CONODONT BIOSTRATIGRAPHY AND PALEOECOLOGY OF THE PERTH LIMESTONE MEMBER, STAUNTON FORMATION (PENNSYLVANIAN) OF THE ILLINOIS BASIN, U.S.A.

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The Perth Limestone Member of the Staunton Formation in the southeastern part of the Illinois Basin consists of argillaceous limestones that are in a facies relationship with shales and sandstones that commonly are calcareous and fossiliferous. The Perth conodonts are dominated by *Idiognathodus incurvus*. *Hindeodus minutus* and *Neognathodus bothrops* each comprises slightly less than 10% of the fauna. The other species are minor constituents. The Perth is assigned to the *Neognathodus bothrops–N. bassleri* Subzone of the *N. bothrops* Zone, but we were unable to confirm its assignment to earliest Desmoinesian as opposed to latest Atokan. Conodont biofacies associations of the Perth reflect a shallow near-shore marine environment of generally low to moderate energy, but localized areas are more variable, particularly in regard to salinity.

Key words: Conodonta, biozonation, paleoecology, Desmoinesian, Pennsylvanian, Illinois Basin, U.S.A.

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INTRODUCTION

Study of conodonts from the Perth Limestone Member of the Staunton Formation in the eastern and southern parts of the Illinois Basin is part of our ongoing project on Desmoinesian conodont biostratigraphy in the Illinois Basin. One part of the overall study involves collecting individual marine units over broad areas; the other component is sampling long cores to provide vertical continuity that can be problematic in working with limestones that are only presumed to be more or less contemporaneous and more or less continuous in lateral extent. In total we emphasize interpreting the vagaries of paleoenvironment and compiling a local biostratigraphic zonation in the Illinois Basin to provide a reference for comparison with other areas in North America and ultimately the world. Our study of the Perth is part of the first component (Fig. 1).

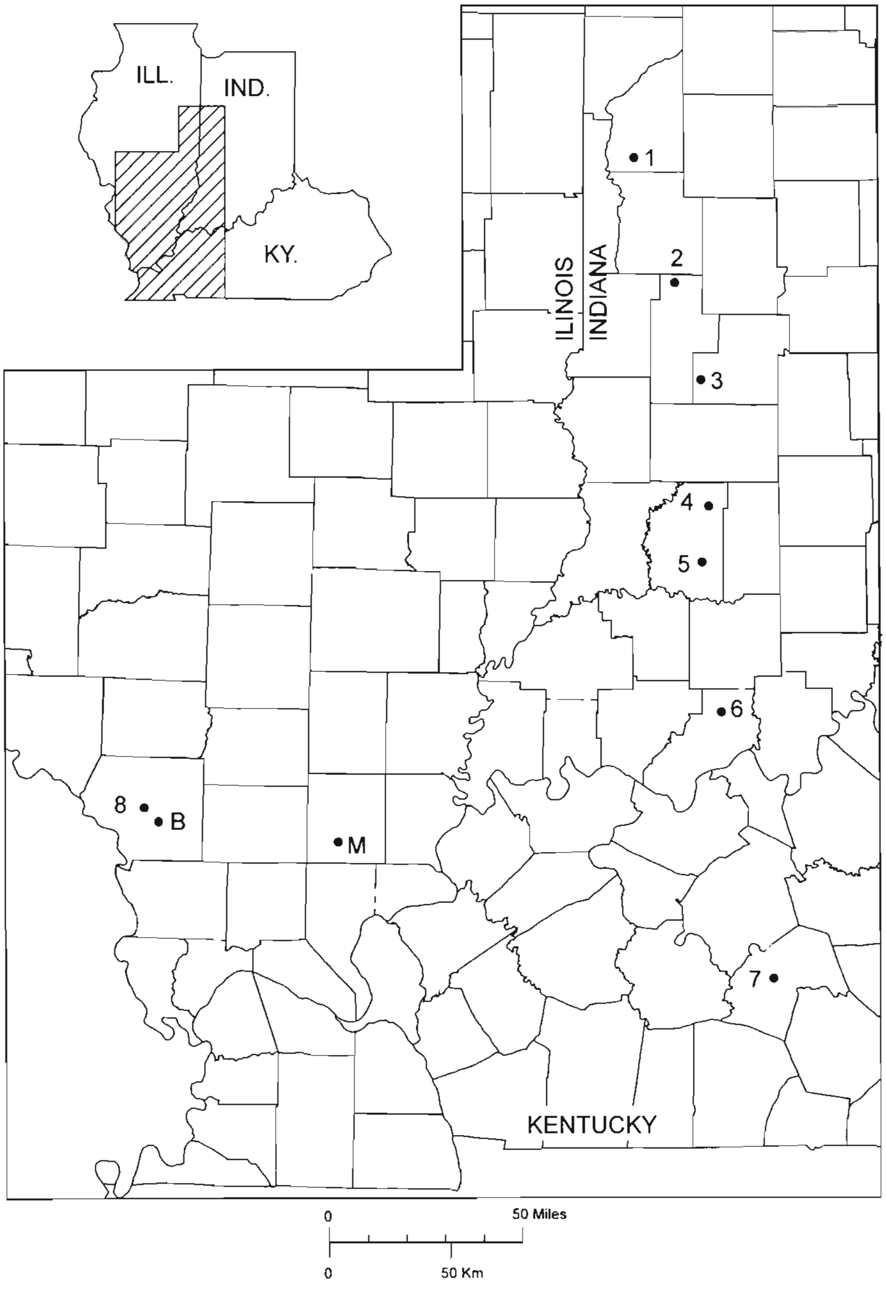

Fig. 1
Map showing collecting localities for the Perth Limestone Member (numbered) and the type sections of the Mitchellsville Limestone Bed (M) and the "Boskydell Sandstone" (Bd). Precise locations are given in the Appendix.

Acknowledgments. — We particularly want to thank David WILLIAMS of the Kentucky Geological Survey for taking us to the Curlew section in Kentucky. Thanks are also due to Glen K. MERRILL, University of Houston – Downtown, and Rodney D. NORBY, Illinois State Geological Survey, for critically reading the manuscript and providing helpful comments. Finally, we appreciate the kindness of the landowners who allowed us to collect samples on their property. All specimens are housed in the Indiana Geological Survey-Indiana University Repository curated by Alan S. HOROWITZ.

