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A CONODONT FAUNA FROM THE JOINS FORMATION (ORDOVICIAN), OKLAHOMA

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CONTENTS

I. ABSTRACT

The Joins Formation has yielded more than 5,800 conodonts, which represent 56 species and 26 genera. Eleven species are described for the first time. The fauna has affinities with faunas previously described from Lower Ordovician and Middle Ordovician rocks of the midcontinent and portions of the formation contain elements characteristic of Balto-Scandian faunas of Arenigian age. The Joins fauna is herein suggested to be part pre-Chazyan and part post-Canadian in age. Work on the brachiopods and graptolites from previous Joins studies has indicated a transition between Chazyan and Canadian faunas. The present work corroborates these past studies and offers new evidence for the suggested age determination in the form of diagnostic conodonts.

II. INTRODUCTION

The well-known Simpson Group of Oklahoma has provided past investigators with material for faunal analyses along several lines. Harris (1957) published an exhaustive monograph on the Oklahoma Simpson Group Ostracoda (including the Joins Formation). More recently, Harris (1962, 1964a, 1964b) and Harris and Harris (1965), in a series of short papers, have initiated work on the conodonts of the Joins, Oil Creek, and West Spring Creek formations of Oklahoma. After noting the abundance and diversity of the conodont fauna in

the Joins, it was decided to conduct an exhaustive faunal analysis.

The purposes of this paper are twofold:

(1) To advance the knowledge of Middle Ordovician conodont faunas in the hope that the potential value of the described conodont faunas may be realized,

(2) To utilize the faunal evidence thus gained toward the ultimate zonation and correlation of super- and subjacent strata of the Simpson and Arbuckle groups in Oklahoma, Texas, and New Mexico in future studies.

III. Acknowledgments

Gratitude is expressed to the following individuals: Dr. Alfred R. Loeblich, Jr., of Chevron Research Company, Dr. Helen Tappan Loeblich, and Mr. and Mrs. Jere H. Lipps, of the University of California at Los Angeles, who collected and measured the Joins Formation at the Highway 77 locality in Oklahoma; Mr. E. R. Myers who processed the samples and Mr. Jake Keeser who prepared certain illustrations, both of Chevron Research Company; Dr. R. W. Harris of the University of Oklahoma, who kindly loaned the Joins type specimens; Dr. R. L. Ethington of the University of Missouri, Drs. W. M. Furnish and B. F. Glenister of the State University of Iowa, Dr. J. W. Huddle of the United States Geological Survey, and Dr. W. C. Sweet of Ohio State University, all of whom made the collections at their respective institutions available for study and discussed various problems regarding Ordovician conodonts with me.

Dr. C. C. Branson, Director of the Oklahoma Geological Survey; Dr. C. W. Collinson of the Illinois Geological Survey; and Dr. R. L. Ethington of the University of Missouri read the manuscript and offered many valuable suggestions.

IV. The Joins Formation

The history of the naming of the Joins Formation is well presented by Harris (1957, pp. 55-61). Simpson stratigraphic nomenclature, lithologic descriptions, and stratigraphic relationships are also reviewed (*loc. cit.,* pp. 10-103), and need no further amplification.

The Joins Formation is exposed along U. S. Highway 77 on the south side of the Arbuckle Mountains, SE ¼, sec. 24, T2S, R1E, Carter County, Oklahoma. Samples for the present study were collected at five foot intervals by A. R. Loeblich, Jr., and H. T. Loeblich at the above locality (Figure 1). All 294 feet of the Joins were sampled except for the covered intervals 75-80 ft and 85-90 ft above the basal contact with the West Spring Creek Limestone. According to Harris (1962, p. 199), this locality is the same as that on which the latter's short study of new conodonts from the Joins was based. This study is intended to further document and detail the distribution of Harris' new forms (topotypes) and to investigate the other previously described elements represented in the Joins fauna. Samples were uniformly processed in the laboratory using one kilogram as a standard size.

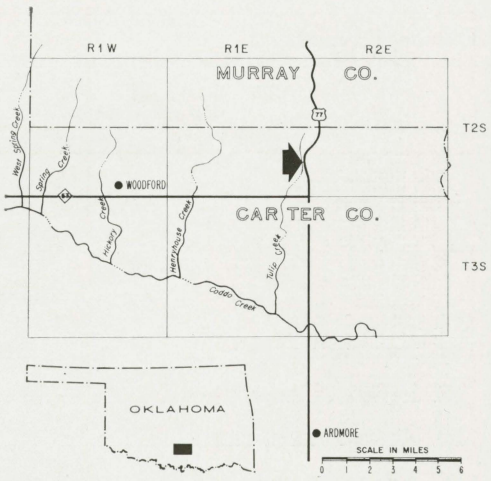


Figure 1—Index map showing location of Joins conodont collection.

The Joins is underlain unconformably by the West Spring Creek Limestone of the Arbuckle Group and overlain disconformably by the next higher Simpson Group unit, the Oil Creek Formation (Harris, 1957; pp. 58, 59). Harris (1962, p. 200) included the Joins and Oil Creek in the Chazyan Stage which he depicted as belonging to the uppermost Canadian Series. Graptolites and brachiopods belonging to the *Didymograptus bifidus* Zone are present in the Joins and include *Didymograptus bifidus, Desmorthis nevadensis,* and *Anomalorthis.* Sweet (1963, p. 506), noting these occurrences, observes that the Joins should be assigned to this Zone. Chenoweth and Hansen (1964, p.

GENUS AND SPECIES

EXPLANATION OF ABUNDANCE SYMBOLS: S: SPARSE, 6 or less specimens; C: COMMON, 6 – 20 specimens; A: ABUNDANT, 20 + specimens

SAMPLE NUMBER (SAMPLES ARE UNIFORMLY 5 FT. IN COVERAGE; NUMBERS INCREASE TOWARD TOP OF FORMATION)

Genus and species	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	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
Acodus auritus Harris	S											C	C	S						C	S			C	C	C	C	C								S	S		S				C					S		
Acodus campanula, n. sp.									C		C	S					S		S	C	C	C	S	C	S		S	S	A	S	S	S	C	S	S	C	A	C	C	C	S	S	S	C	S	S	S	C	S	
Acodus tetrahedron Lindström																								S					S			S							S											
Acodus tripterolobus, n. sp.		S	S		S	S	S	S	C	C		S	S	C			S			C								C	C		S		S	S	C	C	A	S	C		S	S	A	C	S	S	S	S		
Acontiodus bialatus, n. sp.	S				S		S	S	C			C	S	S					S	S	S						S	S	S		S		S	S	S	S			S											
Acontiodus curvatus, n. sp.	S											C	S				S		S	C	C	S	S	C	S	C	S	C	C	S	S	S	S		S	S	A	S		S	S		S	C	C	C	S		S	
Acontiodus rectus Lindström										S				S			S		S	S	C													S			S	S	C	S		S			S					
Acontiodus staufferi Furnish	S		S	S	S																																		S											
Coleodus? levis Branson and Mehl	S																																																	
Coleodus cf. C. simplex Branson and Mehl																																						S							S					
Cordylodus delicatus Branson and Mehl									S																							S	S					S	S	S				S	S	S		S		
Cordylodus flexuosus (Branson and Mehl)									S	S										S																						S								
Dichognathus extensa Branson and Mehl																																												S	S					
Dichognathus typica Branson and Mehl										S																			S			S	S	S					S	S							S			
Distacodus symmetricus, n. sp.	C				S	S	S	S	S		S	C	S	S			S		C	C	C	S	S	A	C	S	C	C	C		S		C	S	S	S	A	S	C	S										
Drepanodus concavus (Branson and Mehl)							S	S	S	C	S	C	S	C	S		S		C	C	A	S	S	S	S		S	S	A	S	S	S	S	S			A	S	C	C		S	S	S		S	C	S	S	
Drepanodus homocurvatus Lindström												S			S		S		S	S	C	C	S	C	S	C	C		C		S	S	S	S	S	S	A	C	C	C	C							S	S	
Drepanodus incurvus (Pander)									S			S	S	S			S				S			S					S			S	S		S	S	S			S		S	S					S		
Drepanodus proteus Lindström		S							C	S	S			S			S		S			S		S										S			S		S					S		S				
Drepanodus subarcuatus Furnish		S							S	S			S	S			S			C	S		S	C	S		S		A		S	S	S	S	S	S	C	S	C	S	C		C	A	A	C	C	C	C	
Eoneoprioniodus cryptodens Mound	S						S	S	C		S	S	S	C			S				S						S	C	S		S		S	C	S	C	C	C	S	C		S	C		S	S	S	S	S	
Erismodus incurvescens Harris					S																																													
Falodus prodentatus (Graves and Ellison)										S									S									S									S				S			S	S	S				
Gothodus communis Ethington and Clark									C	C				S	S		S		S	S	S										S								S			S								
Haddingodus? aff. H. serra Sweet and Bergström										S																																								
Histiodella altifrons Harris									C	S							S				S																		S											
Histiodella minutiserrata, n. sp.									S	S				S														S					S						C			S								
Histiodella serrata Harris									S	S				S														S					S		S		S	S	C			S	S	S						
Histiodella sinuosa (Graves and Ellison)																												S							S			C	A	C		C	C	C	S	S		S		
Histiodella triquetra, n. sp.												S									S																		S	S		S								
Multioistodus compressus Harris and Harris	S		S	S	S				S																														S	S										
Multioistodus lateralis Cullison			S			S			S	A		S	S	C			C		C	C	A				S			S			S									S	S			S	S	C	A	C	C	
Multioistodus subdentatus Cullison	S		S		S		S		S	A		S	C	S			S		C	C	C										S							S			S			S	S	S	C	C	C	
Multioistodus tridens Cullison	S		S	S	S	S			C	A		S	S	S			S		C	C	C				S			S			S	S											S	S	S	S	C	C	S	
Oistodus abundans Branson and Mehl		S		S			S	S	C	C	S	C		C	S		C		C	C	A	S		S		S		S	C	S		S	C	C	S	S	A	C	C	S	S	S	C	S	S	C	A	C	C	
Oistodus contractus Lindström									S	S		S		S			S		S	S	C	S		S				S	C			S			S	S	C		S		S		S	S	S				S	
Oistodus forceps Lindström						S			C	C				S			S			S							S															S	S					S		
Oistodus linguatus Lindström									S				S																S	S		S						S											
Oistodus longiramis Lindström									S	S										S																													
Oistodus multicorrugatus Harris								S							S		S		S	S	S	S	S	C	C	C	C	S	C			S	S		S		C		S	S	S		A	C	C	C		C	C	
Oistodus pseudomulticorrugatus, n. sp.																					S			S	S	S	C						S			S	A	S	S	S	S	S	A	C	C	C		C	S	
Oistodus scalenocarinatus, n. sp.											S		S		S					S	S	S		S	S		S	S	C	S	S	S		S		S	A		S			S	S	S		S				
Ozarkodina delecta Stauffer	S						S																						S	S			S						S	S									
Paltodus variabilis Furnish								S											S		S		S		S			S	C				S							S										
Panderodus panderi (Stauffer)	S									S																																							
Polycaulodus reversus Sweet	S		S	S	S																																												
Pravognathus idoneus (Stauffer)									S	S																																							
Prioniodus evae Lindström							S		C	C																							S	S		S		S	S	S					S					
Ptiloncodus simplex Harris																	S				C								S										S	S				S	S			C	S	
Rhipidognathus? aff. R. curvata Branson, Mehl, and Branson	S				S																																												
Scandodus sinuosus, n. sp.	S		S		S				S	S		S	S				S		S	C	S	S	S	C	C	C	C	C	A		S	S	S	S	S	C	A	S	S	S	C	S	S	S	A	C	C	C	C	
Scolopodus filosus Ethington and Clark									S					S	S		S				S	S		S		S	S																						
Scolopodus quadraplicatus Branson and Mehl									C	S		C	S	S	S		S		S	S		S		S										S								S								
Tetraprioniodus costatus, n. sp.													S																				C				S							S	S		S	S		
Tetraprioniodus robustus? Lindström														S						S	S							C	C			S	S	C		S	S	S	C	S			C	S		S	S	S	S	
Tricladiodus clypeus Mound	C		S	S	S	S	S	S																																										

Table 1—Distribution of Joins condont species.

854) assign the Joins and the overlying Oil Creek to the Champlainian Series.

Cooper (1956) and Amsden (1957) consider the Joins to be in the Whiterock Stage. Harris (1957, p. 53) also followed this assignment. Sweet states further that the Whiterock is post-Canadian and contains rocks of older aspect than the Champlain Valley Chazy Group (the standard for the Chazyan Stage). Sweet considers the Joins to be post-Canadian, pre-Chazyan (pre-Marmor in the sense of Cooper, 1956 and Amsden, 1957) in age. This view is subscribed to herein. The conodonts, in fact, support a pre-Chazyan, post-Canadian assignment, when compared to described faunas assigned to either age.

The *Didymograptus bifidus* Zone was defined by Berry (1960, p. 7) as characterized by the species *D. artus* and *D. bifidus* in the lowest zone (Zone 7) of the Whiterock Stage in the Marathon region. The Whiterock age was apparent to Berry because both diagnostic species of didymograptids were found in the Joins.

The Joins consists mostly of gray limestone with varying degrees of crystallinity. A shaly unit is present near the lower middle portion of the formation. The basal portion includes an edgewise intraformational conglomerate, just above the topmost Arbuckle (Harris, 1957, p. 56).

V. The Conodont Fauna

Heavy residues from the Joins Formation have yielded more than 5,800 well-preserved conodonts. They are referred to 56 species distributed among 26 genera. Eleven species are described for the first time.

Generally, the Joins conodonts are unusually well preserved. All are amber and white and a large proportion of the better preserved forms possess a basal filling of reddish clay or granular material.

Although no detailed survey was made, both simple and compound forms are present and are represented by nearly as many dextral as sinistral forms. Most species are amply represented; Table 1 exhibits a rough

approximation of abundance and distribution of individual forms. Oistodids and drepanodids are particularly characteristic of the major part of the formation, multioistodids generally dominate the lower and middle portions, and acontiodids dominate the middle and upper.

Acodids are not abundant in lower strata but abound in higher beds. The more prolific faunal yields were from the higher beds. Few species are restricted to any one level except for some of the new forms such as *Tricladiodus clypeus,* which is found only in the lower 40 ft.

VI. Distribution and Stratigraphic Significance of the Joins Conodonts

Meaningful comparison of Middle Ordovician conodont faunas is difficult owing to the relatively few published results of studies of the sequence of conodonts from this age in the United States. This situation has existed for a number of years, although recent work by Sweet and others (1959, 1960, 1962), Ethington and others (1959, 1960, 1964), and Harris (1962, 1964, 1965) have greatly increased the fund of paleontological and biostratigraphic evidence.

Acodus auritus is found sparingly in the lower and upper Joins but is common in places in the middle beds. *A. auritus* was originally described from the West Spring Creek Limestone which underlies the Joins. Apart from this linking of the Joins with the older West Spring Creek fauna, little can be stated concerning the stratigraphic value of the species.

Acodus campanula is not found in lowest Joins strata, although the upper 65 feet are characterized by significant numbers of the species.

Acodus tetrahedron has been found previously only from the Tremadocian *Ceratopyge* zone of Stora Backor and the Lower *Planilimbata* zone of Lanna, both in Sweden. Its sparsity in the lower middle Joins indicate that the age of the lower Joins may be older than Middle Ordovician.

Acodus tripterolobus represents a new, long-ranging form of *Acodus* which is found throughout the formation.

Acontiodus bialatus is particularly characteristic of the lower Joins and, with *Tricladiodus clypeus,* dominates the lower Joins conodonts. *Acontiodus curvatus* is a robust and conspicuous form in the middle Joins. The suggested link with the pteracontiodids of the West Spring Creek (Harris and Harris, 1965) lends weight to an early Ordovician age assignment for the lower half of the Joins.

Acontiodus rectus has been reported as first appearing in the lower Arenigian (Billingen Stage, Isle of Öland) in the Baltic region (Lindström, 1960, p. 90). It is a non-diagnostic form which appears in irregular abundance throughout the Joins.

Acontiodus staufferi occurs in moderate numbers in the lower Joins. Previous accounts have recorded *A. staufferi* from the lower Ordovician Prairie du Chien of the upper Mississippi Valley and the younger (?) Ordovician El Paso Formation of Texas.

Coleodus? levis is restricted to the lowest Joins. Its stratigraphic significance is doubtful. Similarly, *Coleodus* cf. *C. simplex* is not considered particularly important stratigraphically.

Cordylodus delicatus, found in lower and upper Joins beds, has been recorded from rocks of Ordovician age from such widely separated areas as England, Sweden, and eastern and midwestern United States. Apart from the widespread occurrence of this species, little can be determined stratigraphically other than to reconfirm its long range within the Ordovician. *C. flexuosus,* found in lower and upper strata, is similarly undiagnostic.

Dichognathus extensa and *D. typica,* restricted to the upper Joins, are common in Middle and early Upper Ordovician faunas in the American midcontinent (Sweet, *et al.,* 1959, p. 1036), thus providing a link with the Middle Ordovician.

Distacodus symmetricus is absent only from the uppermost beds and is a conspicuous element in the entire fauna. Future investigations will be necessary to determine its stratigraphic worth.

Drepanodus concavus is present in moderate quantities in most of the Joins except for the lowest beds. *D. concavus* has been recognized in rocks ranging in age from Early to Late Ordovician. It is a distinctive and robust element but has little stratigraphic significance.

Drepanodus homocurvatus and *D. incurvus* are found in almost all Ordovician fau-

nas in North America as well as Scandinavia. In the latter region, however, they are apparently lacking in the Tremadocian (Lindström, 1960, p. 90).

Drepanodus proteus is more plentiful in the lower Joins. It has not previously been recognized outside of Scandinavia. Similar forms from other areas have been referred to species of *Drepanodus* which closely resemble the Scandinavian species. *Drepanodus subarcuatus* has been reported from Lower and Middle Ordovician strata in various American faunas and appears to be undiagnostic except that it has not been reported from younger rocks. The presence of *D. subarcuatus* throughout the Joins does not indicate any definitive age restriction.

Eoneoprioniodus cryptodens is sparse in most Joins samples and appears to be restricted to no particular portion of the formation.

Erismodus incurvescens is restricted to the lower Joins, which confirms the original occurrence reported by Harris (1964b, p. 174). *Falodus prodentatus* is best represented in the middle Joins strata and has been reported previously from rocks ranging from Early to Middle Ordovician age.

Gothodus communis has been reported previously only from the El Paso Formation of West Texas which is of late early or early Middle Ordovician age. *G. communis* is found in lower and middle Joins beds.

Haddingodus? aff. *H. serra* is rare in the lower part of the Joins. Its previously reported occurrences are from the *Climacograptus haddingi* Subzone in Sweden and the Pratt Ferry Formation (Middle Ordovician) of Alabama (Sweet and Bergström, 1962, p. 1218).

Species of *Histiodella* are found in most Joins beds in modest quantities. *H. sinuosa,* previously reported only from the Middle Ordovician Fort Peña Formation of Texas, is common in upper Joins beds. This occurrence provides further evidence for a Middle Ordovician age of the upper portion of the formation.

The range of *Multioistodus compressus* is here extended to include most of the Joins. All of the other species of *Multioistodus* in the Joins *(M. lateralis, M. subdentatus, M. tridens)* have been noted previously only in the Middle Ordovician Dutchtown Formation of Missouri.

Oistodus abundans is a long-ranging and distinctive form; almost all Joins samples contain some specimens.

Oistodus contractus is found in most Joins samples, except for the lowest beds.

Oistodus forceps is long-ranging and has been found in Lower and Middle Ordovician rocks in this country as well as in northern Europe. *Oistodus linguatus* and *O. longiramis* have been reported from Arenigian and younger rocks in both Europe and the United States, and at many places frequently are found together. *Oistodus multicorrugatus, O. pseudomulticorrugatus* and *O. scalenocarinatus* are peculiar to the middle and upper Joins beds where they are conspicuous and diagnostic elements.

Ozarkodina delecta is rare in lowest Joins beds and is not accorded much significance.

Paltodus variabilis, rare in middle and upper Joins strata, is known from Middle and Lower Ordovician rocks.

Panderodus panderi, characteristically found in Middle and Upper Ordovician rocks, is here represented by only a few specimens. No particular stratigraphic significance is therefore attached to their presence in the basal Joins strata.

Polycaulodus reversus, a minor element of the Joins, has been reported only from the Middle Ordovician Harding Sandstone of Colorado.

