

UPPER DEVONIAN AND LOWER MISSISSIPPIAN CONODONT  
ZONES IN MONTANA, WYOMING, AND SOUTH DAKOTA

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ABSTRACT.—Three conodont zones, one Upper Devonian and two Lower Mississippian, have been recognized on a regional basis in Montana, Wyoming, and South Dakota. The Lower *Spathognathodus costatus* Zone (Upper Devonian, upper *toV*) occurs in Wyoming in the lower part of the dark shale unit of SANDBERG at Cottonwood Canyon, Big Horn Mountains; throughout the dark shale unit at Bull Lake Creek and Dinwoody Canyon, Wind River Range; and in the basal Madison Limestone at Dinwoody Canyon. The same zone occurs in South Dakota in the middle part of the Englewood Formation at Boxelder Canyon, Black Hills.

A Mississippian conodont zone, correlative with the middle to upper part of the *Gattendorfia-Stufe* (*cul*) in Germany, occurs in Montana in the dark shale unit at three localities. In Wyoming the same zone occurs in the upper part of the dark shale unit at Cottonwood Canyon, in the basal part of the dark shale unit at four other localities, and in the basal Madison Limestone at Clarks Fork Canyon, Beartooth Mountains. The Lower *Siphonodella crenulata* Zone (Lower Carboniferous, *culIa*) occurs in the basal Lodgepole Limestone at nine localities in Montana and at Teton Canyon in Wyoming.

The Devonian-Mississippian boundary has been located precisely within both the Englewood Formation at Boxelder Canyon and the dark shale unit at Cottonwood Canyon. The dark shale unit of SANDBERG is a widespread transgressive unit subjacent to either the Madison or Lodgepole Limestone and overlying a significant regional unconformity, demonstrated by the fact that the dark shale unit truncates all members of the Three Forks and Jefferson Formations.

Two other Upper Devonian conodont zones have been recognized at single localities. The *Scaphignathus velifera* Zone (upper *toIIIa* - lower *toIV*) has been identified in the top limestone bed of the Trident Member of the Three Forks Formation in the Bridger Range, Montana. The Upper *Polygnathus styriaca* Zone (*toV*) has been found in the lower black shale of the Sappington Member of the Three Forks Formation at another locality in the Bridger Range.

The taxonomic section includes a discussion of 34 species, which are referred to 11 genera. Two new species of *Dinodus* and *Siphonodella* are described.

## INTRODUCTION

The purpose of this report is threefold: (1) to trace one Upper Devonian (Lower *Spathognathodus costatus* Zone) and two Lower Mississippian conodont zones on a regional basis in Montana, Wyoming, and South Dakota (Figs. 1, 2); (2) to determine the position of the Devonian-Mississippian boundary at as many sections as possible; and (3) to discuss the taxonomy of the major constituents of these three regional zones.

Two other Upper Devonian conodont zones (*Scaphignathus velifera* Zone, Upper *Polygnathus styriaca* Zone, Fig. 2) were recognized at single localities, but their faunas are merely listed.

A summary of the physical stratigraphy is presented, but no attempt to give an exhaustive account is made because to do so would duplicate what SANDBERG (101, 103, 104<sup>1</sup>) has already published.

## ACKNOWLEDGMENTS

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R. L. ETHINGTON, A. J. SCOTT, and WILLI ZIEGLER freely gave advice concerning problems of conodont taxonomy. R. L. ETHINGTON, University of Missouri, J. W. HUDDLE and R. S. BOARDMAN, U.S. National Museum, and C. B. REXROAD, Indiana Geological Survey, allowed the examination of conodont type material housed at their respective institutions.

Parts of three field seasons (1959-1961) were spent in collecting material for this study. Field assistance was given on occasion by JAMES FLEECE, W. M. FURNISH, C. W. GEISEWITE, P. W. GOODWIN, and S. J. KOZAK. The paper was written in the Department of Geology, The University of Iowa, which furnished laboratory facilities. JULIA A. KLAPPER is responsible for the drafting. Financial support was provided by two Summer Fellowships of the National Science Foundation, and field expenses were obtained from the Shell Oil Company, Denver.

## DEVONIAN-MISSISSIPPIAN BOUNDARY

Because the Devonian-Mississippian boundary in North America still remains generally controversial, a statement concerning the matter is considered appropriate. A quotation from WEL-  
LER, *et al.* (128, p. 105) demonstrates an aspect of the controversy:

Because the Devonian and Carboniferous systems were originally recognized in Europe and have their type localities there, it may appear logical to assume that the proper solution to the Devonian-Mississippian boundary problem in America demands that this boundary be drawn as nearly as possible to conform with the European Devonian-Carboniferous boundary. This might be true if a definite boundary between the systems were recognized and agreed upon in Europe. The situation there, however, is fully as unsatisfactory and confusing as it is in America, and uniformity of opinion on this matter does not appear to exist except in local areas.

The situation in Europe is far from unsatisfactory, however. At the second Heerlen Congress in 1935, the Devonian-Carboniferous boundary was placed

between the *Wocklumeria-Stufe* and the *Gattendorfia-Stufe* (88, 111). Since 1935, agreement among German students of ammonoids, as well as conodont workers, has been unanimous concerning placement of this boundary. The same boundary has been recognized by British ammonoid workers (e.g., SELWOOD, 116; HOUSE, 63). French workers (e.g., SERRE & LYS, 117) have generally regarded the Strunian Stage, which contains *Wocklumeria-Stufe* ammonoids, at Lower Carboniferous, thus posing the only remaining point of dispute in Europe. The Strunian (Tn1a), in addition to containing Upper Devonian ammonoids, also has yielded conodonts which are Upper Devonian in terms of the German reference sections. This statement is based on the list given for the Strunian (30, p. 328), which includes *Spathognathodus aculeatus* and species of *Icriodus* and *Pelekysgnathus*.

A sequence of conodont zones and phylogenies has been established in Germany at many of the same sections where the Upper Devonian ammonoid sequences are best known (e.g., HELMS, 59; ZIEGLER, 134, 137, 138). With the recognition of

<sup>1</sup> Italicized numbers distributed throughout the text indicate publications serially numbered in the list of References at the end of this paper.

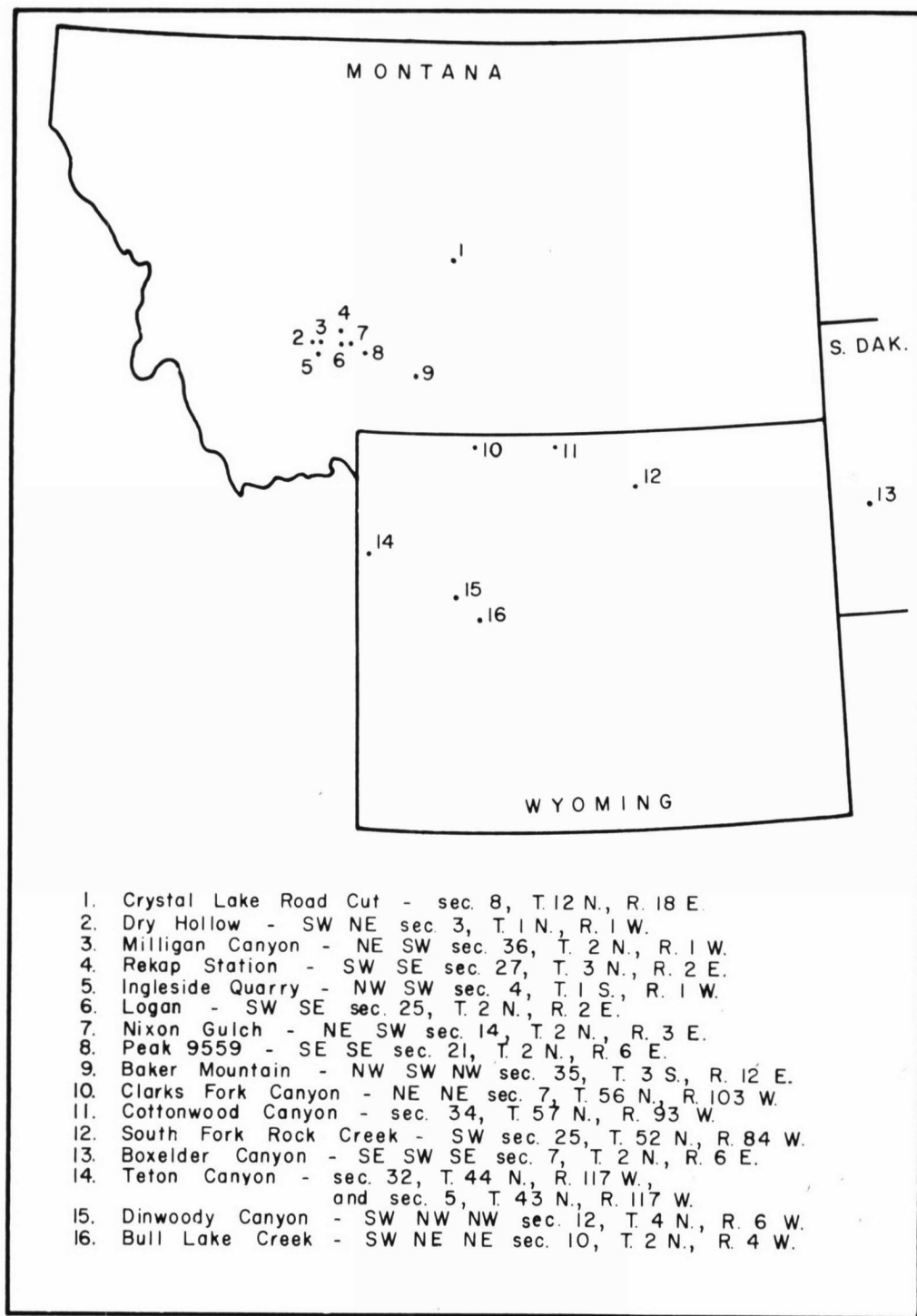


Fig. 1. Locality map.

conodont faunas in North America identical to those in Germany (*e.g.*, KLAPPER & FURNISH, 68, MÜLLER & MÜLLER, 87), the solution to the Devonian-Mississippian boundary problem is possible. Furthermore, a significant contribution has been made by HOUSE (62), who recognized many hitherto unknown occurrences of critical ammonoids in the North American Devonian.

