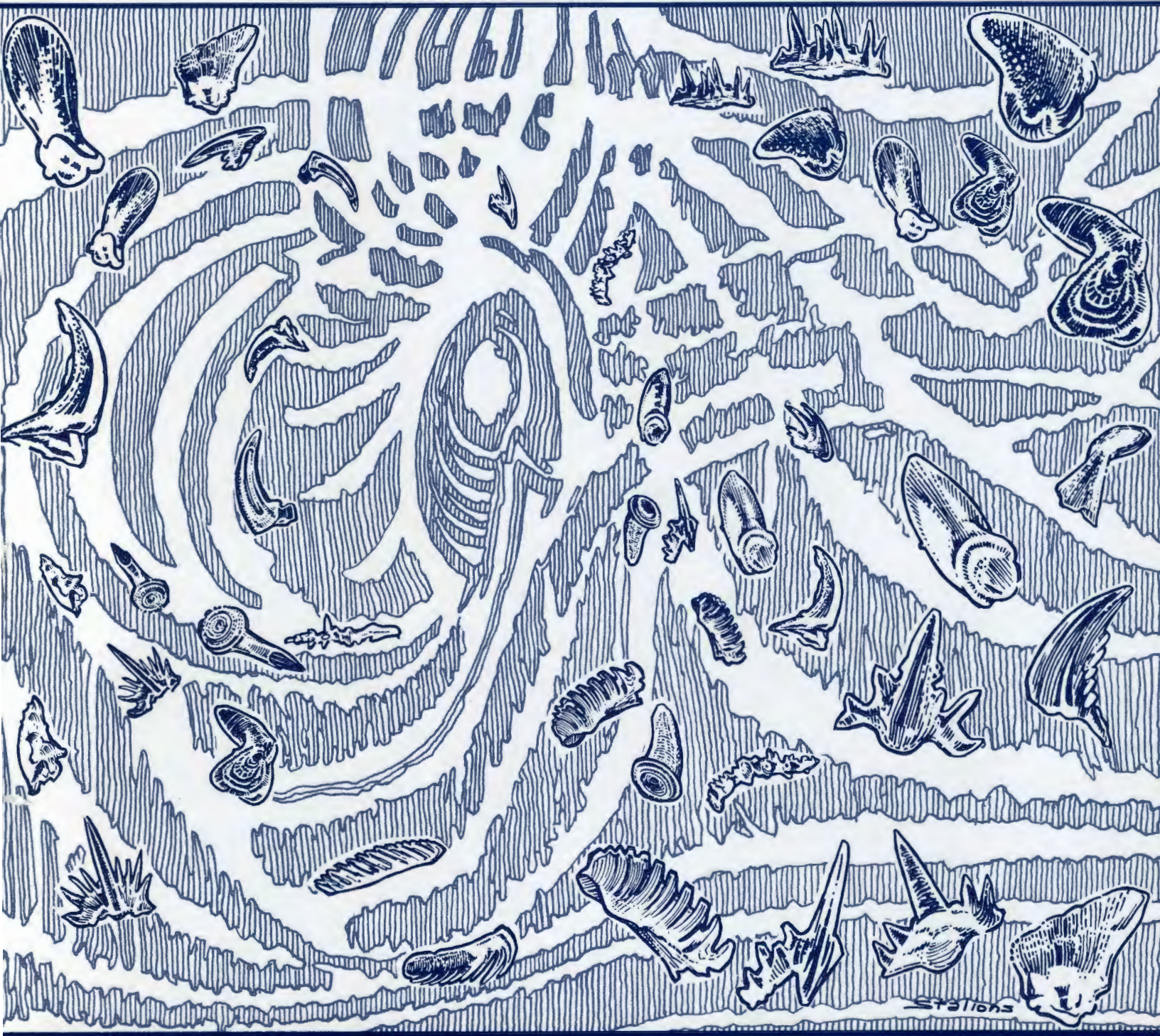


CONODONTS FROM SUBSURFACE CHAMPLAINIAN (ORDOVICIAN) ROCKS OF EASTERN INDIANA

Special Report 37



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Conodonts from Subsurface Champlainian (Ordovician) Rocks of Eastern Indiana

By RAYMOND L. ETHINGTON, JOHN B. DROSTE, *and* CARL B. REXROAD

DEPARTMENT OF NATURAL RESOURCES
GEOLOGICAL SURVEY SPECIAL REPORT 37



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Contents

	Page
Abstract	1
Introduction	1
Stratigraphic summary	2
Conodont paleontology	5
Introduction	5
Champlainian biostratigraphy	5
Ibexian biostratigraphy	10
Acknowledgments	11
Core locations	11
Systematic paleontology	11
Genus <i>Coleodus</i> Branson and Mehl	11
Genus <i>Curtognathus</i> Branson and Mehl	15
Genus <i>Erismodus</i> Branson and Mehl	16
Genus <i>Leptochirognathus</i> Branson and Mehl	17
Genus <i>Lumidens</i> n. gen.	20
Genus <i>Oneotodus</i> Lindström	21
Genus <i>Prionognathodus</i> Fay	22
Genus <i>Scapulidens</i> n. gen.	24
Genus <i>Stereoconus</i> Branson and Mehl	25
New genus A	27
New genus B	28
Stellate plates	29
Literature cited	30

Illustrations

	Page
[Plates follow Literature Cited]	
Plate 1	Conodonts from the Dutchtown Formation
2	Conodonts from the Dutchtown Formation
Figure 1	Map showing the location of the five cores studied for conodonts 2
2	Chart showing stratigraphic relationships of the Dutchtown Formation in Indiana 3
3A	Map showing the thickness of the Shakopee Dolomite in Indiana 4
3B	Map showing the thickness of the Oneota Dolomite in Indiana 4
4	Induction electric logs of parts of the five cores studied showing the stratigraphy and the sample intervals on expanded logs 6-7
5	Camera lucida drawing of a specimen of new genus B showing the configuration of growth lamellae 29

Table

	Page
Table 1	Distribution of conodonts from the studied parts of the five core intervals 8

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Conodonts from Subsurface Champlainian (Ordovician) Rocks of Eastern Indiana

By RAYMOND L. ETHINGTON, JOHN B. DROSTE, and CARL B. REXROAD

Abstract

Conodonts from the Dutchtown (Champlainian) part of five cores in Rush, Fayette, Franklin, and Decatur Counties, Ind., represent 17 hyaline species that include two newly named genera, *Lumidens* and *Scapulidens*; two new genera left in open nomenclature; two newly named species, *Leptochirognathus resimus* and *Stereoconus crepidiformis*; and three new species of *Coleodus?*, which are also left in open nomenclature. Of the eight remaining species only two *Oneotodus? ovatus* (Stauffer) and *Prionognathodus ordovicicus* (Branson and Mehl) are identified without question with known species; three more are questionably so identified, *?Coleodus delicatus* Branson and Mehl, *?C. simplex* Branson and Mehl, and *?Curtognathus typus* Branson and Mehl. Some of the remaining forms have affinities with known species; others are referred only questionably to previously described species. Five species of albid conodonts are represented in the Dutchtown Formation by rare specimens. The Shakopee Dolomite (Ibexian) contains few conodonts that are of the same age as those of the Oneota Dolomite in its type area.

Recovering a fauna from the Dutchtown Formation in Indiana differing so markedly from previously described Champlainian conodonts came as a surprise. It may be that the fauna represents a time interval from which conodonts have not been described, for example, the interval of the St. Peter Sandstone below the Dutchtown Formation in Missouri or the time represented by pre-St. Peter erosion. The depositional environment of the Dutchtown rocks of eastern Indiana is unusual, and it is more likely that the fauna is

specialized in response to an unusual ecology of limited geographic extent.

Introduction

Parts of five cores drilled in a small area in Rush, Fayette, Franklin, and Decatur Counties, Ind. (fig. 1) by the Gulf Oil Corp. were given to the Indiana Geological Survey for file and for study. Included were strata across the boundary between rocks of the Shakopee Dolomite (Prairie du Chien Group) below and rocks of the Dutchtown Formation (Ancell Group) above (fig. 2). This stratigraphic interval was part of a sequence being studied lithostratigraphically by John B. Droste and John B. Patton. One publication has already resulted (Droste and Patton, 1985). Biostratigraphic control was lacking, however, and so a split of the core was made available to us to process for conodonts.

The lower part of the Dutchtown Formation in particular represents an environment not known from equivalent outcropping rocks. Although the fauna has general affinities with the conodont faunas of the Midcontinent Province, it differs in detail from previously described conodont faunas, apparently because it has ecologic peculiarities but possibly because this time interval is not represented in collections from other areas. The fauna includes two new genera named here, *Lumidens* and *Scapulidens*; two other new genera left in open nomenclature; two new species, *Leptochirognathus resimus* and *Stereoconus crepidiformis*; and three new species of *Coleodus?* also in open nomenclature. A description of the conodonts recovered and of the depositional setting is the purpose of this paper.

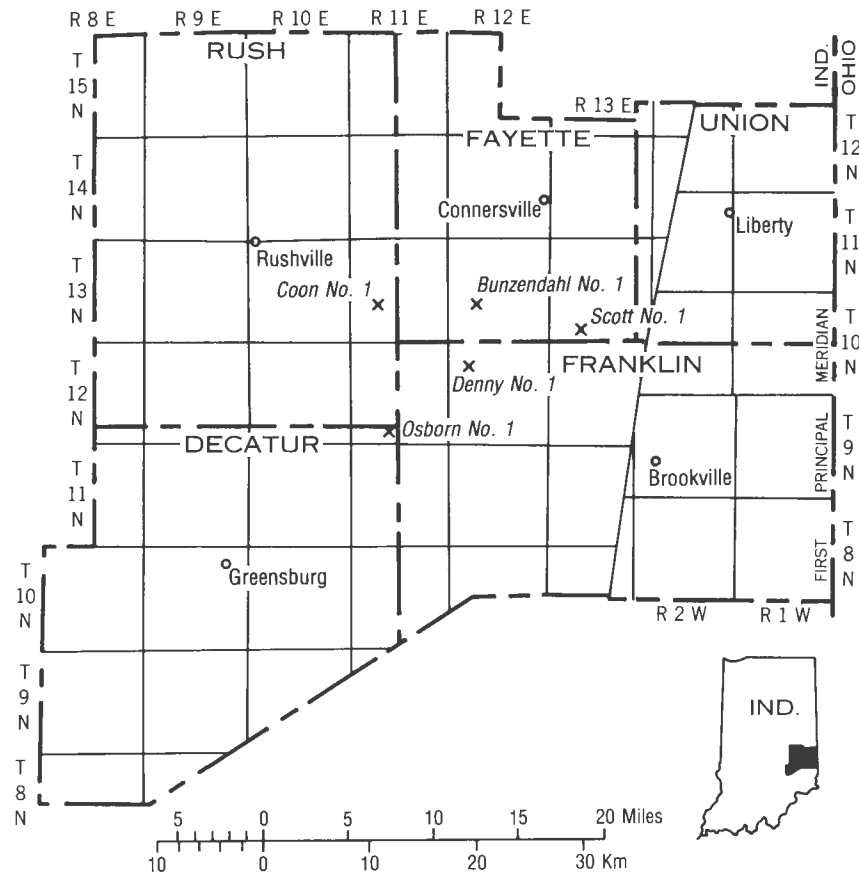


Figure 1. Map showing the location of the five cores studied for conodonts.

Stratigraphic Summary

The Ancell Group in Indiana consists of three formations, the St. Peter Sandstone, the Dutchtown Formation, and the Joachim Dolomite (fig. 2), and these three formations show partial facies relationship to one another (Droste, Abdulkareem, and Patton, 1982). Dutchtown rocks grade laterally and vertically into St. Peter rocks, and beyond their merging depositional limits, the Dutchtown and the lower part of the St. Peter Sandstone are stratigraphic equivalents. The Dutchtown Formation also grades upward with transitional interbedding into the Joachim Dolomite. The Joachim Dolomite in turn is laterally and vertically gradational with the upper part of the St. Peter Sandstone, to which it is stratigraphically equivalent.

Ancell rocks lie unconformably on rocks as old as the Potosi Dolomite (late St. Croixan, Cambrian) and on rocks as young as the

Everton Dolomite (early Champlainian). The Ancell is overlain with minor discontinuity to conformable contact with rocks of the Black River Group (middle Champlainian). Ancell rocks are both Chazyan and early Black-riverian in age.

In Indiana, except the southwestern part, the Dutchtown rocks are typically gray and brown, partly argillaceous dolomite with some thin interbeds of green shale. Generally the lowest few feet of the formation consists of very sandy dolomite and sandstone. The lower 10 feet of the Dutchtown, the interval from which nearly all conodonts of this report were recovered, consists of sandy dolomite and sandstone at the base and above that interval very silty and argillaceous dolomite interbedded with gray and green shale.

