angulensis*																					**66**
12. *Drepanoistodus suberectus*	1			42			1	1	1	4	47	5	61	2	3	8		1		2	**825**
13. *Eoplacognathus* sp.																					**15**
14. *Erismodus arbucklensis* n. sp.				22																	**98**
15. *Erraticodon* sp. cf. *E. balticus*										1	6		8		2						**42**
16. *Histiodella* n. sp. 2																					**1**
17. *Leptochirognathus quadratus*	1				1																**18**
18. *Neomultioistodus compressus*																					**695**
19. *Oneotodus*? *ovatus*																	1				**1**
20. *Panderodus panderi*							1										4				**5**
21. *Panderodus* sp.	1								4											1	**24**
22. *Paraprioniodus* sp. cf. *P. costatus*																					**194**
23. *Phragmodus flexuosus* morphotype A	140	3	7	399	1		3	2	24	56	173	30	1,300	8	30	95	71	34		15	**8,007**
24. *Phragmodus flexuosus* morphotype B																					**2,028**
25. *Plectodina* sp. cf. *P. aculeata*									6												**6**
26. *Plectodina* sp.																					**13**
27. *Plectodina*? sp.				10		4		5					6				3		9		**47**
28. *Protopanderodus varicostatus*	1																				**79**
29. *Pteracontiodus*? sp.																					**40**
30. *Scandodus*? *sinuosus*																					**117**
31. *Staufferella* sp.																					**28**
32. "*Tetraprioniodus*" sp.																					**1**
33. *Thrincodus palaris* n. gen., n. sp.																					**1**
34. *Triangulodus alatus*				5			2	1		3	12			1	1		4	2			**64**
35. Genus indeterminate, sp. A																					**37**
36. Genus indeterminate, sp. B																					**11**
Total	**144**	**3**	**7**	**479**	**2**	**4**	**7**	**9**	**57**	**67**	**247**	**35**	**1,383**	**11**	**36**	**109**	**88**	**37**	**9**	**18**	**12,890**

*All samples prefixed OSU 82JA; sample numbers represent distance in feet above the base of the section.

TABLE A1-2.–DISTRIBUTION AND FREQUENCY OF MCLISH AND TULIP CREEK CONODONTS IN THE U.S. 77 SECTION (OSU LOCALITIES 72SE, 72SF)

	SAMPLE*														
	MCLISH FORMATION														
Species	100	125	150	162	174	186	198	210	222	234	246	258	270	282	294
1. *Belodella* sp. cf. *B. jemtlandica*	1	45			1	1	1	3			1		1	13	
2. *Belodella robusta*	8	3	2		2				3	9	3	1			
3. *Belodina monitorensis*														3	2
6. *Cahabagnathus friendsvillensis*															
7. *Cahabagnathus directus* n. sp.															
8. *Cahabagnathus* sp.									2	11	3	2		37	
9. *Coleodus*? sp.															
10. *Dapsilodus*? *nevadensis*	1														
12. *Drepanoistodus suberectus*	11	16	3	1	20	1	17	15	64	8	18	2	13	16	11
13. *Eoplacognathus* sp.	13	7													
14. *Erismodus arbucklensis* n. sp.															
15. *Erraticodon* sp. cf. *E. balticus*	1	32					1	3	10						
21. *Panderodus* sp.	3	4			1		1		1	7	3			11	5
23. *Phragmodus flexuosus* morphotype A															
24. *Phragmodus flexuosus* morphotype B	5	179	9	1	85	27	235	162	54	34	135	27	84	42	70
27. *Plectodina*? sp.						1									
28. *Protopanderodus varicostatus*	25	17	3												5
31. *Staufferella* sp.	1	1							2	3				2	6
33. *Thrincodus palaris* n. gen., n. sp.															
34. *Triangulodus alatus*	1	4			6	2	5	2	31	3	3				1
35. Genus indeterminate, sp. A															
Total	**70**	**308**	**17**	**2**	**115**	**32**	**260**	**185**	**167**	**75**	**166**	**32**	**98**	**124**	**100**

*McLish samples prefixed OSU 72SE; Tulip Creek samples prefixed 72SF; McLish sample numbers represent distance in feet above the base of the section; Tulip Creek sample numbers represent distance in feet above the base of the formation; distances not corrected for 50° dip of section.

TABLE A1-2.–(*Continued*)

	SAMPLE* McLISH FORMATION												TULIP CREEK FORMATION		
Species	306	324	336	348	372	384	428	440	456	516	529	545	310	450	**Total**
1. *Belodella* sp. cf. *B. jemtlandica*	1		2	17						1					**88**
2. *Belodella robusta*			7	13											**51**
3. *Belodina monitorensis*			1	8			3	1							**18**
6. *Cahabagnathus friendsvillensis*				3	4			9	2			9		7	**34**
7. *Cahabagnathus directus* n. sp.							6								**6**
8. *Cahabagnathus* sp.			6												**61**
9. *Coleodus*? sp.									1						**1**
10. *Dapsilodus*? *nevadensis*															**1**
12. *Drepanoistodus suberectus*	6		6	36	4	37	2	5	54	12	8	75	20	49	**530**
13. *Eoplacognathus* sp.															**20**
14. *Erismodus arbucklensis* n. sp.				1					8					8	**17**
15. *Erraticodon* sp. cf. *E. balticus*				2						6		25		2	**82**
21. *Panderodus* sp.				3											**39**
23. *Phragmodus flexuosus* morphotype A				90		40	14	104	68	25	43	1,437	125	345	**2,291**
24. *Phragmodus flexuosus* morphotype B	42	5	46		12										**1,254**
27. *Plectodina*? sp.														5	**6**
28. *Protopanderodus varicostatus*			4	7				2					11		**74**
31. *Staufferella* sp.				3	1					1	1			1	**21**
33. *Thrincodus palaris* n. gen., n. sp.														1	**1**
34. *Triangulodus alatus*	3			2		23	1		4		5	20	3	7	**126**
35. Genus indeterminate, sp. A									2						**2**
Total	**52**	**5**	**72**	**185**	**21**	**100**	**26**	**121**	**139**	**45**	**57**	**1,566**	**159**	**424**	**4,723**

*McLish samples prefixed OSU 72SE; Tulip Creek samples prefixed 72SF; McLish sample numbers represent distance in feet above the base of the section; Tulip Creek sample numbers represent distance in feet above the base of the formation; distances not corrected for 50° dip of section.

INDEX