Pravognathus idoneus, restricted to the lower Joins, has been reported from Lower and Upper Ordovician faunas.

Prioniodus evae is sparse in lower and upper Joins strata. This species, with *Oistodus forceps, O. longiramis,* and *Acontiodus rectus,* is characteristic of Fauna III, the Arenig Billingen Stage, of Öland Isle in the Baltic.

Ptiloncodus simplex is moderately common in middle and upper Joins strata. Not enough is known of its distribution or affinities to evaluate its significance.

Rhipidognathus? aff. *R. curvata* is found sparingly in lowest Joins strata. Ethington and Clark (1964, pp. 695-698) found a similar form but were also reluctant to assign it to *Rhipidognathus* which name has been used only for forms from the Richmond Group (*loc. cit.,* p. 697).

Scandodus sinuosus is common to abundant in most Joins strata and may well provide a good faunal marker for the Joins Formation.

Scolopodus filosus, rare in middle and lower Joins beds, has been reported only from the Early(?) to Middle(?) Ordovician El Paso Formation of West Texas and may be indicative of an older portion of the Joins fauna. *S. quadraplicatus,* similarly, may be a clue to the older Joins, having been reported previously only from Early and questionably Middle Ordovician faunas.

Tetraprioniodus costatus is a rare form that readily distinguishes the upper Joins fauna.

Tetraprioniodus robustus, moderately represented in upper and middle Joins beds, may represent a younger variant of representatives from the Arenigian lower *Planilimbata* Limestone of Sweden.

Tricladiodus clypeus is definitely restricted to the lowest 40 ft of the Joins and readily serves as a marker for this portion of the fauna.

In summary, it is evident that the Joins may conveniently be divided into two faunal parts, each consisting of many definitive species which may characterize either a transitional post-Canadian and pre-Chazyan age or a definitely Middle Ordovician aspect. Further, the fauna may be tentatively subdivided and assigned to several "zones" (Assemblage "Zones") which overlap to some extent.

VII. Assemblage "Zones"

The following three assemblages "zones" from the Joins are tentatively recognized as distinct entities within the formation. Much overlap is evident between "zones" and more extensive collecting is necessary properly to validate the present findings. Nevertheless, the prolific Joins fauna provides a number of species that are locally restricted and fall into several natural faunal units. Although future investigations of Joins-age conodont faunas from geographically separated areas might eventually change the zonal boundaries as presented here, the partition of the formation into three assemblage "zones" is a preliminary step toward ultimate basin-wide zonation of the basal Simpson.

Tricladiodus Assemblage "Zone"

The *Tricladiodus* Assemblage "Zone", here named, is characterized by the prominence of *Tricladiodus clypeus* Mound, *Multioistodus compressus* Harris and Harris, *Acontiodus staufferi* Furnish, *Erismodus incurvescens* Harris, and *Polycaulodus reversus* Sweet (Figure 2). The latter two species are not found in great numbers but are more or less restricted to this lowest "zone". In association with the above species are less important elements of the *Tricladiodus* Assemblage "Zone" which are present in moderate abundance. These include *Acodus auritus* Harris and Harris, *Acodus bialatus,* n. sp., *Acodus tripterolobus,* n. sp., *Acontiodus curvatus,* n. sp., *Coleodus? levis* Branson and Mehl, *Distacodus symmetricus,* n. sp., and *Drepanodus concavus* (Branson and Mehl). The *Tricladiodus* Assemblage "Zone", as here defined, includes the lowest sampled Joins (superjacent to the West Spring Creek) as recognized along Highway 77 in Carter County, Oklahoma. The upper limit of this conodont "zone" is tentatively placed at a level located 40 feet above the base of the formation. No traces of *Tricladiodus* are found in samples from above this upper boundary. The lower boundary is unknown. The fauna present in this and the next higher assemblage "zone" indicates affinity with those faunas previously reported from European Arenigian and American Lower Ordovician rocks and appears closer to those faunas than those known from Middle Ordovician strata.

Gothodus-Multioistodus Assemblage "Zone"

The *Gothodus-Multioistodus* Assemblage "Zone", here named, is characterized by the prominence of *Gothodus communis* Ethington and Clark; and by large numbers of *Multioistodus,* particularly *M. lateralis* Cullison, *M. subdentatus* Cullison and *M. tridens* Cullison (Figure 2). The number of specimens of *Multioistodus* recovered per kilogram sample far exceeds that of *Gothodus.* Both genera are prominent in this zone, and *Gothodus,* found above this level, remains an inconspicuous part of the fauna as a whole. *Multioistodus,* on the other hand, is found in abundance near the top of the next higher "zone". Both genera, as represented in the Joins, lose prominence immediately above the boundary of the *Gothodus-Multioistodus* Assemblage "Zone". *Gothodus* is a lower Middle Ordovician genus; *G. communis* is found in the El Paso Formation of Ordovician age whose general faunal content suggested to Ethington and

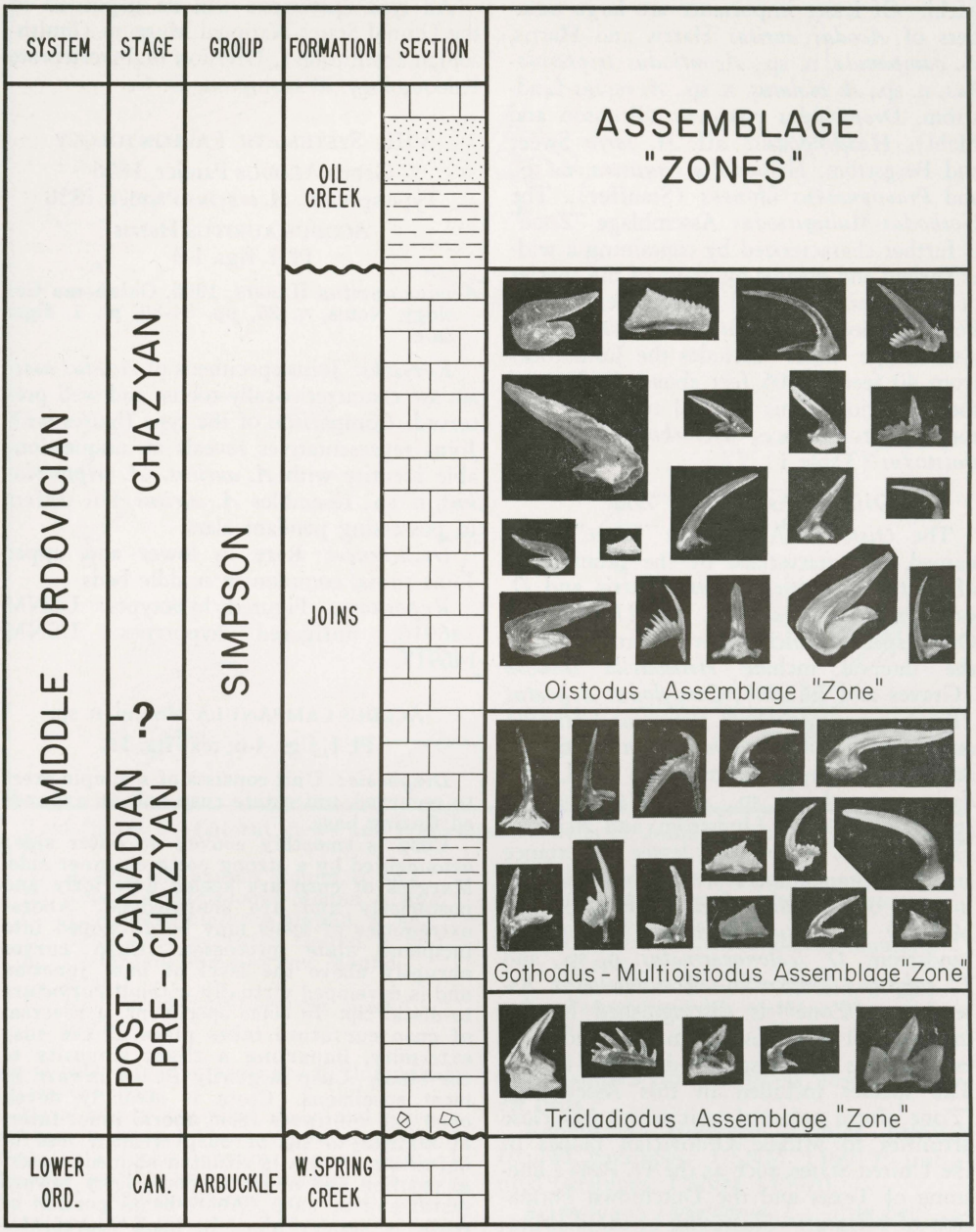


Figure 2—Tentative conodont assemblage "zones" of the Joins Formation (Ordovician) of Oklahoma.

Clark (1964, p. 686) that the El Paso fauna was somewhat younger than most previously described Early Ordovician faunas. *Gothodus* was originally found in the Billingen Stage, immediately above the Swedish Arenigian. Associated with the species of *Gothodus* and *Multioistodus* are representatives of *Drepanodus proteus* Lindström, *Histiodella altifrons* Harris, *H. minutiserrata,* n. sp., *Oistodus forceps* Lindström, *Prioniodus evae* Lindström, *Scolopodus filosus* Ethington and Clark, and *S. quadraplicatus* Branson and

Mehl. Of lesser importance are large numbers of *Acodus auritus* Harris and Harris, *A. campanula,* n. sp., *Acontiodus tripterolobus,* n. sp., *A. bialatus,* n. sp., *A. rectus* Lindström, *Drepanodus concavus* (Branson and Mehl), *Haddingodus*? aff. *H. serra* Sweet and Bergström, *Histiodella triquetra,* n. sp., and *Pravognathus idoneus* (Stauffer). The *Gothodus-Multioistodus* Assemblage "Zone" is further characterized by containing a wider variety and greater numbers of the species of conodonts described in this report. As here defined, the *Gothodus-Multioistodus* Assemblage "Zone" includes the Joins rocks from 40 feet to 105 feet above the base of the formation. This interval coincides with the local prominences of *Gothodus and Multioistodus* (Table 1).

Oistodus Assemblage "Zone"

The *Oistodus* Assemblage "Zone", here named, is characterized by the prominence of *Oistodus multicorrugatus* Harris and *O. pseudomulticorrugatus,* n. sp. (Figure 2). Other species which are most prominent in the interval include *Histiodella sinuosa* (Graves and Ellison), *Cordylodus delicatus* (Branson and Mehl), *C. flexuosus* (Branson and Mehl), *Dichognathus extensa* Branson and Mehl, *D. typica* Branson and Mehl, *Acodus campanula,* n. sp., *A. tripterolobus,* n. sp., *A. tetrahedron* Lindström, and *Acontiodus curvatus,* n. sp. Of lesser importance are the large numbers of species consisting, in part, of *Oistodus abundans* Branson and Mehl, *O. contractus* Lindström, *O. linguatus* Lindström, *O. scalenocarinatus,* n. sp., and *T. robustus* Lindström. The *Oistodus* Assemblage "Zone" is distinguished by the inclusion of the most prominent and largest numbers of the species described herein. The species included in this Assemblage "Zone" form a faunal unit which has close affinities to Middle Ordovician faunas of the United States, such as the Ft. Peña Limestone of Texas and the Dutchtown Formation of Missouri. Clustering of the distribution of certain species such as *Multioistodus lateralis, M. subdentatus, M. tridens, Histiodella sinuosa,* and *Ptiloncodus simplex* Harris, near the top of the *Oistodus* Assemblage "Zone" indicates a possible fourth assemblage zone (Table 1) but the evidence is not here accorded significance of rank to merit the establishment of even a tentative further subdivision.

All type specimens will be deposited in the United States National Museum (Smithsonian Institution), Division of Invertebrate Paleontology, Washington, D. C.

VIII. Systematic Paleontology

Genus Acodus Pander, 1856

Type species: *A. erectus* Pander, 1856

Acodus auritus Harris

Pl. 1, figs. 1-3

Acodus auritus Harris, 1965, Oklahoma Geology Notes, v. 25, pp. 34-35, pl. 1, figs. 2a-c.

Remarks: Joins specimens of *Acodus auritus* are characteristically robust and well preserved. Comparison of the type figures with Joins representatives reveals an unquestionable identity with *A. auritus. A. tripterolobus,* n. sp., resembles *A. auritus,* but differs in possessing pendant alars.

Occurrence: Rare in lower and upper Joins strata, common in middle beds.

Repository: Figured hypotypes: USNM 146916; unfigured hypotypes: USNM 146917.

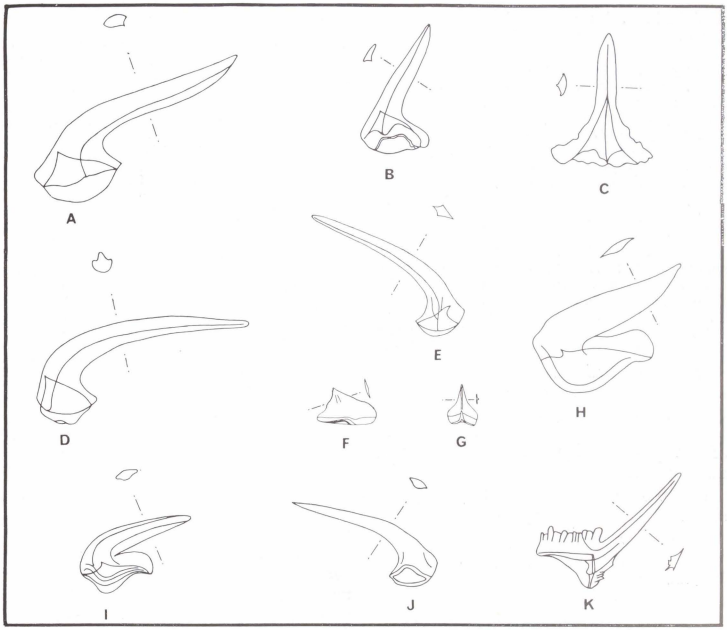
Acodus campanula Mound, n. sp.

Pl. 1, figs, 4-6; text-fig. 1A

Diagnosis: Unit consists of a simple erect to recurved, unicostate cusp and an expanded flaring base.

Cusp is smoothly convex on outer side: ornamented by a strong costa on inner side. Margins of cusp are keeled anteriorly and posteriorly and are sharp-edged. Aboral extremities of keels may be developed into incipient alate processes. Cusp curves abruptly above the level of base junction and is developed virtually without curvature to distal tip. In some specimens, a reversal of cusp curvature takes place at the cusp extremity, imparting a slight sinuosity to the blade. Cusp is gently flexed inward in most specimens. Costa is strongly developed and continues from aboral inner lateral margin to tip of cusp without loss of definition. Costa is situated at medio-lateral position and migrates posteriorly toward distal end of cusp. Aboro-basal portion of costa is faintly alate in most representatives of this species.

Base flares inwardly and continues posteriorly for a short distance behind cusp. Junction of base and cusp is drepanodid in aspect; junction effected by a smooth curve anteriorly and a smooth curve posteriorly. Anterior curve follows an unbroken smooth line from cusp to aboral margin; posterior margin reverses direction of curvature at basal junction. Base flares anteriorly, posteriorly, and laterally on inner side, impart-



Text-figure 1—Lateral views and transverse sections of Joins conodonts. All drawings x 20.

A. *Acodus campanula* Mound, n. sp.;
B. *Acodus tripterolobus* Mound, n. sp.;
C. *Acontiodus bialatus* Mound, n. sp.;
D. *Acontiodus curvatus* Mound, n. sp.;
E. *Distacodus symmetricus* Mound, n. sp.;
F. *Histiodella minutiserrata* Mound, n. sp.;
G. *Histiodella triquetra* Mound, n. sp.;
H. *Oistodus pseudomulticorrugatus* Mound, n. sp.;
I. *Oistodus scalenocarinatus* Mound n. sp.;
J. *Scandodus sinuosus* Mound, n. sp.;
K. *Tetraprioniodus costatus* Mound, n. sp.;

ing a bell-shaped appearance to this portion of the conodont.

Basal cavity is conical, deep, and concavo-convex in lateral view. Apex of cavity is close to anterior margin; tip of cavity is sharply pointed and is distinctly anteriorly directed. All specimens are filled with a granular bony material that extends beyond lower limits of conodont.

Dimensions of holotype: Maximum length: 2.2 mm; basal width: 0.7 mm.

Remarks: Acodus campanula is characterized by its sharply recurved cusp and bell-shaped base. It closely resembles *Acodus inornatus* Ethington from which species it differs chiefly in the shape of the base.

Occurrence: Common to abundant in Joins samples from all levels, absent in lowest beds.

Repository: Holotype: USNM 146918; figured paratypes: USNM 146919; unfigured paratypes: USNM 146920.

Etymology: campanula, L.: little bell; refers to the antero-postero and inner lateral flaring of the distinctive bell-shaped base.

ACODUS TETRAHEDRON Lindström
Pl. 1, figs. 7, 8

Acodus tetrahedron LINDSTRÖM, 1955, Geol. Fören. Förhandl., Bd. 76, p. 546, pl. 4, figs. 1, 2.

Diagnosis: Unit consists of a simple proclined or erect cusp joined to a short,

straight base. A narrow anterior costa parallels the anterior margin on the inner side.

The cusp is triangular in cross-section, broadly flattened and slightly flexed inward. Anterior and posterior edges are sharp and faintly keeled. Distal portion of the cusp is very gently curved and tapers to a sharp point.

The lateral costa is distinct and is characteristically located close to the anterior edge of the inner cusp face. The costa is low, arises from a point near the base and continues onto the blade to the cusp extremity.

The basal cavity is tetrahedral and thin-sheathed. Lateral view of the base reveals the triangular outline of the deep basal cavity having the anterior side of the triangle thus formed parallel to the anterior margin. The apex of the cavity is sharp and anteriorly and upwardly directed.

Remarks: Acodus tetrahedron is characterized by its antero-lateral costa and its tetrahedral base. The degree of prominence of the lateral costa varies widely. The oral edge of the posterior basal extension is short, straight, and sharp-edged.

Occurrence: Rare in middle Joins beds, absent in lowest and uppermost strata.

Repository: Figured hypotypes: USNM 146921; unfigured hypotypes: USNM 146922.

ACODUS TRIPTEROLOBUS Mound, n. sp.

Pl. 1, figs. 9-13; text-fig. 1B

Diagnosis: Unit consists of a simple sharply recurved tricostate cusp and a base produced anteriorly, laterally, and posteriorly.

Cusp is triangular in cross-section, flexed inward slightly, abruptly recurved above base, straight for most of its length, and distally twisted. Anterior and posterior margins are keeled and sharp-edged. Outer lateral face is smooth and broadly rounded; inner lateral face is ornamented by a strong costa, prominent throughout the length of the cusp. Anterior edge is produced into a thickened aboral extension that is continuous with the anterior costa and descends as a pendant alate anticusp. At this level of the base, the edge is anteriorly extended slightly; above the base, the keel is less produced, thus imparting an overall sinuosity to the entire anterior margin. The posterior keel continues as the oral edge of a straight to gently convex posterior basal extension. The basal extension thus formed is a thick, tubular bar extending for approximately one-third the cusp length and is surmounted by an irregularly and indistinctly serrated keel. The posteriormost extremity of the bar is aborally pendant and alate in appearance to the same degree as the aforementioned anterior extremity. The lateral costa is anterior in position on the cusp face and approximately parallels the anterior margin. Proximally, this costa is produced into an antero-laterally directed spatulate process which is also alate and aborally extended. Between the lateral costa and the anterior keel, near the anterior margin, there is a shallow groove that extends from the anterobasal alar to the distal extremity of the cusp. A similar groove is situated anterior to the posterior keel on the inner face.

The basal sheath is thin and presents a scalloped aboral outline. Basal cavity is deep, pyramidal and extends into the alars as tapering grooves. The excavation is filled by a pyramidal plug of dense, granular material that extends aborally for a short distance.

Dimensions of holotype: Maximum length: 1.10 mm; basal stretch: 04.5 mm; length of posterior bar: 0.33 mm.

Remarks: Acodus tripterolobus is characterized by its tricostate cusp and its pendant, downward-directed alars. *A. tripterolobus* most closely resembles *A. auritus* Harris from the underlying West Spring Creek Limestone (Harris, 1965, pp. 34, 35). The latter species, however, has alate processes that are directed orally (or upward). Moreover, *A. tripterolobus* has anterior and posterior processes in the same plane, whereas those of *A. auritus* are flexed in opposing directions. The anterior most portion of the anterior alar is flexed slightly inward in the new species.