The Shakopee Dolomite on which the Dutchtown rests in the study area is pure to

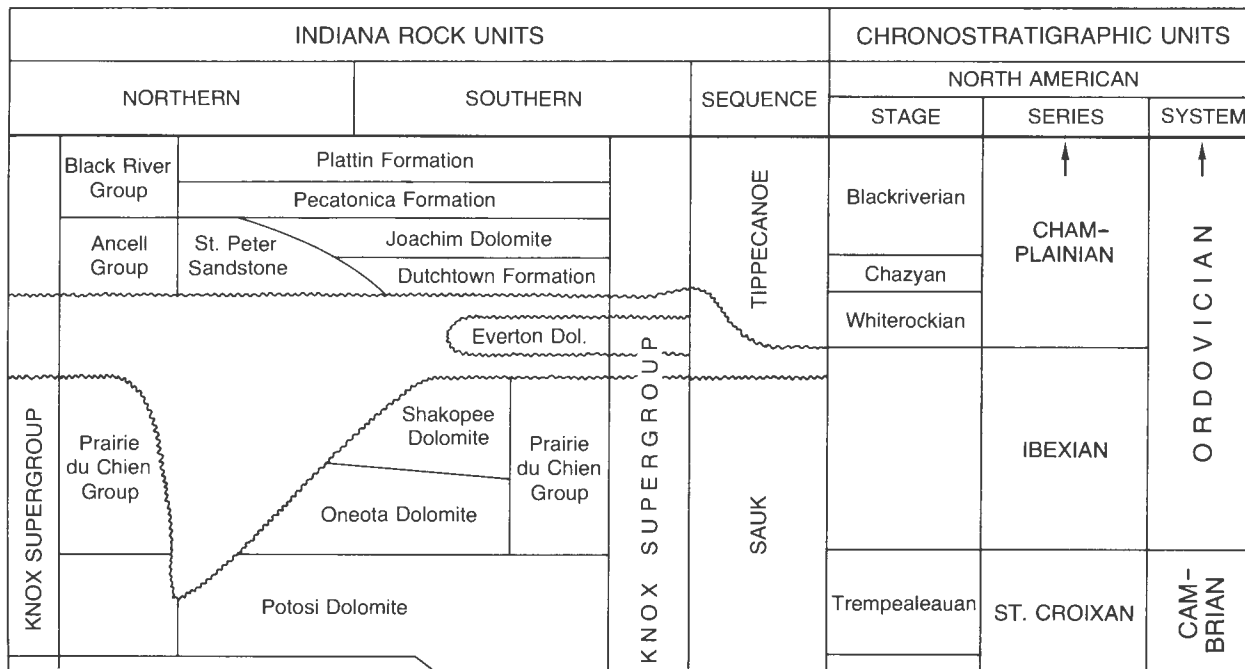


Figure 2. Chart showing stratigraphic relationships of the Dutchtown Formation in Indiana. Slightly modified from Droste and Patton (1985).

impure and very fine grained to fine-grained dolomite with interbeds of shale, siltstone, and sandstone. Fine- to medium-grained dolomite increases in abundance upward in the section. The dolomite ranges from light shades of gray to light to medium shades of brown. Chert in the Shakopee is light colored and is variably vitreous, opaque, and tripolitic and is uniformly colored to banded and oolitic. It is clearly of secondary origin.

Following the deposition of the Shakopee Dolomite of the Prairie du Chien Group (Ibexian)¹ and preceding the deposition of the Ansell Group, an interval of major erosion occurred that resulted in a land surface consisting of major valleys and rolling

¹The name Ibexian Series (Ross and others, 1982) is gradually replacing the term Canadian Series in North America because in contrast with the latter the Ibexian interval has a stratotype of limited geographic extent with well-defined upper and lower boundaries that are based on several different fossil lineages, but especially conodonts and brachiopods. We are using the term provisionally in this paper only in place of Canadian as applied in Indiana.

uplands. Sparse subsurface control precludes detailed interpretation of this topography generally, but in areas where well control is adequate, for example see Keller and Abdulkareem (1980), erosional relief approaching 100 feet within a single section of land bears testimony to some of the topography. Rocks of the Ansell terminate by nondeposition as they abut the higher elevations of the ridges and hills.

The pre-Ansell subcrop (Droste and Patton, 1985) indicates that the rocks of the Shakopee Dolomite are roughly in the southern two-thirds of the state, and they thicken from their eroded limit in the north to nearly 1,300 feet in southwestern Indiana (fig. 3A). This thickness pattern is due partly to erosional thinning to the north and partly to regional thickening from north to southwest. In the area from which our samples came, only 100 to 200 feet of the partly sandy Shakopee Dolomite remains after erosional truncation during Ibexian time. Seventy-five miles to the north and 35 miles to the northeast the entire Shakopee has been

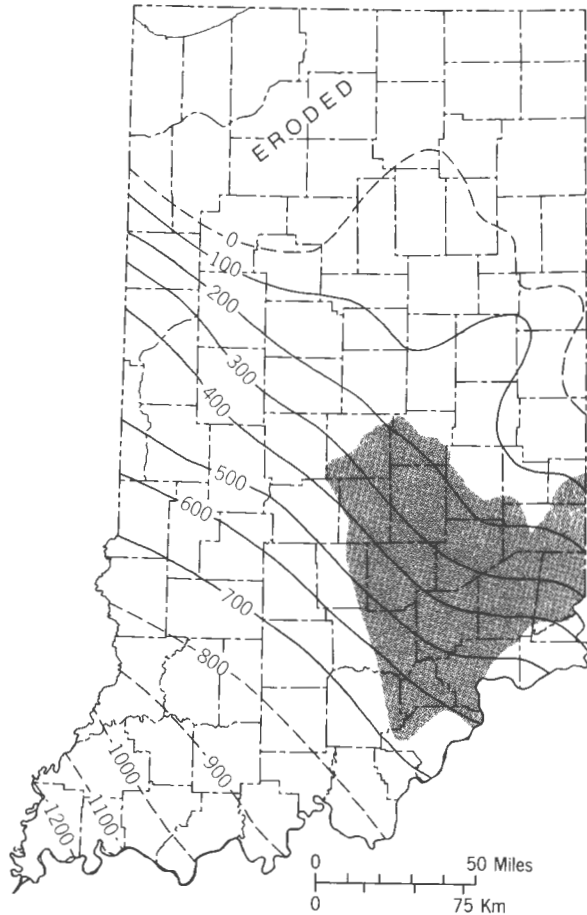


Figure 3A. Map showing the thickness of the Shakopee Dolomite in Indiana. The gray tone indicates the area where sandstones of the Shakopee Dolomite lie directly below rocks of the Ancell Group and where they are prominent rocks in the lower part of the Shakopee. Contour interval is 100 feet. Slightly modified from Droste and Patton (1985).

removed, and the Oneota Dolomite is at the top of the Knox Supergroup. Below the Shakopee in the study area the underlying Oneota Dolomite is a minimum of 300 feet thick (fig. 3B).

The depositional setting in Indiana for early Dutchtown sedimentation included: (1) a southern latitude location in the Southeast Tradewind Belt; (2) a vast, barren, windswept carbonate terrain; and (3) a topographic surface of open-flaring valleys and rolling uplands on which local relief was about 100 feet. The initial Ancell sea invaded Indiana



Figure 3B. Map showing the thickness of the Oneota Dolomite in Indiana. Contour interval is 100 feet. From Droste and Patton (1985).

from the south and the west from the Arkoma Basin and from the southeast from the Appalachian Basin. A separate seaway moved westward into the area of the Michigan Basin from the northeastern Appalachian Basin. As transgression continued these two seaways joined in later Ancell time, and the Midwest was completely submerged beneath shallow marine water.

The initial shorelines in Dutchtown time were much more irregular than the generalized interpretation of Droste and Shaver (1983, fig. 17). The valleys became very shallow water estuaries, parts of which were loci of restricted circulation in which carbonate and terrigenous sands and muds accumulated. The upland areas between the

valleys were rather low lying seaward-extending prominences, and islands of various sizes existed in the seaway near shore and offshore. Large irregularities in shorelines and very shallow water environments produced many niches where initial Dutchtown sediments accumulated. The samples from which we have recovered *Scapulidens* are all from the basal Dutchtown rocks. As transgression continued, normal shallow-water environments expanded areally, and eventually the upland areas were completely submerged, which resulted in widespread normal shallow-water marine conditions.

Conodont Paleontology

INTRODUCTION

Conodonts were obtained from 26 samples distributed among the five studied cores (fig. 4). The samples came from intervals of dolomitic limestone and dolomite whose thicknesses in the cores ranged from 0.4 to 5.0 feet. Because most of the samples represent composites through rather thick successions of rock, the conodonts recovered from them constitute a homogenized record. Accordingly, the relative abundances of the elements within them probably cannot be compared meaningfully with data from collections made elsewhere. Nevertheless, a table of distribution is included here (table 1). We believe that these samples provide a realistic indication of the conodont population that inhabited this part of Indiana during early Champlainian time. The elements in each of the samples are consistent with those from all of the other samples, and so they must have been drawn from a common faunal association that persisted throughout the deposition of the sequence under investigation.

Most of the specimens are well preserved. More than 75 percent of the specimens recovered from each of the samples can be identified with confidence as one of the elements that we report here. Most of them are nearly complete individuals, and the most common loss is the tips of individual denticles. Of the 21 samples from the Champlainian parts of the cores, nine have specimens showing no evidence of alteration (CAI 1). Six samples contain specimens whose

morphologies identify them with typically hyaline species, but whose preservation is as opaque, ivory-colored elements. Another five samples have the same species, but the conodonts have dark-brownish-gray, translucent appearances. These obviously altered specimens probably do not indicate thermal alteration (Epstein, Epstein, and Harris, 1977) because the samples from which some of the altered conodonts were obtained are in places within the cores that are between samples whose conodonts are not altered. Furthermore, several samples that are dominated strongly by thermally unaltered conodonts contain a few specimens that have been altered. Preservation that mimics the states produced by thermal alteration is known to develop during diagenesis and weathering (Harris, 1979). As discussed elsewhere here, we believe that the rocks from which the samples were obtained were deposited in very shallow water and near to shore along a very irregular coast. Such a setting should have provided periods of unusual water chemistry or even of subaerial exposure for a short time. The gray- and ivory-colored specimens were probably altered during such periods.

CHAMPLAINIAN BIOSTRATIGRAPHY

The dominant components in our collections are hyaline conodonts that have been shown to be widespread geographically and moderately long ranging stratigraphically in lower Champlainian rocks of the Midcontinent Province. *Curtognathus* and *Erismodus* occur sparingly in rocks as old as the type Chazy in Vermont (Raring, 1972) and are common in Blackriverian strata (Votaw, 1971); they range as high as the Decorah Shale (Kirkfieldian) (Webers, 1966). These genera have not received detailed consideration in most of the numerous reports of their occurrence. The same species have been recognized repeatedly, but the morphologies of their elements have been discussed in general terms. It is not certain that all forms that have been identified under a particular name are really conspecific. As a consequence, the presence within the cores of species of *Curtognathus* and of *Erismodus* does not of itself allow biostratigraphic placement with greater resolution than early Champlainian.

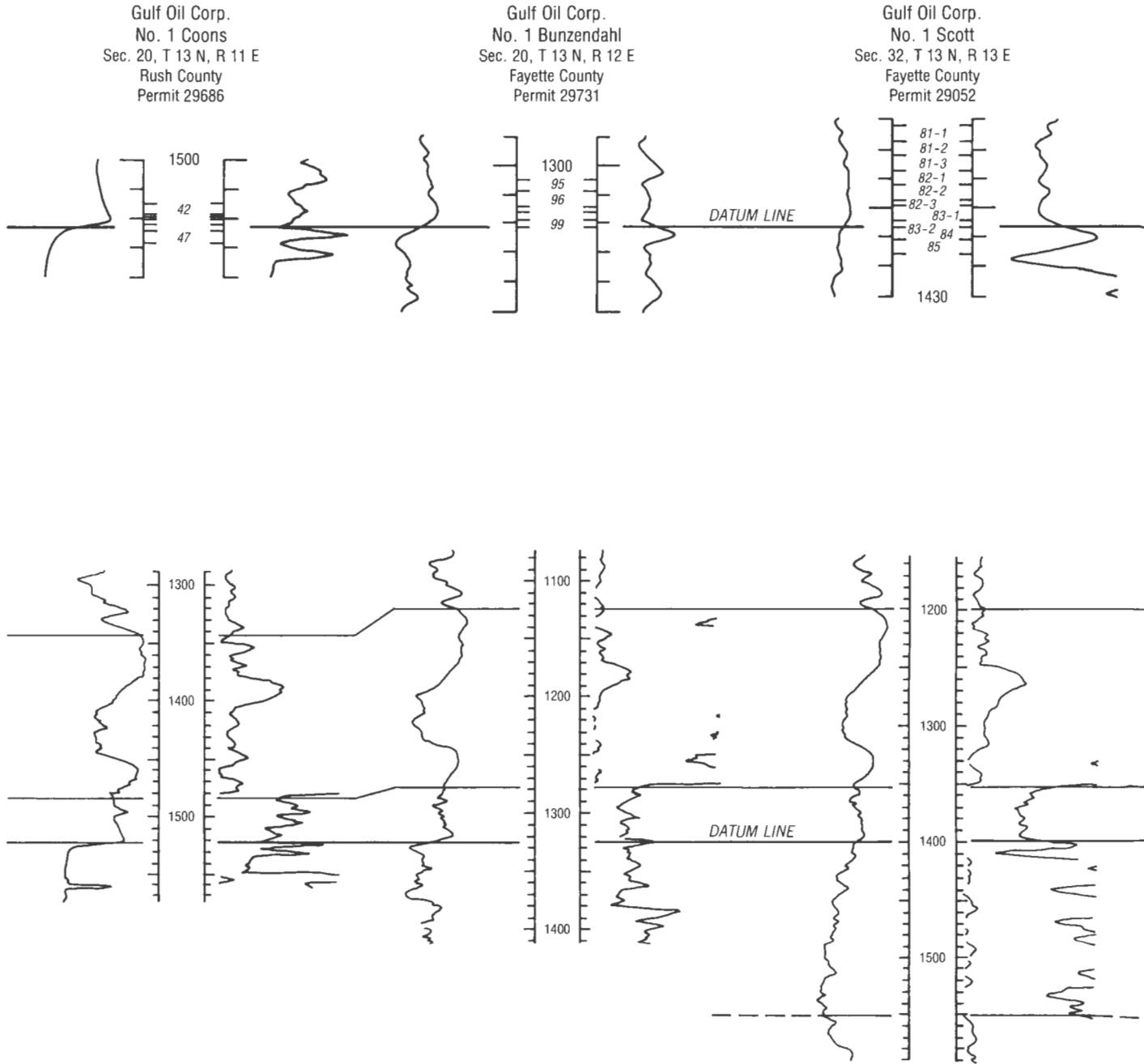


Figure 4. Induction electric logs of parts of the five cores studied showing the stratigraphy (below) and the sample intervals (above) on expanded logs. Slight adjustments have been made between the expanded electric log depths and the core depths. Depth is shown in feet.