The Kinderhookian Series, as interpreted by WELLER, *et al.* (128) and other pre-1961 classifications, is the lowest division of the Mississippian yet includes strata that are now known to be Upper Devonian. For example, certain formations in southeast Iowa formerly classed as Kinderhookian are not Lower Carboniferous. Conodont evidence shows that the Sweetland Creek Shale belongs to the lower part of the Upper Devonian (68, 87) and the Maple Mill Shale belongs to the upper part of the Upper Devonian (28). The *Chonoptectus* Sandstone, the uppermost unit of the English River Siltstone, which overlies the Maple Mill Shale at Burlington, Iowa, contains species of *Cyrtoclymenia* and *Cymaclymenia* that indicate either the *Clymenia-Stufe* or *Wocklumeria-Stufe* (HOUSE, 1962). Therefore, these strata in southeast Iowa should be removed from the Mississippian System, as well as from the Kinderhookian Series, in order to adjust the base of the Mississippian to correspond to the base of the Carboniferous.

COLLINSON (28) and SCOTT & COLLINSON (115) demonstrated that the Champ Clark Group (Syla-

more, Grassy Creek, Saverton, and Louisiana Formations) in Illinois, is Upper Devonian. COLLINSON (28) revised the boundary of the Kinderhookian Series there to exclude the Champ Clark Group, and thus to include only Lower Carboniferous strata (*i.e.*, "Glen Park," Hannibal, and Chouteau Formations).

Related to the problem of the Kinderhookian is that of the Chattanooga Shale of Tennessee and adjacent states. HASS (51, 52) by comparison with the New York Upper Devonian conodont sequence, firmly dated the Chattanooga. He demonstrated that a lower conodont faunal zone, which occurs in all but the upper beds of the Gassaway Member at the top of the Chattanooga Shale, also occurs in the Cassadaga Stage (33) of the standard New York Devonian sequence, ranging from the South Wales Member of the Perrysburg Formation through the Ellicott Shale. HOUSE (62), on the basis of ammonoids, demonstrated that the known limits of the *Cheiloceras-Stufe* (toII) are from the Gowanda Shale to the Ellicott Shale. Thus, the limits of the *Cheiloceras-Stufe* in New York are the same as HASS' lower Gassaway faunal zone in its New York occurrence, with the exception of the South Wales Member of the Perrysburg Formation. The upper Gassaway faunal zone of the Chattanooga Shale (51, p. 22-23) includes *Spathognathodus aculeatus*, a species diagnostic of the *Spathognathodus costatus* Zone (upper toV and toVI) in Germany (138).

## STRATIGRAPHY

SANDBERG (102, 104) redescribed the stratigraphy of the type Jefferson and Three Forks Formations and presented graphic columnar illustrations of their type section (104, text-figs. 2, 3). His classification of the stratigraphy of these units is followed here.

### JEFFERSON FORMATION

The Jefferson Formation was first defined by PEALE (1893) who used the term "Jefferson limestones" for Devonian strata lying between the Three Forks Formation and Cambrian rocks at Logan, Montana. SLOSS & LAIRD (118, p. 1411-1412) included within the Jefferson Formation the lower 115 feet of the Three Forks Formation as

defined by PEALE (90) and HAYNES (55). SANDBERG & HAMMOND (1958, p. 2314-2315) stated the arguments for a return to PEALE's original classification. In the subdivision of the Three Forks Formation at Logan (55, p. 16, section C), units 7 and 6 correspond to the interval that SLOSS & LAIRD (118) erroneously placed at the top of the Jefferson Formation and also to the interval that SANDBERG (104, p. N10-N12) referred to the Logan Gulch Member of the Three Forks Formation.

Strata previously designated as Three Forks Formation at Goose Creek Ridge in the Big Horn Mountains (123, p. 121, 383-385), as Jefferson Limestone and Three Forks Shale undifferentiated (98) in the Big Horn Canyon, and as the Jefferson-Three Forks undivided (41) at Little

SERIES	AMMONOID STUFEN		CONODONT ZONES		CONODONT ZONES REPORTED IN THIS STUDY	PEAK 9559 (loc. 8) and Frazier Lake	BAKER MOUNTAIN (loc. 9)	COTTONWOOD CANYON (loc. 11)	BOXELDER CANYON (loc. 13)	DINWOODY CANYON (loc. 15)	
			L. CARB: VOGES, 1959	U. DEV: ZIEGLER, 1962b							
LOWER CARBONIFEROUS (PART)	Pericyclus - Stufe (cuII)	α	Siphonodella crenulata	U							
			L	Lower S. crenulata	Basal Lodgepole Ls. *	Basal Lodgepole Ls. *	Basal Madison Ls.	Basal Pahasapa Ls.			
	Gattendorfia - Stufe (cuI)		Siphonodella — P. triangula triangula		Montana & Wyoming cuI fauna	Dark Shale Unit *	Dark Shale Unit *	Dark Shale Unit *	Englewood Fm.	Madison Ls. (15 - 25' above base)	
			Siphonodella — P. triangula inaequalis								
			Gnathodus kockeli — P. dentilineata			Sappington Mbr. of Three Forks Fm.					
UPPER DEVONIAN	Wocklumeria	ro VI	Spathognathodus	U							
	Clymenia - Stufe (roV)	ro V	costatus	L	Lower S. costatus					* Basal Madison Ls.	
			Polygnathus styriaca	U	Upper P. styriaca *					* Dark Shale Unit	
	Platyclymenia - Stufe (roIII - roIV)	III α	Scaphignathus velifera	U	Scaphignathus velifera	* Trident Mbr. of Three Forks Fm.					
			Pa. quadrantinodosa	U							
	Cheiloceras - Stufe (roII)	α	Pa. rhomboidea	L		Logan Gulch Mbr. of Three Forks Fm.	Logan Gulch Mbr.				
			Pa. crepida	U							
	Manticoceras - Stufe (roI)	δ	Pa. triangularis	U							
			Pa. gigas	M		Jefferson Fm.	Jefferson Fm.	Jefferson Fm.		Darby Fm.	
			A. triangularis	L							
Polygnathus asymmetrica			U		Maywood Fm.		Souris River Fm. (?)				

FIG. 2. Correlation chart.

Asterisk indicates position of a conodont fauna diagnostic of zone opposite to it. No conodont faunas were recovered from strata older than the Trident Member of the Three Forks Formation. In third column from left,

showing zones in Germany recognized by VOGES and ZIEGLER, "P." is abbreviation for *Pseudopolygnathus*, "Pa." for *Palmatolepis*, and "A." for *Ancyrognathus*.

Tongue Canyon on the east flank of the Big Horn Mountains represent only the lower member of the Jefferson Formation as shown by SANDBERG (101, pl. 10; 104, text fig. 1). A "ninety foot bright purple shale unit" described by KOUCKY, *et al.* (1961) at Little Tongue Canyon along U.S. Highway 14 is composed chiefly of brown and gray dolomite with thin interbeds and is also referable to the Jefferson Formation.

### DARBY FORMATION

Strata continuous with the Jefferson Formation have been termed Darby Formation in northwestern Wyoming (Teton, Washakie, Owl Creek, and Wind River ranges). BLACKWELDER (1918, p. 420-

422) proposed the Darby Formation, taking the name from Darby Canyon in the Teton Range but describing a "typical section" at Sheep Mountain near Green River Lakes in the northwestern part of the Wind River Range. BLACKWELDER intended to apply this term to all Devonian strata in the area, but it is evident from his description of the Sheep Mountain section that unit 25 should be referred to the Madison Limestone. BLACKWELDER (12) did not describe Darby Strata in the Teton Range.

The use of Darby in the Teton Range seems unnecessary. At Teton Canyon (loc. 14, text-fig. 1), Devonian rocks that lie between the Bighorn Dolomite and the dark shale unit of SANDBERG (103) consist primarily of brown fetid dolomite

referable to the Jefferson Formation, whereas the overlying 50- to 60-foot covered interval directly below the dark shale unit probably represents the Logan Gulch Member of the Three Forks Formation.

The name Darby Formation is still applicable to strata in the Wind River, Washakie, and Owl Creek ranges, following the usages of SANDBERG (104, p. N5, text fig. 1).

BRANSON & BRANSON (1941) reported a conodont fauna, containing *Icriodus*, *Polygnathus*, and *Palmatolepis* from a black shale which they considered as part of the Darby Formation at Bull Lake Creek, Wind River Range. KLAPPER (1958) described this fauna and indicated the position of the black shale near the top of the Darby Formation at the south side of Bull Lake Creek (loc. 16, herein). The conodont fauna was determined to be the equivalent of Upper Devonian (toV) of the German reference sequence. Beds 2 to 5 (65, text fig. 1) now are considered referable lithologically to the dark shale unit of SANDBERG (103) and not to the Darby Formation. Bed 1 of the same section is now referred to the Madison Limestone.

### THREE FORKS FORMATION

The term "Three Forks shales" was proposed by PEALE (1893) for strata lying between the Jefferson Formation and the Madison Group at Logan, Montana. HAYNES (1916) subdivided the Three Forks Formation into seven members (numbering from the top downward) at the Logan section (loc. 6, herein), as well as other nearby exposures (e.g., Rekap Station, locality 4, herein). Units 7 and 6 of HAYNES correspond to the Logan Gulch Member of the Three Forks Formation, 5 and 4 to the Trident Member (104, text fig. 3), and 3, 2, and 1 to the Sappington Member. The Logan Gulch Member is largely unfossiliferous and is not discussed further.

### TRIDENT MEMBER

The brachiopod fauna from unit 5 ("fissile green shale") and unit 4 ("bluish gray nodular limestone") was described by HAYNES (1916) who noted its similarity to that of the lower Ouray Limestone of Colorado.

The ammonoid fauna of the Three Forks Formation, described by RAYMOND (1909), is restricted to unit 5 according to HAYNES (55).

SCHINDEWOLF (1934) redescribed this ammonoid fauna and regarded it as equivalent in age to the *Platyclymenia-Stufe* (toIII-IV). HOUSE (1962) refined this assignment by considering the fauna to be equivalent to the *Prolobites delphinus* Zone (toIII $\beta$ ) of the standard German Upper Devonian sequence. HOUSE (62) has tentatively established the limits of the *Cheiloceras-Stufe* (toII) in the New York Devonian, from the Gowanda Shale (with *C. amblylobum*) to the Ellicott Shale (with *Sporadoceras* sp. cf. *S. pompeckji*). Consequently the Trident Member of the Three Forks Formation should be correlated with a higher horizon than the Ellicott Shale, possibly with the Amity Shale as suggested by RENZETTI (1962).

A small conodont fauna belonging to the *Scaphignathus velifera* Zone was collected independently by SANDBERG and me from the upper 2 feet of the top limestone bed of the Trident Member (corresponding to unit 4, 55) at Peak 9559, Bridger Range (loc. 8). The most important elements of this fauna are *S. velifera*, which ranges from upper toIIIa to toIV in Germany (138), and *Polygnathus perplexa*, which ranges from toIII to toIV (57).

