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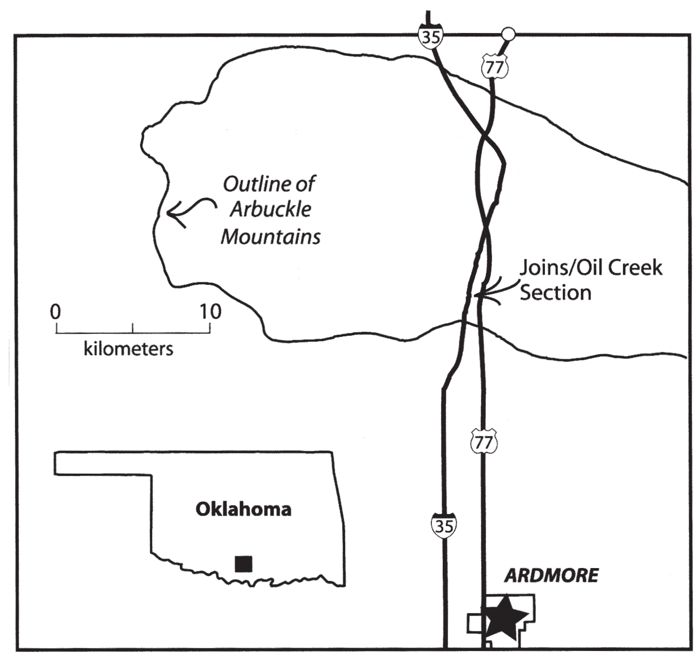
BULLETIN 150

Conodonts and Conodont Biostratigraphy of the Joins and Oil Creek Formations, Arbuckle Mountains, South-central Oklahoma



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2010

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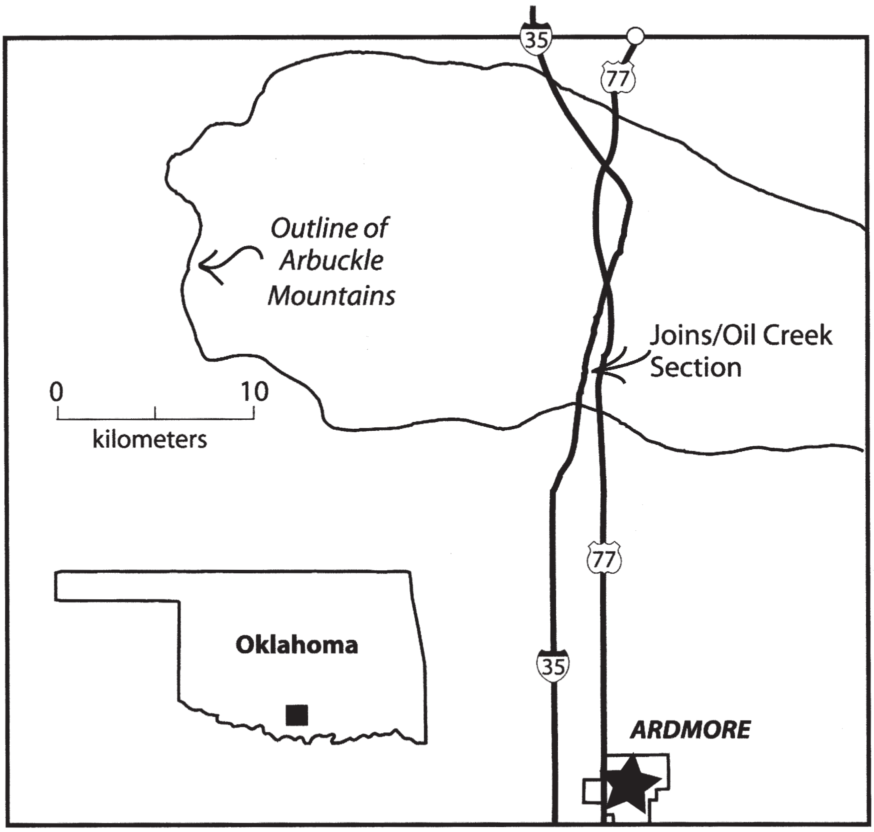

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OKLAHOMA GEOLOGICAL SURVEY

G. Randy Keller, *Director*

TITLE PAGE ILLUSTRATION

Map showing locality of sampled section of the Joins and Oil Creek Formations. Samples from section bear designations 72SB (Joins) and 72SC (Oil Creek).

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Conodonts and Conodont Biostratigraphy of the Joins and Oil Creek Formations, Arbuckle Mountains, South-central Oklahoma

Jeffrey A. Bauer[1]

ABSTRACT. — More than 63,000 conodont specimens were recovered from 112 samples collected from the Joins and Oil Creek Formations of south-central Oklahoma (Figure 1). The bulk of those specimens are assignable to 35 species including new species *Histiodella labiosa*, *Neomultioistodus angulensis*, *N. erectus*, and *Paraprioniodus neocostatus*. In addition, a new genus, *Apteracontiodus*, is established. The Joins–Oil Creek conodont fauna is dominated by species of *Apteracontiodus*, *Drepanoistodus*, *Histiodella*, *Neomultioistodus*, and *Paraprioniodus*. Conodont data indicate that the age of the Joins and Oil Creek ranges from late Dapingian to early Darriwilian age (early to middle Whiterockian).

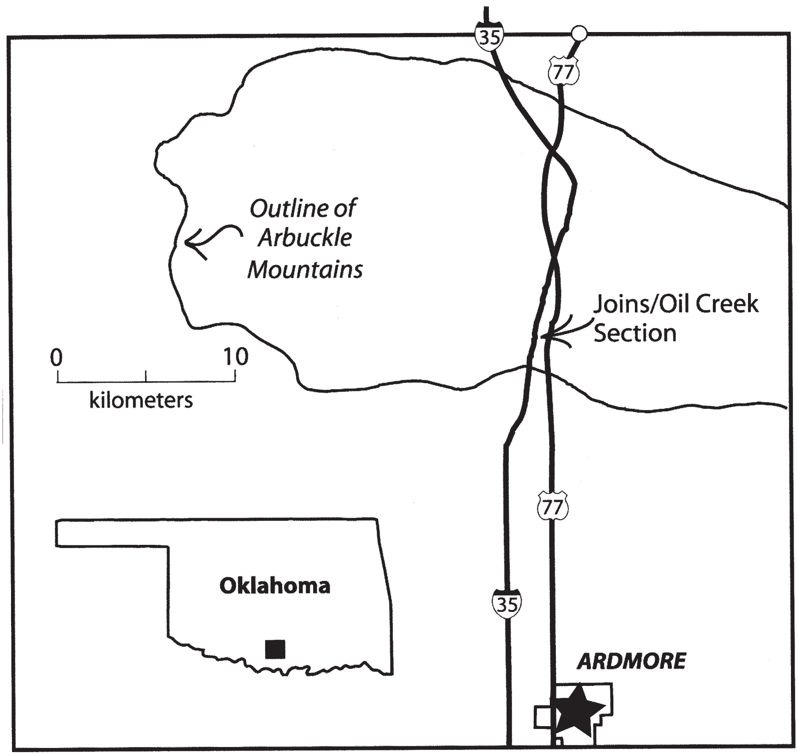

Figure 1. Map showing locality of sampled section of the Joins and Oil Creek Formations. Samples from section bear designations 72SB (Joins) and 72SC (Oil Creek).

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INTRODUCTION

The Arbuckle Mountains region of southern Oklahoma has exceptionally thick and fossiliferous exposures of Ordovician strata. Outcrops of the Simpson Group record 700 meters of shallow, marine sedimentary rock that ranges from Dapingian to Sandbian in age (Bergström and others, 2006; Mitchell and others, 1997; Bergström and others, 2000; Sweet and others, 2005) or from early Whiterockian to early Mohawkian in age. The Simpson is biostratigraphically important because it represents one of the thickest, most nearly complete sections chronologically of fossiliferous rock in the eastern Midcontinent of North America. This report describes the conodont fauna of the Joins and Oil Creek Formations of the lower Simpson Group.

STRATIGRAPHY

The term Simpson was first introduced by Taff (1902). Through contributions and refinements by Ulrich (1911, 1929) and Decker (in Decker and Merritt, 1931), the Simpson Group came to be recognized as strata underlain by the West Spring Creek Formation, the youngest formation of the Arbuckle Group, and overlain by the Viola Group. The Simpson is exposed in a series of outcrops in the Arbuckle Mountains and Criner Hills in southern Oklahoma. Harris (1957) and Schramm (1965) provided exhaustive reviews of early stratigraphic studies of the Simpson.

In southern Oklahoma, Simpson formations include, in ascending order, the Joins, Oil Creek, McLish, Tulip Creek, and Bromide. Each formation, with the exception of the Joins, is characterized by a lower sandstone (quartz arenite) unit and is capped by alternating layers of limestone and shale.

The Joins Formation reaches a thickness of close to 90 m and is composed of light to dark gray, thin- to medium-bedded limestone with some interbedded thin shale. The limestone beds erode into low ledges. Fay (1969, 1989) and Harris (1957) described a thin conglomerate at the base of the Joins. Harris (1957) reported that the Joins is the most geographically restricted of the Simpson formations and rests unconformably on the West Spring Creek Formation.

The Oil Creek Formation is greater than 190 m thick in outcrops in the western Arbuckle Mountains. The quartz arenite unit at the base of the formation varies in thickness from about 10 m in outcrops along Interstate 35 to greater than 100 m in outcrops in the northern Arbuckle Mountains. This unit is succeeded by alternating thin to medium beds of gray limestone and greenish gray shale. In the Criner Hills, the upper part of the Oil Creek is composed of birds-eye and oolitic limestone, which R.W. Harris and R.W. Harris, Jr. (1965) established as the Pruitt Ranch Member.

DEPOSITIONAL ENVIRONMENTS

The Joins and Oil Creek Formations originated in a long, linear, tropical basin near the margin of Laurentia. Within this basin, prolonged slow subsidence allowed for long periods of shallow-water deposition without the long-term hiatuses that characterize many other Ordovician sections in the eastern Midcontinent.

Longman (1981), in his study of the Bromide Formation, described a depositional model for Simpson formations in which each formation, except the Joins, was generated during a transgressive-regressive cycle. Transgressions were the product of subsidence episodes related to continental rifting in the Southern Oklahoma Embayment (Ham, 1969), which was later described as an aulacogen by Hoffman and others (1974).

Lewis (1982) applied Longman's (1981) transgressive-regressive model to explain deposition of the Oil Creek Formation. He interpreted the basal sandstone and overlying limestone and shale of the lower Oil Creek as transgressive facies. These facies are overlain by regressive shoal, lagoon, and tidal-flat facies, respectively.

PREVIOUS PALEONTOLOGICAL STUDIES

Taff (1904) and Decker and Merritt (1931) included lists of a rich and varied invertebrate fauna in their early Simpson reports. Subsequently, Simpson brachiopods were described by Cooper (1956), ostracodes by Harris (1957), and trilobites by Shaw (1974). Lewis and others (1987) and Lewis and Yochelson (1978) described species of echinoderms and gastropods, respectively, from the Oil Creek.

Reports on Simpson conodonts include those by Decker and Merritt (1931), Harris (1962), Mound (1965a, 1965b), McHargue (1982), Bauer (1987, 1990, 1994) and Sweet and others (2005). Mound (1965b) described conodonts from the Joins Formation; however, this report proposes revisions to his taxonomy.

LOCATION

Conodonts used for this study were collected in 1972 by V. Jaanusson, S.M. Bergström, and W.C. Sweet. Samples were taken from the Joins Formation at 1 – 3 m intervals and from the Oil Creek at 3 m intervals (where possible) from rock layers exposed in several low ridges visible from US Highway 77 and Interstate 35, SE1/4, sec. 24, T. 2 S., R. 1 E. Carter County (Figure 1). At this locality, the Joins and Oil Creek Formations are exposed in steeply dipping layers along the south flank of the Arbuckle Anticline, north of Ardmore, Oklahoma. Fay (1969, 1989) described the lithology of the Interstate-35 section near this site.

CONODONT EVOLUTION AND BIOSTRATIGRAPHY

Middle Ordovician conodonts underwent extensive diversification in the shallow seas that encroached on the Laurentian continent. During this time, several important conodont lineages were introduced there and serve as important biostratigraphic indicators for the Dapingian to middle Darriwilian Stage (early to middle Whiterockian Series). The following paragraphs describe the evolution of important prioniodontid genera represented in the Joins and Oil Creek Formations.

Histiodella

McHargue (1982) established several important evolutionary trends in *Histiodella* based on features of the carminate (bryantodontiform) P element. Those trends include development of serrations or denticles, decrease in height/length ratio, and increasing abundance (relative to other components of the skeletal apparatus) for progressively younger species. Ramiform S and coniform M

<table>
<tr><th>Global Series</th><th>Midcontinent Series</th><th>British Series</th><th>Global Stages</th><th>Conodont Zones</th><th>Southern Oklahoma</th></tr>
<tr><td rowspan="8">Middle Ordovician</td><td rowspan="8">Whiterockian</td><td rowspan="2">Llanvirn</td><td rowspan="6">Darriwilian</td><td></td><td></td></tr>
<tr><td>H. holodentata</td><td rowspan="3">Oil Creek</td></tr>
<tr><td rowspan="6">Arenig</td><td>Histiodella labiosa</td></tr>
<tr><td rowspan="2">Histiodella sinuosa</td></tr>
<tr><td rowspan="3">Joins</td></tr>
<tr><td>H. minutiserrata</td></tr>
<tr><td rowspan="2">Dapingian</td><td>H. altifrons</td></tr>
<tr><td></td><td></td></tr>
</table>

Figure 2. Chronostratigraphic chart showing the age of the Joins and Oil Creek Formations. Conodont zones are local zones established on conodont occurrences in the Simpson Group.

elements also show a trend toward increased serration/denticulation; however, those elements tend to be poorly represented in collections.

Repetski (1982) described an early species of *Histiodella*, *H. donnae*, from the El Paso Group of west Texas and southern New Mexico. *H. donnae* has a typical *Histiodella* apparatus, which includes a geniculate coniform M element (Repetski and Repetski, 2002). *H. donnae* is represented in Ibexian-age rocks of the Manitou Formation (p. 50, Ethington and Clark, 1982); Fillmore Formation, Utah (=?*Histiodella* sp., Ethington and Clark,1982); House Formation, Shingle Pass, Nevada (Sweet and Tolbert, 1997); Cool Creek Formation, Oklahoma (= *H.* altifrons and *H.*? sp., Mound, 1968); and Roubidoux Formation, Missouri (Repetski and others, 2000).

Histiodella altifrons is represented in late Dapingian to early Darriwilian rocks of the lower Joins Formation (Figure 2). *H. altifrons* is morphologically similar to *H. donnae*; however, a direct relationship cannot be concluded because of the long temporal separation between their reported occurrences (noted by Repetski and Repetski, 2002).