Gulf Oil Corp.
 No. 1 Denny
 Sec. 8, T 12 N, R 12 E
 Franklin County
 Permit 29232

Gulf Oil Corp.
 No. 1 Osborn
 Sec. 33, T 12 N, R 11 E
 Decatur County
 Permit 29547

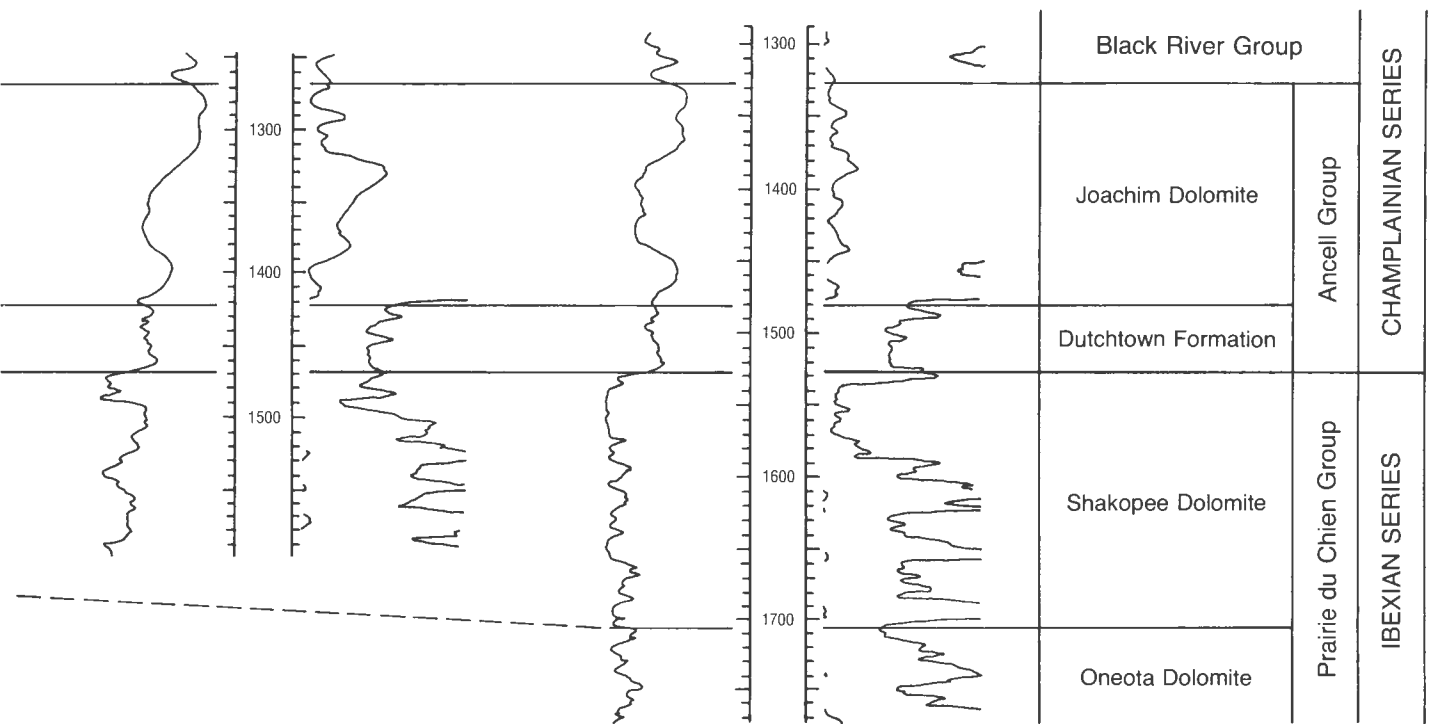
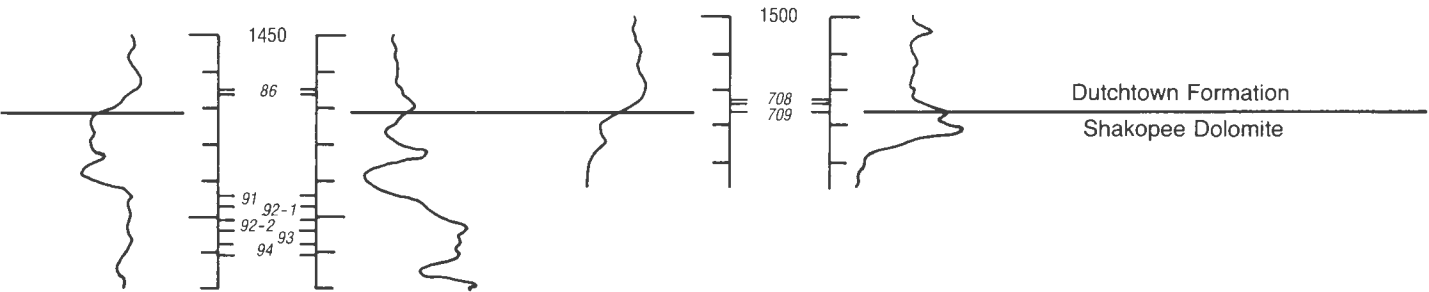


Figure 4—Continued

Table 1. Distribution of conodonts from the studied parts of the five core intervals

Taxa	Core and sample ¹																										Total elements
	Coon No. 1				Bunzendorf No. 1					Scott No. 1								Denny No. 1						Osborn No. 1			
	42	43	44	46	95	96	97	98	99	81-1	81-2	81-3	82-1	82-2	83-1	83-2	83-3	85	86	91	92-1	92-2	93	94	708	709	
<i>?Coleodus delicatus</i>	2				2	1		3						2		1			1						1		17
<i>?Coleodus simplex</i>					2			4	2		1			4	10+				4						3	6	36+
<i>Coleodus? sp. A</i>								1																			1
<i>Coleodus? sp. B</i>								1						2					2						1		6
<i>Coleodus? sp. C</i>																											
bidentate element	8		5	1	11	4		18	14	2	2	6	4	20	4				16								120
bladelike element	6		2		2	2	2	4	4	1			3	10					1						1	3	41
<i>?Curtognathus typus</i>	129	15	43	3	21	75	41	169	308	12	26	72	112	274	92	46	159		228						5	78	1,908
<i>Dapsilodus sp.</i>								1																			1
<i>Erismodus sp.</i>	67	7	44	8	33	88		167	96	26	28	45	46	138	18	10	67		65						11	28	992
<i>Leptochirognathus resimus</i>																											
asymmetrical element	12				1	3		13	6			2	4	7	2				1						3		55
subsymmetrical element	8					1		9	4				4	8	2	3											39
<i>Lumidens vitreus</i>																											
asymmetrical element	66	3	1		44	25	1	107	55	3	11	41	13	84	34	24	23		50	1			1		13	25	625
symmetrical element	13							21	20	4	3	5		8	11	12	8		20						10	10	145
<i>Oneotodus? ovatus</i>	25	1	15	10	67	50		127	19	1		33	78	155	11	2	9		12			1	2		9	4	631
<i>Panderodus sp.</i>					1	3																					4
<i>Phragmodus sp.</i>												1		2													3
<i>Plectodina aff. P. joachimensis</i>						2	7																				9
<i>Prionognathodus ordovicicus</i>	10		1		7	4		36	6	1		7	2	27	8	12	9		8						5	19	162
<i>Scapulidens primus</i>																											
tongue-shaped element	5		1		1			13			1		1	6	1	1	3		8						1	2	44
sickle-shaped element								3						1		1	1		2								8
slipper-shaped element	1	1						3																			5
<i>Stereoconus crepidiformis</i>	2			4	3			11	8			1		5	3	2	2		6						5	9	61
<i>aff. Stereoconus plenus</i>	1				3	1		4	3					5	2										4	2	25
New genus A					3	2						4		1													10
New genus B									1						1	1	1										4
Total elements	355	27	112	28	205	263	44	714	546	50	72	220	267	759	199+	115	289	---	424	1	---	---	2	2	72	186	4,952+
Ibexian conodonts															x	x		x		x	x	x	x				

¹ All samples represent 1.0 kg except 43 (0.83 kg), 44 (0.29 kg), and 708 (0.86 kg).

Correlation of the Dutchtown parts of the cores with the Dutchtown Formation of Missouri is supported by ?*Coleodus simplex* Branson and Mehl and ?*Coleodus delicatus* Branson and Mehl; both are probably the same as the two species found in the Dutchtown by Repetski (1973), but the limits of intraspecific variation are not yet well understood. Branson and Mehl (1933b) first reported *C. delicatus* from the Joachim Dolomite at a locality near Holstein in central Missouri. At that locality the Joachim rests directly on the St. Peter Sandstone in apparent conformity with transitional boundary relations between the two units. In southeastern Missouri the Dutchtown Formation is between the St. Peter and the Joachim in what also appears to be a wholly conformable succession. The facies relations that clearly exist within the St. Peter-Dutchtown-Joachim succession in Missouri have not been studied in detail, but *C. delicatus* probably does not range far above the base of the Joachim at any place. Andrews (1967) did not find this species in his thorough restudy of the Joachim conodonts.

Coleodus simplex occurs in the Glenwood Formation in southern Minnesota (Webers, 1966) and is associated with *C. delicatus* in the Harding Sandstone of east-central Colorado (Branson and Mehl, 1933a; Sweet, 1955). The Harding also contains the simple, peglike elements reported here as *Oneotodus? ovatus* (Stauffer). Species of *Coleodus* are numerically minor components of the conodont faunas of the Glenwood, the Harding, and the Dutchtown, however. Species of *Chirognathus* Branson and Mehl are dominant among the conodonts of the Glenwood and the Harding; *Multioistodus subdentatus* Cullison and *Leptochirognathus quadratus* Branson and Mehl are the most abundant conodonts in samples from the Dutchtown. None of these species is present in our cores, so that the total aspect of the fauna is different from those of the above formations.

Except for the species of *Coleodus*, *Erismodus*, and *Curtognathus* that can be identified at least provisionally with previously known taxa, most of the components of the fauna under consideration are new. Although conodonts of the Champlainian

Series of the North American craton have not been studied as exhaustively as conodonts of the higher parts of the Ordovician System, they have not lacked attention. Besides the studies of Dutchtown, Joachim, and Harding conodonts mentioned above, Blackriverian conodonts have been investigated thoroughly by Votaw (1971) in the central and eastern United States and by Barnes (1967) in southern Ontario. Conodonts from the Winnipeg Formation have been examined by Sweet (1982) in the Black Hills of South Dakota and by Oberg (1966) in the type area of the formation in Manitoba. Thus the significant areas of exposure of Champlainian cratonal rocks east of the Rocky Mountains have been sampled and the conodonts from them have been reported. None of these sections has yielded a fauna comparable to the one we found in the cores. The number of new forms in our collections is surprising, considering the coverage that has been given to faunas that we judge to be potentially correlative with the one under consideration. We can envision two possible explanations for this circumstance.

(1) The fauna may be specialized in response to an unusual ecology of limited geographic extent. The physical setting under which the lower Champlainian rocks were deposited and within which the conodonts presumably lived was outlined in the earlier section on physical stratigraphy. Transgressing seas of the Tippecanoe Sequence encroached over irregular erosional topography of modest relief that developed subaerially during the regression that followed deposition of the Sauk Sequence. This very shallow sea had a markedly irregular coast with estuaries that inherited the geometry of the drowned valleys and whose mouths may have been partly blocked by submerged hills, now islands, or by the growth of bars or spits.

In at least some estuaries, restricted circulation to the open ocean coupled with high evaporation in a tropical environment would result in hypersalinity. Lower than normal marine salinity might be produced at other places where major streams drained into similar estuaries. Departures from normal ranges of water temperature as well as unusual sedimentological settings might also exist

under such circumstances. Localized but unusual environmental conditions may have been established and maintained in response to these conditions and specialized faunas may have evolved as adaptations to them. Such conditions almost certainly would be transitory at any place where they existed, and they probably did not develop at most places. Populations endemic to such geographically and temporally restricted habitats would not be distributed over thick stratigraphic intervals at localities that they once inhabited and would likely not have existed at any time in most localities. If this is the correct explanation for a diversity of previously unreported conodonts in the cores from eastern Indiana, these forms will probably never be known from many places.

(2) The correlative interval may be one from which conodonts have not yet been recovered, for example, the older nonproductive parts of the St. Peter Sandstone or the time represented by the widespread pre-St. Peter unconformity. Witzke (1980) presented a faunal list (genera only) of conodonts that he obtained at an unspecified level in a core through the St. Peter near St. Paul, Minn., and from near the middle of the St. Peter in a core taken near Le Mars, Iowa. The genera that he reported suggest that his two St. Peter faunules are very similar to the conodonts of the Harding, the Glenwood, and the Winnipeg, which are late Blackriverian and Rocklandian in age (Sweet and Bergström, 1976). Witzke interpreted the St. Peter conodonts to be indicative of Chazyan age, although the genera he listed were not characteristic of Chazyan faunas elsewhere. A Blackriverian age is more likely. The conodonts from the St. Peter in extreme southwestern Indiana (Rexroad, Droste, and Ethington, 1982) are correlated with the outcropping Dutchtown (Chazyan) of Missouri. Although the age of the St. Peter that is bracketed by the two sets of conodonts leaves a considerable age range into which our Dutchtown fauna might fit, conodonts have been recorded from other formations representing most of the Chazyan to Rocklandian interval, as summarized by Sweet and Bergström (1976). Therefore, if the conodonts represent an interval not previously recorded, the most likely correla-

tion would be with part of the St. Peter, which is older than the Dutchtown Formation of Missouri, or with the pre-St. Peter erosion interval. This seems a less likely possibility than that the fauna is specialized in response to a specific ecology.