### SAPPINGTON MEMBER

Strata assigned to the Sappington Member of the Three Forks Formation are best exposed at Dry Hollow (loc. 2), Nixon Gulch (loc. 7), and Peak 9559 (loc. 8) of the sections studied herein. At these places the member comprises the following units from bottom to top: a lower black shale (subunits A-D of GUTSCHICK, *et al.*, 1962; unit I of SANDBERG, 1965); a shaly nodular limestone (47, unit E; 104, unit 2); a lower siltstone (47, unit F; 104, unit 3); a middle gray shale (47, unit G; 104, unit 4); and an upper massive siltstone (47, unit H; 104, unit 5). An overlying black shale (47, unit I) is referred to the dark shale unit of SANDBERG (103). The total thickness of the Sappington Member at Logan (loc. 6) is 57 feet (104).

BERRY (1943) proposed the "Sappington Sandstone" as a separate formation for a part of the Sappington Member as presently recognized but did not include the lower black shale and the shaly nodular limestone. The section in Milligan Canyon was designated as the type by BERRY but Logan is now considered to be the reference section for the Sappington Member (104, p. N14). HOLLAND (1952), McMANNIS (1955), ACHAUER (1959), and GUTSCHICK, *et al.* (1962) have also

recognized the Sappington as a distinct formation, but all these authors placed the lower contact at the base of the lower black shale.

The Sappington Member has not been mapped separately from the subjacent parts of the Three Forks Formation (76, 99). I agree with ROBINSON (99) and SANDBERG (104) in their usage of Sappington as the uppermost member of the Three Forks Formation. The arguments for formational status advanced by BERRY (1943) and HOLLAND (1952), both of whom believed the Sappington to be Mississippian in age and thus a formation distinct from the Three Forks Formation as revised by them, should be rejected. It appears that they employed biostratigraphic rather than lithologic criteria in attempting to define the position of the formational boundary.

SLOSS & LAIRD (1947, p. 1411) also considered the Sappington to be a member of the Three Forks Formation, but not for cartographic reasons. They believed that:

the normal shale facies of the Three Forks, bearing the typical *Cyrtospirifer* fauna, is interbedded with the sandy facies bearing *Syringothyris* [Sappington], and that the sandy facies grades laterally into typical shale of the Three Forks formation.

ROBINSON (99, p. 37) followed SLOSS & LAIRD's interpretation, at least in part. Although the inter-tonguing relationship between the Sappington and Trident Members of the Three Forks is possible, as emphasized by McMANNIS (1955, p. 1398) field evidence does not support this concept. The lower black shale of the Sappington at all sections studied by McMANNIS (1955), GUTSCHICK, *et al.* (1962), SANDBERG (1965), and me separates the Sappington from the Trident. This distinctive and persistent basal black shale is well exposed at Rekap Station, Nixon Gulch, and Peak 9559 and can be uncovered easily at Dry Hollow, Milligan Canyon, Ingleside Quarry, and Logan (see Fig. 1 for locations). Furthermore, all five lithologic units (104) of the Sappington are persistent and maintain a constant position. The conodont fauna (upper *Polygnathus styriaca* Zone, discussed later) of the lower black shale of the Sappington is distinctly younger than that of the immediately underlying limestone bed at the top of the Trident Member (*Scaphignathus velifera* Zone). Consequently, the significance of the supposed faunal alternation of the megafaunas of the Sappington and Trident Members, discussed by ROBINSON (1963, p. 34), is greatly minimized.

The problem of the age of the Sappington Member of the Three Forks Formation has been reviewed by ACHAUER (1959) and ROBINSON (1963). The *Syringothyris* fauna of the shaly nodular limestone and lower siltstone was correlated with the brachiopod fauna of the Louisiana Limestone of Missouri (74; 112, p. 546). If such a correlation is correct the lower part of the Sappington Member is Devonian, because the Louisiana Limestone is Devonian (toVI, 115).

Conodont evidence published heretofore regarding the age of the lower part of the Sappington is inconclusive. MORGRIDGE (1954), McMANNIS (1955), and ACHAUER (1959) listed barlike conodonts from the lower black shale of the Sappington Member, none of which allows an exact assignment to either Devonian or Mississippian. THOMAS (in 76) stated that this fauna was similar to the one described from the "basal Lodgepole black shale" in the Big Snowy Mountains (32), but the latter fauna contains at least one diagnostic Mississippian element, *Elictognathus lacerata*.

A small, fragmentary fauna has been found by me from the lower black shale of the Sappington at Peak 9559 (loc. 8). It contains no diagnostic Mississippian conodonts, but does contain specimens of *Palmatolepis glabra* (an Upper Devonian species) which show physical signs of reworking, as well as undiagnostic barlike forms. The age of this sample is regarded as equivocal.

Recently a conodont fauna belonging to the upper *Polygnathus styriaca* Zone (toV) has been secured by me from a sample collected by GUTSCHICK from a sandstone within the lower black shale of the Sappington Member at Frazier Lake [Bighorn Lake], Bridger Range. This sandstone lies directly beneath subunit C of GUTSCHICK *et al.* (1962). The fauna includes *Palmatolepis rugosa postera* and *Spathognathodus jugosus*. This fauna is distinctly younger than the fauna of the *Scaphignathus velifera* Zone (toIIIa-IV) found in the upper 2 feet of the Trident Member at Peak 9559, 1.5 miles to the south of Frazier Lake.

ACHAUER (1959) reported species of *Siphonodella* from the top of the upper massive siltstone of the Sappington Member at Logan, Montana. *Siphonodella* is unknown in strata older than Mississippian. Thus, on the basis of conodonts, the Devonian-Mississippian boundary apparently falls within the Sappington Member of the Three Forks Formation. This evidence supports the earlier assignment of a Devonian and Mississip-

pian age to the Sappington by SANDBERG & HAMMOND (1958), SANDO & DUTRO (1960), GUTSCHICK *et al.* (1962), ROBINSON (1963), and SANDBERG (1965), who reached this conclusion based on other fossils.

### DARK SHALE UNIT

The dark shale unit of SANDBERG (1963) was proposed for strata lying below the Madison Limestone and largely coextensive with it. The dark shale unit overlies a regional unconformity and truncates all members of the Three Forks and Jefferson Formations (103, text fig. 64.2). At the Clarks Fork Canyon, Wyoming, reference section the dark shale unit is 48 feet thick and consists mainly of black shale and orange siltstone. At sections in Montana the dark shale unit is mainly a dark gray to black shale. At some sections in Wyoming, however, the term "dark shale unit" is recognized by SANDBERG (1963, p. C18) to be a misnomer because the unit is dominated by dolomite or dolomitic limestone with only minor partings of dark shale. At many sections a conglomeratic phosphatic sandstone, with fish plates and conodonts visible at 10x, is present at the base (103, p. C18).

The dark shale unit at Teton Canyon, Wyoming (loc. 14), underlies the Lodgepole Limestone and consists of about 10 feet of gray siltstone characterized by impressions of *Taonurus* underlain by 4 inches of dark gray shale. The shale contains Lower Carboniferous (*cuI*) conodonts (Table 1). The same two units, 11 feet thick, were noted by SANDO & DUTRO (1960) at nearby Darby Canyon and were assigned provisionally to the Darby Formation.

Beds 2 to 5 (65, p. 1083, text fig. 1) at the south side of Bull Lake Creek, Wind River Range (loc. 16), are now assigned to the dark shale unit of SANDBERG. Bed 2 is a dolomite with "floating" quartz sand grains and fish fragments, a characteristic lithology of the dark shale unit in Wyoming. Beds 3 and 5 contain Devonian (lower *Spathognathodus costatus* Zone) conodonts. The dark shale unit is also present at Dinwoody Canyon (loc. 15) where 3 feet, 2 inches, is assigned to the dark shale unit and is entirely Upper Devonian (lower *S. costatus* Zone). To the north of Dinwoody Canyon, at Warm Spring Canyon, Wind River Range (SW $\frac{1}{4}$  sec. 31, T. 42 N., R. 107 W., Warm Spring Mountain quadrangle) and

at Horse Creek, Washakie Range (SW $\frac{1}{4}$  sec. 19, T. 43 N., R. 106 W., Ramshorn Peak quadrangle), Lower Carboniferous (*cuI*) conodonts have been collected from the dark shale unit by C. A. SANDBERG and J. F. MURPHY. These Lower Carboniferous conodonts occur in the basal conglomerate of the dark shale unit at Horse Creek and in a conglomerate at or near the base of that unit at Warm Spring Canyon (SANDBERG and MURPHY, personal communication, 1964). Thus the dark shale unit is Devonian at Bull Lake Creek and Dinwoody Canyon, but it is Lower Carboniferous (*cuI*) at Horse Creek and Warm Spring Canyon.

A significant section of the dark shale unit of SANDBERG occurs at Cottonwood Canyon, Big Horn Mountains, Wyoming (loc. 11). The unit is 13 feet, 3 inches, thick and consists of a basal conglomeratic carbonate overlain by orange-weathering dolomitic limestones interbedded with two thin, dark gray shales. The contact with the overlying Madison Limestone is placed arbitrarily at the lowest gray crinoidal limestone, although the lithologic character of the upper 5 feet, 3 inches, is transitional with that of the Madison. A conodont fauna from the upper dark gray shale, which lies about 7 feet above the base, was described by ETHINGTON, *et al.* (1961), who regarded it as Upper Devonian (*toV*). The Devonian-Carboniferous boundary lies 9 to 10 feet above the base of the dark shale unit; the top 3 feet of the dark shale unit at Cottonwood Canyon contains Lower Carboniferous (*cuI*) conodonts.

At South Fork Rock Creek, Big Horn Mountains (loc. 12), 1 foot, 8 inches, of strata lying below the Madison Limestone is assigned to the dark shale unit. The basal 2 inches is a distinctive phosphatic conglomerate containing Lower Carboniferous (*cuI*) conodonts.

The dark shale unit of SANDBERG is recognized in Montana (locs. 1, 4-9, Fig. 1). KNECHTEL, *et al.* (1954) proposed the name Little Chief Canyon Member of the Lodgepole Limestone for the feather-edge of the upper shale of the subsurface Bakken Formation which crops out in the Little Rocky Mountains. They also applied the term Little Chief Canyon to the dark shale unit in the Big Snowy Mountains (loc. 1), and at Logan (loc. 6). The dark shale unit of the Big Snowy Mountains is separated from the Little Chief Canyon Member of the Lodgepole Limestone of the Little Rocky Mountains, according to SANDBERG (1963, p. C18).