All three alars have a concentration of opaque white matter at their oral edges. The minor serrations which are evident on a few specimens may be evidences of incipient denticulation, in which case these specimens might superficially resemble juvenile stages of *Prioniodus* Pander. Because these specimens are well developed and are as large as any representing other Joins species, the *Prioniodus* association is more apparent than real.

Occurrence: Common in lower and upper Joins, rare in middle strata.

Repository: Holotype: USNM 146923; figured paratypes: USNM 146924; unfigured paratypes: USNM 146925.

Etymology: tri-, L., *tres:* three; *-ptero-,* Gr., *pteron:* feather, wing, fin; *-lobus,* Gr., *lobus:* a rounded projection or protuberance; refers to the three rounded, spatulate, pendant alars characteristic of this species.

Genus ACONTIODUS Pander, 1856

Type species: *A. latus* Pander, 1856

ACONTIODUS BIALATUS Mound, n. sp.

Pl. 1, figs. 16-18, 24; text-fig. 1C

Diagnosis: Unit consists of a simple recurved cusp bearing two lateral processes or alars and a posteriorly flaring base.

Cusp is gently convex on anterior face, bilaterally symmetrical, gently recurved and is equipped with two posteriorly located lateral costae. Cusp posterior is keeled and sharp edged; keel runs from the sharply pointed distal tip onto the short flaring basal extremity.

Two laterally widening troughs flank the posterior faces of the two lateral costae; these bordering troughs extend distally as narrowing furrows and aborally as V-shaped depressions, with the V opening in an aboral direction. Each of the lateral costae extends laterally into a bar-like alar process, flattened in a common plane. Each alar, or process thus formed, bears an indistinctly serrated oral edge and departs from the main body of the conodont as a downward curving bar. Aboral extremities of lateral alars are equally disposed in extent to the lowest point of the aboral portion of the posterior basal flare of the posterior process.

The base is formed by the common junction of alars, cusp, and posterior extension. Basal sheath is large; the base is pyramidal and flares posteriorly. Basal cavity is also pyramidal, deep; excavation extends to tips of alar processes and posterior basal extension. Pointed tip of apex of basal cavity is situated deep in the central portion of the cusp.

Remarks: Acontiodus bialatus bears no close resemblance to any previously described species assigned to the genus *Acontiodus.* Its most distinctive and constant feature is the possession of the two pronounced alate lateral extensions.

Acontiodus bialatus might be compared with *Pteracontiodus exilis* Harris from the West Spring Creek Formation of the Arbuckle Group which underlies the Joins along U. S. Highway 77, Oklahoma. The distinction between *Pteracontiodus* and *Acontiodus* is the absence of the produced alate processes in the latter. Such distinction is difficult to justify in the Joins representatives, and it may be that *Acontiodus bialatus* and *Pteracontiodus exilis* are synonymous, in which case the latter species name would prevail. However, *A. bialatus* differs from *P. exilis* in possessing a stouter, more triangular cusp and alate processes which clearly originate as projections from the distinct lateral costae, whereas *P. exilis* appears to be constructed as a trilateral unit. Moreover, the alars in *A. bialatus* are distinctly downwardly oriented.

The possibility that *Acontiodus bialatus* represents a homeomorphic equivalent of *Pteracontiodus exilis* is not without basis. Many forms of *Acontiodus* in the Joins are gradational from definite acontiodids to more subtle variations approaching the pteracontiodids of the West Spring Creek. It would thus appear that if *Pteracontiodus* is a recognizable genus, it is definitely not found as a distinctive entity in the overlying Joins, but that an obvious evolutionary link is found in *A. bialatus* and *A. curvatus,* n. sp.

Occurrence: Common to rare in lower and middle Joins samples, rare in upper beds.

Repository: Holotype: USNM 146926; figured paratypes: USNM 146927; unfigured paratypes: USNM 146928.

Etymology: bi-, L., *bis:* two; *-alatus,* L., *ala:* wing, refers to the two lateral alate processes.

ACONTIODUS CURVATUS Mound, n. sp.

Pl. 1, figs. 19-21; text-fig. 1D

Diagnosis: Unit consists of a recurved, rounded cusp laterally flanked by two posteriorly situated costae; cusp is joined to a triangular, posteriorly flaring base.

The cusp is robust and is strongly convex anteriorly; anterior face is smooth and rounded, proximally expanded into an antero-laterally broadened base. Posterior cusp margin is strongly keeled along an acuminate edge. Each of two strongly developed lateral costae extends the length of the conodont. Distal extremities of the costae are situated extremely close to the posterior margin and gradually migrate to a median lateral position in a proximal direction precisely at the level of the cusp-base junction. From here, the lateral costae form pseudodenticulated laterally extended alars, very short, but well developed. In antero-posterior view, these alate processes are equally extended laterally and are not pendant to any degree. At their aboral limits, the alars are directed orally as well as laterally.

Base of unit joins with cusp posterior in a smooth curve; posterior keel is continuous with oral edge of base. Posteriormost extremity of base flares upward slightly; cross-section of base is distinctly triangular. As seen in aboral profile, base outline describes a nearly equilateral triangle formed by the intersection of the two

lateral faces with the convex curve of the anterior face as the third side.

The basal cavity is generally subpyramidal; a sharp apical tip is centrally located in anterior view, and is located close to the anterior face in lateral view. The cavity thus formed is deep, subconical to subpyramidal, and possesses the anteriorly directed tip common to most distacodids and drepanodids.

Remarks: Acontiodus curvatus is similar to *A. bialatus,* n. sp. from the Joins. It differs from the latter in four important respects: *A. curvatus* has non-pendant and reduced alar processes; the basal cavity does not extend into the alars; the cusp is markedly more robust; and the V-shaped troughs characteristic of *A. bialatus* are reduced or indistinct in *A. curvatus. Pteracontiodus aquilatus* Harris, from the upper West Spring Creek beds (Harris, 1965; p. 41), bears a superficial resemblance to *A. curvatus.* Both species have non-pendant alate processes, but *A. curvatus* possesses a definite acontiodid plan, whereas the pronounced lateral development of *P. aquilatus* is its distinguishing feature. The cusp development of *A. curvatus* is far greater than that of the pteracontiodid species, whose cusp is not as large, nor as strongly convex or recurved as that of *A. curvatus.*

Occurrence: Common to abundant in all but lower Joins strata, where it is sparse or absent.

Repository: Holotype: USNM 146929; figured paratypes: USNM 146930; unfigured paratypes: USNM 146931.

Etymology: curvatus, L., *curvus:* bent; refers to the distinct curvature of the acontiodid cusp.

ACONTIODUS RECTUS Lindström

Pl. 1, fig. 23

Acontiodus rectus LINDSTRÖM, 1955, Geol. Fören. Förhandl. Bd. 76, p. 549, pl. 2, figs. 7-11, text-figs. 2k-m, 3B; SPASOV AND TELLER, 1963, Trudovye V'rchu, Ser. Paleont., v. 5, p. 78, pl. 1, fig. 4.

Diagnosis: Unit consists of a simple erect laterally costate cusp joined to a short thin base.

The cusp is flattened laterally and has a blunted anterior and a very sharp posterior edge. Cusp curvature varies from slightly proclined to slightly reclined; the most common aspect is an erect posture. The anterior margin begins as a rounded nose at the antero-basal corner and proceeds distally as a gently curving dull-edged feature, terminating in the sharp distal tip of the cusp. The posterior margin is extremely sharp and keeled; the junction with the base is a very abrupt one, at an approximate angle of 90°. The cusp is flexed slightly inward in its distal portion and may be gently twisted.

Each of two lateral costae is located near the posterior margin of each cusp face. The costae are strongly developed, sharp-edged, and continue as prominent features distally to the cusp extremity and (in some rare specimens) as slight aboral projections. A deep posterior furrow separates each costa from the posterior cusp edge; these furrows are deepest proximally and extend distally as shallow depressions.

The base extends behind the cusp for a short distance as a thin, flattened process. The oral edge of the base is straight, sharp-edged, high and posteriorly rounded. A concentration of white matter is commonly observed in the posterior extension as seen in lateral view. The aboral outline is rounded and may be slightly sinuous in some specimens.

The basal cavity is moderately shallow and subconical. The apex of the excavation is anteriorly situated as a sharp point as seen in lateral view.

Remarks: Acontiodus rectus is readily distinguished from its congeners by its erect cusp, short, straight base, rounded anterior and posterior aboral corners, and its rounded aboral profile.

The white matter observed in the posterior process (basal extension), the anterior nose, and the aboro-lateral costate extensions suggest a link between this species and forms of *Tetraprioniodus* Lindström.

Occurrence: Sparse to common in lower and upper Joins beds, rare to absent in middle strata.

Repository: Figured hypotype: USNM 146932; unfigured hypotype: USNM 146933.

ACONTIODUS STAUFFERI Furnish

Pl. 1, fig. 22

Acontiodus staufferi FURNISH, 1938, Jour. Paleontology, v. 12, p. 326, pl. 42, figs. 11, 12; ETHINGTON AND CLARK, 1964; Jour. Paleontology, v. 38, pp. 687, 688, pl. 113, figs. 4, 9.

Diagnosis: Unit consists of a simple proclined to suberect antero-posteriorly flattened cusp having lateral keels and a medially grooved posterior carina joined to an expanded base.

The cusp is broadly rounded anteriorly and is commonly ornamented longitudinally by fine striae. The cusp is not flexed, but is bilaterally symmetrical and tapers to a sharp point. The posterior edge possesses

a blunt keel whose central portion is divided by a medial longitudinal groove of a varying degree of prominence. The groove, or furrow, thus formed, is most pronounced proximally, where it terminates at the basal juncture; distally, the furrow loses definition but persists faintly to the cusp tip.

Each of two symmetrically placed costae is posteriorly located and laterally developed into a broad membranous keel which spans the latero-basal margins. The costae are flanked by deep troughs that are well-defined throughout the length of the cusp and run parallel to the postero-lateral borders of the cusp.

The base is subelliptical, compressed antero-laterally, and expanded posteriorly. A shallow basal cavity with a conical shape has its sharply pointed, anteriorly directed apex near the anterior margin. Some robust specimens from the lower Joins are filled by a large aborally extended basal plug.

Remarks: Ethington and Clark (1964, p. 687) suggested that the most distinguishing feature of *Acontiodus staufferi* is its strong posterior carina having the prominent median groove. Although most Joins specimens do have pronounced posterior grooves, others have only a faint hint of the depression. *A. alveolaris* Stauffer is closely allied to *A. staufferi* but the former species has a more laterally expanded base and a greater degree of cusp curvature than *A. staufferi.*

Occurrence: Rare in lower and upper Joins strata, absent in middle and most upper beds.

Repository: Figured hypotype: USNM 146934; unfigured hypotypes: USNM 146935.

Genus COLEODUS Branson and Mehl, 1933

Type species: *C. simplex* Branson and Mehl, 1933

COLEODUS? LEVIS Branson and Mehl

Pl. 1, fig. 15

Coleodus? levis BRANSON AND MEHL, 1933, Missouri Univ. Studies, v. 8. p. 80, pl. 6, fig. 1.

Remarks: This form is extremely rare in the Joins. The Joins representatives compare favorably with the types and, like them, may well belong in a different genus. The lack of denticulation and extensive aboral excavation common to *C.? levis* set the species apart from typically crenulated and denticulated coleodids. Some of the Joins specimens possess a well-developed anterior(?) "horn" or incipient cusp which may represent a stage of development indicating an ancestral or parallel phase of undenticulated coleodids.

Occurrence: Extremely rare in lowest Joins beds, absent elsewhere.

Repository: Figured hypotype: USNM 146936; unfigured hypotypes: USNM 146937.

COLEODUS cf. COLEODUS SIMPLEX Branson and Mehl

Pl. 1, fig. 14

Coleodus simplex BRANSON AND MEHL, 1933, Missouri Univ. Studies, v. 8, p. 24, pl. 1, figs. 22-25; AMSDEN AND MILLER, 1942, Jour. Paleontology, v. 16, p. 303; YOUNGQUIST AND CULLISON, 1946, Jour. Paleontology, v. 20, pp. 581-582, pl. 90, figs. 16-17.

Remarks: The Joins specimens compare well with the types of *Coleodus simplex* except that the latter specimens have less discrete denticles. *Chosonodina lunata* Harris and Harris, 1965, may belong here.

Occurrence: Rare in upper Joins beds, not present in middle and lower strata.

Repository: Figured hypotype: USNM 146938; unfigured hypotypes: USNM 146939.

Genus CORDYLODUS Pander, 1856

Type species: *C. angulatus* Pander, 1856

Pander (1856, p. 33) established the genus *Cordylodus* for forms having a ". . . very long, compressed and high base. A large, rather flat, smooth cusp with smoothly curved lateral faces . . . Several small teeth emerge from the (base) basis at the concave margin of the main tooth, below one another and side by side".

Furnish (1938, p. 337) suggested the restriction of *Cordylodus* to Lower Ordovician occurrences; Middle Ordovician forms were to be regarded as representatives of *Subcordylodus* Stauffer, *Plectodina* Stauffer and related genera. Lindström (1955, pp. 550-551) included *Cyrtoniodus* Stauffer in *Cordylodus* and recognized Ellison's (1946, pp. 108, 110) decision to consider *Barbarodina* Stauffer and *Subcordylodus* as junior subjective synonyms of *Cordylodus.* Bergström (1964, p. 19) suggested that the type species of *Plectodina, P. dilata* Stauffer, might conceivably represent a mature form of *Cordylodus delicatus* Branson and Mehl. Lindström (1964, pp. 147, 149, 176) re-

garded *Cordylodus* and *Cyrtoniodus* as separate entities. In addition, Lindström suggests (*loc. cit.*, p. 176) that the type of *Belodus* Pander is a *Cordylodus*.

As Bergström (*op. cit.*, p. 17) states, the systematics of *Cordylodus* are very confused and should be thoroughly revised. Forms from the Joins which consist of a laterally compressed recurved or reclined cusp joined to a long, denticulated posterior process and having thin wide basal sheaths are here assigned to *Cordylodus*.

CORDYLODUS DELICATUS Branson and Mehl

Pl. 1, figs. 25, 28, 30

Cordylodus? delicatus BRANSON AND MEHL, 1933, Missouri Univ. Studies, v. 8, 129, pl. 10, figs. 14, 15; GLENISTER, 1957, Jour. Paleontology, v. 31, p. 732, pl. 88, fig. 5.

Subcordylodus delicatus BRANSON, 1944, Missouri Univ. Studies, v. 19, pp. 89, 90, pl. 13, figs. 14, 15; ETHINGTON, 1959, Jour. Paleontology, v. 33, p. 288, pl. 41, fig. 13; ETHINGTON AND FURNISH, 1960, Jour. Paleontology, v. 34, p. 268.

Cordylodus rectilineatus RHODES, 1953, Philos. Trans. Roy. Soc. London, Ser. B, no. 647, v. 237, pp. 300, 301, pl. 22, figs. 172-175.

Cordylodus elongatus RHODES, 1953, Philo. Trans. Roy. Soc. London, Ser. B, no. 647, v. 237, p. 299, pl. 21, figs. 114-118.

Cordylodus delicatus SWEET, TURCO, WARNER, AND WILKIE, 1959, Jour. Paleontology, v. 33, p. 1044, pl. 132, figs. 12, 14, 17; PULSE AND SWEET, 1960, Jour. Paleontology, v. 34, p. 251, pl. 36, figs. 4, 7; BERGSTRÖM, 1964, Inst. Mineralogy, Paleontology, Quaternary Geology, Univ. Lund, Publ. 128, pp. 18, 19; BARNETT, 1965, Micropaleontology, v. 11, p. 69, pl. 1, fig. 20; pl. 2, fig. 1.

Remarks: *Cordylodus delicatus* is characterized by its laterally directed anterior keel and its stubby row of posterior denticles.

As in *Cordylodus flexuosus* (Branson and Mehl), most published illustrations of *C. delicatus* are of broken specimens. A fragility inherent in the conodont's structure evidently prevents the possibility of obtaining complete representatives. Specimens illustrated herein approach the most complete forms known of this species.

Occurrence: Rare in lower and upper Joins strata, virtually absent in most lower and all middle beds.

Repository: Figured hypotypes: USNM 146940; unfigured hypotypes: USNM 146941.

CORDYLODUS FLEXUOSUS (Branson and Mehl)

Pl. 1, fig. 26

Prioniodus (?) flexuosus BRANSON AND MEHL, 1933, Missouri Univ. Studies, v. 8, p. 130, pl. 10, fig. 16.

Cyrtoniodus complicatus STAUFFER, 1935a, Geol. Soc. America, Bull., v. 46, p. 140, pl. 11, figs. 44, 46, 48-51; STAUFFER, 1935b, Jour. Paleontology, v. 9, p. 604, pl. 73, figs. 9, 11, 12, 13, 15, 16, 18, 20, 25, 27, 32, 41, 42, 47; AMSDEN AND MILLER, 1942, Jour. Paleontology, v. 16, p. 303, pl. 41, fig. 34; RHODES, 1953, Philo. Trans. Roy. Soc. London, Ser. B, no. 647, p. 302, pl. 22, figs. 193-196; SWEET, 1955, Jour. Paleontology, v. 29, p. 254, 255, pl. 28, fig. 3; GLENISTER, 1957, Jour. Paleontology, v. 31, p. 732, pl. 88, fig. 16; ETHINGTON, 1959, Jour. Paleontology, v. 33, p. 274, pl. 40, fig. 7; ETHINGTON AND FURNISH, 1959, Jour. Paleontology, v. 33, p. 541, pl. 73, fig. 4; ETHINGTON AND FURNISH, 1960, Jour. Paleontology, v. 34, p. 367.

Cordylodus flexuosus SWEET, TURCO, WARNER, AND WILKIE, 1959, Jour. Paleontology, v. 33, p. 1045, pl. 132, fig. 13; PULSE AND SWEET, 1960, Jour. Paleontology, v. 34, pp. 251, 252, pl. 36, figs. 4, 7; BERGSTRÖM, 1964, Inst. Mineralogy, Paleontology, Quaternary Geology, Univ. Lund, Publ. 128, pp. 17, 18; BARNETT, 1965, Micropaleontology, v. 11, p. 69, pl. 1, fig. 4; pl. 2, fig. 3.

Remarks: Most previous illustrations of *Cordylodus flexuosus* generally show a broken cusp and an abbreviated posterior bar with broken denticles. Specimens of the present study are more complete than usual, but a perfect specimen is wanting.

Cordylodus flexuosus has been reported as commonly occurring in faunas from Middle and early Late Ordovician rocks. *C. flexuosus* is distinguished by its arched base, laterally flexed cusp and delicate posterior process.

Occurrence: Very rare in lower and upper Joins strata, absent elsewhere.

Repository: Figured hypotype: USNM 146942; unfigured hypotypes: USNM 146943.

Genus DICHOGNATHUS Branson and Mehl 1933

Type species: *D. prima* Branson and Mehl, 1933

DICHOGNATHUS EXTENSA Branson and Mehl

Pl. 1, fig. 27

Dichognathus extensa BRANSON AND MEHL, 1933, Missouri Univ. Studies, v. 8, p. 114, pl. 9, fig. 21; BRANSON AND MEHL, 1943, Jour. Paleontology, v. 17, pp. 376, 387, pl. 64, fig. 10; GLENISTER, 1957, Jour. Paleontology, v. 31, p. 734, pl. 88, figs. 11, 17; SWEET, TURCO, WARNER, AND WILKIE, 1959, Jour. Paleontology, v. 33, no. 6, p. 1047, pl. 132, figs. 2, 3; BARNETT, 1965, Micropaleontology, v. 11, p. 70, pl. 1, fig. 10.

?Dichognathus cf. *D. extensa* SANNEMANN, 1955, Neues Jahrb. Geol. Paläont., Abhandl., Bd. 102, p. 25, pl. 2, fig. 12.

Diagnosis: Unit consists of a pair of blade-like denticulated processes and an anterior cusp separated from the inner lateral process by a small outer process angle.

Cusp slender, sharp-edged and keeled, laterally compressed, erect, and asymmetrical. Anterior edge of the cusp is directed slightly outward and extends aborally for a short distance. Posterior margin of cusp joins posterior process at an angle of nearly 90°.

Posterior process is thin, straight, laterally compressed, and blade-like. Denticles of this process are flattened, confluent at their bases, and stubby. Anterior cusp edge is separated from inner lateral process by a small outer process angle of less than 15°. Inner lateral process is a short, downwardly directed blade-like limb bearing stubby denticles similar to those of the posterior process.

Basal excavation is moderately deep, subconical in lateral view, and extends to the process extremities. The deepest portion of the base is located directly beneath the central part of the cusp.