Besides the hyaline conodonts that dominate our collections and that are discussed in detail in the systematic section that follows, rare albid elements scattered through the samples merit at least passing attention. Because they occur in such small numbers and typically are very fragmentary, we have been unable to identify them confidently with any known species. The genera that they represent are significant components of many Champlainian faunas that have been described from central North America. The exceedingly low numbers in which they occur in our collections probably indicate that at the time of deposition the environmental conditions were unfavorable for these species. The conodonts in question consist of *Dapsilodus* sp., *Panderodus* sp., *Phragmodus* sp., and *Plectodina* aff. *P. joachimensis* (Andrews).

IBEXIAN BIOSTRATIGRAPHY

All five cores penetrated rocks that have been assigned to the Prairie du Chien Group. Well-preserved conodonts in these collections consist of elements of *Acanthodus lineatus* (Furnish), "*Acodus*" *oneotensis* Furnish, "*Acontiodus*" *iowensis* Furnish, *Chosonodina herfurthi* Müller, *Loxodus bransoni* Furnish, *Oneotodus simplex* (Furnish), "*Paltodus*" *bassleri* Furnish, and *Rossodus manitouensis* Repetski and Ethington. This association of species is very widespread in the Midcontinent Province where it occurs in lower Ibexian strata. It occurs in the Oneota Dolomite in the upper Mississippi Valley region (Furnish, 1938), in the Gasconade Dolomite in Missouri (David Hearn, oral communication, 1984), and in the Mackenzie Hill Formation in southern Oklahoma (Mound, 1968). In all of these occurrences this fauna is succeeded by a younger Ibexian fauna that is dominated by *Eucharodus parallelus* (Branson and Mehl), *Diaphorodus delicatus* (Branson and Mehl), *Glyptoconus quadraplicatus* (Branson and Mehl), and form species of *Ulrichodina* Furnish.

The lower Ibexian conodonts listed above are present in a sample from the interval 1,411.2 to 1,416.0 feet in the Scott core from Fayette County. Samples from the intervals 1,399.2 to 1,404.2 and 1,404.2 to 1,406.7 feet in the same core are dominated by the hyaline Champlainian conodonts discussed above; these latter samples include admixtures of worn elements of the Ibexian species that have likely been reworked. The Champlainian fauna is present in the interval 1,465.0 to 1,466.2 feet in the Denny core from Franklin County; Ibexian conodonts were recovered from all samples below 1,494.3 feet in that core. The intervening segment of core consists wholly of fine-grained sandstone and was not examined for conodonts. The absence of middle and upper Ibexian conodonts (faunas with *E. parallelus* and associated species) in both of these cores indicates an unconformity that has eliminated most of the Ibexian from this part of Indiana, (even though the remaining rocks are as much as about 600 feet thick). The presence in eastern Indiana of conodonts equivalent to those in the Oneota in its type area on the northwest flank of the Illinois Basin indicates that the Shakopee is a time-transgressive unit that was deposited earlier in eastern Indiana than in the upper Mississippi Valley.

Acknowledgments

Without the cores from the Gulf Oil Corp. this fascinating group of conodonts would have remained undiscovered. We appreciate having the opportunity to study the conodonts from the core samples. We also wish to thank Jeffrey A. Bauer, The Ohio State University, for helpful comments on the systematics, particularly in regard to *Oneotodus? ovatus*. The paper was strengthened by the careful critical reading of John E. Repetski, U.S. Geological Survey, Washington, D.C., and we appreciate his helpful suggestions.

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Core Locations

Gulf Oil Corp. Coon No. 1 wildcat. 330 ft S.L., 380 ft E.L., SE $\frac{1}{4}$ SE $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 20, T. 13 N., R. 11 E., Rush County, Ind.

Gulf Oil Corp. Bunzendahl No. 1 wildcat. 1 ft N.L., 1 ft W.L., SE $\frac{1}{4}$ SE $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 20, T. 13 N., R. 12 E., Fayette County, Ind.

Gulf Oil Corp. Scott No. 1 wildcat. Center NE $\frac{1}{4}$ SE $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 32, T. 13 N., R. 13 E., Fayette County, Ind.

Gulf Oil Corp. Denny No. 1 wildcat. 330 ft S.L., 330 ft W.L., SW $\frac{1}{4}$ SE $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 8, T. 12 N., R. 12 E., Franklin County, Ind.

Gulf Oil Corp. Osborn No. 1 wildcat. NE $\frac{1}{4}$ NE $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 33, T. 12 N., R. 11 E., Decatur County, Ind.

Systematic Paleontology

Genus COLEODUS Branson and Mehl, 1933

Type species: Coleodus simplex Branson and Mehl, 1933.

Remarks: Clark and others (1981, p. 179) listed *Coleodus* Branson and Mehl among names that they considered to have been abandoned by students of conodonts. Nevertheless, Moskalenko (1970, 1976) used the name for conodonts from the Middle Ordovician of the Siberian Platform, and Klapper and Bergström (1984) discussed *Coleodus* as having possible close affinities with *Archeognathus* Cullison. The latter authors observed that the type species, *C. simplex*, is based on fragmentary specimens from the Harding Sandstone of Colorado and that the morphology of the species was not clarified in Sweet's (1955) restudy of Harding conodonts that also produced only fragments.

The concept of the genus that has developed during the 50 years since it was first recognized encompasses hyaline elements with a series of short, reclined denticles that are closely set above a thin but deep basal region. A basal slit or groove is on most of the specimens that have been identified with

Coleodus, and deep, heavy basal structures adhering to the basal region have been reported (Moskalenko, 1976; Klapper and Bergström, 1984). The specimens assigned to *Coleodus* in this study are consistent with the generalized description just given and conform to the morphologies that have been described for some forms reported under that genus. We therefore compare them with extant species of *Coleodus*, but we suggest that affinity may not exist with all species that have been assigned to the genus.

?*COLEODUS DELICATUS* Branson and Mehl

Plate 2, figures 17, 18

?*Coleodus delicatus* BRANSON and MEHL, 1933b, p. 80, pl. 6, figs. 3, 4; SWEET, 1955, p. 232-233, pl. 27, fig. 7.

?*Coleodus pectiniformis* YOUNGQUIST and CULLISON, 1946, p. 581, pl. 89, figs. 7, 19.

Remarks: This species is based on fragments that Branson and Mehl (1933b) described in their study of the conodonts of the Joachim Dolomite. Andrews (1967) did not obtain additional specimens in his restudy of the fauna of the Joachim, and the concept of the species, as it is understood at this time, reflects the morphology of a more definitive specimen from the Harding Sandstone of Colorado that was illustrated by Sweet (1955, pl. 27, fig. 7).

The Harding specimen shows slender, closely crowded denticles whose posterior inclination increases progressively and results in a fan-shaped configuration. Collections from the Harding made by one of us (RLE) show that considerable variation on this theme is expressed. Most of the elements are moderately flexed; some are particularly so near the posterior extremity. Some elements are elongate, thin, and gently arched, but others are short, are rather thick, and have more strongly concave lower outlines. The basal cavities are shallow and narrow and extend the length of the longer and thinner elements, but they are broad, slightly depressed basal surfaces on the short, heavy specimens. Translucent basal material is retained on many specimens. Albid material is not present.

About one-third of the samples from the Champlainian part of the cores yielded elements very similar to those from the Harding described above. The range of variation that is displayed is not so great as that for the Harding collection. Compared with the elements from the Harding, those from Indiana have denticles that are shorter relative to the vertical dimension of the element, and none of the specimens is flexed, especially toward the posterior end. Although shallow, the basal cavities are more clearly defined than those in the Harding material. None of the specimens conforms to the short, thick morphotypes in the Harding.

Although the specimens reported here are clearly morphologically close to some of the Harding material and to specimens from the Dutchtown Formation of southeastern Missouri that Repetski (1973) identified with *C. delicatus*, they show enough differences that we cannot assign them to that species without reservation. The differences may be phenotypic in origin, or they may merely reflect that the limited number of specimens available from the cores is insufficient to define the range of morphologic variation.

Number of specimens: 17.

Repository: Figured specimens, 16631 and 16632.

?*COLEODUS SIMPLEX* Branson and Mehl

Plate 2, figure 28

?*Coleodus simplex* BRANSON and MEHL, 1933a, p. 24, pl. 1, figs. 22-25; YOUNGQUIST and CULLISON, 1946, p. 581-582, pl. 90, figs. 16, 17; SWEET, 1955, p. 233, pl. 29, fig. 27.

Remarks: The conodonts that have been reported under this name, including the type specimens, are fragments that must have come from elongate, slender elements with short, stubby fused denticles of subequal sizes. The denticles are inclined at about 60° to the trend of the element. Moskalenko (1970) described new species of *Coleodus* based on material of this general configuration that she collected in the Middle Ordovician rocks of the Siberian Platform. Evaluation of the

affinities of these specimens and those from the Dutchtown of Missouri that Youngquist and Cullison (1946) identified as *C. simplex* with the type specimens of the latter species requires larger collections with more complete individuals than have been assembled so far.

The collections from the cores include many fragments of high, thin hyaline elements with shallow basal troughs and with stubby, partly fused denticles. The only nearly complete specimen (pl. 2, fig. 28) shows an almost straight basal outline; its basal trough narrows markedly posterior to midlength of the element, and the posterior one-third of the basal region is recessive. This specimen shows only slight flexure, but some of the fragments are strongly bent, particularly those that represent the posterior extremities of elements.

An apparatus for *Coleodus* has not been suggested, probably because of the fragmentary character of most specimens that have been reported; perhaps the relative scarcity of elements of *Coleodus* in collections studied to date is also a factor. The common occurrence together of elements of the types here tentatively compared with *C. simplex* and *C. delicatus* suggests that they constitute different parts of a common organism. Our collections, like those reported previously, consist almost wholly of fragments. They display more variation, particularly in degree of flexure, than has been described from other localities. For this reason alone, we cannot identify them with previously named form elements and cannot establish an unequivocal apparatus. Perhaps the elements reported here as *Coleodus?* sp. A and *Coleodus?* sp. B, together with the forms we compare with *C. delicatus* and *C. simplex*, should also be considered as parts of an apparatus. Such elements are not known from other faunas in which elements of *Coleodus* are present, and they occur too infrequently in our collections to allow more than speculation regarding their significance.

Number of specimens: 1 nearly complete individual; 49 fragments.

Repository: Figured specimen, 16633.

COLEODUS? sp. A

Plate 2, figure 21

Remarks: Only one specimen of this type was found in our collections. It is an angulate, slightly flexed pectiniform element whose denticles are poorly defined other than along the serrate upper margin. The element consists wholly of hyaline material, and this, together with the pectiniform outline, suggests possible assignment to *Coleodus*. The cockscomb-shaped element except for a swollen region just above the lower margin is relatively thin. The denticles are irregular but subequal in size; all are inclined posteriorly and become more strongly so toward the posterior extremity. The basal cavity is a shallow, narrow longitudinal trough from which a deep basal structure protrudes.

A distinguishing feature is a pair of downward and anteriorly directed lobes in the lower margin. The one on the inner (slightly concave) side of the element has its beginning as a swelling of the lateral surface at the boundary between the sixth and seventh denticles in the series. This swelling continues and is accentuated in the lobe itself. This lobe is nearly as long as the height of the main part of the element above it. The lobe on the outer (gently convex) side of the element is not swollen. It is a triangular projection of the lower margin that has the same general vertical dimension as the opposite lobe. The outer lobe, beneath the fourth and fifth denticles, is more anteriorly located than its opposite counterpart. The basal outline is distinctly arched posterior to the lobes that it intersects near their position of emergence from the element. Anteriorly the basal outline is inclined distally but flattens proximally to intersect the lobes at about midheight.

Number of specimens: 1.

Repository: Figured specimen, 16634.

COLEODUS? sp. B

Plate 2, figures 23-25

Remarks: The collection consists of six specimens, of which only two are nearly complete, distributed among five samples. Because all are hyaline pectiniform elements with inclined, poorly defined denticles, we assign them with question to *Coleodus*.

Other than their cockscomb outline, the most distinguishing feature of these elements is the sharp-crested ridges on one of their lateral surfaces. These ridges extend from near the apices of the denticles to just above the lower margin. On one of the nearly complete specimens (pl. 2, fig. 23) the last four denticles in the series do not have corresponding ridges, and the fifth denticle from the end is above a ridge that reaches only halfway to the lower margin. The other nearly complete specimen (pl. 2, fig. 25) has no ridge in the position of the last denticle, and the penultimate denticle is in the position of a ridge that begins just above the lower margin and continues upward through about one-third of the height of the element. The ridges follow nearly straight courses in the anterior part of the element, but they are increasingly bowed posteriorly with their convex sides facing anteriorly. The ridges are separated by V-shaped troughs and have steeper and narrower flanks posterior to their crests than anterior. The spacing of the ridges is broadest anteriorly and becomes closer posteriorly in tandem with the progressive decrease in the size of the denticles from anterior to posterior in the series. The surface of the element opposite that with the ridges is planar on all specimens.

The denticles are defined by V-shaped indentations in the upper outline. The gaps in the margin that separate them are progressively narrower and shallower from front to rear. The two to three most anterior denticles have blunt points, but those posterior to them terminate in a blunt edge that is normal to their longitudinal dimension. The last two to four denticles (that is, those lacking corresponding ridges) are barely differentiated from the upper margin of the element.