GEOLOGY

At the type section the Perth (locality 2, Figs 1, 2) consists of a gray, argillaceous, and fossiliferous limestone 2.0 m thick that contains a 0.5 m thick medial band of chert and additional scattered chert in the upper part. The Perth varies considerably in lithologic character and is reported to range up to 5.8 m thick (HUTCHISON 1986), but 3.7 m is the thickest section we collected. In Indiana the Perth was assigned to the Desmoinesian on the basis of ostracodes (SHAVER and SMITH 1974); palynological and fusulind data, however, suggest a late Atokan age (PEPPERS 1996). An unnamed limestone in southern Illinois overlying the Oldtown Coal Bed of the Tradewater Formation approximately in the Perth position also is considered to be Atokan (Fig. 3).

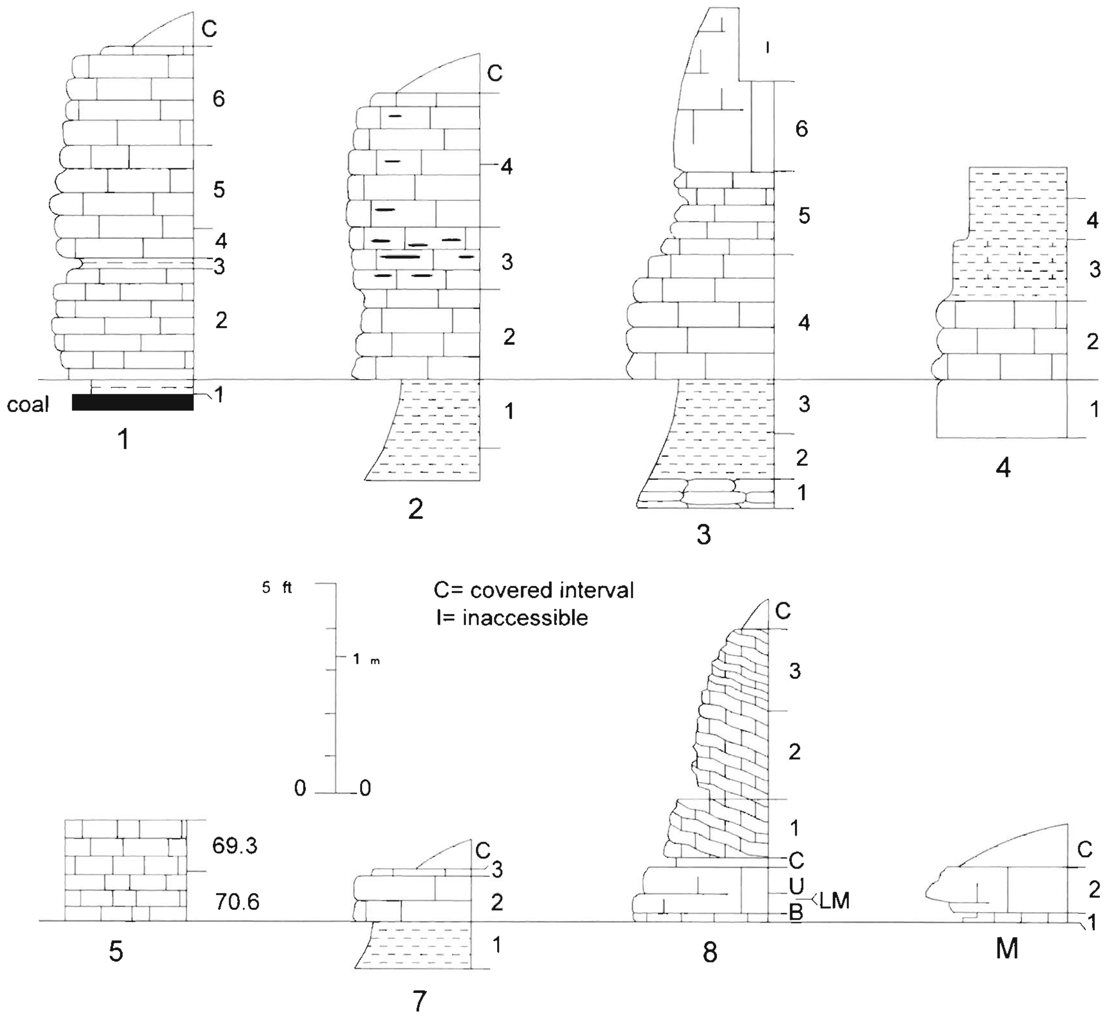

Fig. 2
Columnar sections showing generalized lithologies and sample intervals (numbers and letters on right side of each column) for the Perth Limestone Member (numbered) and the Mitchellsville Limestone Bed (M).