Histiodella minutiserrata evolved from *H. altifrons* during the early Darriwilian and is succeeded by *H. sinuosa* and *H. serrata*, respectively. The transition between those species is marked first by minute serrations then by increasingly conspicuous denticulation along the upper edge of the carminate P or Pa element. The Pa element of *H. serrata* is characterized by a low height/length ratio, indicating that it is an unlikely ancestor to younger species of *Histiodella*.

Histiodella sinuosa occurs in the Joins and Oil Creek and is the most likely ancestor of *H. labiosa* (new species, this report). Transitional morphologies between the carminate P elements of *H. sinuosa* and *H. labiosa* occur in the lower Oil Creek (illustrated in McHargue, 1982, pl. 1.21). Collections of *H. labiosa* show a reduction in the relative abundance of non-carminate S elements; however, the trend of decreasing height/length ratio (McHargue, 1982) for carminate P elements does not hold true for this member of the lineage.

Several carminate elements of *Histiodella holodentata* are represented near the top of the Oil Creek Formation. The carminate element of *H. holodentata* shows similarities to those of *H. labiosa* and *H. sinuosa*; consequently, the evolutionary relationship is unclear.

Stouge (1984) described *Histiodella kristinae* and *H. bellburnensis* from the middle Table Head Formation, Newfoundland. Those species stratigraphically succeed and are interpreted by Stouge (1984) as descendants of *H. holodentata* (= *H. tableheadensis*). *Histiodella kristinae* and *H. bellburnensis* are not represented in the Simpson Group.

Neomultioistodus

Species of *Neomultioistodus* are characterized by a seximembrate skeleton composed of pastinate, geniculate coniform, and ramiform elements (Bauer, 1987). *Neomultioistodus* probably evolved from *Pteracontiodus* in pre- to earliest Middle Ordovician (*sensu* Finney, 2005) which is equivalent to late Ibexian to early Whiterockian time. Species of those two genera are closely associated in time and space and have a similar prioniodontid skeleton composed of hyaline elements. The pastinate and ramiform elements of *Neomultioistodus* differ most notably from those of *Pteracontiodus* by having one broad, compressed denticle on their posterior process.

Three species of *Neomultioistodus* are recognized in the Joins and Oil Creek Formations. *N. erectus* (new species, this report) occurs in samples from the lower Joins. *N. compressus* occurs in samples throughout the Joins and Oil Creek and is reported from the underlying West Spring Creek (R.W. Harris and B. Harris, 1965). Based on morphological similarities and stratigraphic occurrences, *N. angulatus* (new species, this report) was probably derived from *N. compressus* and is represented in the middle to upper Oil Creek.

Pteracontiodus and *Apteracontiodus*

Species of *Pteracontiodus* and *Apteracontiodus* have the potential to be important correlation tools for the Middle Ordovician because of their broad distribution across the Midcontinent and Atlantic Faunal Regions (*sensu* Bergström, 1990). Their usefulness has been largely unrealized because of taxonomic complexities.

Pteracontiodus has a skeletal apparatus composed of hyaline elements with short, adenticulate processes. The skeleton includes pastinate P, geniculate coniform M, and a symmetry transition series of alate, tertiopedate, bipennate, and quadriramate S elements.

The early development of *Pteracontiodus* can be traced back to the earliest stage of the Middle Ordovician (Dapingian or Third Stage as described in Wang and others, 2005; = early Whiterockian Series) where *P. cryptodens* is common at many Midcontinent sites. *P. cryptodens* occurs in the West Spring Creek (R.W. Harris and B. Harris, 1965), Joins, and Oil Creek Formations in Oklahoma. It is represented also in northern and eastern Canada (Barnes, 1977; Ji and Barnes, 1994); Utah (Ethington and Clark, 1982); central Nevada (Sweet and others, 2005); central Appalachians (Brezinski and others, 1999); and South America (Albanesi, 1998).

Zhen and others (2006) described two new species of *Triangulodus*, *T. bifidus* and *T. zhiyii*, from the Honghuayuan Formation, Guizhou Province, South China. These hyaline species are older (*Paroistodus proteus* and *Prioniodus elegans* Zones) than *Pteracontiodus brevibasis* and show enough similarities to be considered as potential ancestors to the *Pteracontiodus* lineage.

Pteracontiodus brevibasis is closely related to *P. cryptodens* and is represented at sites in both Midcontinent and Atlantic Faunal Regions. The ramiform elements of *P. brevibasis* differ most notably from those of *P. cryptodens* by reduction in the length of lateral and posterior processes. *P. brevibasis* is reported from Sweden (Lindström, 1971; van Wamel, 1974; Löfgren, 1978, 1994; Stouge and Bagnoli, 1990); Selwyn Basin, Canada (Pohler and Orchard, 1990); northern Estonia (Viira and others, 2001); China (Wang and Bergström, 1999); and possibly Greenland (= *Pteracontiodus bransoni*; Smith, 1991) and Texas (Repetski, 1982). Previous authors (Löfgren, 1978, 1994; Stouge and Bagnoli, 1990) showed *P. brevibasis* ranging from the *Baltoniodus triangularis* through *Paroistodus originalis* and possibly into the *Microzarkodina parva* Zone.

Pteracontiodus larapintensis and *P. brevibasis* are nearly identical in morphology and age and have been interpreted to be the same species (Stouge and Bagnoli, 1990). Watson (1988) recorded *P. larapintensis* from Western Australia and suggested that its M element was incorrectly described by Cooper (1981). Regardless of whether Cooper's (1981) or Watson's (1988) reconstruction is correct, the M element appears to be different from that of *P. brevibasis*. To date, *P. larapintensis* has been reported from several sites in Australia (Zhen and others, 2003).

Ethington and Clark (1982) described the apparatus of *Pteracontiodus gracilis* from the Lehman Formation. It includes a geniculate coniform M and the symmetry transition series of S elements; however, no pastinate P (acodontiform) elements are known in *P. gracilis*. *P. gracilis* stratigraphically succeeds *P. cryptodens* in the Ibex Area of Utah (Ethington and Clark, 1982) and central Nevada (Sweet and others, 2005). *P. gracilis* is represented in Darriwilian (middle Whiterockian) rocks of the Oil Creek Formation and there overlaps the upper range of *P. cryptodens*.

Pteracontiodus alatus is represented in late Darriwilian (late Whiterockian) strata of the McLish and Tulip Creek Formations (Bauer, 1987) and Sandbian (early Mohawkian) strata of the Bromide Formation (Bauer, 1994). *P. alatus* is comparable to *P. brevibasis*; however, the broadly extended, wing-like processes on the P and S elements of *P. alatus* are distinctive from those of *P. brevibasis*.

The absence of the geniculate coniform M element distinguishes *Apteracontiodus* (new genus, this report) from *Pteracontiodus*. Based on morphological similarities and stratigraphic occurrence, *Apteracontiodus* was probably derived from *P. brevibasis* or *P. larapintensis* during the early Darriwilian (middle Whiterockian). The earliest known species, *A. sinuosus*, is represented in the Joins Formation and is known also from Ordos Basin, China (An and Zheng, 1990); Fort Peña Formation, Texas (Bradshaw, 1969); Rockcliffe Formation, Ottawa, Ontario (Copeland and others, 1989); and likely from the Kanosh Formation, Utah (Ethington and Clark, 1982) .

The apparatus of *Apteracontiodus carinatus* is described by Stouge (1984, = *Trigonodus carinatus*) from the Table Head Formation and is present in samples of the Oil Creek Formation. The apparatus of ancestral *A. sinuosus* includes a distacodontiform element, which is missing from that of *A. carinatus*. In addition, the lateral costae of the S elements in *A. sinuosus* exhibit a conspicuous flare near the base. *A. carinatus* is likely represented in the Lehman and Watson Ranch Formations, Utah (Ethington and Clark, 1982) and is also present in samples from the lowermost McLish Formation (Bauer, 1987).

TAXONOMIC NOTES

Many of the conodont species represented in the Joins and Oil Creek Formations are well known and have been described in previous publications. Those species are not described systematically in this report but, instead, are addressed in the following paragraphs. Ranges for Joins and Oil Creek conodonts are given in Table 1.

Ansella jemtlandica

Plate 1, Figures 1, 2, 4, 5

Ansella jemtlandica, as described by Löfgren (1978), has a quadrimembrate apparatus composed of triangular, planoconvex, biconvex, and geniculate coniform elements. The biconvex element is adenticulate. Other elements of the apparatus are distinguished from those of congeneric species by fine denticulation along the posterior margin. Elements of *A. jemtlandica* have been recovered from the middle to upper Oil Creek Formation and are reported also from Nevada (Sweet and others, 2005); British Columbia (Pyle and Barnes, 2003); Sweden (Löfgren, 1978); Argentina (Serpagli, 1974; Lehnert, 1995; Albanesi, 1998); Newfoundland (Nowlan and Thurlow, 1984; Stouge, 1984); Australia (Cooper, 1981); and China (An and others, 1983; An and Zheng, 1990).

Chosonodina lunata

Plate 1, Figure 3

Chosonodina lunata was described by R.W. Harris and B. Harris (1965) from the uppermost West Spring Creek Formation. The apparatus of *C. lunata* is composed of an inwardly bowed, palmate element with apically discrete denticles that are nearly equal in height and increasingly reclined in one direction. R.W. Harris and B. Harris (1965) reported 12 to 15 denticles. Specimens from the Joins Formation have as few as 10 denticles. *C. lunata* differs from older *C. herfurthi, C. fisheri*, *C. chirodina*, and *C. tridentata* (see An and others, 1983, for illustrations of latter two species) by having more denticles and an angular rather than a rounded basal margin.

Chosonodina rigbyi

Plate 1, Figure 9

Chosonodina rigbyi is sparsely represented in Oil Creek samples. Elements of *C. rigbyi* differ from those of *C. lunata* by having denticles that become increasingly reclined and shorter away from the central denticle. *C. rigbyi* is represented in the Lehman and Watson Ranch Formations, Utah (Ethington and Clark, 1982); Antelope Valley Limestone, Nevada (Harris and others, 1979); and from rocks in central Nevada (Sweet and others, 2005). *C. rigbyi* may also occur in China (An and others, 1983; specimen identified as *Rhipidognathus laiwuensis*, pl. XX, fig. 3).

Dischidognathus primus

Plate 1, Figure 18

Ethington and Clark (1982) described *Dischidognathus primus* from the upper Lehman Formation, Utah. The unimembrate apparatus is characterized by a palmate element whose cusp is flanked on each side by a short, compressed denticle. The basal margin has a posterior groove that extends to the lower part of the cusp where it becomes a narrow slit. *D. primus* is represented in the middle to upper part of the Oil Creek Formation and is reported also from several sections in central Nevada (Sweet and others, 2005).

Drepanoistodus angulensis

Plate 1, Figures 6, 7, 10

Ethington and Clark (1982) described differences between *Drepanoistodus angulensis* and other species of *Drepanoistodus*. The base of the geniculate coniform element of *D. angulensis* has a relatively short posterior margin that flares strongly in a posterior direction. *D. angulensis* ranges through nearly the entire section of the Joins and Oil Creek and is found also in the overlying McLish Forma-

Genus and species	Range	Specimens
Ansella jemtlandica	172 - 279	241
Apteracontiodus carinatus	74 - 282	13,282
Apteracontiodus sinuosus	0 - 72	2,747
Chosonodina lunata	0 - 83	4
Chosonodina rigbyi	110 - 257	8
Coleodus sp.	32 - 157	17
Dischidognathus primus	218 - 257	5
Drepanoistodus angulensis	0 - 282	9,542
Fahraeusodus marathonensis	1 - 282	1,545
Histiodella altifrons	0 - 23	314
Histiodella holodentata	202 - 282	5
Histiodella labiosa	101 - 282	997
Histiodella minutiserrata	5 - 67	1,187
Histiodella serrata	69 - 101	797
Histiodella sinuosa	45 - 199	1,796
Multioistodus subdentatus	0 - 129	166
Neomultioistodus angulatus	172 - 282	298
Neomultioistodus erectus	0 - 81	419
Neomultioistodus compressus	4 - 282	21,221
Neomultioistodus? clypeus	0 - 2	6
Oistodus cristatus	98 - 193	78
Oistodus multicorrugatus	0 - 282	1,309
Oistodus n. sp.	101 - 144	22
Parapanderodus striatus	0 - 279	704
Paraprioniodus costatus	0 - 187	830
Paraprioniodus neocostatus	135 - 279	752
Prioniodus n. sp.	4 - 19	327
Prioniodus? sp.	0 - 52	188
Protopanderodus gradatus	5 - 282	815
Pteracontiodus cryptodens	0 - 272	3,697
Pteracontiodus? gracilis	166 - 279	114
Tripodus combsi	138 - 269	49
Tripodus sp.	5 - 89	186
New Genus, new species	45 - 52	12
Genus and species indeterminate 1	2 - 89	102
Genus and species indeterminate 2	WSC	
Genus and species indeterminate 3	95 - 193	21
Genus and species indeterminate 4	27 - 33	29
Genus and species indeterminate 5	23 - 40	52
Genus and species indeterminate 6	0 - 11	6
Ptiloncodus simplex	27 - 202	22

Table 1. Range of conodont species in the Joins and Oil Creek Formations. Species are shown in the left hand column, range (in meters) in the center column, and total number of specimens is given in the right-hand column. Ranges are given with respect to the base of the Joins Formation. The Joins Formation extends from 0 to 89 m and the Oil Creek Formation from 89 to 282 m. Genus and species indeterminate 2 is represented in the uppermost sample of the West Spring Creek Formation (WSC).

tion (Bauer, 1987). *D. angulensis* occurs in the Kanosh, Lehman, and Watson Ranch Formations, Utah (Ethington and Clark, 1982); Antelope Valley Limestone, Nevada (Sweet and others, 2005); Fort Peña Formation, Texas (Graves and Ellison, 1941; Bradshaw, 1969); Cow Head Group, Newfoundland (described as *Drepanodus arcuatus* by Stouge and Bagnoli, 1988); Burgen and Tyner Formations, eastern Oklahoma (Bauer, 1989); St. George Group, western Newfoundland (Ji and Barnes, 1994); and the Beauharnois Formation, Quebec (Desbiens and others, 1996).

Fahraeusodus marathonensis
Plate 1, Figures 13, 14, 16, 17, 20, 21

Stouge and Bagnoli (1988) established *Fahraeusodus* and included type species *F. adentatus*, *F. marathonensis*, and *F. mirus*. The apparatus of the last species was distinguished by elements having “a thickened rim above the aboral margin, a prominent knob below the cusp and P elements with minute denticles on the cusp” (p. 119, Stouge and Bagnoli, 1988). The ramiform elements of *F. marathonensis* differ from those of *F. adentatus* by having a prominent “shoulder” that extends along each side of the posterior process near the junction of the base and denticles. Ethington and Clark (1982) noted that the ozarkodiniform element of *F. marathonensis* differs from that of *F. adentatus* by having an extended, rather than abruptly terminated, anterobasal margin.