Although fragmented anteriorly, the two

most complete specimens suggest that the anterior extremity of these elements is defined by the leading edge of the first denticle that rises steeply from the basal margin. The upper outline of the element follows a gentle arch along the tips of the denticles and is more strongly curved toward the posterior part of the series. It descends steeply at the posterior extremity; the posterior outline shows a reentrant just above the basal margin. The basal outline is broadly concave except beneath the nonridged posterior region where it is gently convex. The basal cavity is a wide V-shaped trough that extends up into the lower third of the element; it flares somewhat at the posterior extremity of the element.

Number of specimens: 6.

Repository: Figured specimens, 16635, 16636, and 16637.

COLEODUS? sp. C

Plate 2, figures 19, 20

Remarks: Two distinctive kinds of hyaline elements are included here; one is an elongate blade and the other has two denticles surmounting a posteriorly flared base. The latter element resembles the anterior region of the former, and at first consideration we believed that the bidentate forms were fragments of the blades. Careful examination has shown that they are complete specimens, however, so that we interpret them as two elements from the apparatus of a single species.

The bidentate elements have two slender, curved denticles of unequal length. The second denticle is somewhat to the side of and behind the first, so that their basal regions overlap by about one-third of their width and result in a concavo-convex morphology of the element. Denticles are biconvex transversely and generally have a laterally directed costa near their anterior margins on the concave side of the element. The base is thick beneath the denticles and is continued posteriorly to form a broad, nondenticulate but short process. The basal

surface is recessive beneath the denticles but has a broad, anteriorly and somewhat apically directed conical cavity located posteriorly. Some specimens have an amorphous mass of translucent material projecting from the lower surface, and others show a dark residue there that may indicate the former presence of such material.

Bladelike elements are differentiated into an anterior region with as much as five discrete denticles followed by a posterior segment in which the denticles are short, reclined, and largely fused to each other along a high but thin base. The basal margin is recessive, although a median slit may be present.

We are convinced that these two kinds of elements came from one apparatus, but we are uncertain whether additional elements were present there. These two types of elements have not been reported previously, but a fragment of one of the bladelike elements that had lost the anterior region would likely be identified as *Coleodus delicatus*. Possibly some of the fragments that have been reported under that name belong here. This similarity in morphology offers the possibility that these elements are part of an apparatus that also includes *C. delicatus*; if so, that is the name of the species. But the lack of any report of elements like the bidentate forms in association with material assigned to *C. delicatus* and the lack of such specimens in abundant collections from the Harding Sandstone argue against that conclusion. If these elements do not represent a new or extant species of *Coleodus*, they must belong to a closely related genus.

Number of specimens: Bidentate elements, 120; bladelike elements, 40.

Repository: Bidentate element, 16638; blade-like element, 16639.

Genus CURTOGNATHUS Branson and Mehl, 1933

Type species: *Curtognathus tya* Branson and Mehl, 1933.

Cardiodus BRANSON and MEHL, 1933b, p. 80-81 [non TROUESSART, 1881].

Trucherognathus BRANSON and MEHL, 1933b, p. 84.

Polycaulodus BRANSON and MEHL, 1933b, p. 86.

Cardiodella BRANSON and MEHL, 1944, p. 237, 239.

?CURTOGNATHUS TYPUS

Branson and Mehl

Plate 1, figure 3; plate 2, figures 1-11, 22

?*Curtognathus tya* BRANSON and MEHL, 1933b, p. 87, pl. 5, fig. 28.

Remarks: Votaw (1971), in a study of Blackriverian conodonts from the midcontinent of North America, reconstructed an apparatus that included elements that Branson and Mehl (1933b) had assigned to the form genera *Curtognathus*, *Cardiodus* [later redesignated *Cardiodella* because the name was preoccupied], *Polycaulodus*, and *Trucherognathus*. He noted that these forms display a nearly complete gradation in morphology and that they co-occur in many Champlainian units in the central United States. His interpretation of the apparatus was adopted in the recent discussion of conodonts in the "Treatise on Invertebrate Paleontology" (Clark and others, 1981).

Elements of *Curtognathus* dominate our collections from the Dutchtown parts of the cores. All of the morphologic themes that Votaw considered to be represented in the apparatus are included, and as he observed, a nearly complete morphologic sequence can be discriminated among them. We have compared our collections with the specimens from the Joachim Dolomite of Missouri that Branson and Mehl considered when they defined the form genera now subsumed under *Curtognathus* and also with the more numerous specimens from the Joachim that Andrews (1967) described. Although we can recognize specimens in our collections that duplicate the morphologies of these previously studied forms, our material includes many morphotypes that are not duplicated among the Joachim specimens deposited in the UMC collections. We believe it likely that these specimens are intermediate morphologies in an intergrading series that do not have counterparts among the elements selected for

repositing by Andrews and by Branson and Mehl. Examination of large numbers of elements recovered from single samples is needed to evaluate the variation displayed by conodonts whose morphology is so variable, and such collections were not retained when the Joachim conodonts were studied. For this reason we identify our material with *C. typus* with some reservation.

Number of specimens: 1,908.

Repository: Figured specimens, 16640 through 16652.

Genus ERISMODUS Branson and Mehl, 1933

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

Erismodus BRANSON and MEHL, 1933a, p. 25.

Microcoelodus BRANSON and MEHL, 1933b, p. 89-90.

?*Multicornis* MOSKALENKO, 1970, p. 74.

Pteroonus BRANSON and MEHL, 1933b, p. 99 [non HINDE, 1900].

Ptiloonus SWEET, 1955, p. 245-246.

Remarks: *Erismodus*, *Microcoelodus*, and *Ptiloonus* [originally named *Pteroonus*] were identified by Branson and Mehl (1933a, b) as form genera in the hyaline component of the conodonts of the Harding Sandstone and the Joachim Dolomite. Subsequently, specimens from a variety of lower Champlainian formations in North America were identified under these generic names, each subsuming numerous form species. Lindström (1964, p. 89, 176) concluded that the form species represented variants in the *Cordylodus-Roundya* symmetry-transition series that he believed to characterize the apparatuses of *Erismodus* and *Microcoelodus*. He described *Erismodus* as comprising "trichonodella elements" and *Microcoelodus* as consisting of "ligonodina elements."

General similarity of some form species of *Erismodus* to form species of *Microcoelodus* led Harris (1964) to attempt to establish more distinctive diagnoses for these two taxa. The first major effort to revise the taxonomy of

this plexus of hyaline elements was offered by Andrews (1967), who considered that *Erismodus* and *Microcoelodus* differed only in that elements identified by the former name are asymmetrical, and those listed under the latter are symmetrical or nearly so. Because he believed that this difference was not generically significant, Andrews identified all such elements with *Erismodus*. He recognized four form species that he distinguished on the basis of the degree of asymmetry that they displayed, and he placed in synonymy with them nearly all form species that had been established in *Erismodus*, *Microcoelodus*, and *Ptiloonus*. He concluded that evolutionary development within the *Erismodus* lineage had resulted in a gradual shift toward increasing asymmetry. No specific data supporting this conclusion were offered, and it has not been accepted in later work (for example, Votaw, 1971).

Webers (1966) did not identify tentative "natural species" [= apparatuses] for the "fibrous forms" that he recovered from the Glenwood Formation in Minnesota, although he did so for "nonfibrous" conodonts from other stratigraphic units. The first published reconstruction of an apparatus was presented by Sweet and Bergström (1972, p. 34, fig. 2F), who illustrated a transition series showing five elements in a diagram of ramiform-element apparatuses. They suggested that *Erismodus* and *Microcoelodus* might prove to be distinct genera that display the same spectrum of elements in their apparatuses, an arrangement they identified as a simplified prioniodont apparatus.

The reconstruction that is generally used today was made by Carnes (1975), who recognized seven basic types of elements in the apparatus. In the locational nomenclature used in the "Treatise on Invertebrate Paleontology" (Sweet, 1981, p. 19) these are identified respectively as Pa, Pb, M, Sa (two types), Sb, and Sc. Carnes noted that almost complete intergradation in morphology exists among these elements that thus display an almost complete symmetry transition and that many specimens in his collections were hard to categorize according to these seven types of elements. Our experience leads us to concur in this observation.

ERISMODUS sp.

Plate 1, figures 9-13, 16-18

Remarks: Carnes (1975) distinguished two species of *Erismodus* within his collections from lower Champlainian rocks of the southern Appalachian region. One of these, which displays slender, laterally compressed denticles, has been assigned to *E. quadridactylus* (Stauffer) by Sweet (1982). The other species described by Carnes has short, stubby, peglike denticles; these forms are very similar to the specimens of *Erismodus* that we found in the cores. Carnes reported this species in open nomenclature because he could not identify it with any of the previously described species.

We compared our material from the subsurface of eastern Indiana with specimens from the Joachim Dolomite and the Harding Sandstone collections at the University of Missouri-Columbia. Although essentially identical elements can be identified in all of these faunas, many of the elements from Indiana do not have exact counterparts in the other collections. In particular, many elements show rather strong salients in the aboral margin (pl. 1, figs. 9, 11, 12), a feature that is not common in the Joachim material, and others (pl. 1, figs. 13, 16) show symmetry variants that are not represented there at all. Except for the recent study of the fauna of the Winnipeg Formation by Sweet (1982) and the earlier work of Andrews (1967), systematic considerations of hyaline elements have not been published. Andrews's work antedates multielement reconstructions, and thus it represents an outmoded taxonomy that cannot be reinterpreted without assembling new collections from the Joachim.

Because our material is from the subsurface, it cannot be enlarged on. We leave the species of *Erismodus* in open nomenclature because of the as yet uncertain limits of variation that can be encompassed within species of that genus. Barnes and Fähræus (1975, p. 138) postulated that hyaline forms display ecophenotypic variation; those from shallow-water environments are robust, and relatively delicate individuals indicate deep water. Many of the specimens in our

collections are thick and heavy. If the above supposition is correct, the differences between our material and the specimens from the Harding and the Joachim with which we compared them may be the result of environmental influence.

Number of specimens: 992.

Repository: Figured specimens, 16653 through 16659.

Genus LEPTOCHIROGNATHUS
Branson and Mehl, 1943

Type species: *Leptochirognathus quadratus*
Branson and Mehl, 1943.

Remarks: *Leptochirognathus* was offered as a form-generic taxon to encompass a collection of thin hyaline palmate elements that Branson and Mehl (1943) obtained from the McLish and Bromide Formations near Ada, Okla. They distinguished seven form species among the specimens that they assigned to this genus; the distinctions between them were based primarily on the number of denticles and the general symmetry. Most of these form species have not been mentioned subsequently. Conodonts from the Dutchtown (Repet-ski, 1973) and Everton (Golden, 1969) Formations of the southern Ozark region have been reported as *L. quadratus* and *L. primus*. Bergström (1978) found *L. quadratus* in the Woods Hollow Shale in the Marathon area of west Texas, and this species is present in the Womble Shale in west-central Arkansas (Repet-ski and Ethington, 1977; undescribed collections). *Leptochirognathus primus* occurs in the Lenoir Limestone at Friendsville, Tenn., and in the upper part of the Mosheim Limestone at Porterfield, Va. (Bergström, 1971, fig. 10), and *L. extensus* is present in the Lincolnshire Limestone at Strasburg, Va. Harris and others (1979) illustrated but did not describe or name what they considered to be a new species of *Leptochirognathus* from the upper part of the Antelope Valley Limestone in the Monitor Range, central Nevada. All rocks from which this genus has been reported are of early Champlainian age.

Most of the known occurrences of *Leptochoirognathus* are in rocks that are believed to have accumulated in shallow marine environments. For this reason Barnes and Fåhraeus (1975) listed this genus and *Coleodus* Branson and Mehl as representative of a conodont community that inhabited littoral regions of the Midcontinent Province during early Champlainian time. The occurrences in the Mosheim Limestone of the southern Appalachians led Bergström and Carnes (1976) to identify *Leptochoirognathus*, together with the species with which it is associated there, as constituting the *Leptochoirognathus* Recurrent Species Association. They noted that this fossil assemblage may be a composite of taxa that did not occupy the same living space within the water body and so is not a community in the traditional meaning of the term. They believed that the Mosheim was deposited under supratidal to high subtidal conditions and that the conodonts probably occupied the deeper part of that depth range.

The presence of the species of *Leptochoirognathus* in the Womble and Woods Hollow Shales, both of which are believed to have been deposited on continental slopes, is not consistent with the other occurrences of members of the genus. Perhaps these species were eurytopic and these deep-water habitats were within their range of adaptation. But both the Womble and the Woods Hollow are known to contain turbidites, so that conodonts might have been introduced into their deep-water settings from shallow sources.

The apparatus of *Leptochoirognathus* has not been established. Lindström (1964) reviewed the elements from the McLish Formation for which the genus was proposed by Branson and Mehl and concluded that they display intergradations "from symmetrical forms with the biggest denticle in the middle to definitely asymmetrical forms"; he postulated that affinity exists between *Leptochoirognathus* and *Rhipidognathus* Branson, Mehl, and Branson. Sweet and Bergström (1972, p. 41) also suggested that there may be a symmetry transition among the elements of the apparatus. Barnes and others (1979) stated that *Leptochoirognathus* has a type IV apparatus in their system of describing

apparatuses, that is, it has two transition series of elements, but they did not provide a discussion to document the reasons that led them to this conclusion. The treatment of *Leptochoirognathus* in the "Treatise on Invertebrate Paleontology" (Clark and others, 1981) states that the apparatus is not known. Harris (1982) identified carminiplanate, pastiplanate, and stelliscaphate S as well as P and S elements among the few specimens representing *Leptochoirognathus* that he obtained from lower Champlainian rocks in eastern Tennessee. Because he had so few specimens, he acknowledged that his interpretation of the apparatus was provisional. The conodonts of the McLish are under study (Bauer, 1984), and a model for the apparatus may be forthcoming when that work is completed. Our collections from Indiana suggest a bielemental apparatus for the species there rather than the transition series that has been postulated.