CONODONT ZONE	Lower <i>S. crenulata</i>													cuI				Lower <i>S. costatus</i>							
	1	2	3	4	5	6	7	8	9	14	13	10	11	12	14	11			15	13					
LOCALITY	PARENT STRATIGRAPHIC HORIZON																								
NUMBER & DISTRIBUTION OF CONODONT SPECIES	Lodgepole : 0-5' ab. base Lodgepole : 0-3' ab. base Lodgepole : 0-3' ab. base Lodgepole : 0-5' ab. base Lodgepole : 0-3' ab. base Lodgepole : 0-5' ab. base Lodgepole : 0-5' ab. base Lodgepole : 0-5' ab. base Lodgepole : 0-5' ab. base Lodgepole : 0-5' ab. base Lodgepole : 0-5' ab. base Pahansapa : 0-3' ab. base Englewood : 0-9' bel. top Madison : 0-1" ab. base DSU : 9.5" - 10" bel. top DSU : 2'11" - 3'1" bel. top DSU : 0-6" ab. base DSU : 9'10" - 10'2" bel. top DSU : 0-3' bel. top DSU : 4'3" - 5'3" bel. top DSU : 5'3" - 6'4" bel. top DSU : 6'4" - 8'11" bel. top DSU : 8'11" - 13'3" bel. top Madison : 0-4' ab. base DSU : 0-2" bel. top DSU : 8" - 3'2" bel. top Englewood : 10 - 34' bel. top																								
<i>Falcodus angulus</i>	1				1	4																			
<i>Pinacognathus profunda</i>	1																								
<i>Pseudopolygnathus marginata</i>	11	4	1		1	21		2		1															
<i>P. triangula triangula</i>	62		1			13	14	3		2				1											
<i>Siphonodella crenulata</i>	6	10		1	4	91	6		7	2															
<i>S. lobata</i>	4		1			6	7				1														
<i>Spathognathodus abnormis</i>	2					4																			
<i>Pseudopolygnathus prima</i>													7												
<i>P. dentilineata</i>												1	1	34	7	18	1								
<i>Siphonodella duplicata</i>														5		1									
<i>S. sandbergi</i>												4		6	9	3	4								
<i>Dinodus leptus</i>																			3						
<i>D. youngquisti</i>		1					20	1							1										
<i>Elictognathus bialata</i>								1							4	2	1	1							
<i>E. lacerata</i>	26	1	1		2	7	7	1	1	1	3			2	1	3	1								
<i>Polygnathus inornata</i>	32		1	1	2	35	7		2	4	31	1	5	17	71	5	3								
<i>P. longipostica</i>	11					1				1				2	6										
<i>Siphonodella cooperi</i>	41	2	1	2	22	97	44	3	2	7			3	1	17	9	1								
<i>S. obsoleta</i>	51			1	2	28	25	13		18	25	11		8	8	3									
<i>S. quadruplicata</i>	14				6	7		2	2	2	3			7	14	1									
<i>S. sexplicata</i>	1														1										
<i>Spathognathodus crassidentatus</i>	2				3	3	1		1	1		2													
<i>Polygnathus communis</i>	15				2	11	1	6	1	4	10	3		9	7	6	6	1	31	2	10	2	11	8	
<i>P. symmetrica</i>	13				1	1	6	2	1	6	3			1	4	3								1	
<i>Spathognathodus stabilis</i>	21	1			5	21	14			2	1	1		2	4	3	1	2	21	14	3		9	13	
<i>Apatognathus varians</i>																			1	16	3	14		1	37
<i>Icriodus constrictus</i>																								1	
<i>I. costatus</i>																			1	18	4	1	3	11	4
<i>Palmatolepis gracilis gracilis</i>																			6	17		1	5		
<i>P. gracilis sigmoidalis</i>																			31	4	3				
<i>Polygnathus delicatula</i>																				112	3	2	1	20	12
<i>P. obliquicostata</i>																						7	2	27	
<i>Spathognathodus aculeatus</i>																			2	15	4		4	10	7
<i>S. jugosus</i>																						1	14		
<i>S. praelongus</i>																				1	9	3	1		3

TABLE 1. Distribution of conodont species.

All faunas shown were collected by GILBERT KLAPPER except that of locality 10, which was collected by C. A. SANDBERG. Two of the faunas at locality 13 which are

not assigned to a specific conodont zone are Kinderhookian in age. The abbreviation "DSU" stands for the dark shale unit of SANDBERG (1963).

The name Little Chief Canyon Member should not be applied to the south of its zero isopach line which lies well to the north of the Big Snowy Mountains.

KNECHTEL & HASS (1938) and HASS (1943) listed conodonts that occur in the Little Chief Canyon Member at a locality on Peoples Creek, Little Rocky Mountains. The fauna, including *Pseudopolygnathus prima*, is regarded as diagnostic of Lower Carboniferous (*cu1*). The fauna described by COOPER (32, locs. 2, 4, where strata were classed as the basal black shale member of the Madison Group) from the dark shale unit in the Big Snowy Mountains contains one diagnostic Lower Carboniferous element, *Elictognathus lacerata* (= *Solenognathus typica*). The specimen designated by COOPER (32) as *Siphonognathus* cf. *sexplicata* appears to be a species of *Polygnathus*. My collections from the dark shale unit at Crystal Lake Road Cut, Big Snowy Mountains (locality 1), contain a Lower Carboniferous (*cu1*) fauna.

The fauna described by COOPER (32, loc. 1) from the "Exshaw" of the Alberta Plains, Steepleville Oil Field, Alberta, contains no diagnostic Lower Carboniferous elements but does contain *Palmatolepis gracilis sigmoidalis* and *Spathognathodus praelongus*. Both these species are considered indicative of the Upper Devonian (*Spathognathodus costatus* Zone).

The dark shale unit of SANDBERG is a transgressive unit of widespread regional extent. At the sections studied in Montana it is Lower Carboniferous (*cu1*). It is this same age at South Fork Rock Creek (loc. 12), Teton Canyon (loc. 14), Warm Spring Canyon in the Wind River Range, and Horse Creek in the Washakie Range, all in Wyoming. At Cottonwood Canyon in the Big Horn Mountains (loc. 11) the Devonian-Carboniferous boundary falls within the dark shale unit, but at Dinwoody Canyon (loc. 15) and Bull Lake Creek (loc. 16) in the Wind River Range the unit is entirely Upper Devonian.

The dark shale unit is treated as a separate but informal unit. It can not have formational status until its mappability has been demonstrated. When the dark shale unit is formally named, it should be included as a member of the Madison Limestone or of the Lodgepole Limestone at sections where the Madison is a group, because the dark shale unit is lithologically and faunally transitional with the Madison.

## ENGLEWOOD FORMATION

A discussion of the Englewood Formation and its conodont faunas was presented by KLAPPER & FURNISH (1962). At Boxelder Canyon, Black Hills, South Dakota (loc. 13), the Devonian-Carboniferous boundary is 9 to 10 feet below the top of the Englewood Formation. The conodont fauna in the upper 9 feet is definitely Lower Carboniferous but lacks diagnostic elements which serve to differentiate the two Lower Carboniferous conodont zones recognized in this report. The conodont fauna that occurs 10 to 34 feet below the top of the Englewood at Boxelder Canyon is Upper Devonian (lower *Spathognathodus costatus* Zone). The approximate position of the Devonian-Carboniferous boundary is located 2 to 10 feet below the top of the Englewood in Whitewood Canyon (SW $\frac{1}{4}$  sec. 13, T. 5 N., R. 3 E., Deadwood North quadrangle, 67). The Englewood Formation at Boxelder Canyon is a time equivalent of the dark shale unit of SANDBERG at Cottonwood Canyon.

## LODGEPOLE LIMESTONE

COLLIER & CATHCART (1922) regarded the Madison of PEALE (1893) in the Little Rocky Mountains, Montana, as a group consisting of two formations, the Lodgepole Limestone and the overlying Mission Canyon Limestone. The type locality of the Lodgepole Limestone was designated as Lodgepole Canyon (27), *i.e.*, the part of Lodgepole Creek known as Little Chief Canyon (69). The Lodgepole is widely recognized in Montana but has not been successfully differentiated at most Madison sections in Wyoming. The Lodgepole is equivalent to the lower part of the Pahasapa Limestone of the Black Hills.

The unit known as the Little Chief Canyon Member of the Lodgepole Limestone is considered to be the feather-edge of the subsurface Bakken Formation and is not treated herein as a part of the Lodgepole Limestone. In this report the basal 5 feet of carbonate rocks of the Lodgepole Limestone is used as the uppermost reference horizon in the sections studied. Statements made concerning the age of the Lodgepole conodont fauna apply only to this basal unit.

The basal unit of the Lodgepole Limestone is commonly a glauconitic crinoidal calcarenite containing brachiopod, bryozoan, and coral fragments. At all localities (1-9) in Montana and at Teton Canyon (loc. 14) in Wyoming the basal unit of the Lodgepole contains a well-preserved conodont

fauna that is referable to the lower *Siphonodella crenulata* Zone (*cuIIa*) of Germany. A small and poorly preserved Kinderhookian conodont fauna occurs in the basal Madison Limestone at Cottonwood Canyon (loc. 11); forms diagnostic of either of the two Lower Carboniferous conodont zones recognized in this report are lacking. The base of the Madison at Clarks Fork Canyon (loc. 10) contains Lower Carboniferous (*cuI*) conodonts.

The base of the Madison Limestone at Dinwoody Canyon in the Wind River Range (loc. 15), however, is Upper Devonian (lower *Spathognathodus costatus* Zone) according to conodonts collected from the basal 4 feet by me and from the basal 15 feet by SANDBERG and MURPHY. The latter have collected Lower Carboniferous (Kinderhookian) conodonts from 15 to 25 feet above the base of the Madison at Dinwoody Canyon. SANDBERG and MURPHY collected Lower Carboniferous (Kinderhookian) conodonts from the basal 5 feet of the Madison Limestone at the north side of Bull Lake Creek, Wind River Range (SW¼ sec. 3, T. 2 N., R. 4 W., Bull Lake West quadrangle).

In a coral zonation of the Madison Group SANDO & DUTRO (1960) recognized three zones in

the Lodgepole Limestone at several sections in Montana (one at Logan), Wyoming (one in the Teton Range), and Utah. Zone A of their study occurs in the lower 10 to 50 feet of the Lodgepole. The three coral zones, collectively, of the Lodgepole (A, B, and lower C<sub>1</sub>) were regarded as equivalent to the Chouteau Limestone of the standard Mississippi Valley sequence (106).