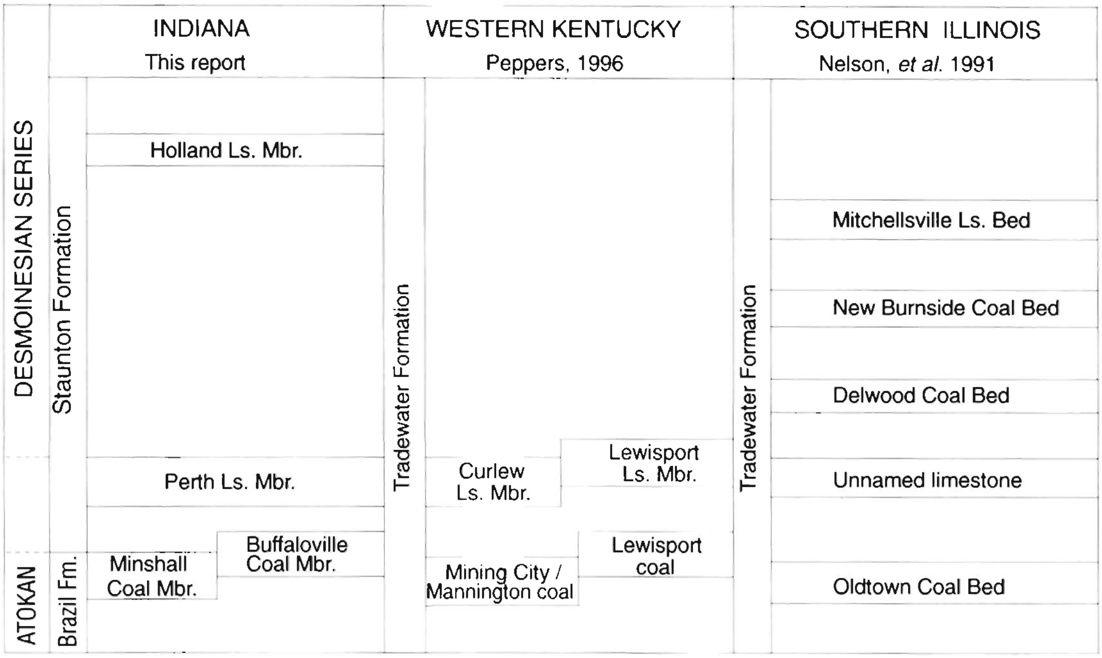

Fig. 3
Stratigraphic nomenclature of part of the Atokan and Desmoinesian Series in Indiana, Kentucky, and Illinois in the southern part of the Illinois Basin. Correlations are only approximate.

The Perth lies variably from about 0.1 to 4.9 m above the Atokan Minshall Coal Member of the Brazil Formation in west-central Indiana, but in the southern part of the state it is above the Buffaloville Coal Member of the Brazil Formation (Fig. 3). Gray shale or gray shale and black shale generally intervene. Where carbonates are absent, gray shale or fine- to medium-grained, gray to brown sandstone occupies the Perth position. We interpret the Perth, like most Pennsylvanian carbonate units in this part of the Illinois Basin, to be very thin discontinuous lenses representing only approximately the same stratigraphic position.

In adjacent Kentucky the Curlew Limestone Member of the Tradewater Formation is considered to be equivalent to the Perth, and in southern Illinois an unnamed limestone is in the position of the Perth and Curlew. A younger limestone in Illinois was called Curlew, but because of the difference in stratigraphic position, it was named the Mitchellsville Limestone Bed of the Tradewater Formation (NELSON *et al.* 1991). It is near the base of the Desmoinesian. We collected the type section of the Mitchellsville and found that the conodonts, like the other fossils, indicated an age younger than the Perth and Curlew. The term Curlew, while still used in western Kentucky, has been abandoned in Illinois because of the confusion with the younger Mitchellsville Limestone Bed. Palynological data (PEPPERS 1996) agree that in northern Illinois the Seville Limestone Member of the Tradewater Formation is equivalent to the Perth and Curlew. The Seville is also marked by lateral discontinuity (MERRILL and KING 1971; MERRILL 1975).

The Perth-Curlew-Seville interval also includes a sporadic but widespread fossiliferous marine sandstone that contains well-preserved ichnofossil assemblages in southern Illinois. Fossil spores recovered from the New Burnside Coal Bed above and the Oldtown Coal Bed below a fossiliferous sandstone near Boskydell, Illinois (Fig. 1), bracket this sandstone within the Perth interval (Fig. 3) (PEPPERS 1993). It is important to note that the "Boskydell Sandstone" is no longer used as a formal stratigraphic name. There are multiple "Boskydell Sandstone" intervals containing marine fossils and marine trace-fossil indicators that have rendered the name useless due to over-application.

In addition to the Mitchellsville type section, samples were collected from ten sections in Indiana and one each in Kentucky and Illinois (Figs 1, 2). However, two sections traditionally considered to be Perth were found on the basis of *Neognathodus* to represent the overlying Holland Limestone Member of the Staunton Formation. Two localities are included only as supplemental localities because they were mishandled by a post-doctoral fellow and could not be recollected. Also, several Indiana cores were examined in which the Perth was absent, presumably through nondeposition, although immediately older and younger carbonate units were represented. Because of the limited size of our outcrops, we did not observe the Perth pinching out in a single outcrop as did MERRILL (1975) for the Seville limestone.

FAUNA, ZONATION, AND CORRELATION

All samples from the final eight localities produced conodonts. Frequencies range from 17 to 561 specimens per kilogram identifiable to species, except that ramiform elements of *Idiognathodus* and *Neognathodus* were not separated. Seven named species and one unnamed species represent seven genera. Perth conodonts express the common Pennsylvanian overrepresentation of Pa elements. Distribution by sample is shown in Table 1.

Idiognathodus incurvus dominates the collection at 78.6% (Pl. 1: 12–34). *Hindeodus minutus* (Pl. 2: 20–23, 25) is next in abundance, 8.2%, followed by *Neognathodus bothrops*, 7.7% (Pl. 2: 1–13). *I. incurvus* and *H. minutus* were present in all sections as was *Aethotaxis* sp. (Pl. 2: 37–42) even though it is the least abundant species in the Perth at less than one percent. *Diplognathodus*, 2.9%, and *D.*? (Pl. 1: 1–11), were present in all but two sections and in one of those were present in the immediately underlying shale. Both *D. coloradoensis* and a more abundant denticulate form, *D.*? *orphanus*, occur in moderate numbers. *Adetognathus lautus*, 1.1% (Pl. 2: 17–19), and *Idioprioniodus conjunctus*, 0.9% (Pl. 2: 30–36), are few in number and each is absent in three sections.

Neognathodus gives the most promise for Desmoinesian zonation in the study area, and on a broader scale *Diplognathodus* should be useful. *Gondolella* is absent from the Perth but where present in the Desmoinesian also should be useful in zonation. Although *Idiognathodus* is abundant, has a very large number of named species, and is highly varied, the validity of many species is in question, and more study is required if it is to fulfill its potential value for stratigraphic studies. The remaining conodonts present have long stratigraphic ranges and provide only paleoecologic data.