LEPTOCHIROGNATHUS RESIMUS n. sp.

Plate 1, figures 14, 15

- aff. *Leptochoirognathus erecta* BRANSON and MEHL, 1943, p. 377, pl. 63, fig. 18.
 aff. *Leptochoirognathus tridactyla* BRANSON and MEHL, 1943, p. 380, pl. 63, figs. 17, 19, 21; ?pl. 63, figs. 20, 22.
 aff. *Leptochoirognathus gracilis* BRANSON and MEHL, 1943, p. 377, pl. 63, figs. 39, 40.
 ?*Leptochoirognathus* cf. *L. gracilis* s.f. Branson and Mehl TIPNIS, CHATTERTON, and LUDVIGSEN, 1980, p. 89, pl. 5, fig. 26.
 ?*Leptochoirognathus* cf. *L. tridactylus* s.f. Branson and Mehl TIPNIS, CHATTERTON, and LUDVIGSEN, 1980, p. 89, pl. 5, fig. 27.

Our collections include two kinds of elements that display the characteristic palmate morphology of *Leptochoirognathus*; one is strongly asymmetrical and nearly planar, and the other is subsymmetrical and somewhat flexed.

Asymmetrical elements: These elements have four denticles, the anterior of which is erect, and those succeeding it are increasingly inclined with the posterior denticle parallel to

the basal margin. The denticles are asymmetrically triangular in outline; the second in the series is the largest, the first and third are subequal to each other, and the fourth is the smallest. The denticles are thin with sharp edges and somewhat swollen medial regions; some show development of keeled edges, but others are more uniformly biconvex transversely. They may be fused through the lower one-third to one-half of their lengths. The basal region is thick but thins to the lower margin, so that it has a swollen appearance, commonly with a narrow flange or lip at the margin. The basal outline is straight to gently convex beneath three rear denticles but curves strongly upward beneath the anterior denticle to produce a tobogganlike configuration for the entire basal outline. The cavity is a shallow but broad trough that is widest beneath the common margin of the two leading denticles and narrows both anteriorly and posteriorly from there.

Subsymmetrical elements: These elements have denticles arranged in a radiating palmate fashion. The denticles are subequal in size, generally discrete throughout their length, and relatively slender. They have clearly developed marginal keels flanking swollen central regions. Four clearly developed denticles are present on all complete specimens in the collection; several show low basal knobs at one or both ends of the row of denticles that may represent incipient or aborted denticles besides the principal four. Typically the denticle at one end of the series is shorter and somewhat broader than the other three; this short denticle is also the most strongly inclined of the four. The second denticle from the opposite end of the series is erect, and those to either side of it are inclined away from it in opposite directions. The entire element is concavo-convex. On the convex side the basal margin is asymmetrically convex, and the deepest position is beneath the erect second denticle; a modest basal salient may be present in this position. The basal margin on the concave side of the element is higher than to the opposite side; its outline is slightly sinuous. The basal cavity is a shallow, broad trough that is widest beneath the erect second denticle.

Remarks: These elements have been compared directly with the specimens in the UMC collection on which *Leptochirognathus* is based. They do not conform to any of the morphologies that are displayed by these specimens. Our collection from Indiana includes small and delicate individuals as well as heavy, robust forms, and the morphologic characters that are displayed by all of them are those described above. We conclude, therefore, that we have a distinct species that justifies creation of a new name. Similarities of a general nature exist between the elements of this species and some of the form species described by Branson and Mehl (1943).

Incipient lobes in the outer basal margin of the subsymmetrical element are suggestive of the more pronounced features of this type displayed by *L. semiflorealis*. The latter elements all have at least five distinct denticles, have an inner basal lobe, and are strongly concavo-convex in comparison with the specimens discussed here. *Leptochirognathus tridactylus* and *L. obesus*, which we cannot differentiate objectively with the deposited type specimens, are very similar to the subsymmetrical elements in the general outline of the specimens and in the configuration of their basal regions. The denticles of these two form species are relatively broader than the elements of *L. resimus*, and they do not show keels on the few specimens that are available to us.

The type specimens of *L. gracilis* share the general outline of the asymmetrical elements of *L. resimus*. They differ in that the anterior denticle is reclined somewhat rather than erect. The second denticle of *L. gracilis* is strongly reclined and occupies well over one-half of the upper part of the element. The third and fourth denticles of *L. gracilis* are small and subequal in size and are crowded between the basal margin and the posterior edge of the second denticle. The three posterior denticles are nearly fused on some of the type specimens of *L. gracilis*. Most specimens of *L. gracilis* display a prominent ledge that is parallel to the aboral margin. Finally, the basal margin in that species does not turn up anteriorly as do the asymmetrical elements of *L. resimus*.

The two types of elements that we include

in *L. resimus* occur together in many samples that we studied; in those in which only one of these elements is present we found only one specimen, so that absence of the other is probably not significant. Either *Leptochirognathus* has a monoelemental apparatus and we are dealing with two species, or these two morphologies represent the two elements of a bielemental species. We believe that the latter is the most probable alternative. We cannot state conclusively that only two types of elements make up the apparatus because elements of *Leptochirognathus* are present in only modest numbers in any of the samples. No evidence for other elements is indicated, however.

Relative abundance of the two types of elements varies among the samples from equal numbers to 3:2 in favor of the asymmetrical element. These ratios may be spurious because of the relatively low numbers of specimens.

Tipnis, Chatterton, and Ludvigsen (1980) illustrated but did not discuss two specimens that are probably conspecific with *L. resimus*. The specimens, which were obtained near the top of the Sunblood Formation at Sunblood Mountain along the Nahani River in the southwestern District of Mackenzie, Canada, are associated with an abundance of elements of species of *Erismodus* and *Curtognathus* and with *Phragmodus flexuosus* Moskalenko and *Appalachignathus delicatulus* Bergström and others. Age of these conodonts was interpreted as Chazyan.

Derivation of name: *Resima*, Latin meaning turned up or bent back, in reference to the diagnostic anterior profile of the asymmetrical element.

Number of specimens: Asymmetrical elements, 55; subsymmetrical elements, 39.

Repository: Holotype (asymmetrical element), 16660; paratype (subsymmetrical element), 16661.

Genus LUMIDENS n. gen.

Type species: *Lumidens vitreus* n. sp.

Diagnosis: The apparatus consists of hyaline

paired asymmetrical coniform elements and bilaterally symmetrical coniform elements. The anterior and posterior edges of the asymmetrical elements are keeled; the symmetrical element has a low medial posterior carina and blunt lateral margins. The surfaces of the elements have faint striae at about the limit of resolution of an optical microscope. The bases of the elements contain a conical cavity that tapers uniformly to a sharp tip in that part of the element that has the strongest curvature.

Remarks: The apparatus of this genus corresponds exactly to the one that Miller (1980) described in an emended diagnosis of *Semiacontiodus*. Elements of that apparatus are reported to be characterized by fine surface striae. Miller emphasized, however, that the cusps of the species that he included in *Semiacontiodus* were almost wholly albid, so that the hyaline material under consideration here must be excluded from that genus. Furthermore, other than *S. carinatus* Dzik, whose spartan diagnosis renders it difficult to evaluate as a species, *Semiacontiodus* has been identified only from Cambrian-Ordovician boundary strata, so that a biostratigraphic hiatus exists between its known occurrences and our material from the subsurface of Indiana.

Similarity also exists with the apparatus of *Staufferella* Sweet, Thompson, and Satterfield, which also comprises nongeniculate symmetrical and paired asymmetrical elements, all of which are finely striate. In this genus also, the cusps of the elements consist largely of albid matter. Further, the basal cavities of the symmetrical elements are very shallow in *Staufferella*, and those elements commonly show marked swelling of the basal region and the development of lateral costae.

The elements of *Scalpellodus* Dzik are generally similar to the asymmetrical elements of *L. vitreus*. *Scalpellodus striatus* Ethington and Clark, an Ibexian species, includes elements whose surfaces feature striae that are much coarser than those of *L. vitreus*. Ethington and Clark (1981) followed the interpretations of Dzik (1976) and of Löfgren (1978) in assigning only asymmetrical elements to *S. striatus*. But symmetrical striate coniform elements that they reported from

the stratigraphic range of *S. striatus* (for example, their scolopodiform F) might belong to that apparatus. The elements that they described were found in western Utah and are somewhat altered thermally, but they indicate that considerable albid matter is present in the cusps. If a symmetrical element is demonstrated to be part of the apparatus of *S. striatus*, reassignment to another genus will be required unless *S. latus* (van Wamel), the type species of *Scalpellodus* is discovered to have this same element. *Lumidens* would be a reasonable place to which it could be reassigned morphologically, but the hyaline character of the elements of *L. vitreus* would not support its placement in the same genus with *S. striatus*.

Derivation of name: *Luma*, Latin meaning thorn, and *dens*, Latin meaning tooth; a thorn-shaped tooth.

LUMIDENS VITREUS n. sp.

Plate 1, figures 19-21

?aff. *Semiacontiodus carinatus* DZIK, 1976, p. 421, pl. 41, figs. 5, 6, text-fig. 13M-O.

Asymmetrical elements: These elements are slender and nongeniculate and are prominently curved at about one-third of their length above the basal margin. The cusp above the region of curvature is straight on some specimens and is recurved in the anterior direction on others. The distal two-thirds of the cusp is bent inward and somewhat twisted relative to the base, so that the anterior margin is rotated slightly inward. The outer surface is uniformly convex transversely; the inner surface is more strongly convex centrally with marginal shoulders that originate somewhat above the base where they are moderately broad and become progressively narrow as they approach the apical extremity. The surface carries faint subparallel longitudinal striae that begin slightly above the basal margin. The base is slightly swollen but is not distinctly differentiated from the rest of the element. The basal margin has subcircular

shape; the cavity is a tapering cone whose apex is anteriorly situated in the region where the element has the strongest curvature. Basal bodies are present.

Symmetrical elements: These elements are gently curved and somewhat compressed in the anterior-posterior dimension. The anterior face is broadly rounded; a low rounded carina is located medially on the posterior surface. Planar flanges to each side of the carina may be subequal in width, so that the bilateral symmetry is nearly absolute, although most specimens are somewhat asymmetrical in this character. The lateral margins are rounded and blunt. A carina expands into a posteriorly swollen base that encompasses a conical cavity. Basal bodies are present.

Remarks: The affinities of this species have been considered above in the discussion of the genus. *Semiacontiodus carinatus* Dzik seems to include elements whose morphologies are very similar to those of *L. vitreus*. That species is known only from erratic boulders collected in Poland. The provenance of those boulders is considered to be upper Llanvirnian rocks, so that *S. carinatus* is somewhat older than our material. The descriptions do not indicate whether albid material is present in *S. carinatus*, and the configuration of the basal cavity is not shown in the illustrations. The morphologic similarity to *L. vitreus* may be superficial.

Derivation of name: *Vitrum*, Latin meaning glass; to call attention to the hyaline nature of the elements of this species.

Number of specimens: Asymmetrical elements, 625; symmetrical elements, 145.

Repository: Holotype (asymmetrical specimen), 16662; paratypes, 16663 and 16664.

Genus ONEOTODUS Lindström, 1955

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

ONEOTODUS? OVATUS (Stauffer)

Plate 2, figures 15, 16

Oistodus ovatus STAUFFER, 1935, p. 147, pl. 12, fig. 34.

Oneotodus ovatus (Stauffer) WEBERS, 1966, p. 67, pl. 2, fig. 7.

?aff. *Stereoconus bicostatus* MOSKALENKO, 1970, p. 49-50, pl. 5, figs. 1a, b, 2; MOSKALENKO, 1972, p. 51, fig. 3; MOSKALENKO, 1973, pl. 20, fig. 11.

Remarks: The samples from the cores produced numerous rather small peglike elements with circular cross sections and strongly swollen bases. The gross morphologies displayed by these elements range from suberect to strongly curved. The swollen bases exhibit annular striae, which indicate recessive basal margins of the successive lamellae (inverted basal cavity of Lindström, 1955). A shallow pit is commonly at the center of the basal surface. The expanded basal regions are yellowish brown; cloudy cusps suggest the presence of diffuse albid matter. Many specimens in our collections show evidence of distal wear or fracture (pl. 2, fig. 16), and a few specimens suggest that partial rejuvenation of lost material has occurred in their apical regions.

Ethington and Brand (1981) redefined *Oneotodus* Lindström to encompass a morphologic transition of albid coniform elements with shallowly excavated bases; they suggested that *O. ovatus* Stauffer probably does not conform to that definition. Our collection displays a range in curvatures and cross sections of cusps that is comparable to the spectrum of morphologies that they recognized in *O. simplex*, the type species. Whether *O. ovatus* can be accepted as a species of *Oneotodus* depends on the significance for classification that is attributed to recessive bases in comparison with those that are excavated.

Moskalenko (1970) described eight new species of *Stereoconus* for hyaline elements from the Siberian Platform that she distinguished from each other by differences in cross sections and in curvature. Study of identified specimens that Moskalenko kindly

provided to one of us (RLE) leads us to believe that these species have closer affinity with *Evencodus* Moskalenko than with species of *Stereoconus*. One of the Siberian species, "S." *bicostatus*, has a swollen recessive basal region with a central invagination; it thus is generally similar in overall outline to *O.?* *ovatus*. (See Moskalenko, 1972, fig. 3.) The three specimens that we have examined are wholly hyaline and show well-developed costae to either side of the cusp, so that the basal similarity to the lower reaches of *O.?* *ovatus* seems superficial.

Collections from the Harding Sandstone contain numerous *O. ovatus* elements, although this form was not reported in previous discussions of the Harding conodonts. It occurs in the Glenwood Formation in Minnesota (Stauffer, 1935; Webers, 1966) and near the top of the Tulip Creek Formation in Oklahoma (Jeffrey A. Bauer, oral communication, 1985).