COPELAND (1960) illustrated conodonts together with an ostracode fauna, which he regarded as Kinderhookian, from strata he considered as belonging to the Exshaw Formation at Crowsnest Pass, Alberta. However, MÜLLER (1962b) described conodonts collected from the same glauconitic limestone bed at Crowsnest Pass, and regarded the parent strata as basal Banff Formation, following the opinion of DE WIT (1953). DE WIT based his conclusions on a physical correlation of the aforementioned limestone bed with basal Lodgepole carbonate which is also glauconitic. The fauna illustrated by MÜLLER (1962b) belongs to the upper *Siphonodella crenulata* Zone of Germany and therefore is somewhat younger than the fauna described herein from basal Lodgepole strata (lower *S. crenulata* Zone) in Montana.

## CONODONT ZONES

A comprehensive zonation of the Upper Devonian has been presented by ZIEGLER (1962b) and nomenclature of the zones is shown in Figure 2. The *Scaphignathus velifera* Zone (upper *toIIIa*-lower *toIV*) is represented in Montana by a small fauna in the top limestone bed of the Trident Member of the Three Forks Formation at Peak 9559 (loc. 8). The fauna includes *Polygnathus perplexa* (*toIII-IV*) and *S. velifera* as its diagnostic elements. The upper *Polygnathus styriaca* Zone (*toV*) has been found in a sample collected by GUTSCHICK from the lower black shale of the Sappington Member of the Three Forks Formation at Frazier Lake, Bridger Range, Montana. *Palmatolepis rugosa postera* and *Spathognathodus jugosus* occur in this sample and together are diagnostic of the upper *P. styriaca* Zone.

The lower *Spathognathodus costatus* Zone (upper *toV*) is found in part of the dark shale unit of SANDBERG (1963) (loc. 11, 15, 16), in the middle part of the Englewood Formation (loc. 13), and in the lower part of the Madison Limestone at Dinwoody Canyon (loc. 15) as indicated in Table 1. Important elements of this fauna are *Spathognathodus aculeatus*, *Icriodus costatus*; *Palmato-*

*lepis gracilis sigmoidalis*, and *Apatognathus varians*. The *S. aculeatus* Zone of the Saverton Formation of the Upper Mississippi Valley sequence (29) is a probable correlative.

A zonation of the Lower Carboniferous *Gattendorfia-Stufe* (*cuI*) and *Pericyclus-Stufe* (*cuII*), based on sections in the Sauerland, Rheinisches Schiefergebirge, Germany, has been published (125). The *Gattendorfia-Stufe* is divided into three conodont zones, of which the oldest is termed the *Gnathodus kockeli-Pseudopolygnathus dentilineata* Zone, characterized by its two name-bearers, as well as by the absence of *Siphonodella*. Such an association has been found in North America only in the Upper Mississippi Valley ("Glen Park" and oldest beds of the Hannibal Formation, 29). The first occurrence of the genus *Siphonodella* is in the second division of the *Gattendorfia-Stufe*, the *Siphonodella-Pseudopolygnathus triangula inaequalis* Zone. The second and third zones are differentiated on basis of the lineage *P. triangula inaequalis* to *P. triangula triangula*.

A fauna characterized by the joint occurrence of *Siphonodella duplicata*, *S. sandbergi*, and *Pseu-*

*dopolygnathus dentilineata* is found in a part of the dark shale unit of SANDBERG at several places (Table 1) and in the Madison Limestone at Clarks Fork Canyon (loc. 10). This fauna correlates with either the second or third zone of the *Gattendorfia-Stufe* (*cu1*). A sample of the *Gattendorfia-Stufe* from the Hönnetal railroad cut (see 126, text fig. 2, table 1) collected by me in 1963 contains *S. sandbergi* in strata equivalent to VOGES' (126) sample 9. This seems to indicate a correlation of the Montana and Wyoming fauna containing *S. sandbergi* with a position at the top of the *Siphonodella-Pseudopolygnathus triangula inaequalis* Zone. However, some evidence for higher correlation of the Montana-Wyoming fauna is found at Baker Mountain (loc. 9) where a specimen of *P.*

*triangula triangula* was found. The Montana and Wyoming Lower Carboniferous (*cu1*) fauna appears to correlate with the *Siphonodella duplicata* Zone (*s. s.*) of the middle part of the Hannibal Formation (29).

The lower *Siphonodella crenulata* Zone (lower *cu1a*) in the Sauerland (125, 126) is characterized by the joint occurrence of *S. crenulata*, *S. lobata*, and *Pseudopolygnathus triangula triangula*. The same association occurs in the basal Lodgepole Limestone at the localities indicated in Table 1 and is regarded as representing the same zone. The lower *S. crenulata* Zone appears to correlate with the *S. quadruplicata-S. crenulata* Zone of upper Hannibal and lower Chouteau strata in the Upper Mississippi Valley (29).

### REWORKING OF CONODONTS

The problem of redeposition of conodonts into younger strata has been discussed by BRANSON & MEHL (1941a), HASS (1959), and in a comprehensive manner by KREBS (1964). In many cases the reworked elements of a fauna can be recognized by physical evidence alone without referring to the disparate stratigraphic ranges of different portions of the fauna, a matter which is usually subject to various interpretations. Where reworking is not indicated by physical characteristics of the fossils, as in the type Chappel Limestone of Texas, it is difficult to dispose of the problem.

At four localities (Crystal Lake Road Cut, Baker Mountain, South Fork Rock Creek, and Teton Canyon), where the base of the dark shale unit of SANDBERG is Mississippian (*cu1*), the fauna contains a few reworked Devonian conodonts. At Baker Mountain (loc. 9), the indigenous Mississippian material is characterized by its translucent brown color, whereas the reworked Upper Devonian fossils are black. The conodonts from the quartzitic sandstone at this place can be separated from the matrix only by the use of hydrofluoric acid. After such treatment, the indigenous conodonts are nearly white, but the reworked ones remain black. At South Fork Rock Creek (loc. 12), the indigenous fossils are unworn, but reworked

specimens are worn, highly rounded, and discolored by a yellow coating. Physical evidence of reworking is also seen in the Devonian conodonts which occur as admixtures in the basal part of the dark shale unit at Crystal Lake Road Cut (loc. 1) and Teton Canyon (loc. 14).

At Cottonwood Canyon (loc. 11) the basal 8 inches of the dark shale unit of SANDBERG is a conglomerate that contains an indigenous Devonian (lower *Spathognathodus costatus* Zone) fauna. Older Devonian conodonts, such as *Palmatolepis rugosa rugosa* and *Polylophodonta* spp., show physical signs of reworking. Above the basal 8 inches at Cottonwood Canyon, reworked conodonts were not observed. Reworking of *Palmatolepis glabra* into the lower black shale of the Sappington Member of the Three Forks Formation at Peak 9559 (loc. 8) has been mentioned previously and was determined by physical signs of reworking. It seems justifiable to omit the occurrence of these reworked elements from Table 1, because in all cases reworking was indicated by physical evidence of the conodont specimens alone. No evidence of reworking was observed in any of the Lodgepole, Madison, Englewood, or Pahasapa samples.

### SYSTEMATIC PALEONTOLOGY

Suprageneric classifications for conodonts have not been widely accepted and are not employed herein for reasons discussed by SCOTT (1962, p. 1399) and LINDSTRÖM (1964, p. 116). The occur-

rence of all species dealt with in the taxonomic section of this report is shown in Table 1. All types are deposited in the Department of Geology, The University of Iowa.

Genus PSEUDOPOLYGNATHUS

Branson & Mehl, 1934

*Pseudopolygnathus* BRANSON & MEHL, 1934b, p. 297-298; BRANSON & MEHL, REXROAD & SCOTT, 1964, p. 37-38; Type species: *P. prima* BRANSON & MEHL, 1934b, p. 298, pl. 24, figs. 24, 25; OD.

*Macropolygnathus* COOPER, 1939, p. 392.

*Range*.—Upper *Scaphignathus velifera* Zone (e.g., *Pseudopolygnathus granulosa* ZIEGLER, *P. micropunctata* BISCHOFF & ZIEGLER, see ZIEGLER, 1962b, p. 100-101) through the *Scaliognathus anchoralis* Zone (*P. triangula pinnata* VOGES, 1959, Table 1).

PSEUDOPOLYGNATHUS MARGINATA (Branson & Mehl), 1934

Plate 1, figures 1-6

*Polygnathus marginata* BRANSON & MEHL, 1934b, p. 294-295, pl. 23, figs. 25-27; REXROAD & SCOTT, 1964, p. 37, pl. 2, fig. 29.

*Polygnathus itha* COOPER, 1939, p. 401, pl. 39, figs. 55, 56.

*Polygnathus lacinata* Huddle, COOPER, 1939, p. 401, pl. 40, figs. 3, 4.

non *Polygnathus marginata* BRANSON & MEHL, COOPER, 1939, p. 401, pl. 41, figs. 15, 16 (= *Polygnathus pura* VOGES).

*Polygnathus omala* COOPER, 1939, p. 401, pl. 39, figs. 71, 72.

*Polygnathus oxys* COOPER, 1939, p. 402, pl. 39, figs. 53, 54.

*Polygnathus scobiniiformis* BRANSON, COOPER, 1939, p. 403, pl. 39, figs. 45-48.

*Polygnathus sruoduz* COOPER, 1939, p. 404, pl. 39, figs. 7, 8.

*Polygnathus xyncha* COOPER, 1939, p. 404, pl. 39, figs. 73, 74.

*Diagnosis*.—Lanceolate with platform equally developed on both sides. Platform bears transverse ridges; unit slightly arched. Raised keel present throughout length, interrupted only by basal cavity. Narrow groove, continuous with keel, traverses basal cavity. Basal cavity nearly symmetrical with characteristic sinus in its flared margins, on both sides, near posterior termination of cavity. Crimp is broad in mature specimens.

*Remarks*.—A growth series is represented by the specimens illustrated on Pl. 1, figs. 1-6; all intermediate stages are known in available material. The basal cavity of Fig. 5 is regarded as atypical. Many specimens are available that could substitute for Fig. 5 in terms of size; these have a basal cavity of the same character as the rest of the illustrated series. Based on material at hand, the size of the basal cavity remains almost constant during growth, whereas the platform enlarges.

*Pseudopolygnathus xyncha* (COOPER) seems to be an abnormal representative of *P. marginata*. The platform of *P. marginata* may or may not reach the posterior tip.

*Range*.—The species has been recorded from the Bushberg Sandstone of BRANSON & MEHL (1934b) and from the Kinderhook (Chouteau) part of the Rockford Limestone (REXROAD & SCOTT, 1964).