Remarks: Dichognathus extensa differs from its most closely allied congener, *D. typica,* by possessing a smaller outer process angle than the latter species.

Sweet, *et al.* (1959, p. 1048), suggested that *Dichognathus extensa* and *D. typica* might be linked by transitional forms in their collections which would make the two conspecific. Although such evidence might exist in some collections, no substantiation was found in the Joins fauna. As the two species are easily separated here on the basis of the relative difference in degree of outer process angle and the resulting external morphology, no conspecificity is assumed for purposes of convenience.

Occurrence: Rare and restricted to the upper Joins beds.

Repository: Figured hypotype: USNM 146944; unfigured hypotypes: USNM 146945.

DICHOGNATHUS TYPICA Branson and Mehl

Pl. 1, fig. 28

Dichognathus typica BRANSON AND MEHL, 1933a, Missouri Univ. Studies, v. 8, pp. 113, 114, pl. 9, figs. 27-29; BRANSON AND MEHL, 1933b, Missouri Univ. Studies, v. 8, p. 163, pl. 9, fig. 19; STAUFFER, 1935a, Geol. Soc. America Bull., v. 46, pp. 141, 159, pl. 11, figs. 2, 3, 5, 8, 10; STAUFFER, 1935b, Jour. Paleontology, v. 9, p. 604, pl. 71, fig. 23; GRAVES AND ELLISON, 1941, Missouri Univ. School Mines and Metallurgy, Bull., Tech. Ser., v. 14, pp. 4, 7; BRANSON AND MEHL, 1943, Jour. Paleontology, v. 17, pp. 376, 387, pl. 64, fig. 9; GLENISTER, 1957, Jour. Paleontology, v. 31, p. 735, pl. 88, figs. 4, 6; ETHINGTON, 1959, Jour. Paleontology, v. 33, p. 274, pl. 40, fig. 17; SWEET, TURCO, WARNER, AND WILKIE, 1959, Jour. Paleontology, v. 33, p. 1048, pl. 132, fig. 6; PULSE AND SWEET, 1960, Jour. Paleontology, v. 34, p. 252, pl. 37, figs. 6, 14; ETHINGTON AND FURNISH, 1960, Jour. Paleontology, v. 34, p. 271; BERGSTRÖM, 1961, Arkiv f. Min. Geol., v. 3, no. 1, pp. 37, 38, pl. 5, fig. 6; BARNETT, 1965, Micropaleontology, v. 11, p. 70, pl. 1, fig. 9; pl. 2, fig. 4.

non *?Dichognathus* cf. *D. typicus* RHODES, 1953, Philo. Trans. Roy. Soc. London, Ser. B, no. 647, pp. 317, 318, pl. 22, figs. 178-180.

Remarks: Dichognathus typica is characterized chiefly by its deep basal excavation and its comparatively large outer process angle. The term "outer process angle" is used in the sense of Sweet, *et al.* (1959, p. 1046) to denote the angle between the inner lateral process and the anterior cusp edge.

The representatives of *Dichognathus typica* in the Joins fauna are some of the most complete forms published. Most illustrations of this rather extensively occurring Middle and Upper Ordovician species are figures of specimens with broken bar denticles and incomplete cusps.

As represented here, *Dichognathus typica* possesses a more slender, longer, and more reclined and sharply tapered cusp than those reported in previous accounts. Although the general aspect of the Joins specimens is noticeably different from that of most representatives of *D. typica,* their conspecificity is based upon the established tendency of *Dichognathus* to exhibit great variation within a species.

Occurrence: Generally restricted to upper Joins beds, rare.

Repository: Figured hypotype: USNM 146946; unfigured hypotypes: USNM 146947.

Genus DISTACODUS Hinde, 1879

Type species: *Machairodus incurvus* Pander, 1856

DISTACODUS SYMMETRICUS Mound, n. sp.

Pl. 2, figs. 1-3, text-fig. 1E

Diagnosis: Unit bilaterally symmetrical, possesses an erect to slightly recurved biconvex cusp. Cusp slightly twisted, has sharp anterior and posterior keels which continue aborally to basal extremities. Main body of blade is symmetrical in cross-section. Antero-basal and postero-basal margins continue as rib-like extensions for a short distance below aboral margin. Each of the two lateral faces of cusp is bisected precisely by symmetrically positioned strongly developed costae which extend from the midpoints of the medio-basal margins to the sharp tip of the distal extremity of the cusp. Produced basal extremities of costae are expressed in an aboral direction. Posterior portion of base is flared and does not depart from the lateral plane of symmetry.

Basal sheath is large. Basal cavity is drepanodid (conical) in plan. Lateral view of cavity reveals a steep convexo-concave upward anterior and a gentler convexo-concave upward posterior outline. Apex of basal cavity is an anteriorly directed sharp tip, anteriorly situated with respect to the lateral midline.

Basal outline of unit is scalloped; this phenomenon is evidently due to the characteristic shape of the basal sheath, which extends, umbrella-like, from the aboral extremities of the antero-posterior and lateral ribs.

Dimensions of holotype: Maximum length of base in antero-posterior direction—0.5 mm; distance from postero-basal margin to tip of cusp—1.2 mm.

Remarks: Distacodus symmetricus most closely resembles *D. incurvus* Pander, from which it differs by possessing a definite posterior oral edge and a more recurved cusp. The umbrella-like scallops resulting from the aboral extensions of the keels and costae serve readily to distinguish *D. symmetricus* from its congeners.

Representatives of *Drepanodus homocurvatus* Lindström from Joins samples common to both species are remarkably similar in superficial morphologic features to *Distacodus symmetricus.* The prominent lateral costae of the latter species is sufficient to eliminate any possibility of confusion between the two forms. No gradational forms are present although forms of *Acodus* in the Joins also exhibit gross features common to *Drepanodus homocurvatus* and the new species of *Distacodus.* Although these three characteristic forms are considered generically exclusive herein, it is not difficult to imagine a natural association of these form-genera as specialized structures within the same animal. Until such time as the form-genera and represented species can be shown to be congeneric, the distinctive form *Distacodus symmetricus* is restricted to a single specific group.

Occurrence: Abundant in middle Joins strata; common to rare in lower and upper beds; absent in uppermost Joins.

Repository: Holotype: USNM 146948; figured paratypes: USNM 146949; unfigured paratypes: USNM 146950.

Etymology: symmetricus, Gr. *symmetros:* symmetrical; refers to the bilaterally symmetrical nature of the conodont unit.

Genus DREPANODUS Pander, 1856

Type species: *D. arcuatus* Pander, 1856

DREPANODUS CONCAVUS (Branson and Mehl)

Pl. 2, figs. 4-6

Oistodus concavus BRANSON AND MEHL. 1933, Missouri Univ. Studies, v. 8, p. 59, pl. 4, fig. 6; FURNISH, 1938, Jour. Paleontology, v. 12, pp. 320, 329, pl. 41, figs. 16, 17.

Drepanodus concavus GLENISTER, 1957, Jour. Paleontology, v. 31, p. 724, pl. 86, fig. 10; BARNETT, 1965, Micropaleontology, v. 11, p. 70, pl. 1, fig. 17.

Diagnosis: Unit consists of a laterally compressed, unequally biconvex cusp joined to an antero-posteriorly extended base.

Cusp is flattened, recurved, sharp-edged, and has distinct anterior and posterior keels. The anterior edge, especially the proximal basal portion, is distinctly flanged and produced in front of the cusp for a short distance. The outer lateral cusp face is broadly rounded and noncarinate. The inner lateral face is convex medially and is bordered by faint longitudinal depressions close to anterior and posterior margins; anterior depression is very pronounced. Most specimens are not flexed, a few are slightly bowed inward.

Base laterally compressed; antero-posterior dimension is unusually long. Junction of posterior cusp margin with base is at a smooth curve; oral margin of base con-

tinues as a convex curve behind cusp for a short distance. Anterior junction of cusp and base is smooth; antero-basal margin reverses curvature above corner of aboral junction and produces a concave upward outline as the edge continues anteriorly. The base is broadly and smoothly convex, flaring equally in inner and outer lateral directions.

Basal cavity is deep, conical and readily observable in transparency. Anterior slope of cavity outline is steep and sigmoidal; posterior slope is gentler and smoothly convex. Anteriorly directed sharp and slender tip of excavation is centrally to posterocentrally located. Excavation extends to base extremities.

Remarks: Drepanodus concavus is distinguished from its congeners by its smoothly curved proximal and distally straight cusp portions, its anterior concave upward nose and its broadly convex basal margin. *D. homocurvatus* Lindström and *D. subarcuatus* Furnish, also well represented in this study, resemble *D. concavus* closely, but the former species lack concave anterior profiles.

Complete specimens of this species are totally lacking; the best of the better specimens lack the distal cusp tip.

Drepanodus concavus, as represented here, forms a unique group of conodonts whose basal features are easily observed through the singular degree of transparency of their respective bases. The "white matter" (of Lindström, 1964, pp. 17-24) of *D. concavus* is frequently restricted to an area distally removed from the base to a degree that is without parallel among the other taxa represented in the extremely rich Joins fauna.

There is considerable latitude in the development of the distinctive anterior marginal furrow.

Occurrence: Rare to abundant in all but lowest Joins samples.

Repository: Figured hypotypes: USNM 146951; unfigured hypotypes: USNM 146952.

Drepanodus homocurvatus Lindström

Pl. 2, figs. 8, 10

Oistodus curvatus Branson and Mehl, 1933, Missouri Univ. Studies, v. 8, pp. 110, 111, pl. 9, figs. 4, 10, 12; Stauffer, 1935a, Geol. Soc. America, Bull., v. 46, pp. 146, 159, pl. 12, figs, 20, 23, 27, 29, 30, 36; Stauffer, 1935b, Jour. Paleontology, v. 9, p. 609, pl. 74, figs. 5, 10, 12; Furnish, Barragy, and Miller, 1936, Amer. Assoc. Petroleum Geologists, Bull., v. 20, p. 1334, pl. 1, fig. 8; pl. 2, figs. 17, 18; Graves and Ellison, 1941, Missouri School Mines and Metallurgy, Bull., Tech. Ser., v. 14, pp. 4, 6, 7, pl. 1, fig. 8; pl. 2, figs. 17, 21, 27; Amsden and Miller, 1942, Jour. Paleontology, v. 16, p. 303, fig. 2B; Branson, 1944, Missouri Univ. Studies, v. 19, pp. 81, 89, pl. 11, figs. 8, 25, 31; pl. 12, figs. 37, 38; Rhodes, 1953, Philo. Trans. Roy. Soc. London, Ser. B, no. 647, p. 295, pl. 21, figs. 82, 89, 90, pl. 22, figs. 157-161; Sweet, 1955, Jour. Paleontology, v. 29, p. 29, p. 251, pl. 28, fig. 7.

Drepanodus homocurvatus Lindström, 1955, Geol. Fören. Förhandl., Bd. 76, p. 563, pl. 2, figs. 23, 24, 39; Sannemann, 1955, Neues Jahrb. Geol. Paläont., Abhandl., Bd. 102, p. 26, pl. 2, fig. 4, pl. 1, fig. 14; Lindström, 1957, Geol. Fören. Förhandl., Bd. 79, p. 164; Glenister, 1957, Jour. Paleontology, v. 31, p. 725, pl. 86, fig. 13; pl. 87, figs. 1-6, 8; Ethington, 1959, Jour. Paleontology, v. 33, p. 276, pl. 39, fig. 16; Sweet, Turco, Warner, and Wilkie, 1959, Jour. Paleontology, v. 33, p. 1049, pl. 130, fig. 7; Pulse and Sweet, 1960, Jour. Paleontology, v. 34, pp. 252, 253, pl. 35, figs. 4, 13; Ethington and Furnish, 1960, Jour. Paleontology, v. 34, p. 271, Lindström, 1960, Inter. Geol. Congress, 21st Session, Rept., pt. 7, p. 90; Bergström, 1961, Arkiv. Mineralogy Geology, Bd. 3, pp. 39-41, pl. 2, figs. 13, 14; pl. 5. fig. 19, text-figs. 3E, 4A; Wolska, 1961, Acta Palaeont. Polonica, v. 6, pp. 344, 348, pl. 2, figs. 7a, b; Sweet and Bergström, 1962, Jour. Paleontology v. 36, p. 1226; Ethington and Clark, 1964, Jour. Paleontology, v. 38, pp. 688, 689, pl. 113, figs. 13, 16; Bergström, 1964, Inst. Mineralogy, Paleontology, Quaternary Geology, Univ. Lund, Publ. 128, pp. 23, 24; Barnett, 1965, Micropaleontology, v. 11, p. 70, pl. 1, fig. 15; pl. 2, fig. 5.

Remarks: Drepanodus homocurvatus is ubiquitous in rocks of Ordovician age. Most representatives of this species from the Joins are large, robust and well-preserved. *D. homocurvatus* is characterized by its slightly convex basal margin and equally flaring anterior and posterior basal portions. *D. homocurvatus* most closely resembles *D. subarcuatus,* from which species it differs principally in possessing a distally curved cusp. *D. homocurvatus* is a highly distinctive form, but its presence in an Ordovician fauna provides little stratigraphic information.

Occurrence: Rare to abundant in all but lowest and generally highest Joins samples.

Repository: Figured hypotypes: USNM 146953; unfigured hypotypes: USNM 146954.

DREPANODUS INCURVUS (Pander)

Pl. 2, figs. 7, 9, 11

Machairodus incurvus PANDER, 1856, Monographie der fossilen Fische des silurischen Systems der Russisch-Baltischen Gouvernements, p. 23, pl. 1, fig. 22.

Distacodus incurvus HINDE, 1879, Quart. Jour. Geol. Soc. London, v. 35, pp. 357, 358, pl. 15, fig. 9; PARKS, 1923, 31st Ann. Rept. Ontario Dept. Mines, p. 36, pl. 6, fig. 23; HOLMES, 1928, Proc. U. S. Natl. Museum, v. 72, p. 9, pl. 1, fig. 12.

Oistodus suberectus BRANSON AND MEHL, 1933, Missouri Univ. Studies, v. 8, p. 111, pl. 9, fig. 7; STAUFFER, 1935a, Geol. Soc. Amer., Bull., v. 46, pp. 147, 159, pl. 12, figs. 14, 19, 28, 31, 35; STAUFFER, 1935b, Jour. Paleontology, v. 9, p. 611, pl. 74, figs. 18, 42, 46; FURNISH, BARRAGY, AND MILLER, 1936, Jour. Paleontology, v. 12, p. 1334, pl. 1, fig. 9; GRAVES AND ELLISON, 1941, Missouri School Mines and Metallurgy, Bull., Tech. Ser., v. 14, pp. 4, 7, pl. 1, fig. 32; BRANSON AND MEHL, 1943, Jour. Paleontology, v. 17, pp. 476, 385, pl. 64, fig. 16; BRANSON, 1944, Missouri Univ. Studies, v. 19, pp. 89, 90, pl. 13, fig. 40; BRANSON, MEHL AND BRANSON, 1951, Jour. Paleontology, v. 25, pp. 8, 9, pl. 2, figs. 1-4; RHODES, 1953, Philo. Trans. Roy. Soc. London, Ser. B, no. 647, p. 295, pl. 21, figs. 93, 94; pl. 22, figs. 166, 167; GLENISTER, 1957, Jour. Paleontology, v. 31, p. 726, pl. 86, figs. 12, 14.

Drepanodus incurvus BRANSON AND MEHL, 1933, Missouri Univ. Studies, v. 8, p. 154, pl. 12, fig. 13.

Oistodus giganteus STAUFFER, 1935, Jour. Paleontology, v. 9, p. 610, pl. 74, fig. 45.

Drepanodus suberectus LINDSTRÖM, 1955, Geol. Fören. Förhandl., Bd. 76, p. 568, pl. 2, figs. 21, 22; SANNEMANN, 1955, Neues Jahrb. Paläont, Abhandl., Bd. 102, p. 27, pl. 1, fig. 22; pl. 2, fig. 1; LINDSTRÖM, 1957, Geol. Fören. Förhandl., Bd., 79, p. 164; ETHINGTON, 1959, Jour. Paleontology, v. 33, p. 726, pl. 39, fig. 17; SWEET, TURCO, WARNER, AND WILKIE, 1959, Jour. Paleontology, v. 33, pp. 1049, 1050, pl. 130, fig. 4; PULSE AND SWEET, 1960, Jour. Paleontology, v. 34, p. 253, pl. 35, figs. 2, 7; ETHINGTON AND FURNISH, 1960, Jour. Paleontology, v. 34, p. 271; CARPENTER AND ORY, 1961, Ohio Jour. Sci., v. 61, p. 375; BERGSTRÖM, 1961, Arkiv Mineral. Geol., Bd. 3, p. 41, pl. 5, fig. 7, text-figs. 3K, 4B; WOLSKA, 1961, Acta Palaeont, Polonica, v. 6, pp. 349, 350, pl. 1, figs. 8a, b; SWEET AND BERGSTRÖM, 1962, Jour. Paleontology, v. 36, p. 1226, pl. 169, fig. 8; ETHINGTON AND CLARK, 1964, Jour. Paleontology, v. 38, pp. 689, 690, pl. 113, fig. 18; BERGSTRÖM, 1964, Inst. Mineral. Geol., publ. no. 128, p. 24; BARNETT, 1965, Micropaleontology, v. 11, p. 70, pl. 1, fig. 29; pl. 2, fig. 22.

Drepanodus sp. LINDSTRÖM (part), 1959, Micropaleontology, v. 5, p. 439, pl. 3, figs. 3, 4.

Remarks: The lengthy synonymy listed above attests to the ubiquitous nature of the species *Drepanodus incurvus,* more commonly known as *D. suberectus.* Ethington and Clark (1964) and Bergström (1961) noted differences of infraspecific variations in the degree of lateral and posterior expansion of the base. The former authors found that these basal expansions are greatest in younger specimens. Joins representatives include both types of conodonts in all samples from which the species was recovered: those having laterally flattened and posteriorly expanded bases and those having bases that are laterally produced and markedly posteriorly developed.

Occurrence: Rare in most Joins samples.

Repository: Figured hypotypes: USNM 146955; unfigured hypotypes: USNM 146956.

DREPANODUS PROTEUS Lindström

Pl. 2, figs. 12, 13

Drepanodus proteus LINDSTRÖM, 1955, Geol. Fören. Förhandl., Bd. 76, p. 566, pl. 3, figs. 18-21; LINDSTRÖM, 1960, 21st Internat. Geol. Congress, pt. 7, p. 89.

Diagnosis: Unit consists of a simple recurved biconvex cusp and a rounded convex base.

Cusp is flattened, lenticular in cross-section, recurved and anteriorly rounded. Anterior and posterior margins are sharp-edged and either lack keels or have indistinct costae. Lateral cusp faces are smooth and symmetrical with respect to each other. Most specimens lie in a single plane. Anterior margin meets basal margin at an extremely blunt to rounded corner. Posterior margin is a smooth curve that joins the base in a virtually unbroken line and continues as the oral edge of the posteriorly expanded base. Base is produced in this posterior direction and flares for a distance behind the cusp.

Aboral basal margin is long and broadly convex. Basal cavity is deep and conical: in lateral view, posterior slope of excavation is convex and gentle; anterior slope is concave and steep, with reversals of curvature. Sharp tip of excavation apex is anteriorly directed and is located near the posterior margin or subcentrally. Deepest and widest portion of basal cavity is posteriorly situated.

Remarks: Drepanodus proteus is best characterized by its broadly rounded anterior margin, biconvex cusp, posteriorly expanded and extended base, and large posteriorly centered basal cavity.

Occurrence: Rare to comomn in lower Joins beds, rare in middle and upper strata.

Repository: Figured hypotypes: USNM 146957; unfigured hypotypes: USNM 146958.

DREPANODUS SUBARCUATUS Furnish, 1938

Pl. 2, figs. 14, 18, 19

Drepanodus arcuatus BRANSON AND MEHL, 1933 (*non* Pander, 1856), Univ. Missouri Studies, v. 8, p. 58, pl. 4, figs. 7, 8, 13, 16.

Drepanodus parallelus BRANSON AND MEHL, 1933, Univ. Missouri Studies, v. 8, p. 59, pl. 4, fig. 17; GRAVES AND ELLISON, 1941, Missouri Univ. School Mines and Metallurgy, Bull., Tech. Ser., v. 14, pp. 3, 7, pl. 1, fig. 13.

Drepanodus simplex BRANSON AND MEHL, 1933 (*non* Branson and Branson, 1947), Univ. Missouri Studies, v. 8, p. 58, pl. 4, fig. 2.