Merrill (1972, 1975) established the fact that in the Desmoinesian most *Neognathodus* represent a shifting continuum of morphologic variation, and he used species names for the dominant forms through time. Thus, any one species includes morphologic representatives of several named species that in a general way form a bell-shaped curve representing these morphologies. Perth morphotypes include *bassleri, bothrops, medadultimus, medexultimus*, and *dilatus* (Pl. 2: 1–13), and we choose the name *Neognathodus bothrops* for the dominant and median Perth morphotype. *N. atokaensis* (Pl. 2: 14–16) is present but rare and does not seem to be a part of the Desmoinesian continuum. The continuum represents the *N. bothrops–N. bassleri* subzone in which the Seville is also placed and correlates to a nonmarine interval between the Lower and Upper Mercer limestones of the Pottsville Group in Ohio. In detail the abundance curves differ between the Seville in northwestern Illinois and the Perth and equivalents in the southern and eastern parts of the Illinois Basin, but there is no consistant shift toward older or younger ages in comparing them (Fig. 4).

The Perth overlies the Minshall coal in west-central Indiana and the Buffaloville in southwestern Indiana, and Peppers (1996) considered the latter to be slightly younger (Fig. 3). Evidence from *Neognathodus*, however, indicates that the Perth is no younger to the south than it is to the north, and possibly is slightly older to the south, but the reverse is true of the Brereton Limestone Member of the Carbondale Formation in the northwest part of the Illinois Basin, which is slightly older than the nearly equivalent Providence Limestone Member of the Dugger Formation to the south (Brown, *et al.* 1991). *Neognathodus* was absent from the Curlew sample collected in Kentucky (Locality 7).

Neognathodus does not help in differentiating an Atokan or Desmoinesian age for the Perth. From the Atoka Formation, Grubbs (1984 pl. 3: 1, 2, 5–9) illustrates *N. bothrops* (his pl. 3: 2 may be *N. bassleri*) and *N. medadultimus* (pl. 3: 3, 4, 10–13) which are also common to the Desmoinesian. We are unable to distinguish Lambert's (1992) Atokan species *N.* spp. n. A and B from Desmoinesian morphotypes of *bassleri, bothrops*, and *medadultimus*, and we are uncertain of separate recognition

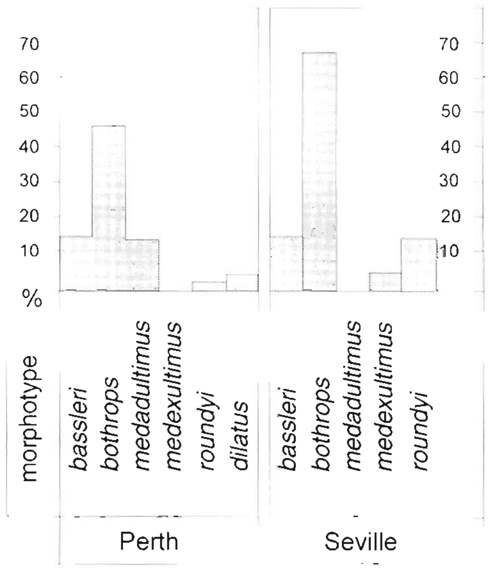

Fig. 4
Bar graph showing comparison of numbers of morphotypes of *Neognathodus* between the Perth Limestone Member and the Seville Limestone Member as given by Merrill and King (1971).

Table 1. Distribution of conodonts by location and samples.

Taxon	Locality	1					2			3			4		5-3, 5, 11				6		7		8						M	
	Sample	2	3	4	5	6	2	3	4	4	5	6	2	3	69.8	70.6	69.3	87.6	d	b	2	3	B	LM	U	1	2	3	1	2
Idiognathodus incurvus	Pa	30	388	255	30	47	204	37	64	16	14	22	180	184	107	104	224	160	20	62	21	75	133	266	328	41	85	69	240	61
Neognathodus atokaensis	Pa	-	-	-	-	-	-	-	-	-	-	-	1	-	1	1	1	-	-	3	-	-	-	-	-	1	-	-	-	-
N. bothrops																														
Pa morphotypes *bassleri*		-	-	-	-	-	1	-	-	-	-	3	12	3	9	6	8	7	-		-	-	2	2	23	5	22	7	-	-
bothrops		1	6	4	3	5	13	2	4	1	1	1	11	16	6	6	9	13	-	2	-	-	6	18	21	-	3	1	-	-
medadultimus		1	2	1	2	1	-	1	-	-	-	-	3	4	-	1	7	3	-	1	-	-	6	13	2	-	-	-	1	-
medexultimus		-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
roundyi		-	-	-	1	1	-	1	-	-	1	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
dilatus		-	3	-	2	2	1	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Idiognathodus/Neognathodus	Pb	2	16	10	3	4	15	3	10	7	-	1	12	10	3	4	15	4	-	2	-	2	6	13	11	-	-	1	5	4
(undifferentiated)		1	18	13	6	5	11	1	4	5	-	-	2	11	2	2	5	1	2	2	1	-	1	7	4	-	-	-	9	4
M		-	4	2	2	1	1	-	-	-	-	-	4	1	-	-	1	-	-	-	-	-	1	7	7	-	-	-	5	1
	Sa	-	5	9	1	1	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	6	-	-	-	-	-	3	2
	Sb	-	4	7	-	1	1	-	2	1	-	-	1	-	-	-	-	-	-	-	-	-	-	1	-	-	1	2	2	1
	Sc																													
Hindeodus minutus	Pa	6	31	21	6	14	7	4	-	-	-	3	5	1	1	6	6	2	1	2	3	10	-	5	7	-	-	-	17	11
	Pb	2	7	15	4	7	7	1	2	-	-	-	1	1	-	3	1	-	-	1	2	-	1	-	2	-	-	-	5	3
	M	1	15	5	3	4	1	2	2	1	-	-	1	3	-	1	2	-	1	1	2	2	-	-	1	-	-	-	9	4
	Sa	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	1	-
	Sb	-	3	9	6	3	4	2	8	1	-	-	-	2	-	-	2	1	-	3	3	1	1	-	-	-	-	-	11	7
	Sc	-	13	3	3	1	-	1	-	1	1	-	-	-	-	-	1	-	1	1	-	-	-	-	-	-	-	-	5	3
Diplognathodus coloradoensis	Pa	-	-	1	11	17	-	1	3	-	-	-	-	1	-	-	-	-	-	1	1	1	-	-	-	-	-	-	4	4
D.? orphanus	Pa	-	39	16	11	6	4	1	1	-	-	-	-	7	-	-	-	-	-	-	-	-	2	1	-	-	-	-	4	7
D/D?	M	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Adetognathus lautus	Pa	-	-	-	-	-	1	-	-	-	-	-	-	3	3	1	-	-	-	1	-	4	2	4	14	2	1	2	-	-
	Pb	-	-	-	-	-	1	-	-	-	-	-	-	2	1	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-
	M	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-
	Sa	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
Idioprioniodus conjunctus	Pa	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
	Pb	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	M	-	2	-	-	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
	Sa	-	1	1	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	-	-	-	-	-	-
	Sb	-	1	-	-	1	3	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Sc	-	1	7	-	1	9	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
Aethotaxis spp.	M	-	1	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
	Sa	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Sb	-	-	-	-	-	1	-	1	-	-	2	-	-	-	-	-	1	-	1	-	-	1	2	-	2	-	-	1	2
	Sc	-	-	1	-	1	1	-	1	-	-	3	-	1	-	-	1	-	-	1	-	-	-	-	-	-	-	-	-	-