*Repository*.—Figured hypotypes, S.U.I. 10904-10906.

PSEUDOPOLYGNATHUS TRIANGULA TRIANGULA Voges, 1959

Plate 1, figures 15-22

*Pseudopolygnathus triangula triangula* VOGES, 1959, p. 304-305, pl. 35, figs. 7-13; FREYER, 1961, in Dvořák & Freyer, p. 894, pl. 2, figs. 6, 7.

*Diagnosis*.—With subtriangular outline. Platform with transverse ridges; carina and keel slightly incurved. Unit arched. Basal cavity small and ovate. Keel usually with median slit.

*Remarks*.—The basal cavity is relatively large compared with the platform in small specimens of *Pseudopolygnathus triangula triangula*, but it is proportionately smaller in larger specimens. Only small (immature) specimens are similar with respect to proportional size of the basal cavity to the drawings of *P. triangula triangula* (VOGES, 1959, text-fig. 5, fig. IV). The basal cavity of the photographed specimens (VOGES, pl. 35, figs. 8, 10, 12) is much smaller relative to platform size.

By virtue of the small size of the basal cavity, *P. triangula triangula* is referable to *Polygnathus* in a strictly morphological sense. However, VOGES (1959, p. 295-296, text-fig. 5) presented phylogenetic evidence showing the relationship of *P. triangula triangula* to *P. triangula inaequalis*, which occurs in the immediately underlying beds in his sections. These two subspecies are closely similar if not identical in upper surface morphology, yet *P. triangula inaequalis* has a basal cavity typical of *Pseudopolygnathus*. The consistent trend in VOGES' lineage (1959, text fig. 5) is toward reduction in size of the basal cavity. Phylogenetic evidence should be given precedence over the dictates of artificial morphological categories, as emphasized by VOGES (1959, p. 296). Accordingly *P. triangula triangula* is retained in *Pseudopolygnathus*.

*Pseudopolygnathus triangula pinnata* has a strongly alate anterior margin on the inner side of the platform. The specimen illustrated here (Pl. 1, figs. 20, 21) approaches this condition, but this type of outline is rare in the material at hand. The specimen which REXROAD & SCOTT (1964, p. 42, pl. 2, fig. 28) designated as *P. triangula* should be assigned to *P. triangula pinnata*.

*Range*.—*P. triangula triangula* occurs in the *Siphonodella-P. triangula triangula* Zone and in the lower *Siphonodella crenulata* Zone in Germany (VOGES, 1959, table 1).

*Repository*.—Figured hypotypes, S.U.I. 10911-10914.

**PSEUDOPOLYGNATHUS PRIMA** Branson & Mehl, 1934

Plate 4, figure 8

- Pseudopolygnathus prima* BRANSON & MEHL, 1934b, p. 298, pl. 24, figs. 24, 25; THOMAS, 1949, p. 437, pl. 4, fig. 17; HASS, 1951, p. 2538, 2539, pl. 1, fig. 11; —, 1956, p. 25, pl. 2, fig. 24; CLOUD, BARNES, & HASS, 1957, p. 813, pl. 5, fig. 10; HASS, 1959, pl. 49, fig. 27 (same specimen as CLOUD, BARNES, & HASS, 1957).
- Pseudopolygnathus foliacea* BRANSON, 1934, p. 316, pl. 26, figs. 27, 28.
- Pseudopolygnathus irregularis* BRANSON, 1934, p. 316, pl. 26, figs. 25, 26; COOPER, 1939, p. 408, pl. 40, figs. 21, 22, 35, 36; YOUNGQUIST & PATTERSON, 1949, p. 68-69, pl. 16, figs. 1-3; BISCHOFF, 1957, p. 51, pl. 6, figs. 12, 13.
- Pseudopolygnathus corrugata* BRANSON, 1934, p. 317, pl. 26, fig. 23.
- Pseudopolygnathus costata* BRANSON, 1934, p. 317-318, pl. 26, fig. 21.
- Pseudopolygnathus distorta* BRANSON, 1934, p. 318-319, pl. 26, figs. 16, 17; COOPER, 1939, p. 407-408, pl. 40, figs. 49, 50.
- Pseudopolygnathus sulcifera* BRANSON, 1934, p. 319, pl. 26, fig. 15.
- Pseudopolygnathus asymmetrica* BRANSON, 1934, p. 320, pl. 26, fig. 12; COOPER, 1939, p. 406-407, pl. 40, figs. 23, 24, 59, 60; pl. 41, figs. 13, 14; HASS, 1959, p. 370, pl. 49, fig. 14.
- Pseudopolygnathus inequicostata* BRANSON, 1934, p. 321, pl. 26, fig. 6.
- Pseudopolygnathus crenulata* BRANSON, 1934, p. 321, pl. 26, figs. 4, 5, 7, 8; COOPER, 1939, p. 407, pl. 40, figs. 25-27.
- Pseudopolygnathus lobata* BRANSON, 1934, p. 322, pl. 26, figs. 1, 2.
- Pseudopolygnathus apetodus* COOPER, 1939, p. 406, pl. 40, figs. 63-67.
- Pseudopolygnathus exotyla* COOPER, 1939, p. 408, pl. 42, figs. 23, 24.
- Pseudopolygnathus aurita* YOUNGQUIST & PATTERSON, 1949, p. 67-68, pl. 16, figs. 5, 6.
- Pseudopolygnathus carinata* YOUNGQUIST & PATTERSON, 1949, p. 68, pl. 16, fig. 4.
- Pseudopolygnathus constrictiterminata* THOMAS, 1949, p. 428, pl. 4, fig. 16.
- Pseudopolygnathus* cf. *P. asymmetrica* BRANSON, THOMAS, 1949, p. 436, pl. 3, fig. 42.

**Diagnosis.**—One side of platform (either inner or outer) with lateral lobe. Right side of platform developed farther anteriorly. Coarse and irregular transverse ridges, or single row of large nodes in immature specimens, on each side of the platform. Basal cavity large and asymmetrical, not covering entire width of platform in mature specimens.

**Remarks.**—The right side of *Pseudopolygnathus prima* (viewed with the posterior end downward) extends farther anteriorly than does the left. The right side may lie on either the outer or inner side of the platform. Exactly the same situation obtains in *P. dentilineata*. This aspect of symmetry in *Pseudopolygnathus* has been discussed and illustrated by VOGES (1959, text fig. 4) and apparently holds true for all specimens of *P. prima* and *P. dentilineata* illustrated in the literature.

In VOGES' (1959, text fig. 4) schematic devel-

opment of the group of *Pseudopolygnathus prima*, stages IIb and IIIa, said to be hypothetical, are suggested by that author to be possibly equivalent to *P. foliacea* and *P. apetodus*, respectively. Both these species are considered here as junior synonyms of *P. prima*. According to the present interpretation stage IIb (VOGES, 1959, text fig. 4) possibly corresponds to an early representative of *P. prima*, still transitional with *P. dentilineata*, and stage IIIa corresponds to a more advanced form of *P. prima*. In this manner, *P. prima* developed from *P. dentilineata*. Such a specimen as *P. irregularis* (BRANSON, 1934, pl. 26, figs. 25, 26) is regarded as transitional between the two species. The arbitrary distinction between *P. prima* and *P. dentilineata* is drawn on the size of the basal cavity relative to the width of the platform, as mentioned later.

*Pseudopolygnathus prima* is similar to *P. triangula inaequalis* VOGES. The distinction given between *P. apetodus* and *P. triangula inaequalis* (VOGES, 1959, p. 297-298) is that the right side of the platform extends farther forward than the left in *P. apetodus*, but the 2 sides of the platform extend the same distance anteriorly in *P. triangula inaequalis*. This difference is accepted as the distinction between *P. prima* (= *P. apetodus*) and *P. triangula inaequalis*. *P. prima* probably gave rise to *P. triangula inaequalis* (as shown by VOGES, 1959, text fig. 4, IIIa-IIIb).

Some specimens of *P. prima* (e.g., YOUNGQUIST & PATTERSON, 1949, pl. 16, fig. 5) have an alate inner anterior margin superficially suggesting the outline of *P. triangula pinnata* VOGES. However, the latter has a much smaller basal cavity.

*Pseudopolygnathus crenulata* BRANSON is interpreted as an early growth stage of *P. prima*. A great number of named species of *Pseudopolygnathus* are placed in synonymy with *P. prima*. They were proposed primarily on the basis of details of upper surface ornamentation, here regarded as within the range of intraspecific variation.

**Range.**—The present species is known in *cul* strata in Germany (BISCHOFF, 1957, table 2).

**Repository.**—Figured hypotype, S.U.I. 10897.

**PSEUDOPOLYGNATHUS DENTILINEATA** Branson, 1934

Plate 5, figures 10, 11

- Pseudopolygnathus dentilineata* BRANSON, 1934, p. 317, pl. 26, fig. 22; BISCHOFF, 1957, p. 50-51, pl. 4, figs. 29-32, 34; VOGES, 1959, p. 300-301, pl. 34, figs. 49, 50; text-fig. 5, fig. II; ZIEGLER, 1962b, p. 99.
- Pseudopolygnathus varicostata* BRANSON, 1934, p. 318, pl. 26, figs. 19, 20; COOPER, 1939, p. 408-409, pl. 40, figs. 44, 45.
- Pseudopolygnathus subrugosa* BRANSON, 1934, p. 318, pl. 26, fig. 18.
- Pseudopolygnathus projecta* BRANSON, 1934, p. 320, pl. 26, figs. 10, 11.

*Pseudopolygnathus brevimarginata* BRANSON, 1934, p. 322, pl. 26, fig. 3.

*Pseudopolygnathus striata* Mehl & Thomas, BISCHOFF & ZIEGLER, 1956, p. 164, pl. 11, fig. 20.

**Diagnosis.**—Right side of platform more fully developed anteriorly along blade. Single row of large nodes or ridges on each side of platform. Basal cavity covers entire width of platform in mature specimens and has flaring margins.

**Remarks.**—*Pseudopolygnathus dentilineata* probably developed from double-rowed forms of *Spathognathodus* (e.g., *S. costatus ultimus* BISCHOFF, as shown in the phylogenetic series discussed by VOGES, 1959, p. 296, text-fig. 5). At least this statement may apply to Lower Carboniferous representatives of *P. dentilineata*. This species still retains essentially the same type of basal cavity as that of *S. costatus ultimus*, although the cavity of the latter is wider than the platform (VOGES, 1959, text fig. I, dextral specimen).