Fahraeusodus marathonensis ranges from samples in the lower Joins to the upper Oil Creek. Some of the S elements (Pl. 1, Fig. 17) exhibit ledges on the posterior process like those illustrated in previous reports. This character is most prominent on larger specimens and may represent an ontogenetic addition to the element. Elements of *F. marathonensis* were originally described by Bradshaw (1969) from the Fort Peña Formation. The species is also represented in the El Paso Group (Repetski, 1982); Fillmore, Wah Wah, Juab, and Kanosh Formations, Utah (Ethington and Clark, 1982); Antelope Valley Limestone, Nevada (Sweet and others, 2005); Kechika and Skoki Formations of British Columbia (Pyle and Barnes, 2003); Cow Head Group of Western Newfoundland (Stouge and Bagnoli, 1988); Tyner Formation, eastern Oklahoma (Bauer, 1989); San Juan Formation, Argentina (Lehnert, 1995; Albanesi, 1998); and from Ordovician rocks in Greenland (Smith, 1991).

Histiodella altifrons
Plate 2, Figures 1–3

Histiodella altifrons has an apparatus composed of carminate pectiniform P, ramiform S, and geniculate coniform M elements (see McHargue, 1982, for detailed description). Carminate elements of *H. altifrons* are distinguished from those of younger congeneric species by their smooth upper margin. *H. altifrons* occurs in the lower Joins Formation (Harris, 1962; Mound, 1965b; McHargue, 1982); Fort Peña Formation, Texas (Bradshaw, 1969); Antelope Valley Limestone, Nevada (Harris and others, 1979; Sweet and others, 2005); and the San Juan Formation, Argentina (Lehnert, 1995).

Histiodella holodentata
Plate 2, Figure 9

Ethington and Clark (1982) described *Histiodella holodentata* from the upper Lehman Formation and the lower Watson Ranch Quartzite of Utah. Their collections of *H. holodentata* elements contained only one type of ramiform element and did not include geniculate coniform elements. The carminate pectiniform element is identical to that described in the multielement apparatus of *H. tableheadensis* (herein considered a junior synonym of *H. holodentata*) by Stouge (1984), who reported both ramiform and geniculate coniform elements in his collection from the Table Head Formation.

Several carminate elements assignable to *Histiodella holodentata* were recovered from the middle to upper Oil Creek Formation. The species co-occurs with *H. labiosa* and is represented above the highest occurrence of *H. serrata* and *H. sinuosa*. *H. holodentata* is reported from the Mystic Conglomerate (Barnes and Poplawski, 1973); Antelope Valley Limestone, Nevada (= *H.* n. sp. 1, Harris and others, 1979; also Sweet and others, 2005); from strata in North China (= *H. infrequensa* of An and others, 1983; and *H. intertexta* of An, 1987, and An and Zheng, 1990);

Buchans Group, Newfoundland (Nowlan and Thurlow, 1984); and the San Juan Formation, Argentina (Lehnert, 1995).

Histiodella minutiserrata
Plate 2, Figures 4–8

Mound (1965b) distinguished the minutely serrated carminate P element of *Histiodella minutiserrata* from that of congeneric species. McHargue (1982) emended the description of *H. minutiserrata* and integrated ramiform S and geniculate coniform M elements in the skeletal apparatus. Skeletal assemblages of *H. minutiserrata* have at least one P element that bears fine serration along the upper margin (McHargue, 1982). *H. minutiserrata* occurs in the Joins Formation and is also reported from the lower Kanosh Formation, Utah (Ethington and Clark, 1982) and the Antelope Valley Limestone, Nevada (Sweet and others, 2005).

Histiodella sinuosa
Plate 2, Figures 19–22

The carminate P element of *Histiodella sinuosa* is characterized by a series of denticles that are developed along the anterior upper margin. The posterior upper margin is smooth. *H. sinuosa* is represented in samples from the middle Joins Formation and ranges into the Oil Creek Formation. *H. sinuosa* is present in the Fort Peña Formation of west Texas (Graves and Ellison, 1941; Bradshaw, 1969); upper Kanosh Formation, Utah (Ethington and Clark, 1982); and the Antelope Valley Limestone, Nevada (Harris and others, 1979; Sweet and others, 2005).

Histiodella serrata
Plate 2, Figures 12, 15–18

The carminate P elements of *Histiodella serrata* bear denticles along the anterior and posterior upper margin. The Pa element has a low height/length ratio in comparison to P elements of congeneric species. *H. serrata* is represented in the upper Joins Formation. McHargue (1982) reported *H. serrata* from the Oil Creek Formation. The species is represented in the Kanosh Formation and the Antelope Valley Limestone, Nevada (Harris and others, 1979; Sweet and others, 2005); Fort Peña Formation, Texas (Bradshaw, 1969); and from Ordovician strata in China (An and others, 1983).

Multioistodus subdentatus
Plate 3, Figures 1–4, 7

Bauer (1987) discussed the differences between species of *Multioistodus* and *Neomultioistodus*. *Multioistodus subdentatus* has a quadrimembrate skeletal apparatus composed of pastinate, alate, tertiopedate or bipennate, and dolabrate elements. All elements are hyaline. *M. subdentatus* is a long-ranging species that was originally reported from the Dutchtown Formation, Missouri (Cullison, 1938). *M. subdentatus* also occurs in the Burgen and Tyner Formations, northeastern Oklahoma (Bauer, 1989); Lehman and Watson Ranch Formations, Utah (Ethington and Clark, 1982); and the Antelope Valley Limestone at Martin Ridge, Nevada (Sweet and others, 2005).

Neomultioistodus compressus
Plate 3, Figures 5, 6, 8, 11, 13

Bauer (1987) described the multielement apparatus of *Neomultioistodus compressus* from collections near the base of the McLish Formation. *N. compressus* ranges from the lower Joins through the Oil Creek Formation. R.W. Harris and B. Harris (1965) reported *N. compressus* from the upper part of the West Spring Creek. *N. compressus* is also represented in the upper Kanosh and Lehman Formations, Utah (Ethington and Clark, 1982); Antelope Valley Limestone, Nevada (Sweet and others, 2005); Haywire Formation, Yukon Territory (Pohler and Orchard, 1990); Skoki Formation, British Columbia (Pyle and Barnes, 2003); and the Fort Peña Formation, Texas (Bradshaw, 1969).

Oistodus cristatus
Plate 1, Figure 8

Ethington and Clark (1982) described a distinctive geniculate coniform element, *Oistodus cristatus*, and noted that it accompanies elements that they assigned to *O. multicorrugatus*. *O. cristatus* is present in the lower to middle Oil Creek Formation and occurs with elements typical of *O. multicorrugatus*. The morphology and stratigraphic position of *O. cristatus* indicate that it is probably a descendant of *O. multicorrugatus* with a similar multielement apparatus.

Oistodus multicorrugatus

Plate 1, Figures 11, 15, 19

Ethington and Clark (1982) described the multielement skeleton of *Oistodus multicorrugatus*. They included a series of coniform elements in their reconstruction and assigned them to non-costate cordylodiform, costate cordylodiform, cladognathodiform, trichonodelliform, distacodiform, and oulodiform morphologies. Collections from the Joins and Oil Creek conform to this description. *O. multicorrugatus* is also represented in the Fort Peña Formation, Texas (Bradshaw, 1969); Antelope Valley Limestone, Nevada (Sweet and others, 2005); Skoki and Ospika Formations, British Columbia (Pyle and Barnes, 2003); Ordovician rocks in China (An and others, 1983); and the Ship Point Formation, Canada (Barnes, 1977).

Parapanderodus striatus

Plate 4, Figures 1-3, 6, 7, 11

The skeletal apparatus of *Parapanderodus* is characterized by a series of coniform elements, which have a posterior furrow and fine striations. Reports by Stouge and Bagnoli (1988), Ji and Barnes (1994), Lehnert (1995), and Albanesi (1998) described four to five distinct elements in the apparatus.

Smith (1991) described fused clusters of *Parapanderodus* from Early Ordovician strata in Greenland. Those clusters include morphologies that have been assigned to two or more species including *Parapanderodus asymmetricus* and *P. striatus*. Smith (1991) considered the clusters to represent a single species, *P. striatus*.

Parapanderodus striatus has a skeletal apparatus consisting of symmetrical, sub-symmetrical and asymmetrical coniform elements. The sub-symmetrical elements have well developed lateral costae. The asymmetrical element has a long base and an inner lateral carina, which together with lateral and anterior costae give it a distinctive triangular cross section. The symmetrical element has a nearly erect cusp and lateral costae.

Parapanderodus striatus ranges through most of the Joins and Oil Creek Formations. Specimens recovered from the Joins are generally more robust than those from the Oil Creek. In addition, the distinctive sub-symmetrical element (*P. asymmetricus* morphology) is absent in Oil Creek collections. Smith (1991) reported an absence of both sub-symmetrical and symmetrical elements in younger collections of *P. striatus* from Ordovician strata in Greenland. *P. striatus* is reported from the Antelope Valley Limestone, Nevada (Sweet and others, 2005); Pogonip Group, Utah (= "*Scolopodus*" *gracilis*, Ethington and Clark, 1982); Broken Skull Formation, Yukon Territory (Pohler and Orchard, 1990); Kechika and Skoki Formations, British Columbia (Pyle and Barnes, 2003); and the St. George Group, Newfoundland (Ji and Barnes, 1994).

Protopanderodus gradatus

Plate 5, Figures 1–3, 7

The apparatus of *Protopanderodus gradatus* was described by Serpagli (1974) from the San Juan Formation, Argentina (also see Albanesi, 1998). *P. gradatus* is represented throughout the Joins and Oil Creek Formations. The species is reported from the Fort Peña Formation, Texas (Bradshaw, 1969); Pogonip Group, Utah (Ethington and Clark, 1982); Antelope Valley Limestone, Nevada (Sweet and others, 2005); Greenland (Smith, 1991); North China (An and Zheng, 1990); and Argentina (Lehnert, 1995).

Ptiloncodus simplex

Plate 6, Figure 19

The simple hook-like element of *Ptiloncodus* simplex was first described by Harris (1962) from the Joins Formation. The affinity of *P. simplex* remains unclear. Although reports have illustrated species of *Ptiloncodus* along with conodonts, it is unlikely that those groups are closely related. Sweet (1963) argued that *P. simplex* was not a conodont because its elements lacked a basal attachment surface.

SYSTEMATIC PALEONTOLOGY

Joins and Oil Creek conodont collections described in this report are stored in the micropaleontology collections of the School of Earth Sciences, The Ohio State University. Illustrated specimens are kept in the Orton Museum of Geology at The Ohio State University. Additional collections of Joins and Oil Creek conodonts are stored at Shawnee State University, Portsmouth, Ohio.

Genus *Apteracontiodus*, n. gen.

Type species.—*Scandodus sinuosus* Mound, 1965b.

Diagnosis.—*Apteracontiodus* is established to include species with a skeletal apparatus composed of four to five hyaline, costate or keeled, non-geniculate coniform elements. The absence of a geniculate coniform M element distinguishes species of *Apteracontiodus* from those of closely related genera.

Description.—Skeletal apparatus composed of four to five hyaline, non-geniculate coniform elements which include acodontiform P, acontiodontiform Sa, asymmetrical acontiodontiform/scandodontiform Sb, and drepanodontiform and/or distacodontiform types. Acontiodontiform, scandodontiform, and drepanodontiform/distacodontiform elements form a symmetry transition series. Elements of *Apteracontiodus* are homologous with pastinate P, alate Sa, tertiopedate/bipennate Sb/Sc, and quadriramate Sd elements of closely related *Pteracontiodus*.

Discussion.—Species of *Apteracontiodus* are parts of a plethora of Middle Ordovician forms with skeletons composed of a morphologically diverse assemblage of coniform or adenticulate ramiform elements. One subset of this group includes skeletal elements with abundant white matter and is assigned to *Rossodus* and *Tripodus* (see discussion of *Tripodus, p. 21*).

The other subdivision includes *Apteracontiodus* and *Pteracontiodus* and has skeletal elements lacking or nearly lacking in white matter. *Apteracontiodus* has a skeleton very similar to that of *Pteracontiodus* but lacks a geniculate coniform element. In addition, the short processes that are conspicuous on elements of *Pteracontiodus* are reduced or absent on homologous elements of *Apteracontiodus*.

Species of *Apteracontiodus* probably evolved from species of *Pteracontiodus*, possibly *P. larapintensis* (Crespin) or *P. brevibasis* (Sergeeva). Those species are reported to have an oistodontiform element (Cooper, 1981; van Wamel, 1974); however, the processes of their P and S elements are reduced and similar to those of *Apteracontiodus sinuosus*.

Apteracontiodus carinatus (Stouge)
Plate 5, Figures 4-6, 11

Trigonodus carinatus n. sp., Stouge, 1984, p. 80, pl. 6, figs. 1–7. An and Zheng, 1990, p. 174, pl. III, figs. 1– 15.
Distacodus sp. Bradshaw, 1969, p. 1149, pl. 131, figs. 3, 4.
Acontiodus robustus (Hadding), Bradshaw, 1969, p. 1148, pl. 131, figs. 8, 10, 13, 14.
Scandodus? sinuosus Mound, Bauer, 1987, p. 28, pl. 5, figs. 1, 2, 5, 7, 8; Bauer, 1989, p. 104, figs. 7.11, 7.12, 7.15-7.18.

Description.—Apparatus is composed of acodontiform P, acontiodontiform Sa, scandodontiform Sb, and drepanodontiform Sc elements. In addition to primary costae and keels, some elements bear a series of fine costae (e.g., Pl. 5, Figs. 4 and 5). Elements with fine costae are rare, generally large compared to the rest of the collection, and are assumed to represent intraspecific variation.

Remarks.—Stouge (1984) described acodontiform, acontiodontiform, scandodontiform, and distacodontiform elements in the hyaline apparatus of *Apteracontiodus carinatus*. Stouge's (1984) distacodontiform element is herein considered to be the same as those designated as drepanodontiform in Oil Creek collections.

Elements of *Apteracontiodus carinatus* are like those of *A. sinuosus*; however, the costae and keels of the former do not flare near the basal margin. The distinctive lateral costae on the distacodontiform element of *A. sinuosus* are reduced or absent from the corresponding element (drepanodontiform) of *A. carinatus*.

Ethington and Clark (1982) described *Scandodus sinuosus* from the lower Kanosh through Watson Ranch Formations of Utah and stated that the distacodontiform element is found in Kanosh samples but not at higher stratigraphic levels. The younger forms from the Lehman and Watson Ranch probably represent *A. carinatus*.

Occurrence.—Upper Joins and Oil Creek Formations. Species is also represented in the Table Head Formation of Newfoundland (Stouge, 1984); Fort Peña Formation, Texas (Bradshaw, 1969); lower McLish, Burgen, and Tyner Formations, Oklahoma (Bauer, 1987, 1989); and Ordovician strata in China (An and Zheng, 1990). Similar forms occur in Lehman and Watson Ranch Formations, Utah (Ethington and Clark, 1982).