in the Illinois Basin of specimens he referred to *N. caudatus* from the Desmoinesian.

We questionably include the form *Diplognathodus*? *orphanus* (Pl. 1: 1–5) in the genus *Diplognathodus* as did VON BITTER and MERRILL (1990). Although generally bearing an edentate spatula, some species that obviously belong in *Diplognathodus* also include a denticulate variant. In forms like *D.*? *orphanus* and *D.*? *ellesmerensis* the relationship is less obvious. Among possibilities, they may represent separate lineages or reiterative division from the edentate forms.

In the Illinois Basin *D. coloradoensis* was reported from the Seahorne Limestone Member of the Tradewater Formation (formerly Spoon) in northwestern Illinois, and *D.*? *orphanus* was reported from the Seville Limestone Member, which is older than the Seahorne and is approximately equal to the Perth (MERRILL 1975). Both species, however, have been reported from the presumably older Atokan Formation of Oklahoma (GRUBBS 1984). Although the Indiana Geological Survey traditionally considers the Perth to be slightly above the base of the Desmoinesian and the Illinois State Geological Survey places the Seville in the same position, they may be Atokan and so may correlate with part of the Atoka Formation in Oklahoma. In Indiana *Diplognathodus* is not known in the Atokan Lead Creek Limestone Member of the Mansfield Formation, which is the next named carbonate unit below the Perth, and *Idiognathoides* is found in the Lead Creek but not in the Perth. This is an important generic difference between the two limestones. The range of *D.*? *orphanus* has been extended up into the next named limestone above the Perth, the Holland Limestone Member of the Staunton Formation. Thus, in this part of the Pennsylvanian *Diplognathodus* is of little help in detailed correlation.

At this time we recognize no correlative value for *Aethotaxis*, although one **Sa** element lacking a posterior process (Pl. 2: 37) almost certainly can be referred to *A. advena*, whereas a more massive group of specimens that includes an **Sa** element with a posterior bar (Pl. 2: 39) is only questionably referred to *Aethotaxis*.

Overall, *Neognathodus* indicates that the Perth equates with the Seville limestone in Illinois, the commonly accepted correlative, and with the non-marine interval between the Lower and Upper Mercer limestones in Ohio. The record of *Diplognathodus*? *orphanus* from the Seville is compatible with this correlation. *D. coloradoensis* has not been reported from the Seville in Illinois, but it is rare in northern Indiana and its extended range into the Atokan Formation also is compatible with a Seville correlation. Comparisons of *Idiognathodus* between the Perth and the sections described by LAMBERT (1992) from the type area of the Desmoinesian Series and between the Perth and sections described by GRUBBS (1984) from the Atokan Series do not assist in the series assignment of the Perth.

COMMENTS ON THE SYSTEMATICS OF *IDIOGNATHODUS*

As previously noted, with the abundant, nearly ubiquitous occurrence of *Idiognathodus*, its morphologic diversity, and the large number of named species, one would expect it to be the most useful genus for detailed biostratigraphic work in the Desmoinesian. Many taxa, however, were erected without regard for probable phylogenetic relationships or morphologic characteristics that tend to be reiteratively similar throughout the range of the genus. As a result, an unusually high proportion of names have been synonymized. GRAYSON, MERRILL, LAMBERT, and TURNER (1989) suggested that a large number of previously named species fit into a single unilinear phylogeny in which much ecophenotypic morphologic variation could be recognized. They subdivided the lineage primarily on the basis of the adcarinal ridges. Within this lineage they recognized *I. incurvus*, ranging from Atokan into Desmoinesian, giving rise to *I. claviformus* in the early middle part of the Desmoinesian, and that species in turn being ancestral to *I. magnificus* near the end of the Desmoinesian. We recognize similar variations in the genus in the Perth, and with the possible exception of *Idiognathodus* sp. n. B of LAMBERT (1992) we presently consider them to represent ecophenotypic morphotypes of little stratigraphic value as did GRAYSON *et al.* (1989).

We identified all of the morphotypes that we could recognize (Pl. 1: 12–34) based on such things as height of platform, its width and curvature, sharpness or roundess of the posterior tip, form of adcarinal ridges, accessory lobes, and pattern of surface ornamentation. They form a continuum without sharp divisions. Although the variants are similar to several named species, *I. incurvus* seems the best choice for a specific name.

The most important comparison in terms of determining an Atokan versus Desmoinesian age for the Perth was with Atokan and Desmoinesian collections from the type area of the Desmoinesian as described by Lambert (1992). He named two new species, described two additional new species in open nomenclature, and recognized *Idiognathodus obliquus* Kossenko and Kozitskaya (1978). Two species were limited to the Atokan and three to the Desmoinesian. We questionably matched the morphology of Lambert's *I.* sp. n. A from Atokan rocks (Pl. 1: 33, 34), and we found a few forms moderately similar to *I. gibbus* (Pl. 1: 19, 20, 23–26), the other Atokan species. On the other hand for his Desmoinesian specimens, none of our morphotypes match Lambert's *I. obliquus* (compare Pl. 1: 32) because of major differences in the adcarinal ridges, which flare out away from the free blade in the Iowa forms (Fig. 4). Some morphologies in the Perth are very similar to *I. amplificus* but do not have the same breakdown of the transverse ridges (Pl. 1: 28–30). Among our variations we do find specimens that essentially match Lambert's *I.* sp. n. B (Pl. 1: 17, 21, 22). This, at best, can only suggest that the Perth is Desmoinesian rather than Atokan in age, and it does not clarify the systematics of the genus.