Drepanodus subarcuatus FURNISH, 1938, Jour. Paleontology, v. 12, pp. 328, 329, pl. 41, figs. 25-32; pl. 42, figs. 2, 3; GRAVES AND ELLISON, 1941, Missouri Univ. School Mines and Metallurgy, Bull., Tech. Ser., v. 14, pp. 4, 7, pl. 2, fig. 12; MÜLLER, 1964, Neues Jahrb. Geol., Paläont., Monatsh. v. 119, pp. 96, 97, pl. 13, figs. 5, 6; ETHINGTON AND CLARK, 1964, Jour. Paleontology, v. 38, p. 689, pl. 113, figs. 15, 20.

Drepanodus cf. *D. subarcuatus* LINDSTRÖM, 1955, Geol. Fören. Förhandl., Bd. 78, p. 568, pl. 2, figs. 41, 44, 50; WOLSKA, 1961, Acta Palaeont. Polonica, v. 6, p. 349, pl. 1, figs. 5, 7.

Remarks: Drepanodus subarcuatus is a highly variable species, especially as represented by the numerous specimens from the present study. Variations in symmetry, curvature, basal margin horizontality, basal cavity configuration, are all gradational, but do not appear to be constant within any natural subgroup. It is possible that *Drepanodus tortus* Furnish may also belong here, but few specimens are as twisted as the figured type of the Shakopee species.

The cross-section of *Drepanodus subarcuatus,* as represented here, varies from lenticular to nearly subcircular. Previous workers have also found this to be the case for both *D. subarcuatus* and *D. parallelus.*

Occurrence: Common to abundant throughout most of Joins strata, except lowest beds where it is rare or absent.

Repository: Figured hypotypes: USNM 146959; unfigured hypotypes: USNM 146960.

Genus EONEOPRIONIODUS Mound, 1965

Type species: *E. cryptodens* Mound, 1965

EONEOPRIONIODUS CRYPTODENS Mound

Eoneoprioniodus cryptodens MOUND, 1965, Proc. Biol. Soc. Washington, v. 78, no. 24, p. 197, 198, figs. 1, 2, 12, 13.

Occurrence: Common to rare in all Joins strata.

Repository: Holotype: USNM 146268; Paratypes: USNM 146269, 146270.

Genus ERISMODUS Branson and Mehl, 1933

Type species: *E. typus* Branson and Mehl, 1933

ERISMODUS INCURVESCENS Harris

Pl. 2, figs. 16, 22

Erismodus incurvescens HARRIS, 1964, Oklahoma Geology Notes, v. 24, pp. 173-174, pl. 1, figs. 1a-d.

Occurrence: Rare, restricted to lower Joins strata.

Repository: Figured topotypes: USNM 146961; unfigured topotypes: USNM 146962.

Genus FALODUS Lindström, 1955

Type species: *Oistodus prodentatus* Graves and Ellison, 1941

FALODUS PRODENTATUS (Graves and Ellison)

Pl. 2, figs. 15, 17, 20

Oistodus prodentatus GRAVES AND ELLISON, 1941, Missouri Univ. School Mines and Metallurgy, Bull., Tech. Ser., v. 14, pp. 13-14.

Falodus n. sp. LINDSTRÖM, 1957, Geol. Fören., Förhandl., Bd. 79, p. 173, pl. 1, figs. 25-26, text-figs. 2-25, 26.

?*Falodus sp.* LAMONT AND LINDSTRÖM, 1957, Edinburgh Geol. Soc. Trans., v. 17, pp. 63-65; WOLSKA, 1961, Acta Paleont. Polonica, v. 6, p. 350, pl. 2, figs. la, b, 5.

Eofalodus brevis HARRIS, 1962, Oklahoma Geology Notes, v. 22, pp. 205-206, pl. 1, figs. 7a-d.

Falodus parvidentatus SERGEEVA, 1963, Paleont. Zhurnal, no. 2, pp. 103, 104, pl. 8, figs. 4-7, text-fig. 8.

Falodus simplex SERGEEVA, 1963, Paleont. Zhurnal, no. 2, pp. 104, 105, pl. 8, figs. 8-10, text-fig. 9.

Falodus prodentatus LINDSTRÖM, 1955, Geol. Fören. Förhandl., Bd. 76, p. 569, pl. 5, figs. 21, 22, 30; LINDSTRÖM, 1957, Geol. Fören. Förhandl., Bd. 79, p. 164; ETHINGTON, 1959, Jour. Paleontology, v. 33, pp. 277, 278, pl. 39, fig. 18; SWEET AND BERGSTRÖM, 1962, Jour. Paleontology, v. 36, pp. 1227-1229, pl. 170, figs. 2-3; text-fig. 2B.

Remarks: Sweet and Bergström (1962, *loc. cit.*) suggested that the reported occurrences of *Falodus prodentatus* may be representative of a taxonomically divisible gradational series of forms from Lower, Middle, and Upper Ordovician rocks. Observed trends in this variable species as reported from successively younger rocks in widely separated geographical locales are the tendency from a sinuous toward a straight aboral margin, and the change from a small, restricted basal excavation to a rather large, extensive cavity. The Joins forms fall into the middle sector of this range of gradations; Joins representatives have moderately deep and well-developed basal excavations and have broadly sinuous aboral margins. Both single- and multidenticulate anteriors are represented in this fauna; the writer concurs with Sweet (1963, p. 505) who maintains that denticle number on any margin or process is extremely unreliable as a generic or even specific guide. For this reason, the Joins forms compared with the type specimens of *Eofalodus brevis* Harris are here included within the species *F. prodentatus.*

Occurrence: Rare in most Joins beds, lacking in uppermost and lowermost strata.

Repository: Figured hypotypes: USNM 146936; unfigured hypotypes: USNM 146964.

Genus GOTHODUS Lindström, 1955

Type species: *G. costulatus* Lindström, 1955

GOTHODUS COMMUNIS Ethington and Clark

Pl. 2, figs. 24, 25

Gothodus communis ETHINGTON AND CLARK, 1964, Jour. Paleontology, v. 38, pp. 690, 692, pl. 114, figs. 6, 14; text-fig. 2F.

Diagnosis: Unit consists of a flattened, erect to reclined laterally costate cusp, and a long, denticulated posterior process.

The cusp is sharp-edged, keeled anteriorly and posteriorly, slender, and gently curved. Distally, the cusp tapers gradually to a sharp point which is slightly flexed outward. The cusp anterior continues aborally as a narrowly triangular process for a considerable distance beyond the base, terminating in a sharp aboral tip. Outer lateral face is broadly convex or faintly carinate. The inner lateral face is ornamented by a long, slender, triangular, posteriorly curving costa. The costa is laterally and aborally directed; a sharp angle is formed between the anterior costa face and the inner lateral cusp face, forming a prominent V-shaped trough. Aboral extensions of lateral and anterior costae are equal.

The posterior margin joins the base at an angle of nearly 90°. The posterior continuation of the cusp is a long, flattened process which bears numerous compressed denticles. The denticles are discrete, subelliptical, and confluent at their bases. They are gradational in size, subparallel to the cusp and posteriorly inclined. The bar is commonly straight, but is bowed slightly in a few specimens; in these latter instances, the convex side is directed inward.

Basal cavity is pyramidal and relatively shallow. The excavation extends as aboral grooves into the process extremities; apex of cavity is located beneath the cusp.

Remarks: Gothodus communis differs from its only other congener, *G. costulatus* Lindström, by possessing a more divergent and more aborally extensive pair of anterior and lateral costae. Moreover, the lateral costa of *G. costulatus* is not prominent and is restricted to the basal portion of the cusp (Ethington and Clark, 1964, p. 692).

Occurrence: Rare in lower middle and lower upper beds, absent in other strata.

Repository: Figured hypotypes: USNM 146965; unfigured hypotypes: USNM 146966.

Genus HADDINGODUS Sweet and Bergström, 1962

Type species: *H. serra* Sweet and Bergström, 1962

HADDINGODUS? aff. H. SERRA Sweet and Bergström

Pl. 2, figs. 21, 28

Arabellites serra HADDING, 1913, Lunds Univ. Årsskr., N. F., Afd. 2, Bd. 9, p. 33, pl. 1, figs. 12, 13.

Periodon serra LINDSTRÖM, 1955, Jour. Paleontology, v. 29, pp. 110, 111, pl. 22, figs. 17, 20-25; LAMONT AND LINDSTRÖM, 1957, Edinburgh Geol. Soc. Trans., v. 17, pt. 1, pp. 63, 64, 67; SWEET, TURCO, WARNER AND WILKIE, 1959, Jour. Paleontology, v. 33, p. 1051; REGNELL, 1960, 21st Int. Geol. Cong., Guide to Excursions A22 and C17, p. 21.

"Arabellites" serra LINDSTRÖM, 1960, 21st Int. Geol. Cong., Repts., pt. 7, p. 95, fig. 7-7.

Haddingodus serra SWEET AND BERGSTRÖM, 1962, Jour. Paleontology, v. 36, p. 1229, pl. 170, figs. 1, 4; HAMAR, 1964, Norsk Geol. Tidskrifft, v. 44, pt. 2, pp. 266, 267, pl. 4, figs. 13, 16; text-fig. 5, nos. 6a-b.

Remarks: This form, represented by several specimens from the lower Joins beds, is assigned to the genus *Haddingodus* with question. Sweet and Bergström (*loc. cit.*, p. 1229) state that *Haddingodus* does not possess an outer lateral process that is continued as a carina on the cusp. According to these authors (*op. cit.*), the nondenticulated process together with the lack of lateral platforms or ledges distinguishes *Haddingodus* from *Ambalodus*. In addition, *Ambalodus* has its lateral process continued as a carina with a denticle anterior to the main cusp. The Joins forms agree with all aspects of the species *Haddingodus serra*, but the outer lateral process is continued onto the main cusp. Moreover, a faint costa is present on the inner cusp face. As the Joins forms lack lateral ledges and do not possess the costa-anterior denticle relationship of *Ambalodus*, they share closest affinity with *Haddingodus* (specifically, *H. serra*).

Occurrence: Rare, restricted to lower Joins beds.

Repository: Figured hypotypes: USNM 146967; unfigured hypotypes: USNM 146968.

Genus HISTIODELLA Harris, 1962

Type species: *H. altifrons* Harris, 1962

HISTIODELLA ALTIFRONS Harris

Pl. 2, figs. 23, 26, 27

Histiodella altifrons HARRIS, 1962, Oklahoma Geology Notes, v. 22, no. 8, pp. 208, 209, pl. 1, figs. 4a-c.

Diagnosis: Unit consists of a simple, flattened, thin, opaque blade blending into a transparent, equally flattened, twisted base having a prominent basal cavity. Entire blade flexed inward, slightly bowed, and broadly triangular to subtriangular. Blade ornamented by a faint to distinct raised midrib visible on either side; midrib inclined posteriorly, transversely terminated near aboral margin by a low lateral ridge.

Anterior margin begins at apex of triangular blade as a long straight edge; faint keels are visible on anterior and posterior edges. Continuation of anterior margin terminates in a smooth semicircular curve (in lateral view) and becomes the aboral margin. In a posterior direction, the curve flattens as it joins the aboral margin and becomes slightly sigmoidal. Aboral margin joins posterior margin at a sharp angle. Posterior margin short, decidedly sigmoidal, strongly concave to apex.

Basal cavity low, elongate, and concavo-convex in profile. Cavity consists of a subcentrally located, shallow, subapical, hemispherical pit that extends anteriorly as a narrow groove for a short distance and as a wide groove to posterior limit. Entire length of cavity reinforced laterally by thick flaring lips.

Remarks: Histiodella altifrons is distinguished from its congeners by the relatively large portion of the flattened blade anterior to the midrib, its straight unserrated edges, and the characteristic broad sweep of the concave anterior edge.

In the original description of this species, Harris (p. 208) refers to the apex as the terminal portion of an apical spine. Examination of the specimens in this study and of the type specimens reveals this as a consistently distinctive feature of *H. altifrons*. It is conceivable that the midrib structure might be the incipient precursor of a more extensive and definite "spine" or main denticle.

Occurrence: Rare in lower and upper beds, absent elsewhere.

Types: Figured homeotypes: USNM 146969; unfigured homeotypes: USNM 146970; unfigured topotypes: USNM 147035.

HISTIODELLA MINUTISERRATA Mound, n. sp.

Pl. 3, figs. 1-3, text-fig. 1F

Diagnosis: A *Histiodella* of distinct bilaterally asymmetrical aspect. Blade flattened, plate-like, slightly twisted, generally opaque, blends into a twisted, elongate base. Blade subtriangular in profile, has a short, curved, sigmoidal, convex and concave posterior outline; anterior profile is high, broad, long, and generally convex.

Both anterior and posterior margins are minutely serrated with numerous incipient denticles(?). Anterior margin curves gently convexly upward toward base from apical-like denticle, continues as a broad semicircular nose into the anterior portion of the base. Posterior margin continues with posterior part of apical denticle, begins as a steeply inclined concave-upward curve, reverses briefly into a convex curve at midlength of posterior portion of blade, reverts to original curvature, and finally curves into a sharply convex posterior but terminating at junction of basal (aboral) margin at a nearly perpendicular angle.

The characteristic *Histiodella* midrib is exceptionally well developed into a distinct apical spine. Apical spine as thus defined is a bluntly pointed to hemispherically

domed extension of midrib, extends aborally at an angle of approximately 60° to the longest basal direction and in the plane of the blade. Midrib is equally developed on both lateral surfaces of plate. Transmitted light reveals clear definition of the apical denticle and its external expression as midrib.

Center of growth of conodont unit is directly above basal cavity. At this point, the greatest plate thickness is developed; here, the conodont is most opaque. Growth lamellae, generally 10 or more in number, are strikingly discernible in transmitted light and are most widely spaced at basal edge, where they are easily observed. The diaphanous nature of the lamellae passes upward into granular and semi-fibrous layers near the posterior and anterior edges. No evidence of the minute and numerous serrations can be observed on any but the last-formed lamella. The importance of this observation is that ontogeny of the individual specimens is manifestly complete with the addition of the serrations, for the penultimate layer and those formed before it bear no traces of serrations.

Basal cavity is an elongate, shallow, subelliptical, subcentrally located, subapical, hemispherical pit. This pit is similar to the spathognathodid type of excavation and is slightly eccentric, extending to anterior and posterior termini of blade as a long shallow slit. Widest part of excavation directly below initial portion of apical denticle (midrib): at this point, the roof of the basal cavity is at its highest, proceeding anteriorly as a concave upward trace and posteriorly as convex upward: the whole imparting a decidedly sigmoidal appearance. Lateral extensions of basal groove persist as thickened, flaring ridges.

Remarks: Histiodella minutiserrata, n. sp. is characterized by its many sharp-pointed peripheral serrations. It differs from its most closely associated species, *H. serrata* by possessing serrations that are more numerous and regularly distributed.

Histiodella minutiserrata and *H. serrata* might be representative of contemporaneous or successive stages of evolution of this particular morphological type of conodont. Until more is known concerning the stratigraphic distribution, little can be of true interpretive value concerning these species.

Etymology: The trivial name *minutiserrata* is from Latin (*minutus,* small, little; *serratus,* toothed as a saw) and refers to the characteristic numerous small teeth on each edge of the plate.

Occurrence: Rare in middle lower, middle, and lower upper beds.

Types: Figured holotype: USNM 146971; figured paratypes: USNM 146972; unfigured paratypes: USNM 146973.

HISTIODELLA SERRATA Harris, 1962

Pl. 3, figs. 4, 6, 7

Histiodella serrata HARRIS, 1962, Oklahoma Geology Notes, v. 22, no. 8, p. 209, pl. 1, figs. 2a, b.

Diagnosis: Bilaterally asymmetrical unit consists of a simple, flattened, subtriangular twisted opaque plate-like blade blending into a transparent thickened base. Blade sinuous, has a bowed concave posterior and a bowed convex anterior.

Anterior and posterior margins of unit serrated and curved. Anterior margin high, broadly sigmoidal, continues as an irregular convex curve to aboral margin; aboral margin lacks serrations. Posterior margin generally short, sharply sigmoidal, begins as a concave serrated edge from apex of triangle, turns upward briefly and proceeds to a point where it joins posterior margin at a relatively acute angle along a resultant convex surface.

Midrib characteristic of *Histiodella* expressed as a faint, strongly inclined carina visible on inner and outer surfaces of plate. Strong suggestions of apical denticle on some specimens which results from the continuation of the midrib to its apical limit. Midrib meets transparent base at a faintly thickened transverse ridge; this latter feature is indistinct on some specimens.

Basal cavity a shallow, elongate, subcentrally located subelliptical subapical pit of narrow lateral dimension. Pit extends to anterior and posterior termini of aboral surface as wide shallow grooves with little variation in width. Aboral margin fortified by lateral thickenings in the form of flaring lips, most prominent and thickest near widest point of aboral excavation.

Remarks: Histiodella serrata is best characterized by its irregularly serrated anterior and posterior edges. Further distinguishing features are its long basal excavation, relatively well-defined apical spine, and apparent lack of anterior and posterior keels. The latter features are commonly observed on specimens of *H. altifrons* Harris. *H. serrata* is most closely related to *H. minutiserrata,* n. sp., differing from the latter by possessing more obvious, numerous, and larger serrations. The gross morphology of *H. serrata* is similar to that of *H. altifrons,* especially the sinuous outline of anterior and posterior margins common to both species.

Some specimens of *H. serrata* possess minute "canalicules" which penetrate from the anterior and posterior edges of the plate

into and through the opaque blade. These canalicules ramify into intricate patterns within the blade concentrated in the area cloest to the anterior edges; the transparency of the canalicules against the opacity of the blade matrix provides a striking contrast.

Occurrence: Rare in lower beds, rare to common in middle and upper strata.

Types: Figured homeotypes: USNM 146974; unfigured homeotypes: USNM 146975; unfigured topotypes: USNM 147036.

HISTIODELLA SINUOSA (Graves and Ellison)

Pl. 3, figs. 5, 8, 9

Bryantodus sinuosa GRAVES AND ELLISON, *err. cit. pro Bryantodina sinuosa* Graves and Ellison, 1941, Missouri Univ. School Mines and Metallurgy, Bull., Tech. Ser., v. 14, pp. 9, 10, pl. 2, fig. 13.

Histiodella sinuosa LINDSTRÖM, 1964, Conodonts, Elsevier Co., New York, pp. 157, 177, fig. 54c.

Remarks: The Joins representatives of *Histiodella sinuosa* conform precisely to the type figure and description of the original from the Marathon Basin in Texas. The present specimens are more complete and denticulation is more closely defined than in previous accounts. Lindström (1964, p. 177) assigned *H. sinuosa* as type species for *Histiodella,* which has *H. altifrons* Harris as its validly proposed type. Transitions from *H. altifrons* through *H. sinuosa,* from a non-serrated through a minutely serrated (*H. minutiserrata,* n. sp.), a definitely coarsely serrated (*H. serrata* Harris), and a denticulated *Bryantodina*-like element (*H. sinuosa)* are indicated, but not readily traceable. It may be that *Histiodella* does, in fact, consist solely of a single, or at most, two highly variable species; but the non-parallel distribution of the several species in the Joins mitigates this possibility.

Occurrence: Rare in middle and highest Joins beds, common to abundant in upper strata, totally lacking in lower beds.

Repository: Figured hypotypes: USNM 146976; unfigured hypotypes: USNM 146977.

HISTIODELLA TRIQUETRA Mound, n. sp.

Pl. 3, figs. 10, 11; text-fig. 1G

Diagnosis: Unit consists of a simple, flat, triangular blade having an inner lateral costa developed into an accessory blade.

The plate (or plate-like undenticulated blade) is symmetrically lanceolate; outer lateral face of the blade is broad and smoothly convex; unit is flexed inward. Anterior and posterior margins are narrowly keeled and sharp-edged; both margins originate at equal and opposite points with respect to the median keel and proceed from an aboral basal junction to a convex proximal portion through a tapered distal portion. At the distal tip, the anterior and posterior margins and the inner lateral costa converge at a sharp triple-edged point. The inner lateral costa is narrow, high, and distinct; development into an accessory plate-like process is greatest at base. A shallow depression runs parallel to the basal margin at the "heel" of the plate. As in other species of *Histiodella,* the plate is opaque and porcellaneous. The greatest height of the conodont is approximately equal to the greatest width.