*Pseudopolygnathus dentilineata* is transitional with *P. prima* as indicated under remarks on the latter species. The arbitrary distinction is drawn here as follows: the basal cavity is as wide as the platform in *P. dentilineata*, whereas the cavity is more restricted in extent in *P. prima*. Furthermore, the margins of the basal cavity are more flaring in *P. dentilineata*.

The upper surface of *Pseudopolygnathus multistriata* MEHL & THOMAS is closely similar to that of *P. dentilineata*. The former is regarded as a lowermost Osage homeomorph of *P. dentilineata* but is distinguished by possession of a more restricted basal cavity.

**Range.**—The species ranges from the upper *Polygnathus styriaca* Zone (ZIEGLER, 1962b, p. 99) to the top of the *Gattendorfia-Stufe* (*cu*1) in Germany. COLLINSON, *et al.* (1962) record *P. dentilineata* from the "Glen Park" and Hannibal Formations in the Upper Mississippi Valley.

**Repository.**—Figured hypotype, S.U.I. 10880.

### Genus SIPHONODELLA Branson & Mehl, 1944

*Siphonognathus* BRANSON & MEHL [*non* RICHARDSON, 1858], 1934b, p. 295.

*Siphonodella* BRANSON & MEHL, 1944, in Shimer & Shrock, p. 245 [*pro Siphonognathus* BRANSON & MEHL]; BRANSON & MEHL, 1948, p. 528. Type species: *Siphonognathus duplicata* BRANSON & MEHL, p. 296-297, pl. 24, figs. 16, 17; OD.

**Diagnosis.**—Lanceolate, asymmetrical platform highly arched with apex of arch at or near position of basal cavity. Anterior rostral or spoutlike extension of platform well developed in all but earliest species. Rostrum arched downward anteriorly and at least slightly incurved. It bears longitudinal (rostral) ridges on the upper side. Outer

side of platform at least as wide as inner side, and may be more than twice that width. Carina well developed on the platform, extending anteriorly as a fixed and free blade.

Raised keel present on lowed side in front of basal cavity. This anterior portion of keel generally bears median groove throughout its length. Basal cavity narrow expansion of median groove in keel. Cavity in mature specimens small and slitlike, without lips. Keel either absent or represented only by thin groove behind basal cavity, except near posterior end where it is raised. Area immediately behind basal cavity characteristically flattened or beveled. Crimp is broad.

**Remarks.**—Heretofore the presence of a rostrum and rostral ridges has been employed to distinguish *Siphonodella* from *Polygnathus*. However, some species of *Polygnathus* (e.g., *P. inornata* BRANSON, *P. perplexa* THOMAS, *P. hassi* HELMS) have rostral ridges; and some (e.g., group of *P. nodocostata*, *sensu* HELMS, 1961a), tend towards development of a rostrum.

The lower side is thought to be of more taxonomic importance in differentiating genera of platform conodonts (e.g., HASS, 1959). The upper side shows only the last growth lamella and reflects superficial ornament. On the other hand the lower side in well-preserved material displays all of the growth lamellae and lacks ornament. Morphology of the lower side is used here to differentiate *Siphonodella* from *Polygnathus*.

*Polygnathus* has a raised keel, interrupted only by the basal cavity, throughout the length of the platform. The basal cavity is relatively large, attenuate, usually circular or ovate, and has strong lips. In some Upper Devonian representatives of *Polygnathus* (e.g., *P. rhomboidea* ULRICH & BASSLER, *P. varinodosa* BRANSON & MEHL) which have a small rostrum, the basal cavity is slitlike, as in *Siphonodella*. However, these species possess a raised keel throughout the length of the platform. In contrast, the keel of *Siphonodella* is either absent or represented by a thin groove for some distance posterior to the basal cavity. In some immature specimens of *Siphonodella* (e.g., forms illustrated by MÜLLER, 1962b, text figs. 4, 8), the keel is split by a relatively wide groove from the basal cavity to the posterior end.

Accordingly, *Polygnathus sulcata* HUDDLE (1934, pl. 8, figs. 22,23), which lacks a strong rostral development, is regarded as a representative of *Siphonodella* on the basis of its lower side (29, chart 2).

Morphology of the upper side is used to differentiate species of *Siphonodella*. The outline of the platform, the number and position of the rostral ridges, and the gross aspects of ornament on the

posterior part of the platform are regarded as important for this purpose.

*Range*.—*Siphonodella* ranges from the *Siphonodella-P. triangula inaequalis* Zone to the top of the *Scaliognathus anchoralis* Zone in Germany (Voges, 1959, table 1). The genus occurs in the Hannibal and Chouteau Formations in the standard Mississippi Valley sequence (29).

#### SIPHONODELLA COOPERI Hass, 1959

Plate 2, figures 10, 11; Plate 3, figures 1-4

*Siphonognathus quadruplicata* BRANSON & MEHL, 1934b, p. 295-296, pl. 24, fig. 21 (non figs. 18-20 = *S. quadruplicata*); COOPER, 1939, p. 409, pl. 41, figs. 44, 45.

*Siphonognathus duplicata* Branson & Mehl, BRANSON, 1934, p. 315, pl. 25, fig. 1 (non fig. 16 = *S. duplicata*).

*Siphonodella duplicata* (Branson & Mehl), YOUNGQUIST & PATTERSON, 1949, p. 69, pl. 16, figs. 7, 10 (non figs. 8, 9 = *S. obsoleta*); THOMAS, 1949, p. 436, pl. 3, fig. 9 (non fig. 8 = ?*Polygnathus inornata* BRANSON); YOUNGQUIST & DOWNS, 1951, p. 789-790, pl. 111, fig. 21; HASS, 1956, p. 25, pl. 2, fig. 7 (non figs. 8-11 = *S. duplicata*); BISCHOFF & ZIEGLER, 1956, p. 165, pl. 12, fig. 14; BISCHOFF, 1957, p. 55, pl. 6, fig. 1 (non fig. 2 = *S. obsoleta*); COPELAND, 1960, p. 41, pl. 1, fig. 21 (non fig. 22 = *S. obsoleta*); FREYER, 1961, in Dvořák & Freyer, p. 894, pl. 2, fig. 13 (non figs. 14, 15 = *S. obsoleta*).

*Siphonodella duplicata* (Branson & Mehl) var. B, HASS, 1951, p. 2539, pl. 1, fig. 7.

*Siphonodella cooperi* HASS, 1959, p. 392, pl. 48, figs. 35, 36; SCOTT & COLLINSON, 1961, p. 131, pl. 2, figs. 31, 33-35; REXROAD & SCOTT, 1964, p. 43-44, pl. 3, figs. 27-29.

*Diagnosis*.—With nodes on inner side of platform and strong transverse ridges on outer side. Two or 3 rostral ridges; longest one on outer platform terminating posteriorly at lateral margin of platform or forming that margin.

*Remarks*.—*Siphonodella cooperi* definitely includes forms with either 2 or 3 rostral ridges as shown by HASS' original definition of the species and his illustrated specimens (HASS, 1959, pl. 48, figs. 35, 36), as well as by the material of this study.

*Siphonodella cooperi* is closely similar to *S. quadruplicata*; the distinction drawn between them

is highly artificial. In *S. cooperi* the longest rostral ridge on the outer platform either terminates posteriorly at the lateral margin about midway between the anterior and posterior ends, or it actually forms the lateral margin. In *S. quadruplicata* the longest rostral ridge on the outer platform terminates posteriorly in the region above the basal cavity and thus does not reach the lateral margin.

The specimen designated as *Siphonodella duplicata* by YOUNGQUIST & PATTERSON (1949, pl. 16, fig. 10) has strong transverse ridges on the outer platform, in contrast to their illustration. The specimen also has a more sharply pointed posterior end than is shown. It should be referred to *S. cooperi*.

*Range*.—The species ranges from the middle part of the Hannibal Formation to the top of the Chouteau Formation (29, chart 2).

*Repository*.—Figured hypotypes, S.U.I. 10920-10922.

#### SIPHONODELLA LOBATA (Branson & Mehl) 1934b

Plate 2, figures 1-4

*Siphonognathus lobata* BRANSON & MEHL, 1934b, p. 297, pl. 24, figs. 14, 15; COOPER, 1939, p. 409, pl. 41, figs. 36, 37, 46, 47.

*Siphonognathus perlobata* COOPER, 1939, p. 409, pl. 41, figs. 28, 29.

*Siphonodella lobata* (Branson & Mehl), BRANSON & MEHL, 1944, in Shimer & Shrock, p. 245, pl. 94, fig. 55; HASS, 1956, p. 25, pl. 2, fig. 25; CLOUD, BARNES, & HASS, 1957, p. 809, pl. 5, fig. 9; HASS, 1959, p. 371, pl. 49, fig. 26 (same specimen as CLOUD, BARNES, & HASS, 1957); VOGES, 1959, p. 309, pl. 35, figs. 35-39.

*Diagnosis*.—Outer lateral lobe present. Transverse ridges on both sides of platform. Rostrum well developed. Keel atypical for *Siphonodella*, raised and continuous throughout length of platform, interrupted only by small, lipped basal cavity. Secondary keel beneath outer lateral lobe joins main keel at basal cavity.