Collection.—13,282 elements; 3,070 acodontiform, 822 acontiodontiform, 2,872 scandodontiform, 6,518 drepanodontiform.

Repository.—OSU 52091, 52092, 52093, 52098.

Apteracontiodus sinuosus (Mound)

Plate 5, Figures 13–15, 20, 21

Scandodus sinuosus Mound, 1965b, p. 33-34, pl. 4, figs. 21, 22, 24, text-fig. 1J.

Acodus campanula Mound, 1965b, p. 8-9, pl. 1, figs. 4, 5, non 6.

Acodus tetrahedron Lindström. Mound, 1965b, p. 9–10, pl. 1, figs. 7, 8.

Acontiodus curvatus Mound, 1965b, p. 11–12, pl. 1, figs. 19–21, text-fig. 1D.

Distacodus symmetricus Mound, 1965b, p. 16, pl. 2, fig. 2 (non figs. 1, 3).

Drepanodus homocurvatus Lindström. Mound, 1965b, p. 17, pl. 2, figs. 8, 10.

Drepanodus subarcuatus Furnish. Mound, 1965b, p. 19, pl. 2, figs. 14, 18, 19.

Paltodus variabilis Furnish. Mound, 1965b, p. 31, pl. 4, fig. 13, 14.

?*Scandodus dubius* Bradshaw, 1969, p. 1161, pl. 134, figs. 19–21.

?*Scandodus biconvexus* Bradshaw, 1969, p. 1161, pl. 134, figs. 16–18.

?*Scandodus brevibasis* (Sergeeva). Serpagli, 1974, p. 82-83, pl. 18, figs. 5a–7c; pl. 27, figs. 10, 11; pl. 30, figs. 2a–3.

?*Scandodus sinuosus* Mound. Ethington and Clark, 1982, p. 94–96, pl. 11, figs.1-4, non 5.

“*Scandodus*” sinuosus Mound. Sweet and others, 2005, table 1.

?*Trigonodus* sp. cf. *T. sinuosus* (Mound). Copeland and others, 1989, p. 8, pl. 1.4, fig.12.

Description.—Skeletal apparatus is composed of five hyaline, non-geniculate coniform elements. Acodontiform P element has erect to slightly reclined cusp. Cusp is anteriorly and posteriorly keeled and bears lateral costa. Keels and costa flare near basal margin.

Cusp of acontiodontiform Sa element is laterally costate and posteriorly keeled. Costae are symmetrically disposed and flare outward near basal margin. Asymmetrical acontiodontiform Sb element like acontiodontiform but displays varying degrees of asymmetry and represents transition to drepanodontiform morphology.

Drepanodontiform Sc element has erect to slight reclined cusp with anterior and posterior keels. Anterior keel flares near basal margin and is turned inward. Base is expanded inwardly.

Cusp of distacodontiform Sd element is reclined, anteriorly and posteriorly keeled, and laterally costate. Lateral costae are asymmetrically disposed. Keels and costae flare near basal margin. Drepanodontiform element is like distacodontiform element but lateral costae are reduced or absent.

Remarks.—Elements of *Apteracontiodus sinuosus* were described by Mound (1965b). The skeletal apparatus differs from that of closely related *Pteracontiodus brevibasis* and *P. larapintensis* by lacking an oistodontiform M element. Although collections containing *A. sinuosus* contain hyaline oistodontiform elements, those elements are considered to be part of co-occurring *Neomultioistodus compressus* or *Pteracontiodus cryptodens* based on their size, color, and abundance.

Occurrence.—*Apteracontiodus sinuosus* is represented in the Joins Formation. Similar forms are represented in the Fort Peña Formation (Bradshaw, 1969); Rockcliffe Formation, Ottawa (Copeland and others, 1989); San Juan Formation, Argentina (Serpagli, 1974); Antelope Valley Limestone, Nevada (Sweet and others, 2005); and Kanosh Formation, Utah (Ethington and Clark, 1982).

Collection.—2,747 elements; 660 acodontiform, 178 acontiodontiform, 577 asymmetrical acontiodontiform, 857 drepanodontiform, 475 distacodontiform.

Repository.—OSU 52100–52102, 52107, 52108.

Genus *Coleodus* Branson and Mehl, 1933

Type Species.—*Coleodus simplex* Branson and Mehl, 1933.

Coleodus species
Plate 6, Figure 18

Description.—Hyaline blade-like element with a series of short, basally fused, reclined denticles.

Remarks.—Fragmentary, hyaline blades are sparsely represented in the Joins and Oil Creek. Similar elements previously have been assigned to species of *Loxodus* and *Coleodus*. Ji and Barnes (1994), in their report on conodonts from St. George Group, described two new genera of bladelike forms, *Loxodentatus* and *Loxognathodus*, and redefined species of *Loxodus* to forms having albid or partially albid bladelike elements. *Loxodus latibasis* and *Loxodus bransoni* display coarse, reclined denticles similar to those of *Coleodus* sp.; however, elements of the latter are hyaline rather than albid. Similar forms described as *Loxodus* aff. *dissectus* and *Loxodus dissectus* by An and others (1983) and An and Zheng (1990), respectively, are presumed to be composed of albid elements.

Species of *Coleodus* are composed of highly variable, hyaline blade-like elements. Although most species of *Coleodus* are represented in considerably younger strata like the type species, *C. simplex*, from the Harding Sandstone (Branson and Mehl, 1933), this genus seems to be the best fit for the species represented in the Joins and Oil Creek. *Coleodus* sp. is reported from the Antelope Valley Limestone, Nevada (= "*Loxodus*" *curvatus*, Sweet and others, 2005). Species similar to *C*. sp. have been reported by Copeland and others (1989, = *C. pectiniformis*) from the Rockcliffe Formation, Ontario, and Bauer (1989, = *C. simplex*,) from the Tyner Formation of northeastern Oklahoma.

Occurrence.—Joins and Oil Creek Formations.

Repository.—OSU 52126.

Genus *Histiodella* Harris, 1962

Type Species.—*Histiodella altifrons* Harris, 1962.

Remarks.—McHargue (1982) published a detailed study of *Histiodella* based on large collections from the Joins and Oil Creek Formations. The typical skeletal apparatus of *Histiodella* is comprised of carminate P (bryantodontiform or spathognathodontiform), alate Sa and digyrate Sb (trichonodelliform and zygognathiform), bipennate Sc (= twisted bryantodontiform of McHargue, 1982), and geniculate coniform M (oistodontiform) elements.

Histiodella labiosa, n. sp.
Plate 2, Figures 10, 11, 13, 14

Histiodella n. sp. 2 Harris, Bergström, Ething– ton, and Ross, 1979, pl. 4, figs. 12, 13. Bauer, 1987, p. 20–21, pl. 2, fig. 6.
Histiodella n. sp. Bauer, 1989, p. 100–102, fig. 4.14, 4.16, 4.18, 4.19, 4.21, 4.22.
Histiodella sp. cf. *H*. n. sp. 2 Harris, Bergström, Ethington, and Ross. Bauer, 1989, p. 102, fig. 4.17.

Diagnosis.—Species of *Histiodella* distinguished from congeneric species by carminate P (described as Pa in this report) element that bears a denticulated upper margin and a prominent lip or shoulder at basal margin near midlength.

Description.—Skeletal apparatus is composed of alate Sa, digyrate Sb, geniculate coniform M, and two different types of carminate P elements.

Carminate Pa element has triangular outline. Upper margin is fully denticulated. Anterior process is distally bent. Basal cavity beneath cusp is produced as prominent lip or shoulder near the basal margin on the outer-lateral surface.

Carminate Pb element is denticulated along the upper margin anterior to the cusp. Posterior upper margin is smooth. Height and length are subequal.

Alate Sa element has two blade-like lateral processes broken by denticles along upper margin. Posterior process is short and adenticulate. Digyrate Sb element like alate but with asymmetrically disposed lateral processes.

Geniculate M coniform element has reclined, anteriorly and posteriorly keeled cusp. Anterior keel is smooth or serrated near the basal margin.

Discussion.—Harris and others (1979) illustrated *Histiodella labiosa* (= *Histiodella* n.

sp. 2) and recorded its occurrence in samples from the upper Antelope Valley Limestone, Nevada. *Histiodella labiosa* differs from closely related *H. holodentata* by the shape and features of its carminate element. These two species have overlapping ranges and probably evolved from a common ancestor, *H. sinuosa*, based on their morphological similarities and stratigraphic occurrences.

The ramiform and geniculate coniform elements of *Histiodella labiosa* are rare in Oil Creek collections. McHargue (1982) described a trend toward reduction of coniform and ramiform elements in *Histiodella* phylogeny. Primitive ramiform and geniculate coniform elements were apparently reduced in number in *H. labiosa* and may have disappeared altogether in younger populations.

Occurrence.—Oil Creek Formation. Bauer (1987, 1989) described *H. labiosa* from the McLish and Tyner Formations of Oklahoma. The species is also represented in the Antelope Valley Limestone (Harris and others, 1979).

Collection.—997 elements; 327 carminate Pa, 583 carminate Pb, 8 digyrate/alate, 18 geniculate coniform, 61 fragments.

Repository.—OSU 52031, 52032, 52034, 52035.

Genus *Neomultioistodus* Harris and Harris, 1965

Type Species.—*Multioistodus (Neomultioistodus) compressus* R.W. Harris and B. Harris, 1965.

Remarks.—Assignment of species to *Neomultioistodus* is based on rationale presented by Bauer (1987). In summary, species differ from those of *Multioistodus* by having a geniculate coniform M element; otherwise similar in basic skeletal structure. Denticle-bearing processes of skeletal elements are characterized by one laterally compressed denticle. Species of *Neomultioistodus* include *N. compressus* and two new species, *N. angulatus* and *N. erectus*, introduced in this report.

Neomultioistodus angulatus, n. sp.

Plate 3, Figures 9, 10, 12, 14, 16

Multioistodus compressus Harris and Harris. Bradshaw, 1969, p. 1153–1155, text-fig. 4W (right illustration), pl. 136, figs. 7, 9.

?*Multioistodus auritus* (Harris and Harris). Ethington and Clark, 1982, p. 58, pl. 6, figs. 5–7.

Diagnosis.—Species is distinguished from congeneric forms by morphology of P and S elements. In those elements, the upper margin of base and posterior edge of posterior denticle form an acute angle rather than a smooth curve.

Description.—Skeletal apparatus is quinquimembrate composed of pastinate P, geniculate coniform M, alate Sa, tertiopedate Sb, and dolabrate Sc. Elements are hyaline.

P element has long, recurved, anteriorly and posteriorly keeled cusp. Posterior process bears one reclined, laterally compressed denticle. Posterior edge of denticle forms acute angle with upper margin of base. Lateral process bears single, small denticle or node.

Geniculate coniform M has long, reclined, anteriorly and posteriorly keeled cusp. Inner-lateral surface is broadly carinate.

Sa element has long, recurved, laterally and posteriorly keeled cusp. Lateral processes are short and adenticulate. Posterior process bears one large, laterally compressed, reclined denticle. Sb like Sa but asymmetrical with one lateral process bearing a small denticle or node.

Sc element has long, recurved, anteriorly and posteriorly keeled cusp. Posterior process bears single reclined, laterally compressed denticle.

Remarks.—*Neomultioistodus angulatus* co-occurs with *N. compressus* in Oil Creek samples. The P element of *N. angulatus* is represented in older samples with S elements that are indistinguishable from those of *N. compressus*. Distinctive S elements are rare and represented only in younger samples of the Oil Creek. The M element of *N. compressus* and *N. angulatus* are identical.

Occurrence.—Middle to uppermost Oil Creek Formation. Species also occurs in the Fort Peña Formation, Texas (Bradshaw, 1969) and elements that appear similar are present in the Lehman Formation, Utah (Ethington and Clark, 1982).

Collection.—298 specimens; 249 P, 1 M, 10 Sa, 9 Sb, 29 Sc elements.

Repository.—OSU 52052, 52053, 52055, 52057, 52059.

Neomultioistodus erectus, n. sp.
Plate 3, Figures 15, 17–20

Diagnosis.—P and S elements distinguished from those of congeneric species by short, erect cusp.

Description.—Quinquimembrate apparatus is composed of pastinate P, geniculate coniform M, alate Sa, tertiopedate Sb, and dolabrate Sc. P and S elements bear short, erect cusp. Cusp and denticles of most elements have some white matter.

Cusp of P element is short, erect, anteriorly and posteriorly keeled and bears an inner lateral costa. Posterior process has one large, laterally compressed denticle. Anterior process is adenticulate. Lateral process is adenticulate or bears a single short, compressed denticle.

M element has anteriorly and posteriorly keeled, laterally compressed, reclined cusp. Inner lateral surface is carinate.

Cusp of Sa and Sb elements is short, erect, laterally costate, and posteriorly keeled. Lateral processes of Sa and Sb bear single antero-posteriorly compressed denticle. Posterior process is adenticulate or has one small, compressed denticle.

Sc has laterally compressed, erect cusp. Posterior process has large, laterally compressed denticle.

Occurrence.—*N. erectus* is represented in the Joins Formation.

Collection.—419 elements; 139 P, 43 M, 28 Sa, 127 Sb, 82 Sc.

Repository.—OSU 52058, 52060 – 52063.

Neomultioistodus ? clypeus (Mound)
Plate 6, Figure 25

Tricladiodus clypeus Mound, 1965a, p. 198-200, figs. 3–11.

Description.—Skeletal apparatus is composed of pastinate P and a symmetry transition series of ramiform elements. Elements are hyaline. Pastinate element has short, erect cusp and short posterior and lateral processes each bearing a single, broad flat denticle. Anterior process directed downward and typically has a short, stubby denticle.

Ramiform elements include alate and tertiopedate elements. Alate Sa element with long, laterally costate and posteriorly keeled cusp. Lateral processes are short and bear a single, compressed denticle. Posterior process is short and either bears a single small denticle or is adenticulate. Tertiopedate like alate but processes are asymmetrically disposed with respect to the cusp.

Discussion.—The pastinate element (= *Tricladiodus clypeus* of Mound, 1965a) of *Neomultioistodus? clypeus* co-occurs with elements of *N. erectus* and, in an earlier report (Bauer, 1987), was included in the apparatus of that species. Based on collections recently provided by Dr. Timothy R. McHargue, it is clear that *N.? clypeus* is distinct from *N. erectus*. The P element of the latter does not have a denticulate anterior process and contains white matter. Homologous ramiform elements of *N. erectus* and *N.? clypeus* are similar. In small collections of *N.? clypeus*, the skeletal apparatus does not appear to have a geniculate coniform element; consequently, genus assignment is questionable.

Occurrence.—Lowermost Joins Formation.