The base is amber and translucent to transparent, passing directly from opacity of the blade in an aboral direction. Greatest width of base is smaller than the widest anteropostero portion of the plate. Basal excavation is shallow; extends through all extremities including the lateral process. At the common junction of the anterior, posterior, and lateral processes, the cavity is deepest and widest; this is situated at the precise center of the blade.

Dimensions of holotype: Maximum height: 0.25 mm; maximum width; 0.25 mm; basal width: 0.23 mm.

Remarks: The orientation of *Histiodella triquetra* is such that the convex side of the unit is "outer" and the costate face is "inner"; the base is oriented so that the excavation opens aborally into all extremities. Similar forms, such as *Pteracontiodus aquilatus* Harris and other acontiodids, are oriented so that the broad convex face is anterior. *Histiodella* is oriented as a typical bladed conodont *(sensu lato)* such that the long dimensions are antero-posterior.

Histiodella triquetra differs from its congeners by possessing an auxiliary medial plate process. In other aspects, such as general outline, base-plate relationship, and relative simplicity of structures, *H. triquetra* is close to *H. altifrons* Harris.

Occurrence: Rare in middle and upper Joins beds.

Repository: Holotype: USNM 146978; figured paratypes: USNM 146979; unfigured paratypes: USNM 146980.

Etymology: tri-, L., *tres:* three; *-quetra,* L., *-questrus:* angled, cornered; refers to the three corners of this species which are

formed by the junction of anterior, posterior, and inner lateral processes.

Genus MULTIOISTODUS Cullison, 1938

Type species: *M. subdentatus* Cullison 1938

MULTIOISTODUS COMPRESSUS Harris and Harris

Pl. 3, figs. 12, 13

Neomultioistodus compressus HARRIS AND HARRIS, *err. cit. pro Multioistodus (Neomultioistodus) compressus* Harris and Harris, 1965, Oklahoma Geology Notes, v. 25, pp. 43, 44, pl. 1, figs. 7a-c.

Diagnosis: Unit consists of a recurved cusp joined to a posterobasally and anterolaterally denticulated base.

Cusp is long, slender, recurved, and sharp-edged. The posterior margin is sigmoidal, the anterior margin is smoothly convex; both anterior and posterior margins bear keels, the posterior keel is wider and more pronounced.

Posterior margin of the cusp joins the base at an angle slightly less than 90°. At this point, the anterior edge of the posterobasal junction of the cusp rises posteriorly and distally from the base. The posterior denticle thus formed is large, plate-like, flattened, and lanceolate. The anterior edge is straight; the posterior edge is curved broadly, especially at the posterior basal junction. The base continues behind the postero-basal denticle for a short distance and "hooks" aborally. The anterior cusp margin joins directly with the trailing posterior edge of the antero-lateral denticle just above the level of the anterior portion of the base. The anterior denticle thus formed is short, subtriangular, flattened, and is smoothly flexed inward at its anteriormost point.

The base is laterally compressed and distinctly arched posteriorly and convex anteriorly below the cusp, so as to impart a sinuous aboral outline. The basal cavity is shallow, conical, and longitudinally extensive. The apex of the excavation is a sharp tip situated directly below the posterior junction of the cusp and the base.

Remarks: Harris and Harris (1964, pp. 42, 43) established the subgenus *Neomultioistodus* and included the species *N. (Multioistodus) compressus* as its only species. The subgeneric division of *Multioistodus* is not used in this study; in my opinion, there is little biological or evolutionary evidence to substantiate such a subgrouping of the multidenticulate oistodids at our present state of knowledge.

The above authors (p. 43) refer to *Neomultioistodus* as a descendant of *Multioistodus* (subgenus, *sensu stricto* of Harris, 1964). As the representatives of the species of the nominate subgenus, *Multioistodus,* are from the Chazyan Dutchtown and Joins strata, it is difficult to establish *N. (M.) compressus* as a descendant of the former group. *N. (M.) compressus* was originally described (Harris and Harris, 1965) from the Canadian (Arbuckle) West Spring Creek Limestone, stratigraphically below the Joins (or the Dutchtown).

Multioistodus compressus differs from all other representatives of *Multioistodus* by its anteriorly directed anterolateral denticle. *M. compressus* resembles *M. lateralis* Cullison, from which it differs by possessing a posteriorly directed postero-basal denticle and an anteriorly and laterally directed anterior denticle; in *M. lateralis,* the anterior denticle is posteriorly and laterally directed.

Occurrence: Rare in lowest beds, rare in upper beds, absent elsewhere.

Repository: Figured hypotypes: USNM 146981; unfigured hypotypes: USNM 146982.

MULTIOISTODUS LATERALIS Cullison

Pl. 3, figs. 14-16

Multioistodus lateralis CULLISON, 1938, Jour. Paleontology, v. 12, pp. 222, 226, 227, pl. 29, fig. 14.

Multioistodus (Dirhadicodus) lateralis HARRIS, 1964, Oklahoma Geology Notes, v. 24, pp. 115, 116, pl. 1, figs. 3, 4.

Diagnosis: Unit consists of a recurved cusp joined to a posteriorly and laterally denticulated base.

Cusp is lanceolate, flattened and asymmetrical; basic cusp plan is acodid. Outer face is smoothly rounded and gently convex. Inner face is ornamented by a faint to prominent costa, anteriorly located, that extends from the distal tip to the basal lateral denticle. On some specimens the costa serves as a divide between a steeply sloped anterior facet and a gently sloped posterior facet. Proximally, the costa is continuous with the plate-like pointed minor accessory denticle which is characteristically laterally and slightly anteriorly or posteriorly directed. Anterior and posterior edges may be keeled or acostate, and are sharp.

Posterobasal denticle is variable in shape and expression: may be plate-like, lanceolate, sharp edged, and directed posteriorly and upward; or it may be biconvex, acicular, and directed posteriorly and hooked downward. In either case, the posterior denticle closely resembles the main cusp.

The cusp joins the base at an angle of

about 90° or less. As a general rule, the cusp and posterior denticle are not continuous. The base is low, thick, tubular, and, in some specimens, is continuous beyond the posterior denticle and is arched. In arched specimens, the base is extended anteriorly for a short distance as well as posteriorly, thereby imparting a distinct basal development unique in multioistodids.

The basal cavity is moderately deep and extends posteriorly as a shallowing groove. The apex of the excavation is located deep within the cusp, near the anterior edge.

Remarks: *Multioistodus lateralis* is best characterized by its medio-laterally directed accessory denticle arising from the lateral costa, a feature which sets it apart from *M. compressus* Harris and Harris, whose denticle arises from the anterior edge of the cusp and is anteriorly, laterally, and posteriorly directed. Both species bear a close resemblance to forms of *Ptiloconus* Sweet which, however, has the cusp and accessory denticles all oriented in a single plane.

Occurrence: Common to rare in most Joins samples, most abundant in lower beds, absent in middle strata.

Repository: Figured hypotypes: USNM 146983; unfigured hypotypes; USNM 146984.

MULTIOISTODUS SUBDENTATUS Cullison, 1938

Pl. 3, figs. 17, 18, 20, 25

Multioistodus subdentatus CULLISON, 1938, Jour. Paleontology, v. 12, p. 226, pl. 29, figs. 13a, b; CULLISON AND MEHL AND MCLAUGHLIN, *in* BRANSON, 1944, Missouri Univ. Studies, v. 19, p. 66, pl. 9, figs. 17-21; YOUNGQUIST AND CULLISON, 1946, Jour. Paleontology, v. 20, p. 586, pl. 89, figs. 12, 17, 18; pl. 90, figs. 2, 13.

Multioistodus (Multioistodus) subdentatus HARRIS, 1962, Oklahoma Geology Notes, v. 24, pp. 111, 112, pl. 1, figs. 1, 2.

Diagnosis: Unit consists of a large recurved major cusp, a smaller satellite postero-basal denticle, and an expanded basal portion.

The cusp is ellipsoidal to compressed in cross-section and has faint anterior and posterior keels which may be totally lacking in some specimens. The basic cusp plan is drepanodid to subscandodid; most commonly occurring type is the planar drepanodid scheme as represented in this study. The anterior margin of the cusp traces a line of curvature having a lesser radius than the inner cusp margin (posterior); both anterior and posterior margins meet distally at a sharp point. This feature lends a scimitar-like aspect to the cusp. As a general rule, the lateral faces of the blade are smooth, having no fine striae or carinae, and are equally biconvex. The posterior margin of the cusp joins the anterior (oral) margin of the single satellite basal denticle in a smooth drepanodid curve. At this juncture there is a slight channeling and the keel, when present, is most strongly developed. The postero-basal denticle is similar to the major cusp and ranges in general shape from blade-like to acicular; in some specimens, the denticle is hooked downward (aborally). The distal extremity of this denticle is sharply pointed; denticle is gently flexed inward as is inner lateral basal face.

The posterior (aboral) margin of the denticle meets the base in a smooth curve at an angle of approximately 90°. The base characteristically continues behind cusp for a short distance to aboral margin.

The inner lateral margin of the anterior portion of the base is sharply flexed inward in some specimens. Base of entire unit is smoothly continuous with inner lateral faces of major and minor denticles. The basal margin is gently convex downward. Basal cavity is deep, conical, and has the Phrygian cap aspect characteristic of drepanodids. Tip of cavity is sharp, anteriorly directed and very near the anterior margin; apex of cavity pointed orally, nearly perpendicular to long axis of base. A thin, straight line, corresponding to the growth axis, can be observed in transmitted light in some specimens to extend to tip of cusp near the posterior margin.

Remarks: *Multioistodus subdentatus* is characterized by its scandodid to drepanodid cusp plan, its single postero-basal minor denticle and its large recurved major cusp. The Joins specimens of this study contain representatives of *M. subdentatus* which vary greatly in the shape and size of the minor denticle. Most specimens possess acicular or flattened blade-like postero-basal structures; others have large trapezium-shaped minor denticles. Variants of the characteristic *M. subdentatus* figured in previous studies (Cullison, 1938; Youngquist and Cullison, 1946; Harris, 1962) are all present in the fauna forming the basis of this study.

Occurrence: Rare to common in most of Joins beds; lower Joins strata are locally abundant, middle Joins beds contain few or no specimens.

Repository: Figured hypotypes: USNM 146985; unfigured hypotypes: USNM 146986.

MULTIOISTODUS TRIDENS Cullison, 1938

Pl. 3, figs. 19, 24, 26

Multioistodus tridens CULLISON, 1938, Jour. Paleontology, v. 12, pp. 222, 226, 227, pl. 29, figs. 15a, b; YOUNGQUIST AND CULLISON, 1946, Jour. Paleontology, v. 20, p. 587, pl. 90, figs. 10, 11, 18.

Multioistodus (Trirhadicodus) tridens HARRIS, 1964, Oklahoma Geology Notes, v. 24, pp. 117, 118, pl. 1, figs. 5, 6.

Diagnosis: Unit is highly variable, consists characteristically of a large, laterally costate cusp, two symmetrically or asymmetrically arranged lateral denticles, and a posterior basal denticle.

Cusp is gently recurved and commonly is flattened; cusp is inwardly flexed in most specimens. Anterior and posterior edges are keeled and sharp edged; each lateral cusp face bears a strong costa leading from distal tip to lateral denticles. In some Joins specimens, the outer lateral costa is divided by a longitudinal furrow. Basic cusp plan varies from distacodid in older specimens to acontiodid in stratigraphically higher individuals. Costae in specimens representing the latter group are situated very close to the posterior margin and have deep posterior grooves. Lateral denticles arise from the basal continuation of lateral costa; in distacodid specimens, the lateral denticles are relatively symmetrical and extend laterally and gently sweep posteriorly. Acontiodid specimens generally have asymmetrically placed lateral denticles which are strongly swept backward and extend laterally and upward. A third type that is similar to the more common distacodid asymmetrical plan but has a rounded anterior face instead of a sharp edge occurs in lower beds.

Lateral denticles are either curved or straight, rounded or flattened, but are similar with respect to each other on an individual specimen.

Postero-basal denticle is straight and laterally compressed. Most specimens have large plate-like posterior denticles with wide bases. These postero-basal features are steeply inclined posteriorly and are wider than the widest portion of either lateral denticle or main cusp.

Basal cavity flares laterally; moderately deep, triangular in outline and anteriorly directed.

Remarks: Multioistodus tridens Cullison is a highly variable species; at least three distinct types fall into the species originally defined by Cullison. The recent attempt (Harris, 1964) to place *M. tridens* as the nominal species of the subgenus *Trirhadiocodus* is not followed here. Unquestionably, the distacodid, subdrepanodid, and acontiodid architectural schemes reflected in Joins representatives of *M. tridens* present a confusing array of variation within a single specific group. Until more can be learned concerning the interrelationships among the symmetry, architectural morphology, and denticle contours of each subgroup, the name *M. tridens* should continue to be applied to simple forms consisting of a main cusp, a postero-basal and two laterally opposed denticles.

Occurrence: Distacodid group common in lower and middle Joins beds; acontiodids common in upper strata.

Repository: Figured hypotypes: 146987; unfigured hypotypes: USNM 146988.

Genus OISTODUS Pander, 1856

Type species: *O. lanceolatus* Pander, 1856

OISTODUS ABUNDANS Branson and Mehl, 1933

Pl. 3, figs. 21-23, 29

Oistodus abundans BRANSON AND MEHL, 1933, Missouri Univ. Studies, v. 8, p. 109, pl. 9, figs. 11, 17; STAUFFER, 1935a, Geol. Soc. Amer. Bull., v. 46, pp. 146, 159, pl. 12, fig. 22; STAUFFER, 1935b, Jour. Paleontolgy, v. 9, p. 609, pl. 75, figs. 2, 7, 11-13; LOOMIS, 1936, Jour. Paleontology, v. 10, p. 664; STAUFFER, 1940, Jour. Paleontology, v. 14, p. 426, pl. 60, fig. 20; BRANSON AND MEHL, 1943, Jour. Paleontology, v. 17, pp. 376, 386, pl. 64, fig. 11; BRANSON, 1944, Missouri Univ. Studies, v. 19, pp. 79, 80, pl. 11, figs. 26, 38; SANNEMANN, 1955, Neues Jahrb. Geol. Paläont. Abh., Bd. 102, pp. 4, 28, pl. 2, fig. 8; GLENISTER, 1957, Jour. Paleontology, v. 31, p. 725, pl. 86, fig. 5; ETHINGTON, 1959, Jour. Paleontology, v. 33, p. 282, pl. 39, fig. 21; PULSE AND SWEET, 1960, Jour. Paleontology, v. 34, pp. 254, 255, pl. 35; figs. 1, 8.

?Oistodus abundans GRAVES AND ELLISON, 1941, Missouri Univ. School Mines and Metallurgy, Bull., Tech. Ser., v. 14, pp. 4, 7, 14, pl. 2, figs. 19, 20.

non *Oistodus abundans* RHODES, 1953, Philos. Trans. Roy. Soc. London, Ser. B, no. 647, p. 294, pl. 21, figs. 91, 92.

nec *Oistodus abundans* SWEET, TURCO, WARNER, AND WILKIE, 1959, Jour. Paleontology, v. 33, p. 1052, pl. 130, fig. 3.

Remarks: Oistodus abundans is characterized by its flange-like blade, its arched base, its pointed anterior and posterior basal extremities and its anterior prong. The specimen figured by Sweet, *et al.* (1959, *op. cit.*) is here excluded from *O. abundans,* because it lacks the pronounced anterior prong and is a fragmentary specimen whose actual assignment is difficult to determine in any case.

Oistodus abundans is one of the most common and abundant forms found in Joins rocks along with representatives of *O. inclinatus* Branson and Mehl.

Occurrence: Common to abundant in all Joins beds. Not restricted to any zone.

Repository: Figured hypotypes: USNM 146989; unfigured hypotypes: USNM 146990.

OISTODUS CONTRACTUS Lindström

Pl. 3, figs. 27, 28

Oistodus contractus LINDSTRÖM, 1955, Geol. Fören. Förhandl., Bd. 76, p. 573, pl. 4, figs. 45, 46, text-fig. 3H.

Oistodus angulensis HARRIS, 1962, Oklahoma Geology Notes, v. 22, no. 8, pp. 199-201, pl. 1, figs. 1a-c.

Diagnosis: Unit consists of a simple unequally biconvex cusp, sharply reclined on a short, straight base.

The cusp is flattened, laterally flexed, and unequally biconvex. Anterior and posterior margins are keeled and sharp edged. A broad, rounded carina is present on the inner lateral face. Anterior edge of cusp is nearly straight, meets antero-basal margin at a bluntly pointed corner. Entire anterior keeled portion of blade is thin, as is posterior distal portion. Posterior margin is gently curved, meets base at a sharp angle; in some specimens the posterior keel is developed across the cusp-base junction as a membranous flange.

The oral edge of the base is short, straight, or slightly convex. Posterior aboral margin of the base is subparallel to the proximal portion of the anterobasal margin. The aboral anterior margin is squared off and forms a nearly right angle with anterior cusp margin, imparting a rectangular basal outline. The basal cavity is shallow to moderately deep and wide, flares posteriorly and postero-laterally; cavity does not extend to anterior extremity.

Remarks: Oistodus contractus is characterized by the short oral edge of its base and the distinctive rectangular aboral outline. The present study represents the first complete specimens to be figured. The types of *O. angulensis* were examined and were found to be identical to those from the present study.

Occurrence: Common in middle and upper Joins strata, rare or lacking in lowest beds.

Repository: Figured hypotypes: USNM 146991; unfigured hypotypes: USNM 146992.

OISTODUS FORCEPS Lindström

Pl. 3, figs. 30, 33

Oistodus forceps LINDSTRÖM, 1955, Geol. Fören. Förhandl., Bd. 76, p. 574, pl. 4, figs. 9-13; LINDSTRÖM, 1957, Geol. Fören. Förhandl., Bd. 79, p. 174; BARNETT, 1965, Micropaleontology, v. 11, p. 71, pl. 1, fig. 7.

Oistodus forceps? SWEET AND BERGSTRÖM, 1962, Jour. Paleontology, v. 36, p. 1231, pl. 168, figs. 14, 15; text-figs. 2D, E.

Diagnosis: Unit consists of a simple broadly carinate cusp sharply reclined on a long, flattened base.

Cusp is long, laterally compressed and sharp edged. Cusp is unequally biconvex, possesses broad lateral carinae, the inner carina more pronounced; distal end of cusp is flexed inward slightly. Anterior margin of blade is straight to gently curved; posterior margin is slightly sinuous, joins base at a sharp angle of about 30°.

Basal margin is slightly to moderately convex; the antero-basal margin is commonly upturned. Basal excavation is shallow, extends the length of the base; as seen in lateral view, the anteriorly directed sharp tip of the cavity is situated subcentrally and just anterior to the cusp-base junction.

Remarks: Oistodus forceps differs from morphologically similar *O. excelsus* Stauffer and *O. venustus* Stauffer by possessing an unequal cusp and base and a straight, untwisted, anterior edge.

Occurrence: Rare to common in lower Joins beds, sparse or lacking in upper strata.

Repository: Figured hypotypes: USNM 146993; unfigured hypotypes: USNM 146994.

OISTODUS LINGUATUS Lindström, 1955

Pl. 3, fig. 36

Oistodus linguatus LINDSTRÖM, 1955, Geol. Fören. Förhandl., Bd. 76, pp. 577, 578, pl. 3, figs. 39-41.

Oistodus bilongatus HARRIS, 1962, Oklahoma Geology Notes, v. 22, no. 8, pp. 201, 202, pl. 1, figs. 8, 9, 10.

Diagnosis: Unit consists of a simple, reclined, unequally biconvex cusp and a strongly arched base having anterior and posterior bar extensions. Cusp is compressed, elongate and flexed inward, inner face bears a thick, broadly rounded carina. Blade is strongly keeled anteriorly and posteriorly by sharp flanges. Proximal portions of keels developed into thin, wide fringes.

Anterior margin of cusp joins base in a downward projecting blunt curve. Posterior margin joins posterior oral edge of base sharply at an angle of about 60°.

Base strongly arched, continuous posteriorly as a thick, compressed bar-like process, terminating in a blunt, squared-off postero-basal portion. Oral edge of posterior bar keeled at angular junction of bar and cusp. Anterior portion of base developed into an incipient anterior bar, approximately one-half as long as the posterior process. Basal margin follows a smoothly curved line of arching; margin is slightly sinuous at widest portion of basal cavity. Basal cavity is a shallow, laterally flaring conical opening, flares slightly more toward the inner side. Excavation continues as aboral grooves or slots for short distances anteriorly and posteriorly. Outline of basal cavity is crudely triangular in lateral view; the sharp apical tip of the cavity is slightly pointed in the anterior direction.