Number of specimens: 631.

Repository: Figured specimens, 16665 and 16666.

Genus PRIONOGNATHODUS Fay, 1959

Type species: *Prionognathus brandtii* Pander, 1856.

Prionognathus PANDER, 1856 [*non* Ferté-Sénéctere, 1851].

PRIONOGNATHODUS ORDOVICICUS
(Branson and Mehl)

Plate 1, figure 1

Prionognathus ordovicica BRANSON and MEHL, 1933a, p. 27, pl. 1, figs. 13-14; SWEET, 1955, p. 260-261, pl. 28, fig. 9.

Remarks: Pander reported three fragments, each consisting of closely spaced teeth that appear to be erupting from enclosing basal material, as constituting the type collection of *Prionognathus brandtii*. His discussion indicates that the denticles consist of dense white material, although the base of his specimens is

yellowish and translucent. The illustrations in Pander's monograph are not sufficiently definitive to establish the affinities of these fragments unequivocally, but they are listed among the conodonts that he describes as compound teeth (zusammengestezte Zähne). His description is consistent with the morphologic features of many pectiniform elements that, like Pander's types, have been found in Silurian rocks. Many authors have concluded that Pander's material may not have been part of a conodont (for example, Lindström, 1964; Clark and others, 1981). Fay (1959) noted that the generic name had been used in 1851 for a species of the Coleoptera and substituted *Prionognathodus* for it.

Only one species other than the type species has been assigned to this genus, *P. ordovicicus* (Branson and Mehl) from the Harding Sandstone of Colorado. In defining this latter species, Branson and Mehl (1933a, p. 37) observed that they were dealing with discrete denticles rather than "dental units" of the type illustrated by Pander. Their generic assignment must have been a convenience in that they assigned simple coniform denticles to a taxon of questionable status. They further commented that they had obtained plain denticles of this configuration from many Paleozoic units. Sweet (1955) followed this convention in his thorough study of the conodonts of the Harding, but he also was hesitant about the affinities of his material.

We have examined the remaining type specimen of *P. ordovicicus* in the University of Missouri-Columbia collection (the specimen of Branson and Mehl's pl. 1, fig. 14; the specimen of pl. 1, fig. 13, has been lost) and many conspecific specimens in bulk collections from the Harding. The remaining type specimen is coated with an irregular reddish film as are many specimens in some samples from the Harding, but this coating is not so thick as to obscure the waxy hyaline material of the underlying element. The constricted basal region that was reported by Branson and Mehl and shown in their illustration of the specimen (a heavily retouched photograph) is an artifact of abrasion that has removed all or most of the lower part of the element and

exposed dense material that fills the basal cavity. The specimen thus is a slender hyaline coniform element. The many specimens in the bulk samples of Harding rocks confirm this conclusion.

The specimens that we describe here are more variable in the ratio of length of element to basal diameter than are the specimens from the Harding. The morphology of the collection from Indiana ranges from slender coniform elements with circular cross sections to such squat forms as the one illustrated here on plate 1. The slender forms are identical to many specimens in the Harding and support assignment to Branson and Mehl's species. The stout forms differ principally in having greater basal diameter, but their average length is not obviously greater than that of the slender specimens. As shown by the illustration, the stout forms have coarse longitudinal striae that extend from just above the basal margin to near the tip; the distal reaches are commonly somewhat necked, which suggests possible loss by abrasion. Several specimens appear to have been rejuvenated. Slender forms in the Harding collections and comparable material from the subsurface of Indiana have faint striae that are barely resolved by the optical microscope. Basal bodies protrude beyond the basal margin in some specimens, but most show open conical cavities that penetrated to about midlength.

Possibly the stout specimens from Indiana are advanced growth stages, but if this is so, the collections from the Harding consist wholly of immature specimens. Another possibility is that the variability displayed by the material from Indiana is a phenotypic phenomenon that is not shared by the elements in the Harding. Regardless, these specimens are improperly assigned to *Prionognathodus*, for Pander's description clearly documents white matter in the denticles of *P. brandtii*. His illustrations further suggest that the denticles of that species are embedded in a basal process from which they would likely not have been separated to yield complete but discrete specimens.

The hyaline character, circular cross sections, and striae suggest affinity of our material with *Evencodus* Moskalenko, but

comparison with illustrations of the type collection and with a few specimens generously provided by Moskalenko shows the similarities to be superficial. In particular, *Evencodus* has a prominent lobe in the basal margin that is not shown by any of our specimens. The ridges on species of *Evencodus* are more widely spaced and more distinctly developed than the striae on *P. ordovicicus*. *Evencodus* seems morphologically closer to species of *Scolopodus*, for example, *S. rex* and *S. cornutiformis*, than to anything known from the Harding or in our collections from Indiana.

We are reluctant to define a new genus for these forms without more extensive collections than are presently available to us. We have considered the possibility that *P. ordovicicus* is part of the apparatus of *Lumidens vitreus* n. sp. here, although the seeming absence from the Harding of the elements we assign to that species in the Harding argues against that conclusion. Because we are left with considerable uncertainty as to the proper interpretation of these forms, we are continuing the probably improper generic assignment they received from Branson and Mehl.

Number of specimens: 162.

Repository: Figured specimen, 16667.

Genus SCAPULIDENS n. gen.

Type species: *Scapulidens primus* n. sp.

Diagnosis: The apparatus of this new genus comprises both hyaline tongue-shaped elements that display symmetry transition and thin sickle-shaped elements. Hyaline slipper-shaped elements are also included tentatively in our reconstruction. Descriptions of each of these kinds of elements as they are expressed in the type species are given below.

Derivation of name: *Scapula*, Latin meaning shoulder blade, and *dens*, Latin meaning tooth; a tooth shaped like a shoulder blade.

SCAPULIDENS PRIMUS n. sp.

Plate 1, figures 22-33

Tongue-shaped elements: These are elements whose distal part is laterally expanded but thin in the anterior-posterior dimension, so that a distinctly lingulate configuration results. The margins of this part of the element are rounded and blunt (pl. 1, figs. 29, 30); they may be directed laterally (pl. 1, figs. 30, 33) or turned somewhat posteriorly (pl. 1, fig. 29). These margins continue downward as costae across the basal region and are reflected as lobes in the basal outline (pl. 1, figs. 27, 29, 31-33) on specimens with low, posteriorly inflated bases, or they are confined to the lingulate distal region on elements with high conical bases (pl. 1, fig. 30). The elements are continuously curved in the anterior-posterior direction (pl. 1, figs. 29, 32), or the expanded and flattened distal region is subplanar and reflexed at an angle of 90° to 120° from the trend of the basal reaches of the element (pl. 1, figs. 30, 33). The anterior surface of the element is broadly convex, but the posterior surface is gently swollen medially but depressed near the margins. The base may be deep (pl. 1, fig. 30) or shallow (pl. 1, figs. 29, 32). The deep bases are slender and conical, but the shallow bases show considerable expansion in the posterior direction (pl. 1, figs. 27, 31, 32). The cavity is conical and deep and shows heavy concentric ribbing on the internal surface; basal bodies may be present (pl. 1, fig. 29). Most of the tongue-shaped elements are bilaterally symmetrical or nearly so in their distal reaches (pl. 1, fig. 33), but the costae in their basal reaches are asymmetrically distributed. About one-fourth of the tongue-shaped specimens in our collections show distinct asymmetry throughout (pl. 1, fig. 29).

Sickle-shaped elements: These are hyaline elements whose distal reaches are thin enough to be transparent. Their outline in lateral view is distinctly sickle shaped with a rounded anterior profile, a nearly straight distal

margin, and a posteriorly directed, somewhat pointed terminal region. In posterior view the outline is visible, but some specimens (pl. 1, fig. 25) have the subtriangular shape of a shoulder blade. These elements might be interpreted as coniform specimens in which the cusp is not clearly differentiated from the base. The distal edge is sharp; the proximal margins are rounded in response to progressive basal thickening of the element. The base is strongly expanded to one side; the opposite side has a narrow, irregular triangular lobe that projects downward and to the side (pl. 1, figs. 23, 24, 26). The basal cavity is conical, and the apex is in the lower part of the blade. Basal bodies may be retained (pl. 1, figs. 22, 25); the inner surface of the cavity shows concentric ribbing and radial longitudinal fluting (pl. 1, figs. 23, 24, 26), a configuration very like that already described for the tongue-shaped elements.

Slipper-shaped elements: These are hyaline elements with the general form of a Persian slipper with a turned-up toe. The posterior surface is broadly rounded medially and has marginal flattened or depressed regions. The anterior surface is straight transversely or somewhat depressed. The basal outline is subcircular, and the basal edge is blunt to swollen. All available specimens retain a basal body (pl. 1, fig. 28) or have a cavity partly filled with detrital material. The exposed walls of the cavity suggest that it is a very shallow, broad cone.

Remarks: The slipper-shaped elements are the least abundant of the three kinds of elements that we assign to this apparatus, although the stratigraphic range through which the few specimens are distributed within the cores is comparable to those of the other two elements. The slipper-shaped elements may be stubby variants in a symmetry-transition series that also includes the linguatate elements. We cannot identify any of these morphologies as analogous with elements in conodonts whose apparatuses have been reconstructed. We are confident that the *Scapulidens*

apparatus includes the tongue-shaped and sickle-shaped elements. Another possible assignment for the slipper-shaped elements is to the apparatus of *Lumidens vitreus* n. sp. here, but they do not display the surface striae that are characteristic of the other elements we include in that species. Another possibility that we cannot dismiss is that the slipper-shaped elements represent an unnamed species that is monoelemental or that is represented in our collections only by the five elements described above. We believe that on the basis of available material the most reasonable alternative is inclusion of the slipper-shaped elements in the apparatus of *Scapulidens primus*.

No genera with affinities with *Scapulidens* have been reported from Ordovician rocks. Its wholly hyaline construction limits the possibilities to early Champlainian taxa, some of which resemble it closely.

Derivation of name: *Primus*, Latin meaning original or first.

Number of specimens: Tongue-shaped elements, 44 of which 32 are symmetrical; sickle-shaped elements, 8; slipper-shaped elements, 5.

Repository: Holotype (symmetrical element of pl. 1, figs. 27, 31, 32), 16668; paratypes, 16669 through 16676.

Genus STEREOCONUS Branson and Mehl

Type species: *Stereoconus gracilis* Branson and Mehl, 1933.

STEREOCONUS CREPIDIFORMIS n. sp.

Plate 2, figures 12, 13

Description: The specimens are hyaline coniform elements of varying transverse sections and with very shallowly excavated basal surfaces. Small aligned chevrons of albid matter are visible within the elements where they define a growth axis. One of the

morphotypes is a gently curved boot-shaped element with a blunt anterior margin and a rather broad posterior surface. The cross section of the cusp in such specimens is acutely triangular and has almost planar anterolateral surfaces. These elements thicken uniformly from their apices to their basal margins; the base is not expanded laterally. The posterior margin is continuously curved, and the basal region is not clearly set off from the cusp in the posterior outline. The basal margin is shallowly concave to straight in lateral view.

The other morphotype is more strongly curved. One lateral face has a prominent trough that begins above the basal margin and continues upward nearly to the tip of the element. The trough may be medial in the lateral surface or may be to either side of this position. Whatever its location, the trough, whose width remains nearly constant throughout its course, occupies about one-third of the width of the face proximally and much more than one-half distally. The surface opposite the one with the trough may be strongly convex transversely, or it may have a rounded carina whose position corresponds to that of the trough. The basal margin is sinuous and has an anterior recess followed by a posterior lobe. The basal cavity is shallow but somewhat deeper than in the other morphotype. Some specimens, including the one shown here on plate 2, figure 12, have a mass of dense material that may be the remains of a basal body protruding from the cavity.

Remarks: These specimens have been compared directly with an abundance of *S. robustus* and *S. gracilis*, two of the three species of *Stereoconus* that have been described from the Harding Sandstone of Colorado. Enough common characters exist, for example, shallow basal cavities, hyaline nature, and general cross-sectional morphology including grooved faces, to demonstrate that these are related species, but differences in details of curvature and of basal configuration are too great for them to be conspecific.

The apparatus of *Stereoconus* has not been reconstructed, and the only citation of the genus in recent literature in North America

(Sweet, 1982) identified only one species, *S. gracilis*, without discussion. We are including the two morphotypes as elements of a single apparatus and suggest that a similar relationship may exist with *S. gracilis* and *S. robustus*. The apparatus may include a third element, the one we report as having affinity with *S. plenus*. We are discussing that element separately because it shows additional denticles posterior to the cusp, a feature not otherwise known in *Stereoconus*, which renders its assignment to the genus tentative. Moskalenko (1972) postulated that *Stereoconus* has a bimembrate apparatus in her interpretation of new species that she recognized in strata on the Siberian Platform. Specimens that she provided to one of us (RLE) seem not to be close to the type species, *S. gracilis*, other than being hyaline elements, and we believe that they should be placed in another genus.

Derivation of name: *Crepida*, Latin meaning boot, and *forma*, Latin meaning shape; the lower part of the nongrooved element has the shape of a boot in lateral view.

Number of specimens: Elements with lateral trough, 12; elements without troughs, 49.

Repository: Holotype, 16677; paratype, 16678.

aff. STEREOCONUS PLENUS
Branson and Mehl

Plate 2, figure 14

aff. *Stereoconus plenus* BRANSON and MEHL, 1933a, p. 27-28, pl. 1, figs. 19-21; SWEET, 1955, p. 247, pl. 28, fig. 29.

Remarks: Branson and Mehl (1933a) distinguished *S. plenus* from *S. robustus* because they considered the former to be more strongly curved and from *S. gracilis*, which they interpreted as consistently slender rather than short and stout. They indicated that *S. plenus* is quite variable in the amount of curvature that is developed among the specimens.