Repository.—OSU 52133.

Genus *Oistodus* Pander, 1856

Type species.—*Oistodus lanceolatus* Pander, 1856.

Remarks.—Multielement species of *Oistodus* are represented throughout the Joins and Oil Creek Formations. Most elements representing species of *Oistodus* are assigned to *O. multicorrugatus* and conform to the species description given by Ethington and Clark (1982). In samples from the Oil Creek Formation, two additional distinctive morphologies appear with elements typical of *O. multicorrugatus*. One is an element that Ethington and Clark (1982) assigned to *O. cristatus*. Ethington and Clark (1982) stated that the elements of *O. cristatus* might represent a morphotype of the cordylodiform element of *O. multicorrugatus*. The other element is dolabrate with a prominent denticle on the posterior process. That element is herein considered to represent a new species of *Oistodus*.

***Oistodus* n. sp.**
Plate 1, Figure 12

Multioistodus sp. Bradshaw, 1969, p. 1155, pl. 136, figs. 5 and 6, text-fig. 4 X.
Belodina? sp. Pyle and Barnes, 2003, fig. 11.9.
Oistodus n. sp. Sweet and others, 2005, p.

39, pl. 1, fig. 31.

Description.—Dolabrate element has reclined, posteriorly and anteriorly keeled cusp. Inner lateral surface of cusp has three or more costae. Posterior process has one large, reclined, laterally compressed denticle. Base is capacious, expanded posteriorly. Element is hyaline.

Discussion.—*Oistodus* n. sp. is probably multimembrate with an apparatus similar to its likely ancestor, *O. multicorrugatus*. The distinctive dolabrate element is commonly broken at the juncture between the cusp and posterior denticle, which gives the appearance of two distinct elements.

Sweet and others (2005) described *Oistodus* n. sp. from samples of the Antelope Valley Limestone taken at Martin Ridge. Those authors indicated that *O*. n. sp. is useful for the purposes of graphic correlation of Whiterockian strata.

Oistodus multicorrugatus probably gave rise to two descendants, *O. cristatus* and *O*. n. sp., based on morphological similarities and stratigraphic occurrences. Ethington and Clark (1982) described the diagnostic element of *O. cristatus* from the upper Kanosh Formation, Utah. The diagnostic element of *O*. n. sp. was described and illustrated by Bradshaw (1969,= *Multioistodus* sp.) from the Fort Peña Formation. Bradshaw (1969) noted similarities between *O*. n. sp. and a species she referred to *O. lanceolatus* (= *O. multicorrugatus*).

Occurrence.—*Oistodus* n. sp. is represented in the lower to middle Oil Creek Formation, the Fort Peña Formation, Texas (Bradshaw, 1969); Skoki Formation, British Columbia (Pyle and Barnes, 2003); and Whiterockian strata in Nevada (Sweet and others, 2005).

Repository.—OSU 52012.

Genus *Paraprioniodus* Ethington and Clark, 1982

Type species.—*Tetraprioniodus costatus* Mound, 1965b.

Remarks.—Ethington and Clark (1982) established *Paraprioniodus* and included species with "two kinds of prioniodiform elements and a transition series of ramiform elements" (p. 77, Ethington and Clark, 1982). Elements are mostly hyaline although some may have small amounts of white matter dispersed in their denticles.

Paraprioniodus costatus (Mound)

Plate 4, Figures 10, 14–16, 19, 20, 22

Tetraprioniodus costatus Mound, 1965b, pl. 4, p. 34–35, figs. 19, 25, 31.
Cordylodus delicatus Branson and Mehl. Mound, 1965b, p. 14, pl. 1, figs. 25, 28, 30.
Dichognathus extensa Branson and Mehl. Mound, 1965b, p. 15, pl. 1, fig. 27.
Dichognathus typica Branson and Mehl. Mound, 1965b, p. 15-16, pl. 1, fig. 29.
Oistodus linguatus Lindström. Mound, 1965b, p. 27–28, pl. 3, fig. 36.
Ozarkodina delecta Stauffer. Mound, 1965b, p. 30–31, pl. 4, fig. 15.
Tetraprioniodus robustus? Lindström. Mound, 1965b, p. 35–36, pl. 4, fig. 29, non figs. 28, 33.
?"*Eoneoprioniodus*" sp. Barnes, 1977, p. 102, pl. 2, figs. 1, 2.
? "*Prioniodus*" n. sp. Harris and others, 1979, pl. 1, figs. 13–15.
?*Paraprioniodus costatus* (Mound). Brezinski and others, 1999, fig. 3B.

Emended diagnosis.—Species of *Paraprioniodus* with a geniculate coniform M element.

Description.—Skeletal apparatus is composed of pastinate Pa and Pb, geniculate coniform M, alate Sa, tertiopedate Sb, dolabrate Sc elements, and quadriramate Sd element.

Remarks.—Two species of *Paraprioniodus* are recognized from Joins–Oil Creek collections, one that bears a dolabrate M element and the other with a geniculate coniform M element. The former is described by Ethington and Clark (1982) as *P. costatus* but, in this report, is considered to be a younger species, *P. neocostatus*, n. sp.

Elements of *Paraprioniodus costatus* were first described by Mound (1965b) from the Joins Formation. Collections of *Paraprioniodus* from the Joins yield a skeletal apparatus with a geniculate coniform M element.

Occurrence.—*Paraprioniodus costatus* occurs in the Joins and middle Oil Creek Formations. It also is reported from the Burgen Sandstone, northeastern Oklahoma (Bauer, 1989); and the Antelope Valley Limestone at Martin Ridge, Nevada (Sweet and others, 2005). In addition, elements of *Paraprioniodus* have been described from several North American sites (Barnes, 1974; Barnes, 1977; Brezinski and others, 1999); however, the M-element is not illustrated in those reports.

Collection.—830 elements; 263 P, 71 M, 436 S, 60 fragments.

Repository.—OSU 52073, 52077, 52078, 52079, 52082, 52083, 52085.

Paraprioniodus neocostatus, n. sp.

Plate 4, Figures 4, 5, 8, 9, 12, 13, 18

Paraprioniodus costatus Mound. Ethington and Clark, 1982, p. 77–79, pl. 8, figs. 20–26. Rexroad and others, 1982, p. 9, pl. 1, figs. 7–20, 22–26. fig. 7. Bauer, 1989, p. 103, figs. 6.10, 6.13–6.23. Pyle and Barnes, 2003, figs. 12.21-12.28.

Eoneoprioniodus? sp. 2 Stouge, 1984, p. 79, pl. 15, figs. 14, 17–20.

Paraprioniodus sp. cf. *P. costatus* (Mound). Bauer, 1987, p. 23–24, pl. 3, figs. 6, 8, 11-13, 16.

?*Eoneoprioniodus*? sp. 1 Stouge, 1984, p. 78–79, pl. 15, figs. 7, 13, 15, 16.

Diagnosis.—Species of *Paraprioniodus* that differs from congeneric species by having a dolabrate M element.

Description.—Skeletal apparatus is composed of pastinate P, dolabrate M, alate Sa, tertiopedate Sb, dolabrate or bipennate Sc, and quadriramate Sd.

P elements have erect, anteriorly and posteriorly keeled cusp. Processes are variable in length. Lateral and anterior process of Pa element is directed horizontally. Lateral process of Pb element is directed downward.

Cusp of M element is anteriorly and posteriorly keeled. Posterior process is short, with erect to reclined denticles. Base is inwardly expanded.

Cusp of Sa element is erect to recurved and has lateral and posterior keels. Lateral processes are short, posteriorly directed, and adenticulate or may bear several small denticles. Posterior process is long and bears a series of erect, subequal denticles. Sb is like Sa but lateral processes are asymmetrically disposed.

Sc element has anteriorly and posteriorly keeled, laterally compressed cusp. Posterior process is long with a series of erect to distally reclined, subequal denticles. Anterior keel is commonly developed into a short, adenticulate to weakly denticulate, inwardly deflected process.

Sd element has erect to recurved, anteriorly and posteriorly keeled, laterally costate cusp. Anterior process is short and adenticulate. Lateral processes are short and adenticulate or may bear several small denticles. Posterior process is long and denticulate.

Remarks.—Elements of *Paraprioniodus neocostatus* show a high degree of variability both in process development and denticulation. An earlier report (Bauer, 1989) recognized two morphotypes, one with widely spaced denticles and the other with closely spaced, basally fused denticles. These morphotypes are considered to represent ontogenetic or intraspecific variation.

Occurrence.—*Paraprioniodus neocostatus* is represented in the middle to upper Oil Creek Formation. Ethington and Clark (1982) illustrated *P. neocostatus* from Lehman and Watson Ranch Formations, Utah; Bauer (1989) from the Tyner Formation, northeastern Oklahoma; Rexroad and others (1982) from Everton Dolomite, Indiana; Stouge (1984) from the Table Head Formation, Newfoundland; and Pyle and Barnes (2003) from the Skoki Formation, British Columbia. *P. neocostatus* is also reported from the Antelope Valley Limestone, Nevada (= *P*. n. sp. in Sweet and others, 2005).

Collection.—752 elements; 160 P, 107 M, 389 S, 96 fragments.

Repository.—OSU 52067, 52068, 52071, 52072, 52075, 52076, 52081.

Genus *Prioniodus* Pander 1856

Type Species.—*Prioniodus elegans* Pander, 1856.

Discussion.—Sweet (1988) summarized the differences among species of *Prioniodus*, *Oepikodus*, and *Baltoniodus*. Zhen and others (2005) more recently described differences between *Prioniodus* and *Oepikodus*. Species of *Prioniodus* differ from those of *Baltoniodus* by having one type of P element (pastinate) and from those of *Oepikodus* by having morphologically diverse S elements including alate, tertiopedate, bipennate, and quadriramate. In species of *Oepikodus*, the S position is occupied by a series of quadriramate elements.

Prioniodus n. sp.

Plate 4, Figures 17, 21, 23, 24

cf. *Prioniodus amadeus* n. sp. Cooper, 1981, p.173–174, pl. 31, figs. 1–3, 5, 6, 8, 9.
cf. *Gothodus costulatus* Lindström. Lindström, 1971, p. 54–55, pl. 1, figs. 1–5. Bagnoli and Stouge, 1997, p. 140–141, pl. 2, figs. 10–17.
cf. aff. *Oepikodus minutus* (McTavish). Ethington and Clark, 1982, p. 62-65, pl. 6, figs. 19, 23, 24, 26-28.
cf. *Baltoniodus communis* (Ethington and Clark). An, 1987, p. 125–126, pl. 19, figs. 1–11.

Description.—Apparatus is seximembrate composed of pastinate P, bipennate M, alate Sa, tertiopedate Sb, bipennate Sc, and quadriramate Sd. Denticles contain white matter. Pastinate element has erect, anteriorly and posteriorly keeled cusp with innerlateral costa. Posterior process is relatively long, slightly twisted, with closely spaced, proximally erect and distally reclined denticles. Lateral process is short and either adenticulate or with several small denticles.

M element has reclined, anteriorly and posteriorly keeled cusp. Posterior process is short and adenticulate. Anterior process is short and adenticulate or bears several small denticles.

Sa element has proclined, laterally and posteriorly costate cusp. Posterior process is long with closely spaced, subequal denticles. Lateral processes are adenticulate. Sb element is like Sa, but lateral processes are asymmetrically disposed.

Sc element has erect cusp and long, denticulate posterior process. Denticles are small and subequal. Anterior process is adenticulate and laterally deflected. Sd element is like Sc but has lateral costae.

Discussion.—Cooper's (1981) illustration of the skeleton of *Prioniodus amadeus* from the Horn Valley Siltstone is similar to that of *Prioniodus* n. sp.; however, one of the illustrated prioniodontiform elements of *P. amadeus* has a relatively long, denticulate lateral process not observed in the small collections of *P*. n. sp. In addition, the M element of *P. amadeus* is described as oistodontiform whereas the M position in *P*. n. sp. is occupied by a bipennate (falodontiform) element.

Bagnoli and Stouge (1997) illustrated *Gothodus costulatus* from samples of the Orthoceras Limestone, Sweden. In their report, they emended the description of *Gothodus* and separated it from *Prioniodus*, presumably based on its apparatus having two distinct P elements rather than one. The illustrated Pa and Pb elements of *G. costulatus* are very similar and almost indistinguishable. The apparatus of *G. costulatus* is similar to that of *P. amadeus*. Like *P. amadeus*, it differs from *P.* n. sp. by having an oistodontiform M element.

Zhen and others (2005) illustrated a new species of *Prioniodus*, *P*. *honghuayuanensis*, and another species that was described in open nomenclature as *Prioniodus* sp. The latter has a skeletal apparatus that is similar to that of *P*. n. sp. but has two P elements. *P. honghuayuanensis* also has two P elements.

Occurrence.—Lower Joins Formation.

Collection.—327 elements; 85 P, 102 M, 27 Sa, 53 Sb, 60 Sc/Sd.

Repository.—OSU 52080, 52084, 52086, 52087.

Prioniodus ? species

Plate 6, Figures 3, 6, 7, 11, 14

Haddingodus? aff. *H. serra* Sweet and Bergström. Mound, 1965b, p. 20–21, pl. 2, figs. 21, 28.
Pravognathus idoneus (Stauffer). Mound, 1965b, p. 31–32, pl. 4, fig. 23.

Description.—Skeletal apparatus is seximembrate. Pa element is carminate with flexed posterior process bearing short, basally fused denticles. Anterior process is bladelike with laterally costate, basally fused denticles.

Pb element pastinate with short, laterally compressed, anteriorly and posteriorly keeled cusp. Posterior process bears short, basally fused, reclined denticles. Anterior process directed downward with several small denticles. Lateral process is short, adenticulate bar or knob.

M element is angulate with blunt, laterally compressed, anteriorly and posteriorly keeled cusp. Anterior process directed downward; anterior edge broken by several small denticles. Posterior process is short and adenticulate.

Sa element is alate with recurved, posteriorly and laterally keeled cusp. Posterior process is long with short, reclined denticles. Lateral processes are short and adenticulate.

Sb-Sc elements grade from digyrate to bipennate. Digyrate Sb has proclined cusp. One lateral process is relatively long and bears short denticles. Other lateral process is short and adenticulate. Sc element is bipennate with long denticulate posterior process and short adenticulate anterior process.

Remarks.—Elements of *Prioniodus*? sp. occur in several samples in the lower Joins Formation. The apparatus is similar to that of *Prioniodus* or *Baltoniodus* although a variety of characters (e.g., cusp of Sa element, denticles of P and S elements) are different from previously reported species of those genera.

Occurrence.—Lower to middle Joins Formation.

Collection.—188 elements; 14 Pa, 50 Pb, 55 M, 14 Sa, 55 Sb-Sc.

Repository.—OSU 52111, 52114, 52115, 52119, 52122.