Remarks: *Oistodus linguatus* is an easily recognized species in the Joins fauna. Its characteristic tongue-like posterior process and arched base serve to distinguish it from all other species of *Oistodus*. Sweet (1963, p. 505) called attention to the difficulty in distinguishing *O. bilongatus* Harris, 1962, from *O. linguatus*. Harris kindly sent me the Joins types of *O. bilongatus* which do not differ significantly from *O. linguatus* in my opinion. The representatives of *O. linguatus* from the present study were compared directly with Harris' types. I do not subscribe to the opinion expressed by Harris (1962, p. 202) that the cusp of *O. bilongatus* does not possess a carinate inner face *(sensu lato)* as does typical *O. linguatus*. The Joins specimens of *O. linguatus* are complete, whereas the Swedish types are invariably broken. The anterior basal expansion of the representatives of *O. linguatus* from the Joins of Harris and those studied here do differ from the Swedish types in being more pronounced; moreover, some Joins specimens show definite indication of incipient prioniodinid-like microdenticulation in both anterior and posterior basal extensions. These differences do not, however, warrant assignment to separate specific categories in my opinion.

Occurrence: Rare in Joins strata, absent from most beds.

Repository: Figured hypotype: USNM 146995; unfigured hypotypes: USNM 146996.

OISTODUS LONGIRAMIS Lindström

Pl. 3, fig. 32

Oistodus longiramis LINDSTRÖM, 1955, Geol. Fören. Förhandl., Bd. 76, p. 579 pl. 4, figs. 35-37; LINDSTRÖM, 1957, Geol. Fören. Förhandl., Bd. 79, p. 164; LAMONT AND LINDSTRÖM, 1957, Edinburgh Geol. Soc. Trans., v. 17, p. 62; LINDSTRÖM, 1960, Int. Geol. Cong., 21st Sess. Rept., pt. 7, p. 90; ETHINGTON AND CLARK, 1964, Jour. Paleontology, v. 38, pp. 693, 694, pl. 114, figs. 2, 7.

Remarks: The Joins specimens are somewhat variable in form of base-cusp angle and carinal development. The forms described by Ethington and Clark (1964, *loc. cit.*) were also noted by the latter workers to be more variable than the original Swedish specimens. These variations, however, are minor and in all other respects the Joins representatives compare favorably with the type illustrations.

Oistodus longiramis is here found with *O. linguatus* Lindström, as was the case in the original study of both species. The close similarity in morphology (with the single exception of the extreme proportions of the posterior arched bar characterizing *O. longiramis*) suggests that the two species are simply divergent variations of a single subgeneric unit. Indeed, specimens of *O. longiramis* which have significantly broken bases cannot be distinguished from *O. linguatus*. For practical purposes, such damaged specimens, not easily referred to either species, have been assigned to *O. linguatus*. Unless a common species for specimens currently assigned to *O. linguatus* or *O. longiramis* is established, the disposition of incomplete forms will be in doubt. The combination of these two species is not made herein, because too little is yet known about the stratigraphic occurrence of either species with respect to the other. For example, Ethington and Clark (1964, *op. cit.*) found *O. longiramis* but not *O. linguatus* in the El Paso Formation of the Franklin Mountains in Texas. It is possible that a combination of the two species at this state of our knowledge might obscure the stratigraphic usefulness of one or the other. Detailed study and comparisons of the type specimens of both species would be only a beginning of the approach to the solution of this problem, the true answer to which lies in the future discovery of their geographic and stratigraphic distribution.

Occurrence: Rare, restricted to lower and middle Joins beds.

Repository: Figured hypotype: USNM 146997; unfigured hypotypes: USNM 146998.

OISTODUS MULTICORRUGATUS Harris

Pl. 3, figs. 31, 34, 35; pl. 4, fig. 2

Oistodus multicorrugatus HARRIS, 1962, Oklahoma Geology Notes, v. 22, no. 8, p. 204, pl. 1, figs. 2a-c.

Diagnosis: Cusp inclined, asymmetrical, flattened, lenticular to subelliptical in cross-section. Blade has a wide anterior and posterior rim and sharp edges. Cusp tapers to a blunt point and joins base at an angle of 60° and may be flexed inward slightly. Blade is faintly costate in anterior portion, costae becoming more pronounced and numerous laterally and posteriorly. Costae are imbricated in the posterior direction; each costal ridge is separated from the next by a short, shallow, and parallel groove. Costae blend upward into blade at midlength.

Basal cavity conical, shallow; most specimens have basal cavity filled by a dense bony material. Cavity begins anteriorly as a point on the aboral surface that expands rapidly posteriorly and laterally, encroaching slightly onto the oral margin of the bar. Apex of cavity directed anteriorly.

Base thick, compressed laterally; thick aboral ridgelike flange or lip borders basal cavity. Base continues as thin flange posteriorly on most specimens.

Remarks: Some specimens from the lower Joins do not possess the long sigmoidal aboral basal margin mentioned in the original description of *Oistodus multicorrugatus.* The narrow channel bordering the aboral margin and extending anteriorly into the blade along the anterior margin (Harris, 1962, p. 204) is present on some specimens. The sinuous character of the basal margin and the presence or absence of the channel do not appear to be constant features of *O. multicorrugatus* and are unnecessary for identification. Rather, the robust, smoothly curved base and the large imbricate costae serve as most distinctive structures of this species.

Occurrence: Common in all but lower Joins strata.

Types: Figured homeotypes: USNM 146999; unfigured homeotypes: USNM 147000; unfigured topotypes: USNM 147001.

OISTODUS PSEUDOMULTICORRUGATUS Mound, n. sp.

Pl. 4, figs. 3-5, 8, 9; text-fig. 1H

Diagnosis: Unit consists of a large laterally compressed, distally twisted cusp tightly reclined on a wide, strongly convex base.

Cusp is sinuous, flattened, inwardly flexed, broadly carinate, sharp edged, and pointed. Anterior edge of cusp has a slight channel on the inner side; anterior margin is extremely sinuous, joins antero-basal margin at a blunt, rounded corner. Posterior margin essentially parallel to anterior, joins base in an extremely acute angle. Inner lateral cusp face ornamented by a flattened broad carina that extends through the entire cusp length.

Posterior basal extension is long, high, and keeled. The gap between the oral edge of the posterior keel and the posterior margin of the cusp is very slight. In some specimens the keel is so high as to approach the width of the cusp. Highest point of posterior keel is attained at posteriormost portion of basal extension; at this point, the keel is rounded smoothly and follows a curved contour to the blunt postero-basal margin.

The base is extremely convex, is produced as aborally as the cusp is high in some specimens. Aboral margin is bordered laterally by a shallow groove which extends onto the anterior margin and intersects the anterior edge of the lateral carina.

Basal cavity is deep, compressed, narrow, and extends through nearly the entire aboral surface. Lateral view of cavity reveals a gently arched convex posterior and a more steeply curved concave anterior outline. Apex of cavity is situated at approximate mid-cusp, well forward on the unit body.

Sharp tip of the cavity is anteriorly directed, is located at approximate level of cusp-base junction. Aboral view of cavity reveals a thickened lip bordering the excavation. All specimens contain a granular body material filling the basal cavity.

Dimensions of holotype: Maximum length: 1.3 mm; maximum length of base: 0.9 mm.

Remarks: Oistodus pseudomulticorrugatus exactly fits the description of *O. multicorrugatus* Harris, except that the new species lacks the series of several riblets which characterize the latter species. *O. pseudomulticorrugatus* is best characterized by its distally twisted cusp, its sinuous cusp margins, its high, thin posterior keel, its strongly convex aboral extremity, and its tightly reclined, broadly carinate cusp.

Occurrence: Rare in middle Joins strata, common to abundant in upper beds, absent in lower beds.

Repository: Holotype: USNM 147002; figured paratypes: USNM 147003, unfigured paratypes: USNM 147004.

Etymology: pseudo-, Gr., *pseudos:* lie, false; refers to the superficial resemblance between this species and true *Oistodus multicorrugatus.*

OISTODUS SCALENOCARINATUS
Mound, n. sp.

Pl. 4, figs. 6, 7, 10-12; text-fig. 1I

Diagnosis: Unit consists of a simple reclined biconvex cusp having a modified lateral carina and an aborally produced, posteriorly arched base; entire unit is a robust, moderately ornamented form.

The cusp is acuminate, unflexed, and sharp edged, without an anterior keel. The anterior margin of the cusp is broadly rounded and follows a smooth curve from the distal tip to the obtuse antero-basal angle. The posterior margin possesses a thin, narrow keel which forms a chord at the proximal arc segment formed by the keel margins and the posterior cusp margin; the keel terminates abruptly at the postero-basal portion of the cusp. This latter keel forms an extremely acute angle between itself and the wide flange-like keel of the base proper. Each of the lateral faces is ornamented by a single large carina; the anterior part of this carina is formed by a shallow vertical furrow which extends distally between convex portions of the cusp face for a short distance at a medio-anterior position. The posterior portion of the carina is expressed as a sharp ridge located directly anterior to the junction of cusp and base. The sharp edge thus formed blends aborally into the base as a rounded ridge but does not reach the aboral margin. Distally, the posterior edge of the carina disappears into the convex lateral contour of the cusp face.

The posterior portion of the base is strongly arched and is a thick, tubular bar that is triangular in cross-section and is orally channeled. A high, crest-like trapezoidal keel ornaments the oral edge of the bar from cusp junction along the postero-basal margin to the aboral edge.

The base anterior is narrowly channeled aborally; this channel extends posteriorly beneath a pronounced extension of the base that is strongly produced aborally. The channel terminates at a point halfway along the aboro-lateral surface of the posterior bar and is reinforced aborally by a low ridge (or lip) which parallels the aboral margin.

The aboro-basal outline is erismodid; anterior and posterior to the pronounced aboral projection, the outline is horizontal. Basal cavity is shallow and subpyramidal. Lateral view shows a triangular outline with an anteriorly directed apical tip located at approximately midcusp position. Anteriorly and posteriorly, the cavity continues as narrowing groove-like extensions. A basal filling of material similar to the substance of the conodont is present in most specimens.

Dimensions of holotype: Maximum length: 1.0 mm; maximum cusp width: 0.2 mm; length of base: 0.5 mm.

Remarks: Oistodus scalenocarinatus resembles *O. lanceolatus* Pander and *O. abundans* Branson and Mehl. The newly described species is characterized by its distinctive lateral carina; its arched posterior bar; its high, thin flange; its extremely sharp cusp-base angle; its channeled posterior; its aboral lip; its pronounced erismodid extension.

Oistodus scalenocarinatus most closely resembles *O. multicorrugatus* Harris, but differs from the latter in possessing only a single, broadly convex carina, whereas *O. multicorrugatus* has several well-developed parallel costae extending from aboral margin to the distal tip of the cusp. Moreover, *O. multicorrugatus* has an invariably flexed distal tip which reverses its curvature.

The posterior basal extension is arched much like *Oistodus abundans* Branson and Mehl and *O. linguatus* Lindström. The keel surmounting the oral margin of the basal posterior contains the "white matter" of Lindström (1964, p. 19): "Encroachment of white matter in specks on the fringes of the base can be taken as a tendency toward denticle formation". Many species in the Joins fauna which possess large keels, especially those with the keels in an oral position, contain this "white matter" which, together with its canaliculated clear spaces, are interpreted as indicating incipient microdenticulation.

Occurrence: Rare in middle Joins, essentially lacking in lower strata, locally common in upper beds.

Repository: Holotype: USNM 147005; figured paratypes: USNM 147006; unfigured paratypes: USNM 147007.

Etymology: scaleno-, Gr. *skalenos;* unequal, *carinatus,* L., *carinatus:* keeled; refers to the lateral carina which is unequally developed anteriorly and posteriorly.

Genus OZARKODINA Branson and Mehl, 1933

Type species: *O. typica* Branson and Mehl, 1933

OZARKODINA DELECTA Stauffer

Pl. 4, fig. 15

Ozarkodina delecta STAUFFER, 1935, Geol. Soc. America, Bull., v. 46, pp. 148, 149, pl. 10, fig. 40; GLENISTER, 1957, Jour. Paleontology, v. 31, p. 735, pl. 88, figs. 8, 9; ETHINGTON, 1959, Jour. Paleontology, v. 33, pp. 283, 284, pl. 41, fig. 17.

Prioniodina delecta SWEET, TURCO, WARNER, AND WILKIE, 1959, Jour. Paleontology, v. 33, p. 1060, pl. 131, fig. 11; PULSE AND SWEET, 1960, Jour. Paleontology, v. 34, pp. 258, 259, pl. 36, figs. 10, 11.

Remarks: The specimens assigned to *Ozarkodina delecta* from the present study of the Joins fauna agree favorably with the original figures and description and are remarkably similar to the form illustrated by Ethington from the Galena Formation. The Maquoketa form of Glenister's *(op. cit.)* is slightly different from the Joins forms, because the former has a denticulated anterior limb, developed to a greater degree.

Occurrence: Rare, in lowest and upper middle Joins strata.

Repository: Figured hypotype: USNM 147008; unfigured hypotypes: USNM 147009.

Genus PALTODUS Pander, 1856

Type species: *P. subaequalis* Pander, 1856

PALTODUS VARIABILIS Furnish

Pl. 4, figs. 13, 14

Paltodus variabilis FURNISH, 1938, Jour. Paleontology, v. 12, p. 331, pl. 42, figs. 9, 10; GRAVES AND ELLISON, 1941, Missouri School Mines and Metallurgy, Bull., Tech. Ser., v. 7, p. 57, pl. 2, fig. 17.

non *Paltodus variabilis* SERGEEVA, 1963, Paleont. Zhurn., no. 2, pp. 99, 100, pl. 7, 7, figs. 10-12, text-fig. 5.

Paltodus volchovensis SERGEEVA, 1963, Paleont. Zhurn., no. 2, pp. 100-102, pl. 7, figs. 13, 14, text-fig. 6.

Diagnosis: Unit consists of a simple drepanodid to subscandodid multicostate cusp and a posteriorly flaring convex base. Cusp is erect to recurved, asymmetrical and flexed slightly inward. Outer side of cusp face is smoothly convex and may have a faint costa near the anterior margin. Inner lateral face commonly has two prominent costae which extend along entire length of unit.

Base is convex, flared posteriorly and rounded anteriorly. Basal excavation conical, shallow to moderately deep, triangular in lateral view. Apex of cavity is sharp and anteriorly directed.

Remarks: This species is highly variable, both in distribution and prominence of costae and in the degree of curvature of the cusp. *Paltodus bassleri* Furnish, a close relative of *P. variabilis,* supposedly differs in being more flexed. This latter distinction may actually be infraspecific.

Occurrence: Rare in middle and upper Joins beds.

Repository: Figured hypotypes: USNM 147010; unfigured hypotypes: USNM 147011.

Genus PANDERODUS Ethington, 1959

Type species: *Paltodus unicostatus* Branson and Mehl, 1933

PANDERODUS PANDERI (Stauffer)

Pl. 4, fig. 1

Paltodus panderi STAUFFER, 1940, Jour. Paleontology, v. 14, p. 427, pl. 60, figs. 8, 9, GLENISTER, 1957, Jour. Paleontology, v. 31, pp. 728, 729, pl. 85, figs. 8, 9.

Panderodus panderi ETHINGTON, 1959, Jour. Paleontology, v. 33, p. 285, pl. 39, fig. 5.

Remarks: The Joins representatives of *Panderodus panderi* are more compressed than the figured types.

Occurrence: Sparse, restricted to lowest Joins beds.

Repository: Figured hypotype: USNM 147012; unfigured hypotypes: USNM 147013.

Genus POLYCAULODUS Branson and Mehl, 1933

Type species: *P. inclinatus* Branson and Mehl, 1933

POLYCAULODUS REVERSUS Sweet

Pl. 4, fig. 16

Polycaulodus reversus SWEET, 1955, Jour. Paleontology, v. 29, p. 251, pl. 28, fig. 26.

Remarks: Polycaulodus reversus is a minor element of the Joins conodont fauna, but is distinctive where found. The reversal of the denticle inclination direction along the bar curvature distinguishes *P. reversus* from other species of *Polycaulodus.*

Occurrence: Figured hypotype: USNM 147014; unfigured hypotypes: USNM 147015.

Genus PRAVOGNATHUS Stauffer, 1936

Type species: *Heterognathus idoneus* Stauffer, 1935

PRAVOGNATHUS IDONEUS (Stauffer)

Pl. 4, fig. 23

Heterognathus idoneus STAUFFER, 1935, Jour. Paleontology, v. 9, p. 607, pl. 72, figs. 9, 14, 15, 18, 20, 26, 29, 32; GRAVES AND ELLISON, 1941, Missouri School Mines and Metallurgy, Bull., Tech. Ser., v. 14, pp. 4, 7, pl. 1, figs. 5, 9.

Pravognathus idoneus STAUFFER, 1936, Jour. Paleontology, v. 10, p. 79.

Diagnosis: Unit consists of a series of laterally compressed, slender denticles borne on a thin bar-like process.

Bar is indistinctly divided into an anterior and a posterior limb. A pair of slender, laterally compressed, subequal denticles, the longest on the bar, approximate the demarcation of limbs; these denticles are located directly above the widest expansion of the basal cavity. Anterior limb shortest, possesses several flattened, lanceolate denticles that are confluent at base. Anteriormost denticle is a scalene triangle whose longest side is continuous with the bluntly pointed antero-basal margin. Posterior limb possesses two series of denticles; a row of subequal, long, thin teeth and a row of scalene triangular denticles, unequal in size, rapidly decreasing in height to the tapered posterior extension of the bar.

Bar slightly arched, sinuous, bowed, thin, and tapering to each extremity. A thickened ridge is located at the level of denticle insertion and parallels a second ridge or lip bordering the basal excavation. Basal excavation is a long, shallow groove that extends anteriorly and posteriorly to bar extremities. Anterior to the center of the bar, the basal excavation is inflated and expands laterally and slightly aborally.

Remarks: Pravognathus idoneus is characterized by its thin tapering bar and its two series of long, sharp, and shorter scalene denticles. The sinuous, arched and bowed base also serves to distinguish *P. idoneus* from its congeners.

Ethington (1959, p. 285) considered *Pravognathus* to be synonymous with fragments of *Phragmodus* Branson and Mehl. Until more is known about this problem, material such as that recovered from the Joins is best assigned to Stauffer's concept of *Pravognathus idoneus.*

Occurrence: Rare in lower Joins beds.

Repository: Figured hypotype: USNM 147016; unfigured hypotypes: USNM 147017.

Genus PRIONIODUS Pander, 1856

Type species: *P. elegans* Pander, 1856

PRIONIODUS EVAE Lindström

Pl. 4, figs. 17, 18

Prioniodus evae LINDSTRÖM, 1955, Geol. Fören. Förhandl., Bd. 76, pp. 589, 590, pl. 6, figs. 4-10.

Diagnosis: Unit consists of a large, straight to slightly recurved cusp and an anterior, a posterior, and a lateral process, all denticulated.

The cusp is flexed inward, unequally biconvex, flattened and sharp edged; each of two antero-lateral carinae is located on the lateral faces of the cusp. The inner lateral carina is thicker, sharper, and more pronounced than the outer ridge. The cusp also bears two keels forming the anterior and posterior edges. These keels are narrow near the distal tip and become progressively wider and more fringe-like in a proximal direction. The anterior keel continues as a denticulated portion of the downwardly directed anterior process (anticusp). The anterior process thus formed is minutely ornamented with short inclined denticles and is continuous below the base with respect to the direction and dimension of the cusp. Antero-basal margin of the anterior process is a smooth curve which is truncated by the aboral basal margin.

The posterior process is thick, tubular, and is twisted outward. The posterior portion of the cusp keel is continuous with the oral edge of the postero-basal keel of the posterior process. The cusp is joined to the posterior bar at a sharp angle of slightly less than 80°. The posterior process is nearly as long as the main cusp and is minutely denticulated with subequal stubby square teeth. These denticles are increasingly inclined in the posterior direction; the posteriormost denticles continue around the postero-basal margin of the process where the terminal denticle is oriented in a nearly perpendicular direction with respect to the main cusp.

The lateral process is broken or missing on most Joins specimens; this bar is the shortest of the three and is directed anteriorly and nearly perpendicular to the main plane of orientation in which lies the major portion of the conodont. Minute denticles are indicated on the oral surface of the lateral process.

The basal cavity is of medium depth; the greatest excavation is in the area where the processes converge aborally below the cusp. The cavity flares strongly inward and continues into each of the process extremities as deep, wide grooves, with the exception of the anterior process, whose excavation is restricted to a shallow, narrow slit. The posterior excavation is greater, and is more laterally expanded.