The specimens that we are comparing with

S. plenus have the same generally short habit of that form species, and they are strongly curved. The anterior basal region is drawn out to resemble an anticusp. The base is modestly inflated behind the anticusp and is very shallowly excavated. The cusp is transversely biconvex and has blunt anterior and posterior edges. Several short, stubby denticles are in the posterior basal region. All specimens are totally hyaline.

Were the accessory denticles not present, we would have little reason not to assign these forms to *S. plenus*. Careful examination of the cotypes of that form species and of similar morphotypes in collections from the Harding Sandstone has not demonstrated the presence of even incipient denticles on those forms. The occurrence of denticles is not a trivial morphologic feature and might justify assignment of our specimens from Indiana to a new species in another genus. As indicated in the discussion of *S. crepidiformis*, however, we believe that this morphotype may be another element in the apparatus of that species. In the same way, *S. plenus* may belong in an apparatus that also includes *S. gracilis* and *S. robustus*. The general morphology of *S. plenus* and of the elements described here is that of the dolobrate element that has been recognized as occupying the M position in many reconstructed apparatuses.

Number of specimens: 25.

Repository: Figured specimen, 16679.

NEW GENUS A

Plate 1, figures 2, 6-8

Remarks: A small number of elements from four samples may represent a new genus. Most of the specimens are badly fragmented, but their morphologies are so diagnostic that recognition of them is quite easy. We do not know how many individual elements are in the collections because some of them are so badly broken; the three most complete ones as well as a fragment are illustrated here.

The basic morphology that they display is that of pectiniform elements with a broadly

excavated base. One individual (pl. 1, fig. 7) appears to be angulate, although it probably has almost one-half of its length missing. Two additional specimens (pl. 1, figs. 6, 8) have downwardly directed processes that branch laterally to each side from near midlength. Some of the fragments in the collection are medial regions of such elements that have lost all but the proximal parts of all processes (pl. 1, fig. 2).

The elements show a linear series of discrete conical denticles surmounting a flaring basal region. Two of the specimens (pl. 1, figs. 6, 8) show this series to be nearly straight, but another (pl. 1, fig. 7) has distinct sinuosity in the preserved anterior part of the element. The denticles of the anterior region have distinct spaces between them on two of the specimens (pl. 1, figs. 7, 8), but the third shows crowded to basally fused denticles both anteriorly and posteriorly. All specimens have a large denticle that divides the element into anterior and posterior segments. This denticle may be isolated from the others (pl. 1, fig. 7), or it may show smaller denticles fused to its base (pl. 1, figs. 2, 6, 8). Auxiliary denticles are developed laterally on each side of the anterior process. These denticles generally alternate in position; each side has a denticle adjacent to one of the denticles in the axial series. This is not uniformly developed, for in some specimens two lateral denticles in succession are on the same side of an element (pl. 1, figs. 6-8). The only nearly complete specimen (pl. 1, fig. 6) shows the lateral denticles of the posterior process of the element joined to those of the axial series to form transverse ridges.

Denticulate processes branch laterally at the base of the large denticle on three of the illustrated specimens (pl. 1, figs. 2, 6, 8), but such processes are not present on the other one (pl. 1, fig. 7). The latter specimen shows a flaring of the base in this position, which gives it the morphology of an angulate pectiniform element. The length of the lateral processes must have been quite large, judging from the area of the scars where they have been broken away (pl. 1, figs. 2, 8), but one specimen (pl. 1, fig. 6) has only lobes bearing single denticles in the position of the supposed processes.

The basal cavity is a broad trough with a V-shaped cross section that extends along the entire underside of the element (pl. 1, figs. 2, 7). The basal region is amber colored and apparently hyaline. Albid matter is present but diffuse in the distal parts of the denticles.

No conodonts that conform to the morphologies displayed by these specimens have been described. They are somewhat similar to elements of *Scyphiodus primus* Stauffer, a species whose apparatus consists of only angulate (or rarely pastinate) pectiniform elements according to the recent evaluation of that species by Sweet (1982). The forms at hand occupy a medial stratigraphic position within the range of *S. primus*, which is known to occur in rocks as old as the Simpson Group (early Champlainian) and to range into strata as young as the upper part of the Decorah Shale (late Champlainian). The lateral denticles of *S. primus* are more regularly arranged and are confined to the anterior part of the element where they are generally united to those of the axial series to form transverse ridges. Lateral processes have not been mentioned in any of the discussions of occurrences of *S. primus*.

Icriodella Rhodes has bladelike (pectinoscaphate) elements with two parallel series of denticles on the anterior segment that may be fused to each other transversely. A distinct medial flare in the base of the elements of *Icriodella* might be analogous to the lateral processes shown by some of the specimens reported here. *Icriodella* occurs in late Champlainian rocks through Alexandrian rocks and thus could be an evolutionary descendant of the species whose elements are described above. Arguing against this is the well-established apparatus of *Icriodella*, which includes at least five basic kinds of elements, four of which have no obvious analogues in our collections.

Moskalenko (1970) established a new species that she placed in *Ambalodus* Branson and Mehl for six specimens collected in the Middle Ordovician rocks of the Siberian Platform ("bed with *Coleodus* and *Neocoleodus*"). The illustrated specimen of *Ambalodus? cruciformis* appears to be a fragment of the medial region of an element

in which processes radiate in five directions from the base of a massive denticle. No denticles are proximal to the cusp on any of the processes, but one of them has three low knobby denticles near its broken extremity. A specimen from the same locality and horizon in Siberia from which the types of *A.? cruciformis* were obtained has been provided by Moskalenko. It has only four fragmented processes whose orientation we judge to be anterior, posterior, and to each side. The single central denticle on this specimen is massive and consists of diffuse albid matter in contrast with the brownish translucent basal region and processes. The specimen is strikingly similar to specimens in our collections from which all or most of the processes have been lost (pl. 1, fig. 2). This similarity may be coincidental, however, and better definition of the species from Siberia will be needed to properly evaluate possible affinity with the forms described above.

We believe that the apparatus includes at least two types of elements, those with and those without lateral processes. The collection is too meager and too fragmented to describe either of them thoroughly, and it does not preclude other elements in the apparatus. We treat this as a species of a new genus, but we do not propose a name for it because an adequate type collection is not available and additional material cannot be assembled.

Number of specimens: About 10; most are fragmented.

Repository: Figured specimens, 16680 through 16683; specimen not figured, 16684.

NEW GENUS B

Plate 1, figures 4, 5

Remarks: We include here four specimens whose external morphologies show little variation. Their form is that of a broad, somewhat curved, relatively thin blade-shaped element whose curved posterior margin has as many as seven short fused denticles arranged along its length. These denticles increase regularly in length, and their orientation increasingly approaches parallelism with the

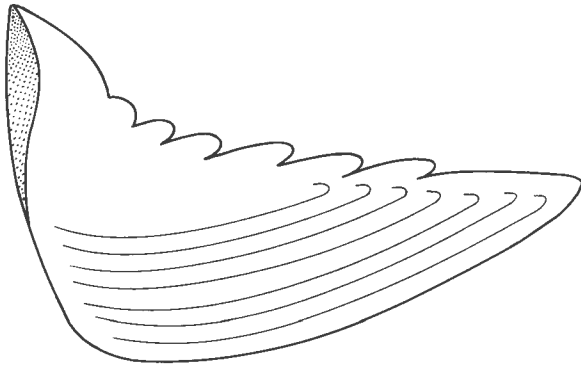


Figure 5. Camera lucida drawing of a specimen of new genus B showing the configuration of growth lamellae.

trend of the margin of the element as they approach the distal extremity. One lateral surface is uniformly convex (pl. 1, fig. 5), and the opposite face has a ridge just under the denticles (pl. 1, fig. 4) that is most prominent near the base of the element and attenuates distally. The surface of the element between the ridge and the anterior margin is markedly depressed. The cavity is a broad trough that begins above the antero-basal region and continues from there to the postero-basal corner. It is widest and deepest at the place where the lateral ridge meets the basal region.

The illustrated specimens show patterns of albid matter alternating with hyaline matter in their interiors. We believe that these patterns reflect the mode of growth of the element and that some lamellae (or groups of successive lamellae) are albid and others are hyaline. What is seen is analogous to the successive chevrons that occur along supposed growth axes in some hyaline elements. As shown in figure 5, this growth was asymmetrical; little material was added with each increment along the denticulate margin, but a major increase in length and width took place toward the convex side of the element. The spacing of the increments is relatively broad in the medial part of the element but is closely crowded anteriorly; the change in spacing suggests a reduction in the rate of growth at maturity.

The plan of these elements is similar to that expressed in *Belodina* Ethington, *Belodella*

Ethington, *Culumbodina* Moskalenko, *Parabelodina* Sweet, *Plegagnathus* Ethington and Furnish, and *Pseudobelodina* Sweet. We regard these similarities in outline to be superficial; no close affinity exists with any of the above genera. Apparatuses of those genera have from two to five elements; only one is indicated by our admittedly sparse collection, which may be insufficient for definition. We do not see evidence for longitudinal hairline slits on the surface of these elements or for a region of faint striae near the base, such as is characteristic of panderodontacean genera like those mentioned above. Further, the basal cavity is too shallow in our specimens to be compatible with assignment to any of these taxa. Our collection is, however, an inadequate basis for naming a new genus.

Number of specimens: 4.

Repository: Figured specimens, 16685 and 16686.

STELLATE PLATES

Plate 2, figures 26, 27

Remarks: One sample (95) contains a modest number of isolated stellate bodies with warty upper surfaces and broadly excavated undersides. Most of them approach bilateral symmetry, but two have no symmetry. As many as seven rays are present; six rays are the most common arrangement, and two specimens have only four rays. The warts are crowded but irregularly distributed along the crests of the rays and more subdued or absent in the interray regions. The excavation of the lower side has a sharp apex in a subcentral position; it extends into all of the rays and is broad and open. Most of the specimens have sediment retained in the cavity, so that details of the lower surface are obscure. The illustrated specimen (pl. 2, fig. 26) does not show any indication of striae or ridges that might indicate a lamellar internal structure. These plates are probably not conodonts for this reason. They may be dermal plates from an armored organism, such as an ostracoderm, although their morphology is not close to the ossicles of species of *Astraspis* Walcott that

have been recovered from units, such as the Harding Sandstone, that are of the same general age as the Champlainian part of the cores.

Number of specimens: 18.

Repository: Figured specimens, 16687 and 16688.

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Plates 1-2

PLATE 1

- 1 *Prionognathodus ordovicicus* (Branson and Mehl), 16667, × 29.
2, 6-8 New genus A; 2, 16680, × 38; 6, 16681, × 38; 7, 16682, × 58;
8, 16683, × 38.
3 ?*Curtognathus typus* Branson and Mehl, 16640, × 51.
4, 5 New genus B, 16685 and 16686, both × 32.
9-13, 16-18 *Erismodus* sp.; 9, 16653, × 77; 10, 16654, × 51; 11, 16655, ×
51; 12, 16656, × 26; 13, 16657, × 38; 16, 16658, × 35; 17,
16659, × 64; 18, specimen lost, × 38.
14, 15 *Leptochirognathus resimus* n. sp.; 14, paratype, 16661, × 35;
15, holotype, 16660, × 35.
19-21 *Lumidens vitreus* n. sp.; 19, symmetrical element, paratype,
16663, × 61; 20, asymmetrical element, holotype, 16662, ×
48; 21, asymmetrical element, paratype, 16664, × 48.
22-33 *Scapulidens primus* n. sp.; 22, posterolateral view of
sickle-shaped element, paratype, 16669, × 38; 23, 24, lateral
and lower views of sickle-shaped element, paratype, 16670, ×
51 and × 58; 25, 26, lateral views of sickle-shaped elements,
paratypes, 16671 and 16672, × 42 and × 35; 27, 31, 32,
lower, inclined lower, and lateral views of tongue-shaped
element, holotype, 16668, × 67, × 38, and × 35; 28, lower
view of slipper-shaped element, paratype, 16673, × 74; 29,
lateral view of asymmetrical tongue-shaped element,
paratype, 16674, × 35; 30, posterolateral view of
tongue-shaped element with high base, paratype, 16675, ×
38; 33, lower view of symmetrical tongue-shaped element,
paratype, 16676, × 32.



CONODONTS FROM THE DUTCHTOWN FORMATION

PLATE 2

- 1-11, 22 ?*Curtognathus typus* Branson and Mehl; 1, 16641, × 51; 2, 16642, × 70; 3, 16643, × 70; 4, 16644, × 61; 5, 16645, × 48; 6, 16646, × 51; 7, 16647, × 61; 8, 16648, × 51; 9, 16649, × 67; 10, 16650, × 67; 11, 16651, × 45; 22, 16652, × 32.
- 12, 13 *Stereoconus crepidiformis* n. sp.; 12, paratype, 16678, × 38; 13, holotype, 16677, × 38.
- 14 aff. *Stereoconus plenus* Branson and Mehl, 16679, × 38.
- 15, 16 *Oneotodus? ovatus* (Stauffer); 15, 16665, × 83; 16, 16666, × 77.
- 17, 18 ?*Coleodus delicatus* Branson and Mehl; 17, 16631, × 70; 18, 16632, × 35.
- 19, 20 *Coleodus?* sp. C; 19, bidentate element, 16638, × 54; 20, bladelike element, 16639, × 80.
- 21 *Coleodus?* sp. A, 16634, × 22.
- 23-25 *Coleodus?* sp. B; 23, 16635, × 35; 24, 16636, × 45; 25, 16637, × 32.
- 26, 27 Stellate plates; 26, lower view, 16687, × 96; 27, upper view, 16688, × 86.
- 28 ?*Coleodus simplex* Branson and Mehl, 16633, × 48.



CONODONTS FROM THE DUTCHTOWN FORMATION