Genus *Pteracontiodus* Harris and Harris, 1965

Type species.—*Pteracontiodus aquilatus* R.W. Harris and B. Harris, 1965. *Eoneoprioniodus* Mound, 1965a. *Trigonodus* Nieper, 1969. ?*Triangulodus* van Wamel, 1974.

Discussion.—*Pteracontiodus* was established by R.W. Harris and B. Harris (1965) for specimens from the West Spring Creek Formation, Oklahoma. Ethington and Clark (1982) described the multielement apparatus of *Pteracontiodus cryptodens* and *P. gracilis*. *Pteracontiodus* is defined by a skeletal apparatus composed of hyaline pastinate, geniculate coniform, and ramiform elements. The cusp of ramiform elements may have two, three or four costae, which are extended into short, adenticulate processes. The upper edge of lateral processes is commonly albid.

Species now recognized as *Pteracontiodus* have been classified as *Scandodus* (Lindström, 1971), *Eoneoprioniodus* (Mound, 1965b), *Trigonodus* (Nieper, 1969; Cooper, 1981), and *Triangulodus* (van Wamel, 1974). Sweet (1988) considered the last three to be junior synonyms of *Pteracontiodus*. Wang (1992) reported *Trigonodus* to be an invalid name because it had been used previously for a bivalve genus.

Triangulodus was defined by van Wamel (1974) who included species that had a mix of albid and hyaline elements. It is unclear whether species of *Triangulodus* belong in *Pteracontiodus* or rather represent elements from species in separate genera (see Zhen and others, 2006, for additional discussion).

Lindström (1971) emended *Scandodus* and described the type species, *S. furnishi*, as having coniform elements that lack costae. *S. brevibasis* has an apparatus composed of costate coniform elements comparable to those of *Pteracontiodus* and is herein reassigned to that genus.

Pteracontiodus cryptodens (Mound)
Plate 5, Figures 12, 16–19

Eoneoprioniodus cryptodens Mound, 1965a, p. 197-198, text-figs. 1, 2, 12, 13. Mound, 1965b, p. 19.
Acodus auritus Harris and Harris. Mound, 1965b, p. 8, pl. 1, figs. 1–3.
Acodus tripterolobus Mound, 1965b, p. 10, pl. 1, figs. 10–13 (non fig. 9).
Acontiodus bialatus Mound, 1965b, p.11–12, pl. 1, figs. 16–18 (non fig. 24), text-fig. 1C.
?*Oistodus linguatus* Lindström. Mound, 1965b, p. 27–28, pl. 3, fig.36.
Tetraprioniodus robustus? Lindström. Mound, 1965b, p. 35–36, pl. 4, figs. 28, 29, 33.
?*Acodus auritus* R.W. Harris and B. Harris, 1965, p. 34–35, pl. I, fig. 2.
Pteracontiodus cryptodens (Mound). Ethington and Clark, 1982, p. 88–89, (synonymy to date) pl. 10, figs.1–4, 6–10. Ji and Barnes, 1994, p. 55, pl. 16, figs. 19-26. Albanesi, 1998, p. 148-149, pl. 10, figs. 25-32, text-fig. 21.

Description.—*Pteracontiodus cryptodens* was originally described by Mound (1965a, 1965b) and assigned to *Pteracontiodus* by Ethington and Clark (1982). *P. cryptodens* has an apparatus composed of hyaline elements that include pastinate P, geniculate coniform M, alate Sa, tertiopedate Sb, bipennate Sc, and quadriramate Sd. Processes are short, adenticulate, and commonly have white matter along their upper margin.

Occurrence.—Occurs throughout the Joins and Oil Creek. *Pteracontiodus cryptodens* is reported from the Kanosh Formation, Utah (Ethington and Clark, 1982); Antelope

Valley Limestone, Nevada (Sweet and others, 2005); St. George Group, western Newfoundland (Ji and Barnes, 1994); Ship Point Formation (Barnes, 1977); and San Juan Formation, Argentina (Albanesi, 1998).

Collection.—3,697 elements; 1199 P, 577 M, 202 Sa, 919 Sb/Sd, 800 Sc.

Repository.—OSU 52099, 52103–52106.

***Pteracontiodus* ? *gracilis* Ethington and Clark**

Plate 5, Figures 8-10

Pteracontiodus gracilis Ethington and Clark, 1982, p. 90, pl. 10, figs. 11–13, 17.

Remarks.—Ethington and Clark (1982) described trichonodelliform (alate), distacodontiform (quadriramate), cordylodontiform (bipennate), and oistodontiform elements of *Pteracontiodus? gracilis*. All but the oistodontiform element are represented in samples from the Oil Creek Formation. *P.? gracilis* apparently lacks a pastinate element which is prominent in the apparatus of *P. cryptodens*. In addition, the oistodontiform element of *P.? gracilis* illustrated by Ethington and Clark (1982) is significantly different from those of *P. cryptodens* and other species of *Pteracontiodus*.

Occurrence.—Middle to upper Oil Creek Formation. Species is reported from the Lehman Formation, Utah (Ethington and Clark, 1982) and the Antelope Valley Limestone (Sweet and others, 2005).

Repository.—OSU 52095 – 52097.

Genus *Tripodus* Bradshaw, 1969

Type species.—*Tripodus combsi* (Bradshaw).

Discussion.—Previous authors (Lindström, 1977; Kennedy, 1980; Ethington and Clark, 1982; Stouge, 1984; Sweet, 1988; Stouge and Bagnoli, 1988; Ji and Barnes, 1990; Albanesi, 1998; among others) have attempted to resolve the taxonomic confusion concerning Early to Middle Ordovician conodont species that have skeletal apparatuses with morphologically diverse coniform elements (includes species previously assigned to *Acodus*, *Diaphorodus*, *Tropodus*, *Scandodus*, *Trigonodus*, *Triangulodus*, *Tripodus*). The presence or absence of white matter is assumed to be taxonomically significant. Skeletons of species assigned to *Acodus*, *Diaphorodus*, *Tropodus*, and *Tripodus* have been reported to have white matter. These species are closely related and probably congeneric. Kennedy (1980) and Sweet (1988) regarded *Acodus* as a *nomen dubium* because of multielement uncertainties with the type species, *Acodus erectus* Pander. *Tripodus* was established by Bradshaw (1969) and has priority over the other generic names.

Species of *Tripodus* have a skeletal apparatus composed of acodontiform P elements, oistodontiform M, acontiodontiform Sa, distacodontiform or paltodontiform Sb, and drepanodontiform Sc elements. Cusp of all elements is albid.

***Tripodus combsi* (Bradshaw)**

Plate 6, Figures 1, 2, 9, 10, 12

Acodus combsi Bradshaw, 1969, p.1147, pl. 132, figs. 11, 12. Stouge, 1984, p. 76, pl. 14, figs. 13–19.

Scolopodus alatus Bradshaw, 1969, p. 1162, pl. 132, figs. 1-4.

Tripodus laevis Bradshaw, 1969, p. 1164, pl. 135, figs. 9, 10.

Tripodus combsi (Bradshaw). Sweet and others, 2005, p. 39-41, pl. 1, figs. 25–30.

Tripodus laevis Bradshaw. Ethington and Clark, 1982, p. 110-112, pl. 12, figs. 24, 25, 27-29, text-fig. 33.

“*Scandodus*” *robustus* Serpagli. Ethington and Clark, 1982, p. 94, pl. 10, figs. 25-27.

Description.—Skeletal apparatus composed of coniform elements with albid cusps. Acodontiform P element with short, erect to slightly reclined, keeled cusp bearing a carina on inner lateral surface. Base is expanded inwardly. Oistodontiform M element has reclined, keeled cusp. Acontiodontiform Sa element has erect, laterally costate and posteriorly keeled cusp. Costae are developed as wing-like extensions near the basal margin. Asymmetrical acontiodontiform or distacodontiform Sb has relatively long posterior process and two well developed lateral costae. Some Sb elements have an additional fine costa that terminates above the basal margin. Drepanodontiform Sc element with erect, anteriorly and posteriorly keeled cusp. Inner lateral surface has fine costae.

Remarks.—*Tripodus combsi* is poorly represented in samples from the Oil Creek

Formation. The entire skeletal apparatus does not occur in any one sample; however, the multielement apparatus can be reconstructed from several closely spaced samples.

Bradshaw (1969) described form species *Acodus combsi*, *Scolopodus alatus*, and *Tripodus laevis* from the Fort Peña Formation, Texas. Ethington and Clark (1982) established the multielement species *T. laevis* by comparing Bradshaw's (1969) specimens with those that they collected from the Upper Wah Wah and Juab Formations from the Ibex Area, Utah. They included oistodontiform M and a symmetry transition series of trichonodelliform Sa, distacodontiform Sb, and drepanodontiform Sc elements in their skeletal reconstruction. Later, Ethington (personal communication) added an acodontiform P element in his reconstruction.

Stouge (1984) described the multielement species *Acodus combsi* from the Table Head Formation. His skeletal reconstruction incorporated prioniodontiform (acodontiform) P, oistodontiform M, and a symmetry transition series of ramiform elements. Those elements compare favorably with ones recovered from the Oil Creek Formation. *A. combsi* is represented in the *Histiodella kristinae* Zone of the Table Head Formation.

Dr. Ethington provided comparative specimens of *Tripodus laevis* collected from the Whiterock Canyon section, Monitor Range, Nevada. Based on those specimens, *T. laevis* appears to have two types of acodontiform P elements, one with a lateral costa that is well defined at the basal margin and another that has a broad flat cusp and bears a short, sharp-edged process. The former is similar to those recovered from the Oil Creek but the latter has no counterpart in the collection. Forms represented in the Oil Creek and Whiterock Canyon section may represent two distinctive species.

Sweet and others (2005) described *Tripodus combsi* occurrences in the Antelope Valley Limestone. Their illustrated elements of *T. combsi* are consistent with those in Oil Creek collections.

Occurrence.—Oil Creek Formation.

Collection.—49 elements; 21 P, 5 M, 9 Sa, 8 Sb, 6 Sc.

Repository.—OSU 52109, 52110, 52117, 52118, 52120.

Tripodus species

Plate 6, Figures 4, 5, 8, 15

Description.—Skeletal apparatus is composed of at least four different types of coniform elements including acodontiform, geniculate coniform, acontiodontiform, and scandodontiform elements. Elements are albid.

Acodontiform element has erect, posteriorly keeled, anteriorly rounded cusp with capacious basal cavity. Inner lateral surface bears a costa that is turned posteriorly near the basal margin.

Geniculate coniform element has wide, compressed, keeled cusp. Posterior margin of cusp joins the base at nearly a right angle. Base is expanded inwardly.

Acontiodontiform element has posteriorly keeled and laterally costate cusp. Costae are extended near basal margin. Scandodontiform element has compressed, anteriorly and posteriorly keeled cusp. Anterior keel is turned inward near basal margin. Base is expanded inwardly.

Remarks.—*Tripodus* sp. has a skeletal apparatus similar to that of *T. combsi* (as described in this report); however, the elements are larger, the geniculate coniform M is distinctively different and the processes on the acontiodontiform Sa are more widely flaring.

Occurrence.—Joins Formation.

Collection.—186 elements; 50 acodontiform, 28 geniculate coniform, 9 acontiodontiform, 99 scandodontiform.

Repository.—OSU 52112, 52113, 52116, 52123.

New genus and species

Plate 6, Figure 26

Description.—Species is represented by acodontiform element with laterally compressed, anteriorly and posteriorly keeled cusp. Anterior margin is broken by several serrations. Lateral process is developed near basal margin. Basal cavity is shallow and narrow.

Occurrence.—Joins Formation.

Repository.—OSU 52134.

Genus and species indeterminate 1

Plate 6, Figure 20

Description.—Species is represented by geniculate coniform element with erect to slightly reclined, albid cusp. Base is shallow and flares inwardly.

Remarks.—Several samples in the lower Joins contain geniculate coniform elements that have no apparent link to multielement species.

Occurrence.—Joins Formation.

Repository.—OSU 52128.

Genus and species indeterminate 2
Plate 6, Figure 23

Description.—Species is represented by small, hyaline, pastinate element with shallow basal cavity. Cusp is short, anteriorly and posteriorly keeled. Posterior process is bladelike with several denticles. Anterior process is short and denticulate. Lateral process is short and adenticulate or may bear several small denticles.

Remarks.—Elements occur in the uppermost sample of the West Spring Creek Formation (initially thought to be the lowermost sample of the Joins Formation) and co-occur with pastinate elements of *Neomultioistodus? clypeus* with which they share similarities. Both are small, hyaline elements; however, the pastinate element of *N.? clypeus* has only one broad, flattened denticle on each of its processes.

Occurrence.—West Spring Creek Formation.

Repository.—OSU 52131.

Genus and species indeterminate 3
Plate 6, Figures 22, 24

Description.—Skeleton is composed of at least two types of pastinate elements. One type has short, thin cusp and bladelike posterior and anterior processes with several apically discrete denticles. Lateral process is developed as a short knob near base. Basal cavity is shallow.

Other pastinate element has erect to slightly reclined cusp. Posterior and lateral processes bear one to two flattened denticles. Anterior process is short and adenticulate.

Occurrence.—Oil Creek Formation.

Repository.—OSU 52130, 52132.

Genus and species indeterminate 4
Plate 6, Figures 13, 17

Description.—Skeletal apparatus includes dolabrate and bipennate elements. Dolabrate element has short, stubby cusp and long posterior process which bears small, posteriorly inclined denticles. Inner surface has a subtle knob near the anterobasal margin. Bipennate element has a short adenticulate posterior process and long finely serrated, downwardly directed anterior process.

Occurrence.—Joins Formation.

Repository.—OSU 52121, 52125.

Genus and species indeterminate 5
Plate 6, Figure 16

Description.—Alate? element with deep basal cavity. Processes adenticulate.

Remarks.—Skeletal morphology of Genus and species indeterminate 5 is similar to that of the triangular element of *Ansella jemtlandica*; however, the posterior process of *A. jemtlandica* is broken by fine denticulation.

Occurrence.—Joins Formation.

Repository.—OSU 52124.

Genus and species indeterminate 6
Plate 6, Figure 21

Description.—Bipennate element. Short cusp; posterior process with basally fused denticles; anterior process is turned inward and is nearly equal in length to the posterior process. Processes bear ledges near juncture with denticles.

Remarks.—Genus and species indeterminate 6 is represented by 6 elements in the lower to middle Joins. The ledges on the processes are similar to those on some of the elements of *Fahraeusodus marathonensis* with which it co-occurs.

Occurrence.—Lower Joins Formation.

Repository.—OSU 52129.