Remarks: Prioniodus evae is characterized by its antero-lateral cusp carinae, cyrtoniodid posterior process, minutely denticulated processes and pick-shaped main portion. The Joins specimens closely resemble the conodonts originally figured by Lindström (1955, *op. cit.*), especially plate 6, figure 7. Lindström's specimens possess posterior processes which are twisted in an inner direction; the Joins representatives twist to the outer side. As in typical *P. evae,* the specimens here studied have ornamental features which

are best developed on the inner surfaces of the unit.

Occurrence: Rare in lower and upper Joins strata, absent in middle beds.

Repository: Figured hypotypes: USNM 147018; unfigured hypotypes: USNM 147019.

Genus PTILONCODUS Harris, 1962

Type species: *P. simplex* Harris, 1962

PTILONCODUS SIMPLEX Harris

Pl. 4, fig. 20

Ptiloncodus simplex HARRIS, 1962, Oklahoma Geology Notes, v. 22, no. 8, p. 207, pl. 1, figs. 5a-c, 6.

Diagnosis: Unit consists of a simple hook-shaped shaft having a proximally expanded base.

The hook-shaped shaft is subcylindrical, translucent to transparent, distally pointed and lacks ornamentation. Basal portion of the shaft is laterally flattened and is the thickest part of the unit. Base does not possess any cavity or signs of attachment such as aboral depressions or grooves.

Remarks: Ptiloncodus simplex has been challenged by Sweet (1963, pp. 505, 506) and Lindström (*Ptilonchodus* [sic], 1964, p. 175) as not being representative of a true conodont. Sweet *(loc. cit.)* has suggested the probable affinity of these forms to the holothurians. The material composing *Ptiloncodus* is similar in appearance and substance to many of the Joins conodonts; moreover, *P. simplex* is a consistent, though minor, element of the entire Joins fauna. Little more can be said to validate its affinity to the conodonts in view of the lack of an observable surface of attachment.

Petrographic examination of a homeotype specimen of *Ptiloncodus simplex* revealed two important facts:

1) The body is definitely composed of numerous crystals (rather than a single crystal) and is fibrous in structure.

2) The mineralogical composition is most definitely apatitic.

In view of this and other petrographically revealed features, the suggestion that *Ptiloncodus simplex* is a holothurian sclerite is untenable; because sclerites from these echinoterms are unit crystal structures and are not apatitic. Conodonts, however, consist of numerous crystals of apatite, either lamellar or fibrous in structure. Therefore, the assignment of *P. simplex* to the conodonts certainly is warranted.

Occurrence: Rare in middle and upper Joins strata, sparse or lacking in lower beds.

Repository: Figured homeotype: USNM 147020; unfigured homeotype: USNM 147021; unfigured topotypes: USNM 147037.

Genus RHIPIDOGNATHUS Branson, Mehl, and Branson, 1951

Type species: *R. symmetrica* Branson, Mehl, and Branson, 1951

RHIPIDOGNATHUS? aff. R. CURVATA Branson, Mehl, and Branson, 1951

Rhipidognathus curvata BRANSON, MEHL, AND BRANSON, 1951, Jour. Paleontology, v. 25, pp. 10, 11, pl. 3, figs. 1-7.

Remarks: Most of the Joins representatives bear a close resemblance to the type figures of *Rhipidognatus curvata* but the Joins forms are more asymmetrical and bear shorter denticles similar to some species of *Leptochirognathus* Branson and Mehl.

Occurrence: Rare, restricted to lowest Joins beds.

Repository: Unfigured hypotypes: USNM 147022.

Genus SCANDODUS Lindström, 1955

Type species: *S. furnishi* Lindström, 1955

SCANDODUS SINUOSUS Mound, n. sp.

Pl. 4, figs. 21, 22, 24; text-fig. 1J

Diagnosis: Cusp erect to recurved, acostate, unequally biconvex, slightly twisted. Well defined anterior and posterior keels are present; anterior keel swings over laterally onto inner antero-lateral margin directly above base and continues in this orientation throughout the cusp length. Antero-basal margin of cusp is produced into a characteristically anteriorly projecting nose. Inner lateral face of cusp is bordered by two shallow sulci which parallel both anterior and posterior keels. Outer lateral face has an unbroken semicircular cross-section and has the greater radius of curvature.

Posterior margin of cusp joins base in a sharp curve. Base strongly flared inward; does not flare at all on outer face; base is continued posteriorly for a short distance behind cusp. A conical basal cavity opens on inner lateral side of aboral surface. Outer aboral margin of basal cavity is smoothly convex downward. Inner aboral margin is sinuous, having a concave downward medial portion where the base flares

inward to its greatest degree. Basal cavity drepanodid in lateral view; cavity is shallow with a sharp tip directed anteriorly.

Dimensions of holotype: Maximum length: 1.2 mm; length of base: 0.35 mm.

Remarks: Scandodus sinuosus is best characterized by its sinuous inner basal margin and its distinctive drepanodid shape. The cusp curvature of *S. sinuosus* is more gently recurved than in other described species of *Scandodus*. The cusp morphology is strikingly similar to that of representative specimens of *Drepanodus homocurvatus* Lindström from which species *S. sinuosus* differs in possessing a flared basal cavity.

Occurrence: Common to rare in lower Joins strata, abundant in middle beds (100-160 ft above base), and rare to abundant in upper beds.

Repository: Holotype: USNM 147023; figured paratypes: USNM 147024; unfigured paratypes: USNM 147025.

Etymology: sinuosus, L. *sinuosus:* full of bendings, sinuous; refers to the sinuous nature of the aboral inner lateral basal margin.

Genus SCOLOPODUS Pander, 1856

Type species: *S. sublaevis* Pander, 1856

SCOLOPODUS FILOSUS Ethington and Clark

Pl. 4, figs, 27, 32

Scolopodus filosus ETHINGTON AND CLARK, 1964, Jour. Paleontology, v. 38, p. 699, pl. 114, figs. 12, 17-19, text-fig. 2E.

Remarks: Scolopodus filosus is readily distinguished by its characteristic numerous thread-like striae which extend from base to distal tip of the cusp. The generalized cross-section of the cusp is a geometrical limacon; the indentation is formed by the longitudinal posterior groove.

Occurrence: Rare in lower and middle Joins beds.

Repository: Figured hypotypes: USNM 147026; unfigured hypotypes: USNM 147027.

SCOLOPODUS QUADRAPLICATUS Branson and Mehl

Pl. 4, figs. 26, 30

Scolopodus quadraplicatus BRANSON AND MEHL, 1933, Missouri Univ. Studies, v. 8, pp. 62, 63, pl. 4, figs. 14, 15; FURNISH, 1928, Jour. Paleontology, v. 12, p. 332, pl. 41, figs. 1-12; GRAVES AND ELLISON, 1941, Missouri School Mines and Metallurgy, Bull., Tech. Ser., v. 14, pp. 6, 7, pl. 1, fig. 10; pl. 3, figs. 2, 5; ETHINGTON AND CLARK, 1964, Jour. Paleontology, v. 38, pp. 699, 700, pl. 115, figs. 12, 25.

Remarks: Joins specimens are more variable in cusp curvature and degree of compression than those of the original study. In all other respects of form and position of the cusp and costae, the Joins representatives are identical with previously described forms.

Occurrence: Common to rare in lower and middle Joins beds, absent in most upper strata.

Repository: Figured hypotypes: USNM 147028; unfigured hypotypes: USNM 147029.

Genus TETRAPRIONIODUS Lindström, 1955

Type species: *T. robustus* Lindström, 1955

TETRAPRIONIODUS COSTATUS Mound, n. sp.

Pl. 4, figs. 19, 25, 31; text-fig. 1K

Diagnosis: Entire unit twisted, compound; consists of a large main costate cusp and four denticulated processes.

Cusp is long, flexed inward, sharp edged, and keeled to varying degrees. Anterior margin is faintly keeled, posterior margin more strongly so; posterior keel varies from expression as a narrow fringe to a broad crest-like flange that is continuous with the denticulation of the posterior process. The outer lateral face is ornamented by a pair of pronounced costae separated by a deep furrow that extends from the level of the brow at the base junction to the distal cusp tip. The more anterior lateral costa migrates from an anterior position at the distal portion onto the antero-lateral portion of the proximal area of the cusp, where it continues laterally as a buttressed face of the outer lateral process. The posterior lateral costa maintains a medio-lateral position for its entire length, passing laterally and aborally into the denticulated portion of the outer lateral process. The inner lateral costa of the cusp is central in position, as in the aforementioned outer lateral ridge, and passes laterally and aborally into the denticulated portion of the inner lateral process extension. The anteriormost of the five costae ornamenting the cusp passes from an inner lateral position on the distal portion to an anterior posture. The aboral portion of this latter costa is produced anteriorly and downwardly into a plate-like process that is incipiently denticulated and serrated.

Inner and outer lateral processes are nearly laterally symmetrical to one another as regards their length, direction, and denticulation. Approximately six to eight discrete, sharp-pointed, lanceolate, distally inclined denticles are borne on the thick, tu-

bular lateral processes. These lateral processes are nearly one-half as long as the cusps; they are swept back posteriorly for approximately half their respective lengths and then swing forward, imparting a definite alate appearance to the conodont.

The posterior process is the longest of the four; it begins at the nearly perpendicular cusp-base junction and is posteriorly expressed as a straight, tubular bar that bears eight or more laterally compressed posteriorly inclined lanceolate denticles.

The basal sheath is thin, forms a sparingly membranous connection between individual processes. The base is formed by the common junction of processes and cusp. Basal cavity is large, deep, and subpyramidal; excavation extends as narrow grooves into each of the processes. The posterior slope of the basal cavity is gentle, anterior slope steep, as seen in lateral view. Anteriorly directed sharp tip of cavity is located near the antero-lateral face on the outer side. Excavation is filled with an aborally projecting granular mass of bony material.

Dimensions of holotype: Maximum length: 0.8 mm; length of cusp: 0.5 mm; length of lateral processes: 0.3 mm, 0.25 mm; length of posterior process: 0.35 mm.

Remarks: The side toward which the cusp is flexed is arbitrarily chosen herein as the inner side of *Tetraprioniodus costatus.*

There is a distinct difference in denticle development between the anterior abbreviated process and the well developed lateral and posterior bars. In the case of the anterior process, denticulation is indistinct or, at best, incipient; whereas in both lateral and posterior processes, denticulation consists of well-defined lanceolate teeth.

Tetraprioniodus costatus closely resembles figures of *T. robustus* Lindström from the Swedish Lower Ordovician. The better developed denticulated processes and laterally bicostate cusp of *T. costatus* serve to make the two species readily distinguishable.

Occurrence: Rare in upper and upper middle Joins strata, absent in most lower beds.

Repository: Holotype: USNM 147030; figured paratypes: USNM 147031; unfigured paratypes: USNM 147032.

Etymology: costatus, L. *costatus:* ribbed; refers to the unusually costate cusp characteristic of this species.

TETRAPRIONIODUS ROBUSTUS? Lindström

Pl. 4, figs. 28, 29, 33

Tetraprioniodus robustus LINDSTRÖM, 1955, Geol. Fören. Förhandl., Bd. 76, p. 597, pl. 6, figs. 13-15.

Diagnosis: Unit consists of a large costate cusp and four incipiently denticulated processes. Entire unit is twisted slightly and flexed inward.

The main cusp is erect to recurved, slender, flattened, and bears four prominent costae. Anterior and posterior cusp edges are sharp and continue proximally and aborally as anterior and posterior processes, respectively.

Each of two lateral costae ornament the medio-posterior portions of the cusp faces. The unit is distinctly acontiodid in distal cusp morphology, departing from this structure into a compound prioniodid element at the level of the base. Keels are thin and narrow and span cusp-basal junctions.

Anterior process is short and virtually lacks denticles. Aboral continuation of the latter process is short and plate-like and is characteristically inwardly deflected. Posterior process is long, nearly straight or convex, and bears a very indistinct oral edge having minute irregular serrations and no discreet denticles. Each of two short lateral processes continues aborally and laterally downward as a posteriorly directed incipiently denticulated bar. As in the posterior process, the oral edges of the two lateral processes are minutely and irregularly serrated.

The basal cavity is shallow and extends as grooves into the processes. An anteriorly directed tip marks the apical position of the excavation deep within the anterior portion of the main cusp.

Remarks: This species is tentatively assigned to *Tetraprioniodus robustus* due to the lack of a definitely denticulated posterior process. Pulse and Sweet (1960, p. 260), in discussing the infraspecific level of the feature of degree of denticulation and its role in subgeneric differentiation, suggested that denticulation may be as variable in *Tetraprioniodus* as in other genera and questioned the reliability of minor variations as specific parameters. *T. robustus* was based on a single specimen from the lower *Planilimbata* Limestone of Latorp, south-central Sweden. Reference has not been made heretofore to this species; it may well be that the spectrum of variations possible within the species, *T. robustus,* cannot be extrapolated from the single representative illustration. Hence, the well-defined, erect and discrete denticles of typical *T. robustus* and the presence of incipient denticulation on some or all processes of *T. robustus* as here represented appear to fall within the expectable range of variation of the species. *T. robustus,* lacking the lanceolate denticles and the thick, tubular processes characteristic of *T. costatus,*

n. sp., is a clearly distinctive entity within the Joins.

Occurrence: Rare to common in upper and middle Joins strata.

Repository: Figured hypotypes: USNM 147033; unfigured hypotypes: USNM 147034.

Genus TRICLADIODUS Mound, 1965

Type species: *T. clypeus* Mound, 1965

TRICLADIODUS CLYPEUS Mound

Tricladiodus clypeus MOUND, 1965, Proc. Biol. Soc. Washington, v. 78, no. 24, p. 199, 200, figs. 3-11.

Occurrence: Rare in lower Joins strata; restricted to lower 40 ft.

Repository: Holotype: USNM 146271; paratypes: USNM 146272, 146273, 146274.

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Explanation of Plate 1

All photographs are unretouched figures of coated specimens.

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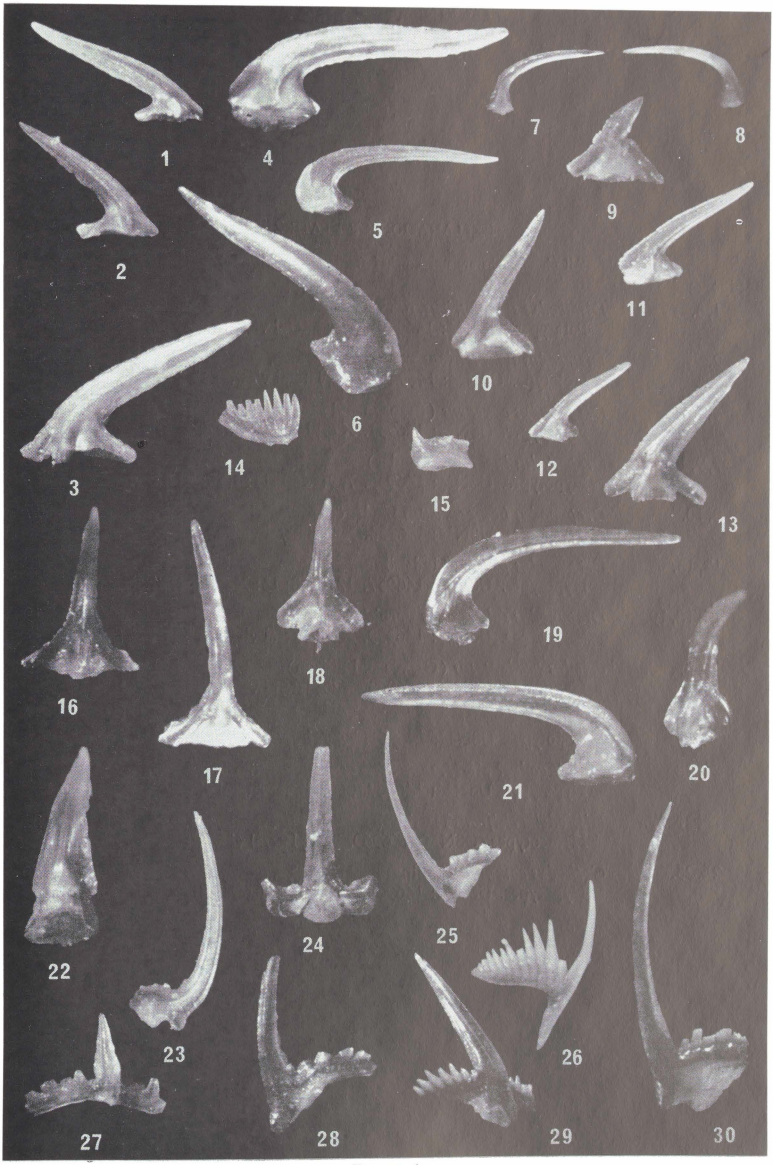
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PLATE 1

Explanation of Plate 2

All photographs are unretouched figures of coated specimens.

PLATE 2

Explanation of Plate 3

All photographs are unretouched figures of coated specimens.

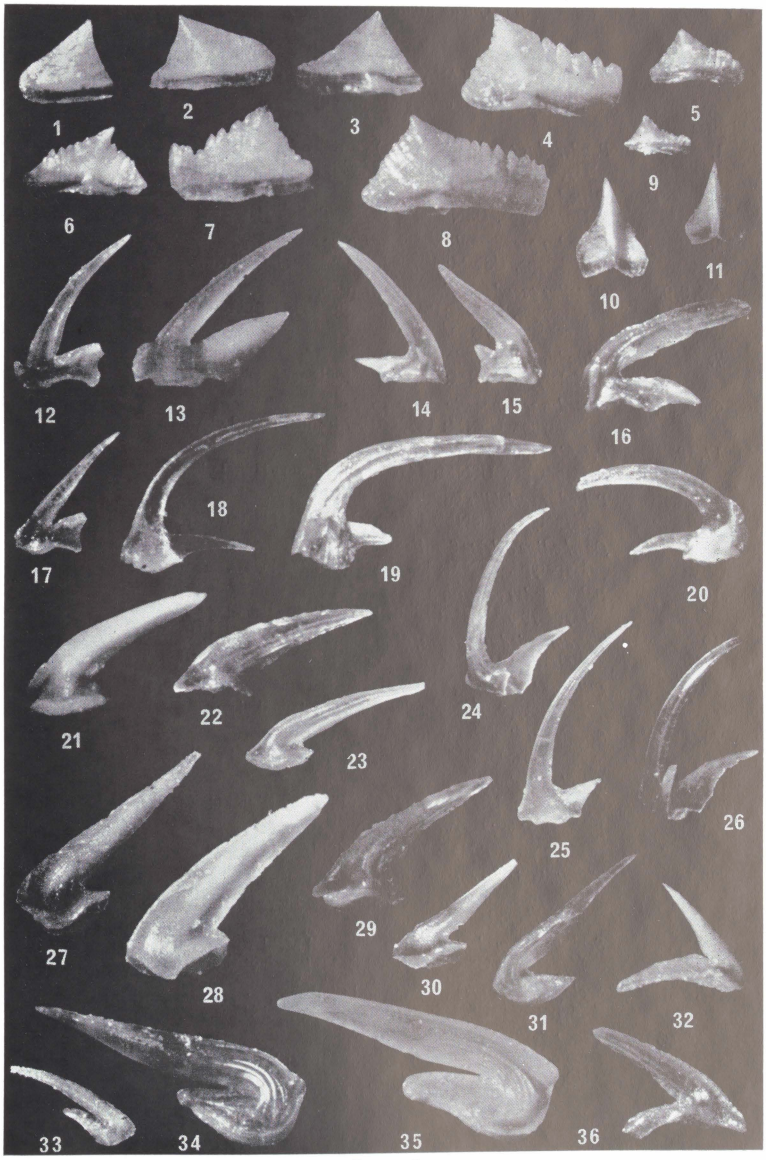
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PLATE 3

Explanation of Plate 4

All photographs are unretouched figures of coated specimens.

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PLATE 4

ERRATA

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NO. 4—Miocene planktonic Foraminifera from Newport Bay, California, by Jere H. Lipps:

page 112, column 1, line 14. Read: Mohnian (samples 23 to 36), for Mohnian (samples 22 to 36).

page 121. The caption for figure 3, line 5, should read: (Top row: After Bolli, Loeblich, and Tappan, 1957, pl. 7, figs. 2-4; Lower left: UCLA hypotype 34722; Lower right: After Blow, 1956, text-fig. 2, No. 16).