PALEOECOLOGY

Pennsylvanian biofacies associations are relatively well understood and in the Perth reflect a shallow, near-shore, quiet to moderate energy environment much like that which we previously reported for the middle Desmoinesian Providence Limestone Member of the Dugger Formation (Brown *et al.* 1991) and the upper Desmoinesian West Franklin Limestone Member of the Shelburn Formation (Brown *et al* 1992). The *Idiognathodus* biofacies dominates and fits the part of this environment characterized by near-normal salinity.

Variations in detail are shown by the slightly elevated numbers of *Hindeodus* and *Diplognathodus* in the northern sections, which suggest possible higher energy conditions in a near-shore environment in that area. Somewhat higher numbers of *Idioprioniodus* in the lower part of the type section suggest possible conditions of quiet, organic-rich water of variable salinity and lower than normal pH.

Ichnology of the sandy portion within the Perth-Curlew-Seville interval near locality 8 and near Boskydell, Illinois (Fig. 1), have yielded abundant *Olivellites plummeri, Chondrites* isp., and *Zoophycos* isp. These trace fossils have been documented in marine-dominated sheet deltas in England (Eager *et al* 1985) under conditions similar to those found in the study interval. A change in behavior up-section from horizontal repichnia like *Olivellites* to vertical behaviors like *Chondrites* and *Zoophycos* indicates an environmental shift, which suggests that a small rise in sea level may have occurred during deposition of this interval. Areas farther east in Williamson County, Illinois, however, show monospecific ichnofaunas within this interval, which suggest lower salinities and/or higher topographic conditions within the delta complex. The ichnology supports the conodont paleoecology by reflecting complex paralic conditions during the deposition of the Perth-Curlew-Seville interval.

The varying near-shore sedimentation patterns forming the discontinuous lenses of the Perth limestone probably were influenced by (1) deltaic and near-shore processes, in part related to changes in the source area and sediment supply that may have been climatically controlled, (2) topographic irregularities related to the influence of tectonism, differential compaction, and isostatic adjustment, (3) penecontemporaneous river channels, and (4) possible small changes in sea level.

SUMMARY

The Perth and Curlew have a moderately variable but predictable conodont fauna dominated by *Idiognathodus*. They are in the *Neognathodus bothrops–N. bassleri* Subzone and correlate approximately with the Seville in northwestern Illinois and with the interval between the Lower and Upper Mercer limestones in Ohio. Traditionally, in Indiana the base of the Desmoinesian has been placed slightly below the Perth, and the Perth conodonts are compatible with this age, but Peppers (1996) on the basis of palynological and fusulinid data places the boundary at the top of the Perth-Curlew-Seville complex. Deposition was in a shallow, near-shore, quiet to moderate energy marine environment.

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APPENDIX

COLLECTING LOCALITIES

1. Bank on east side of stream immediately above bridge; NE1/4 SE1/4 NE1/4 sec. 28 T18N, R8W, Kingman quadrangle, Fountain County, Indiana. Field designations are SS7 and 7R.

2. South side of pond in small abandoned coal strip pit; NE1/4 SE1/4 sec. 3, T13N, R7W, Brazil West quadrangle, Clay County, Indiana. Field designations are P and PR. Type section of the Perth Limestone Member.

3. South end of lake in abandoned coal strip pit; SW1/4 SW1/4 sec. 2, T9N, R6W, Coal City quadrangle, Owen County, Indiana. Field designations are PCC and MCC.

4. Active pit of Foertsch Construction Company's Little Sandy pit 6; NE1/4 NW1/4 sec. 6, T4N, R5W, Epsom quadrangle, Daviess County, Indiana. Field designation is LS6.

5. Cores. Solar Sources, Inc. 13 EN-3, NW1/4 NW1/4 NW1/4 SE1/4; 13 EN-5, SW1/4 SE1/4 NE1/4 NW1/4; and 13 EN-11, NW1/4 NE1/4 SW1/4 NE1/4; all sec. 13, T2N, R6W, Glendale quadrangle, Daviess County, Indiana. Field designations are EN-3, EN-5, and EN-11.

6. Spoil bank adjacent to road (not *in situ*); NE1/4 NW1/4 sec. 9, T5S, R5W, Santa Claus quadrangle, Spencer County, Indiana. Field designation is BO. Type area of Buffaloville Coal Member.

7. Cut on east side of Green River Parkway; Carter coordinates 300' NL, 1700' WL, 7-I-34, Morgantown quadrangle, Butler County, Kentucky. Field designations are MP29 and RMP29.

8. Stream bed and bank; SW1/4 NE1/4 NE1/4 sec. 14, T9S, R3W, Gorham quadrangle, Jackson County, Illinois. Field designation is P154D, G.

SUPPLEMENTAL LOCALITIES

A. Small abandoned quarry just south of railroad overpass; NE1/4 NW1/4 NW1/4 sec. 10, T13N, R7W, Brazil West quadrangle, Clay County, Indiana. Field designation is T&S26.

B. West side of southern pit of Marigold Mining Company's Liberal Pit (abandoned); SW1/4 NE1/4 SE1/4 sec. 35, T5S, R5W, Santa Claus quadrangle, Spencer County, Indiana. Field designation is ML.

M. North facing gulley just north of road; line between SW1/4 SE1/4 and NW1/4 NW1/4 sec. 27, T10S, R6E, Harrisburg quadrangle, Saline County, Illinois. Field designation is Illinois, Type Mitchellsville.

Bd. Type section of the "Boskydell Sandstone;" east fork of intermittent stream south of U.S. Highway 51; middle of south line of SW1/4 NE1/4 sec. 8, T10S, R1W, Carbondale Quadrangle, Jackson County, Illinois

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PLATE 1

All magnifications are × 40. Locality and sample number are in parentheses following the five-digit repository number.