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PLATES

PLATE 1
Conodont Species in the Joins

Figures

1, 2, 4, 5	***Ansella jemtlandica***. *Figure 1*, geniculate coniform M, X88, OSU 52001; *Figure 2*, planoconvex Sc, X69, OSU 52002; *Figure 4*, triangular Sa, X69, OSU 52004; *Figure 5*, biconvex P, X62, OSU 52005; all specimens from sample 72SC-320.
3	***Chosonodina lunata***. X56, OSU 52003, sample 72SB-0.
6, 7, 10	***Drepanoistodus angulensis.*** *Figure 6*, geniculate coniform M, X71, OSU 52006; *Figure 7*, drepanodontiform Sb, X88, OSU 52007; *Figure 10*, suberectiform Sa, X90, OSU 52010; all specimens from sample 72SB-127.
8	***Oistodus cristatus***. X46, OSU 52008, sample 72SC-90.
9	***Chosonodina rigbyi***. X111, OSU 52009, sample 72SC-510.
11, 15, 19	***Oistodus multicorrugatus.*** *Figure 11*, costate cordylodontiform Sb, X40, OSU 52011, sample 72SC-580; *Figure 15*, acodontiform P, X15, OSU 52015, sample 72SC-160; *Figure 19*, non-costate cordylodontiform M, X74, OSU 52019, sample 72SC-350.
12	***Oistodus*** n. sp. dolabrate element, X22, OSU 52012, sample 72SC-160.
13,14, 16,17, 20, 21	***Fahraeusodus marathonensis***. *Figure 13*, geniculate coniform M, X69, OSU 52013, sample 72SC-20; *Figure 14*, bipennate Sc, X78, OSU 52014, sample 72SB-49; *Figure 16*, tertiopedate Sb, X90, OSU 52016, sample 72SC-20; *Figure 17*, alate Sa, X76, OSU 52017, sample 72SB-49; *Figure 20*, alate Sa, X89, OSU 52020, sample 72SB-73; *Figure 21*, dolabrate P, X65, OSU 52021, sample 72SB-73.
18	***Dischidognathus primus***. X103, OSU 52018, sample 72SC-510.

PLATE 1

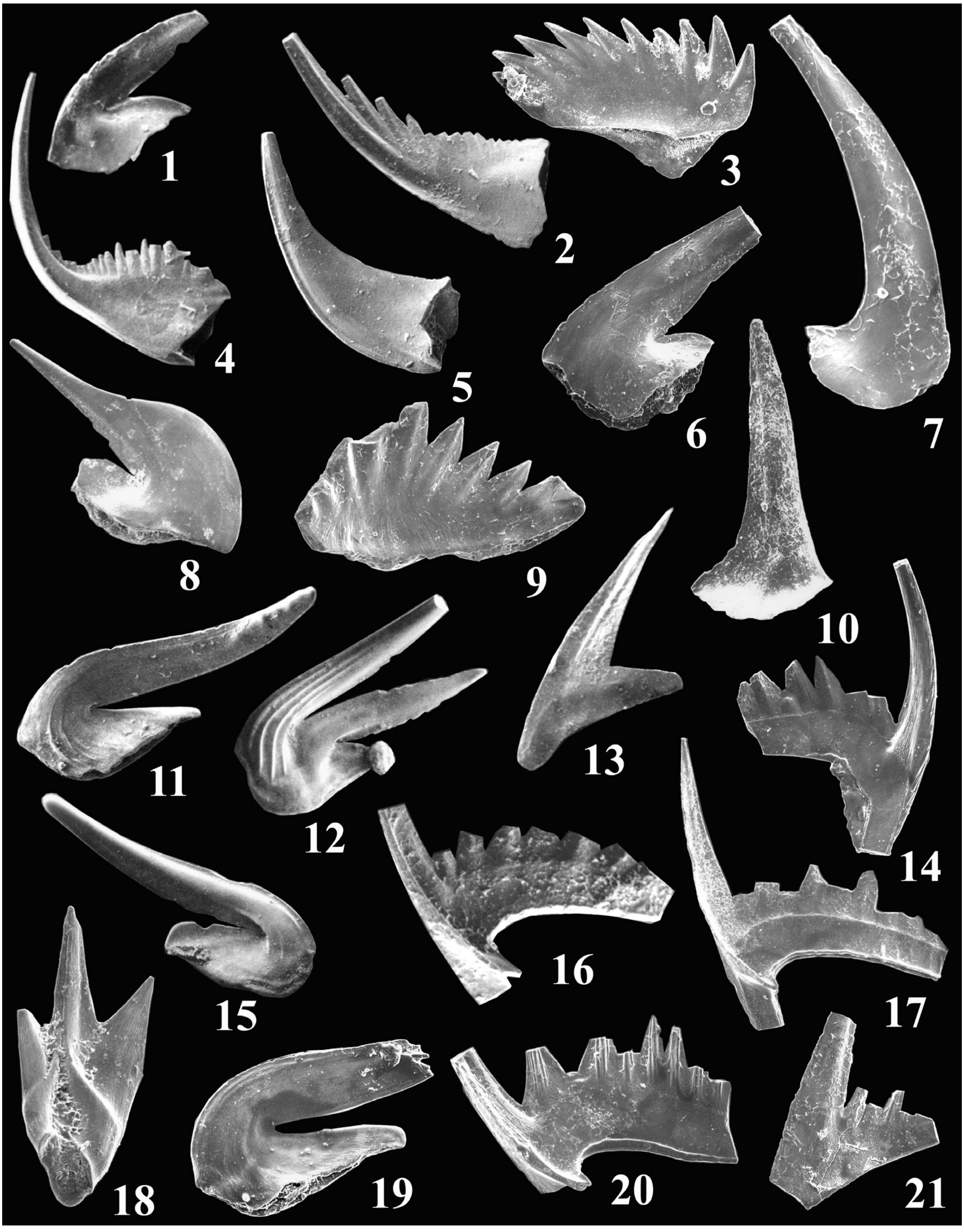

PLATE 2
Conodont Species in the Joins

Figures

1 - 3 ***Histiodella altifrons***. *Figure 1*, carminate P, X77, OSU 52022; *Figure 2*, geniculate coniform M, X90, OSU 52023; *Figure 3*, alate Sa, X83, OSU 52024; all from sample 72SB-49.

4 - 8 ***Histiodella minutiserrata***. *Figure 4*, geniculate coniform M, X63, OSU 52025; *Figure 5*, carminate P, X76, OSU 52026; *Figure 6*, bipennate Sc, X75, OSU 52027; *Figure 7*, alate Sa, X94, OSU 52028; *Figure 8*, digyrate Sb, X90, OSU 52029; all from sample 72SB-127.

9 ***Histiodella holodentata***. carminate P, X82, OSU 52030, sample 72SC-620.

10,11,13, 14 ***Histiodella labiosa***. *Figure 10*, geniculate coniform M, X118, OSU 52031, sample 72SC-500; *Figure 11*, alate Sa, X88, OSU 52032, 72SC- 470; *Figure 13*, carminate Pa, X57, OSU 52034, sample 72SC-500; *Figure 14*, carminate Pb, X68, OSU 52035, 72SC-620.

12,15,16, 17,18, ***Histiodella serrata***. *Figure 12*, digyrate Sb, X65, OSU 52033; *Figure 15*, geniculate coniform M, X65, OSU 52036; *Figure 16,* carminate Pa, X54, OSU 52037; *Figure 17*, carminate Pb, X74, OSU 52038; *Figure 18*, alate Sa, X85, OSU 52039; all from sample 72SB-365.

19–22 ***Histiodella sinuosa***. *Figure 19*, carminate Pa, X74, OSU 52040, sample 72SC-50; *Figure 20,* carminate Pb, X52, OSU 52041, sample 72SC-270; *Figure 21*, bipennate Sc, X84, OSU 52042, sample 72SC-270; *Figure 22*, alate Sa, X84, OSU 52043, sample 72SC-50.

PLATE 2

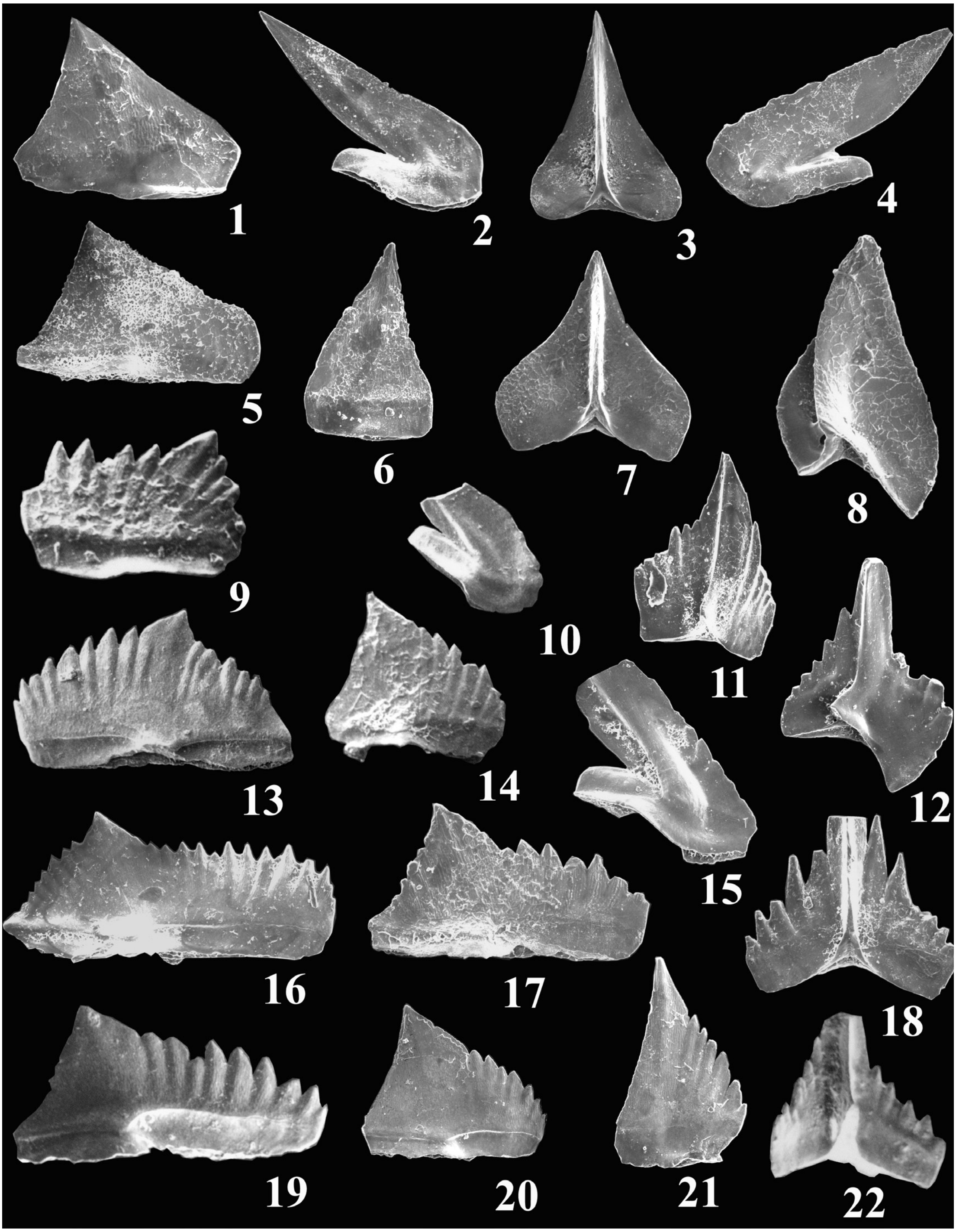

PLATE 3
Conodont Species in the Joins

Figures

1 - 4, 7	***Multioistodus subdentatus***. *Figure 1*, dolabrate Sc, X61, OSU 52044, sample 72SC-20; *Figure 2*, bipennate Sb, X108, OSU 52045, sample 72SC-80; *Figure 3*, alate Sa, X105, OSU 52046, sample 72SB-190; *Figure 4*, digyrate, X107, OSU 52047, sample 72SC-80; *Figure 7*, pastinate P, X40, OSU 52050, sample 72SB-190.
5, 6, 8, 11,13	***Neomultioistodus compressus***. *Figure 5*, dolabrate Sc, X75, OSU 52048,sample 72SC-320; *Figure 6*, geniculate coniform M, X35, OSU 52049, sample 72SC-630; *Figure 8*, alate Sa, X75, OSU 52051, sample 72SC-320; *Figure 11*, tertiopedate Sb, X55, OSU 52054, sample 72SC-320; *Figure 13*, pastinate P, X35, OSU 52056, sample 72SC-630.
9, 10,12, 14, 16	***Neomultioistodus angulatus***. *Figure 9*, dolabrate Sc, X56, OSU 52052, sample 72SC-510; *Figure 10*, alate Sa, X67, OSU 52053, sample 72SC-520; *Figure 12*, pastinate P, X66, OSU 52055, sample 72SC-450; *Figure 14*, geniculate coniform M, X48, OSU 52057, sample 72SC-320; *Figure 16*, alate Sa, X59, OSU 52059, sample 72SC-520.
15, 17-20	***Neomultioistodus erectus***. *Figure 15*, alate Sa, X67, OSU 52058, sample 72SB-38; *Figure 17*, geniculate coniform M, X87, OSU 52060, sample 72SB-19; *Figure 18*, tertiopedate Sb, X64, OSU 52061, sample 72SB-38; *Figure 19*, pastinate P, X63, OSU 52062, sample 72SB-38; *Figure 20*, dolabrate Sc, X65, OSU 52063, sample 72SB-19.