Diplognathodus? *orphanus* MERRILL, 1973

1–5. **Pa** elements, *1* 18, 911 (1–3), *2* 18, 912 (2–2), *3* 18, 913 (1–3), *4* 18, 914 (1–1), *5* 18, 915 (1–4).

Diplognathodus sp. or *Diplognathodus*? sp.

6. **Pb** element, 18, 916 (1–4).

Diplognathodus coloradoensis MURRAY *et* CHRONIC, 1965

7–11. **Pa** elements, *7* 18, 917 (1–6), *8* 18, 918 (1–5), *9* 18, 919 (1–3), *10* 18, 920 (1–5), *11* 18, 921 (1–3).

Idiognathodus incurvus DUNN, 1966

12–34. **Pa** elements, *12* 18, 922 (1–4), *13* 18, 923 (1–1), *14* 18, 924 (1–2), *15* 18, 925 (1–1), *16* 18, 926 (2–2), *17* 18, 927 (4–3), *18* 18, 928 (1–1), *19* 18, 929 (1–3), *20* 18, 930 (1–1), *21* 18, 931 (2–2), *22* 18, 932 (2–2), *23* 18, 933 (6-d), *24* 18, 934 (1–1), *25* 18, 935 (5.3–69.3), *26* 18, 936 (3–3), *27* 18, 937 (1–4), *28* 18, 938 (1–3), *29* 18, 939 (1–3), *30* 18, 940 (7–3), *31* 18, 941 (1–2), *32* 18, 942 (1–1), *33* 18, 943 (2–2), *34* 18, 944 (8-LM). Compare *17*, *21*, and 22 with *I.* n. sp. B of LAMBERT (1992); *19*, *20*, and *23–26* with *I. gibbus* Lambert; *28–30* with *I. amplificus* LAMBERT; *32* with *I. obliquus* KOSSENKO *et* KOZITSKAYA of LAMBERT (1992); and *33* and *34* with *I.* n. sp. A of LAMBERT (1992).

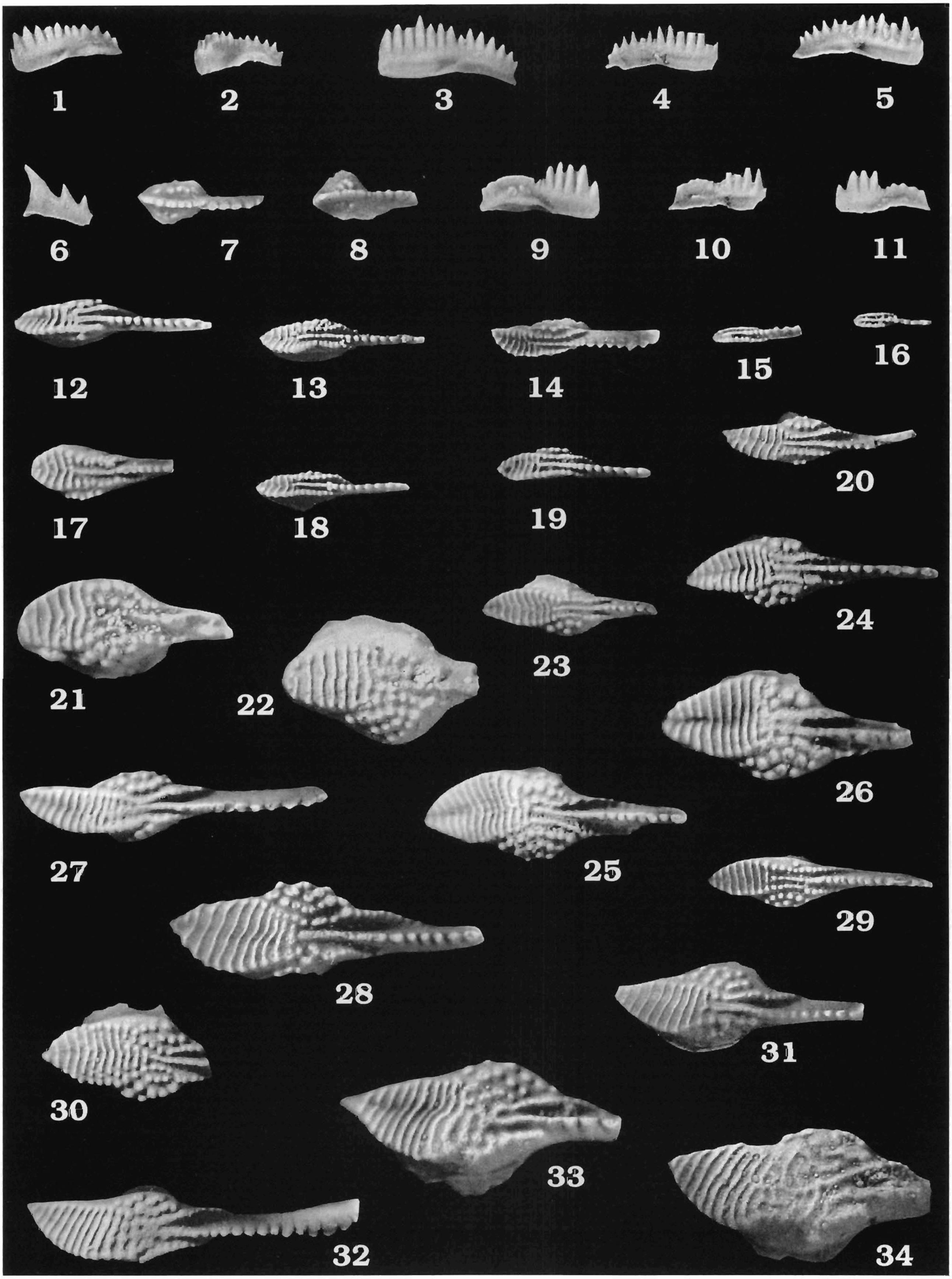
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PLATE 2

All magnifications are × 40. Locality and sample number are in parentheses following the five-digit repository number.