PLATE 3

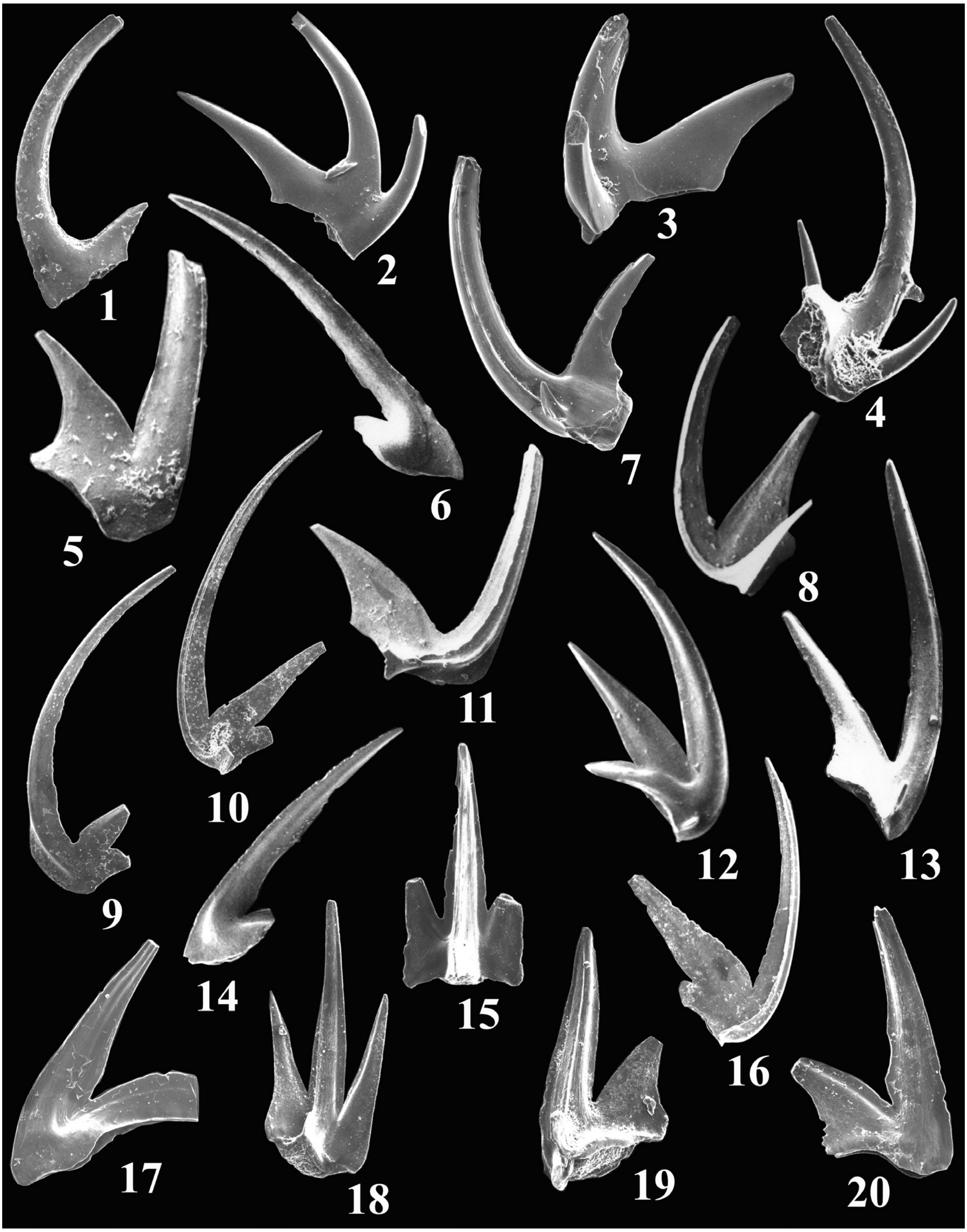

PLATE 4
Conodont Species in the Joins

Figures

1-3,6, 7,11	***Parapanderodus striatus***. *Figure 1*, scandodontiform, X58, OSU 52064, sample 72SB-34; *Figure 2*, sub-symmetrical coniform, X56, OSU 52065, sample 72SB-57; *Figure 3*, acontiodontiform, X63, OSU 52066, sample 72SC-350; *Figure 6*, short-base coniform, X42, OSU 52069, sample 72SB-34; *Figure 7*, long-base coniform (posterior), X56, OSU 52070, sample 72SC-170; *Figure 11*, long-base coniform (lateral), X54, OSU 52074, sample 72SC-420.
4,5,8, 9,12, 13,18	***Paraprioniodus neocostatus***. *Figure 4*, pastinate Pa, X60, OSU 52067, sample 72SC-440; *Figure 5*, alate Sa, X21, OSU 52068, sample 72SC-630; *Figure 8*, dolabrate M, X32, OSU 52071, sample 72SC-590; *Figure 9*, dolabrate Sc, X32, OSU 52072, sample 72SC-400; *Figure 12*, dolabrate Sc, X92, OSU 52075, sample 72SC-440; *Figure 13*, pastinate Pb, X105, OSU 52076, sample 72SC-450; *Figure 18*, dolabrate M, X49, OSU 52081, sample 72SC-440.
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PLATE 4

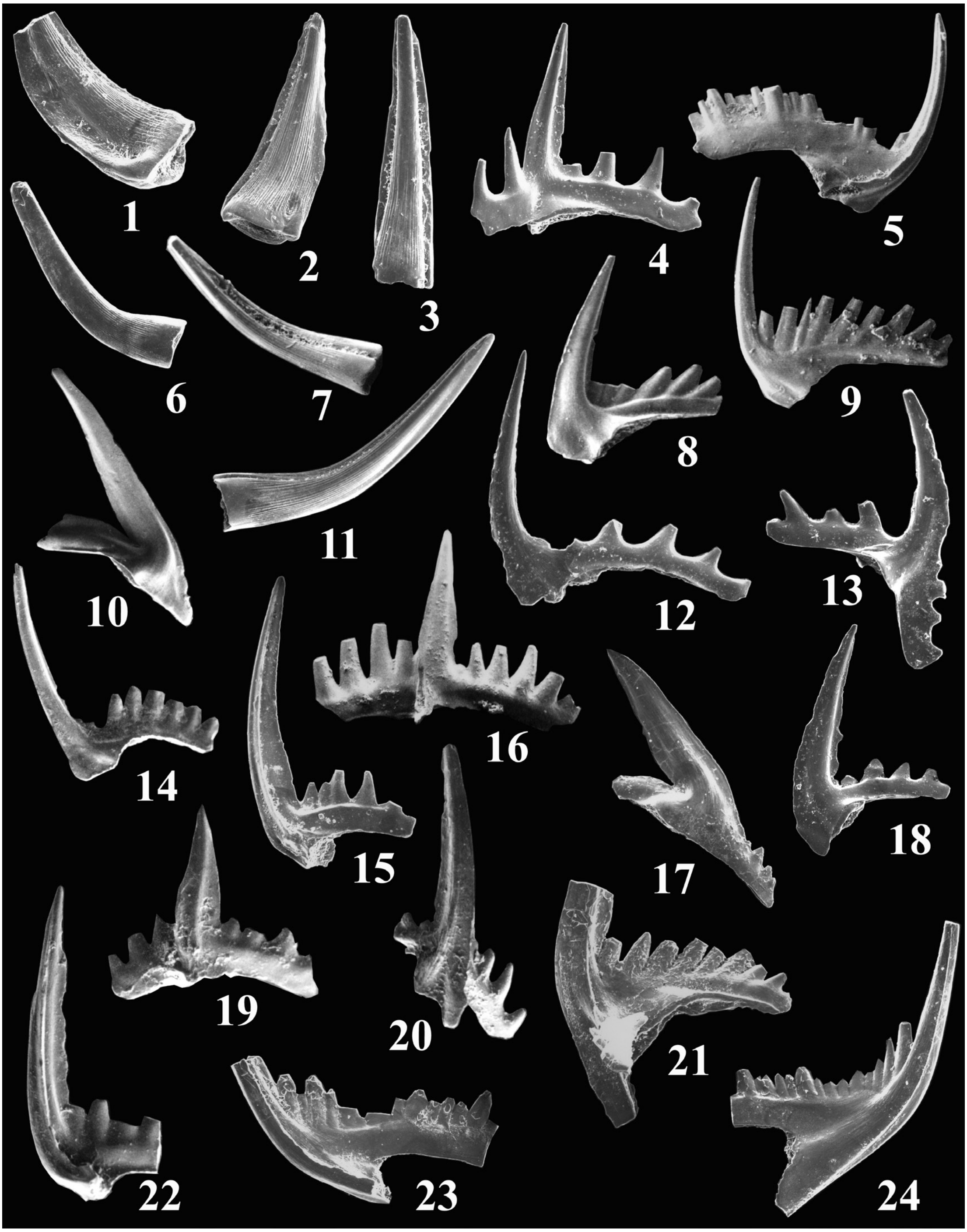

PLATE 5
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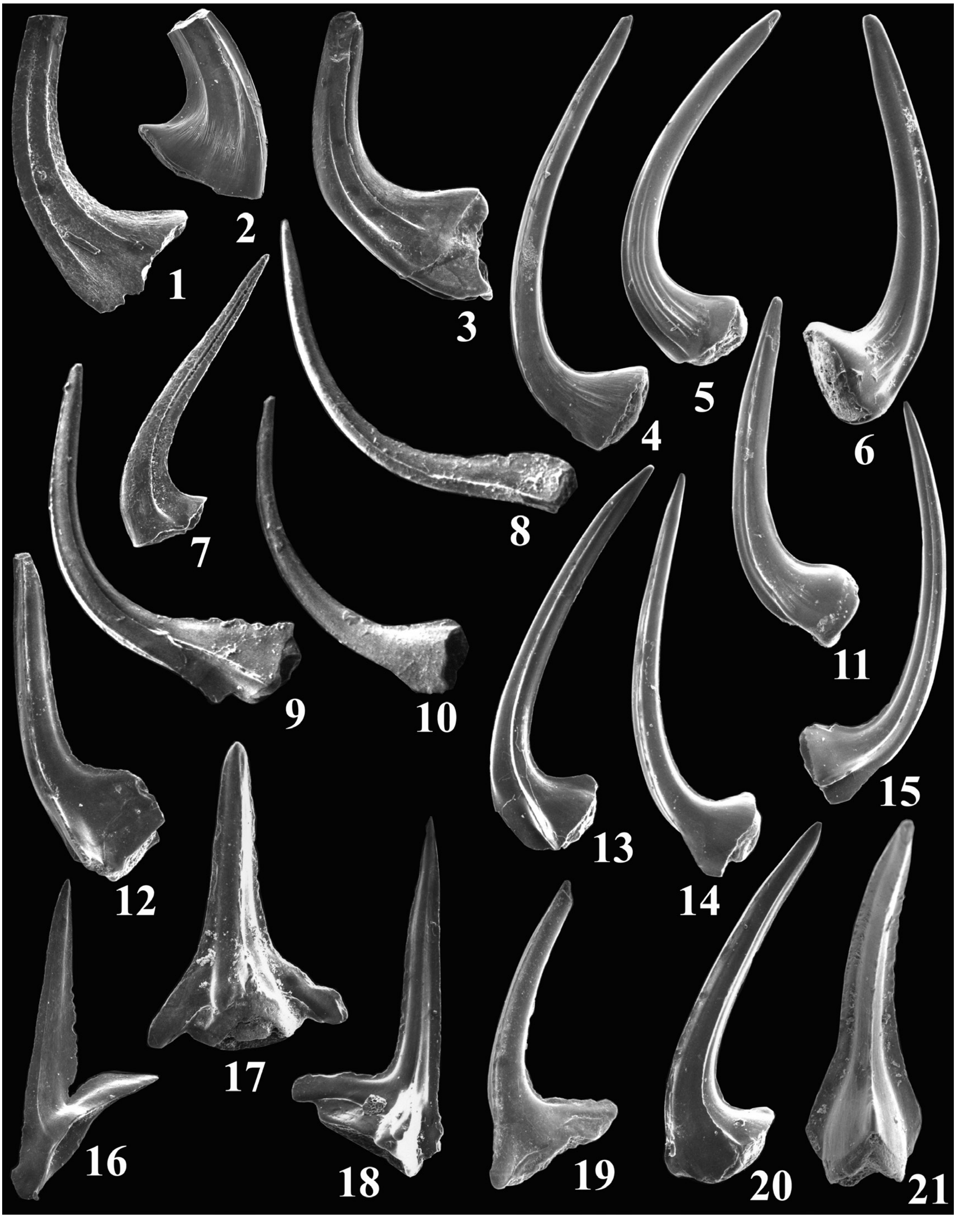
PLATE 5



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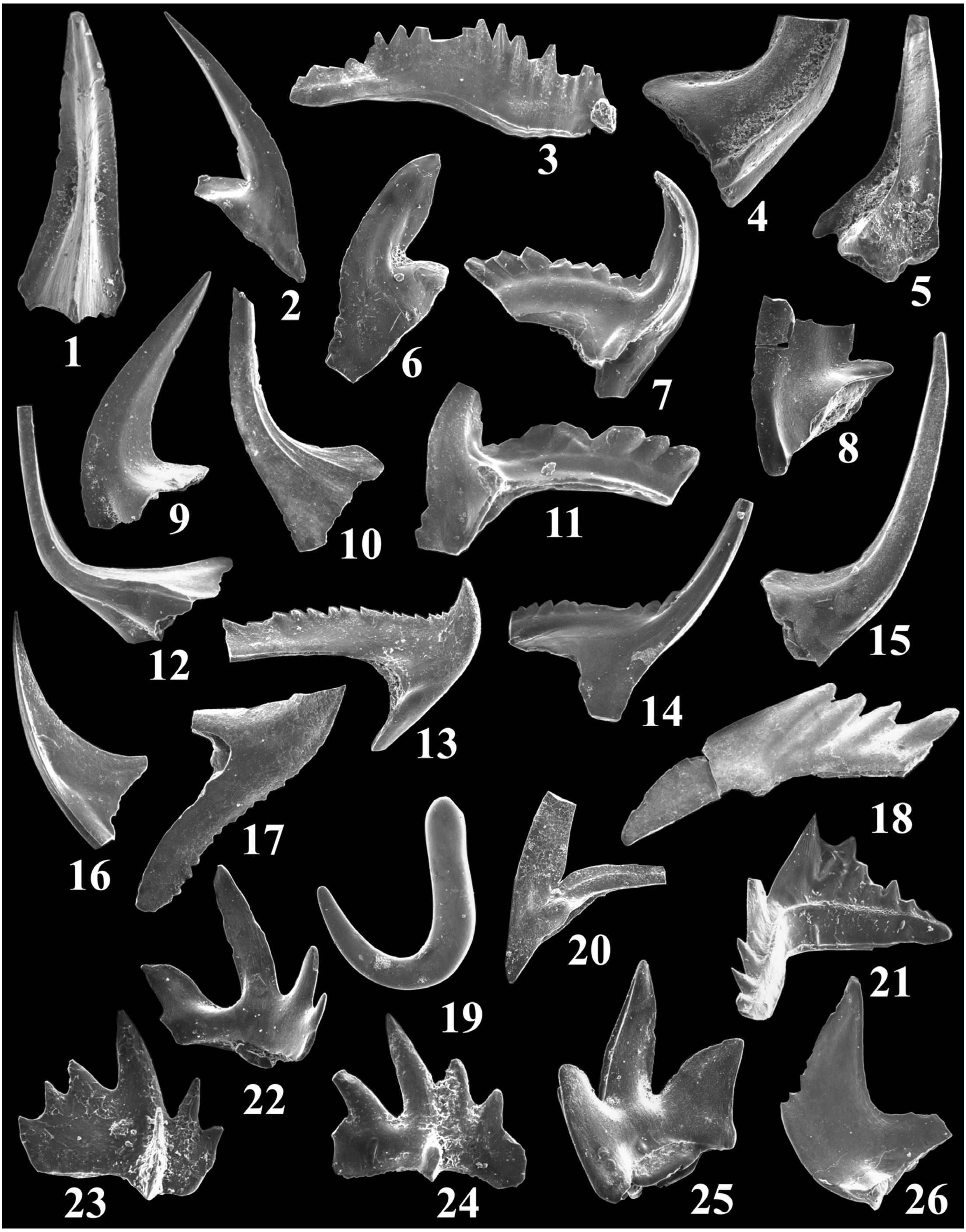
26	**New genus and species**. X65, OSU 52134, sample 72SB-221.

PLATE 6



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