Neognathodus bothrops MERRILL, 1972

1–13. **Pa** elements showing morphotypes; *dilatus* morphotypes, *1* 18, 945 (2–4), *2* 18, 946 (1–3); *roundyi* morphotype, *3* 18, 947 (1–3); *medexultimus* morphotypes, *4* 18, 948 (1–1), *6* 18, 949 (2–3); *medadultimus* morphotype *5* 18, 950 (1–4); *medadultimus-bothrops* transition, *7* 18, 951 (3–3); *bothrops* morphotypes, *8* 18, 952 (2–2), *9* 18, 953(1–3), *10* 18, 954 (1–6); *bothrops-bassleri* transition, *11* 18, 955 (3–2); *bassleri* morphotypes, *12* 18, 956 (2–2), *13* 18, 957 (8-U).

Neognathodus atokaensis GRAYSON, 1984

14–16. **Pa** elements, *14* 18, 958 (6-d), *15* 18, 959 (8-U), and *16* 18, 960 (6-d).

Adetognathus lautus (GUNNELL, 1933)

17–19. **Pa** elements, *17* 18, 961(7–2, 3), *18* 18, 962 (6-b); **Sc** element *19* 18, 963 (1–1),

Hindeodus minutus (ELLISON), 1941

20–23, 25. **Pb** element, *20* 18, 964 (1–4); **M** element, *21* 18, 965 (1–2), **Pa** elements, *22* 18, 966 (4–2), *23* 18, 967 (1–4); **Sb** element, *25* 18, 968 (1–1).

Idiognathodus/ Neognathodus ramiforms undifferentiated

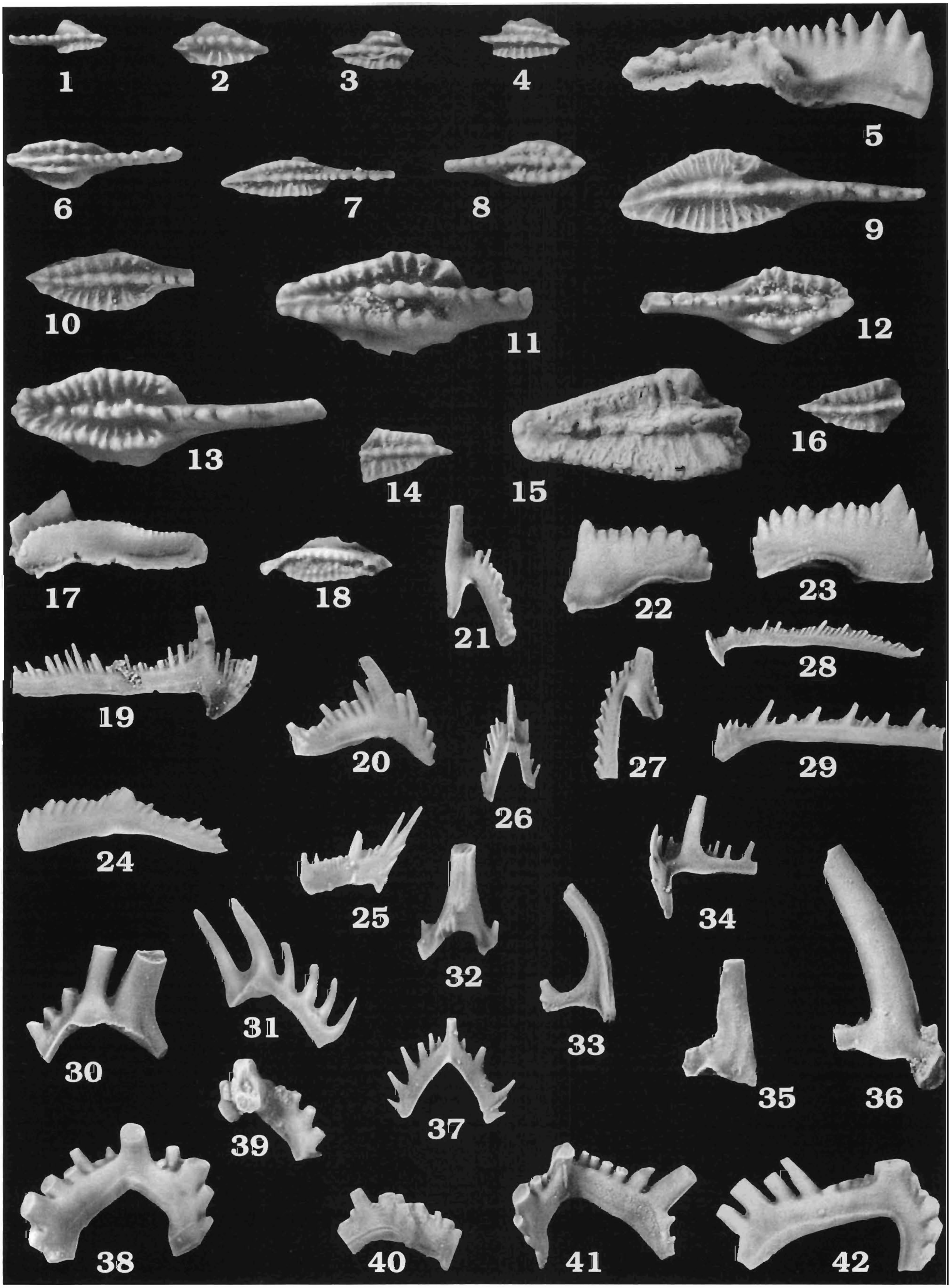
24, 26–29. **Pb** element, *24* 18, 969 (1–5); **Sa** element, *26* 18, 970 (1–4); **M** element, *27* 18, 971 (2–2), **Sc** elements, *28* 18, 972 (1–3), *29* 18, 973 (2–2).

Idioprioniodus conjunctus (GUNNELL), 1931

30–36. **Pa** elements, *30* 18, 974 (7–2), *31* 18, 975 (1–4); **Sa** elements, *32* 18, 976 (1–4), *33* 18, 977 (lost); **Sc** elements, *34* 18, 978 (1–4), *36* 18, 979 (2–2); **M** element *35* 18, 980 (2–2),

Aethotaxis spp.

37–42. **Sa** element closely similar to *A. advena*, *37* 18, 981 (1–3); **Sb** elements, *38* 18, 982 (2–2), *41* 18, 983 (1–4); **Sa** element?, *39* 18, 984 (3–2); *40* 18, 985 (8- LM); **Sc** element, *42* 18, 986 (2–4).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