*Remarks*.—*Siphonodella lobata* is an atypical species in that the character of the keel does not fit the diagnosis of *Siphonodella* but is more like that described for *Polygnathus*. The species does have

### EXPLANATION OF PLATE 1

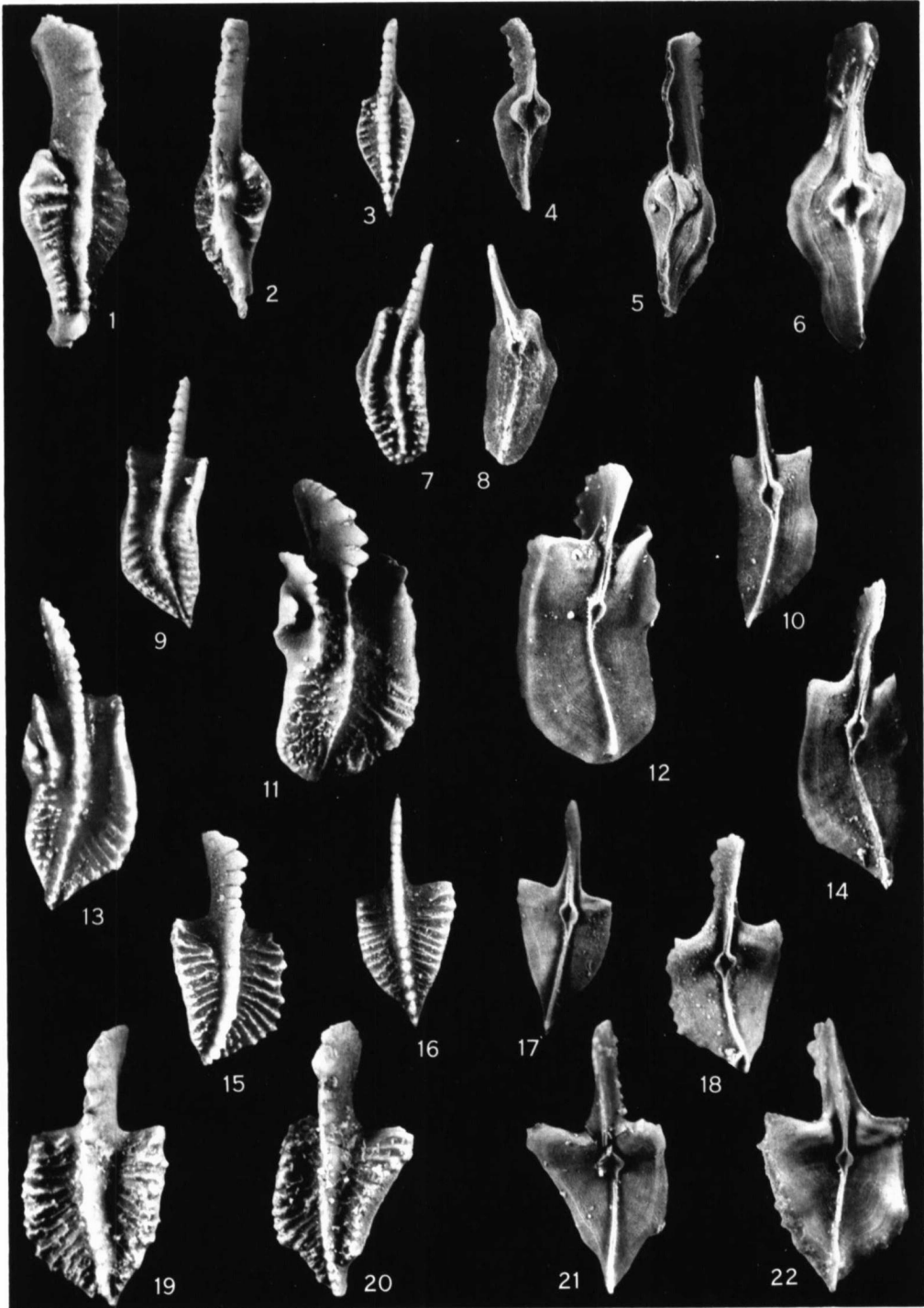
All specimens are from the basal Lodgepole Limestone, Montana and Wyoming; all figures are unretouched photographs (X26).

#### FIGURE

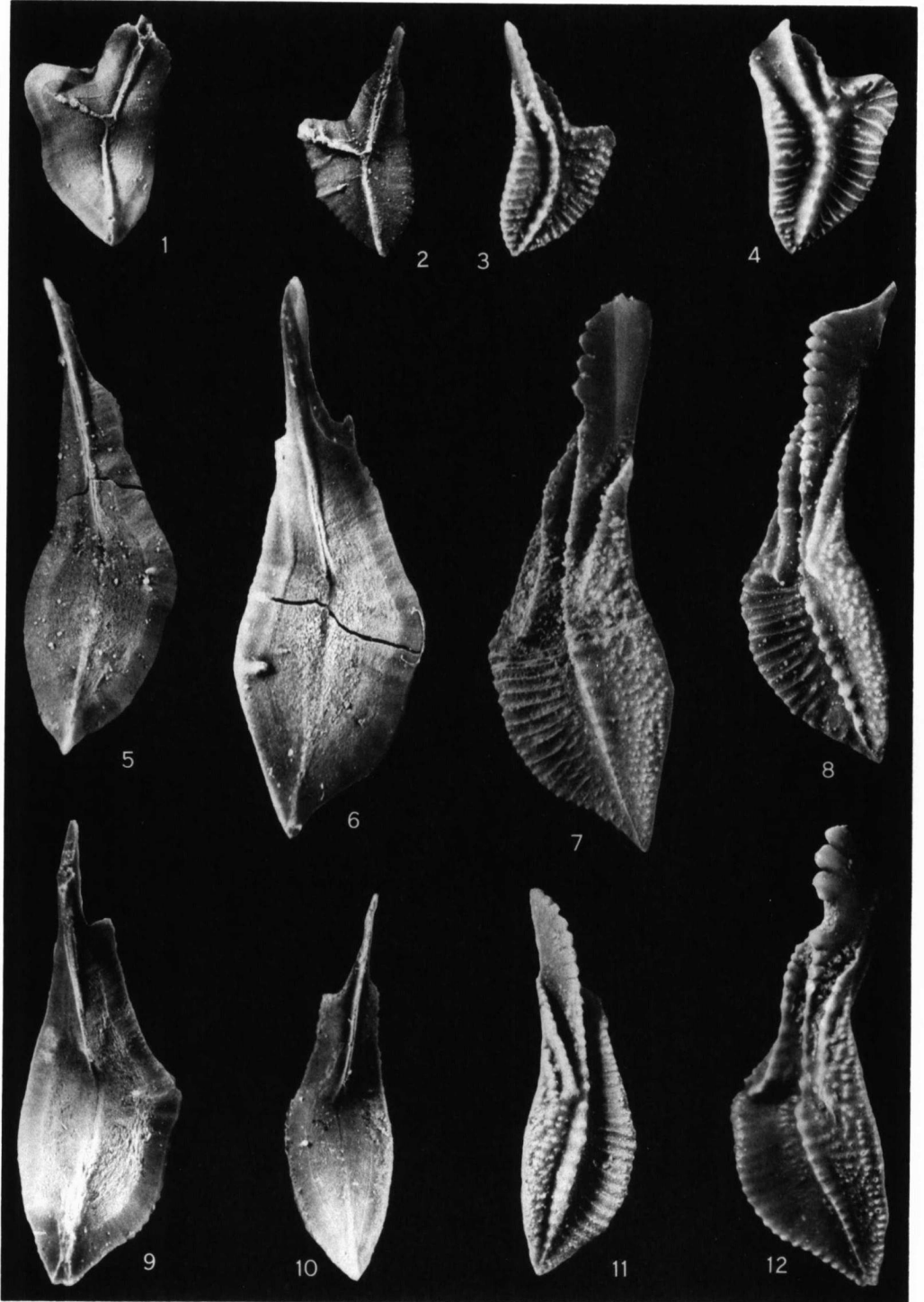
1-6. *Pseudopolygnathus marginata* (BRANSON & MEHL).—1-3. Upper views.—4-6. Lower views of S.U.I. hypotypes 10906, 10905, 10904, from loc. 6. .... (p. 13)  
7-14. *Polygnathus inornata* BRANSON.—7. Upper view.—8. Lower view of S.U.I. hypotype 10907 from loc. 14.—9. Upper view.—10. Lower view of

S.U.I. hypotype 10908 from loc. 6.—11. Upper view.—12. Lower view of S.U.I. hypotype 10909 from loc. 1.—13. Upper view.—14. Lower view of S.U.I. hypotype 10910 from loc. 4. .... (p. 19)  
15-22. *Pseudopolygnathus triangula* VOGES.—15. Upper view.—18. Lower view of S.U.I. hypotype 10911 from loc. 3.—16. Upper view.—17. Lower view of S.U.I. hypotype 10912 from loc. 7.—19, 20. Upper views.—21, 22. Lower views of S.U.I. hypotypes 10913-10914 from loc. 1. .... (p. 13)





Klapper--Devonian and Mississippian Conodont Zones



Klapper--Devonian and Mississippian Conodont Zones

a well-developed rostrum, however, and the basal cavity is smaller than that of typical *Polygnathus*. In the character of the ornamentation *S. lobata* is closely related to *S. duplicata*, from which it differs in the aspect of its lower side and the presence of an outer lateral lobe. *S. lobata* probably developed from *S. duplicata*.

*Range*.—The species occurs in the *Siphonodella-P. triangula triangula* Zone and in the lower *S. crenulata* Zone in Germany (VOGES, 1959, table 1).

*Repository*.—Figured hypotypes, S.U.I. 10915, 10916.

**SIPHONODELLA OBSOLETA** Hass, 1959

Plate 2, figures 9, 12; Plate 4, figures 17, 19

*Siphonognathus duplicata* BRANSON & MEHL, BRANSON & MEHL, 1938b, p. 148, pl. 34, fig. 34.

*Siphonodella duplicata* (BRANSON & MEHL), YOUNGQUIST & PATTERSON, 1949, p. 69, pl. 16, figs. 8, 9; BISCHOFF, 1957, p. 55, pl. 6, fig. 2; COPELAND, 1960, p. 41, pl. 1, fig. 22; ZIEGLER, 1960b, in Kronberg *et al.*, pl. 3, fig. 10; FREYER, 1961, in Dvořák & Freyer, p. 894, pl. 2, figs. 14, 15.

*Siphonodella quadruplicata* (BRANSON & MEHL), YOUNGQUIST & DOWNS, 1951, p. 790, pl. 111, figs. 23-25; BEACH, 1961, p. 45, pl. 6, fig. 13.

*Siphonodella* sp. A HASS, 1956, p. 25, pl. 2, fig. 12.

*Siphonodella obsoleta* HASS, 1959, p. 392-393, pl. 47, figs. 1, 2; VOGES, 1959, p. 309-310, pl. 35, figs. 40-50; ZIEGLER, 1960b, in Kronberg *et al.*, pl. 3, fig. 8; FREYER, 1961, in Dvořák & Freyer, p. 894, pl. 2, figs. 16-19; MÜLLER, 1962b, p. 1388, text-figs. 4, 8; REXROAD & SCOTT, 1964, p. 45, pl. 3, fig. 25.

*Siphondella* aff. *S. obsoleta* HASS, COLLINSON *et al.*, 1962, chart 2.

*Diagnosis*.—Narrow, elongate, with single rostral ridge on outer side of the platform continuing to near posterior end and forming outer margin. Rostral ridges usually 2 to 4 in number. Nodes present on inner side of platform, but ornamentation weak to absent on outer side between long rostral ridge and carina.

*Remarks*.—*Siphonodella obsoleta* differs from *S. sandbergi* in outline of the platform. *S. obsoleta* and *S. cooperi* are comparable, but the former is distinct in lacking strong transverse ridges on the outer side of the platform. *S. isosticha* (COOPER)

*sensu* REXFORD & SCOTT (1964) lacks a long rostral ridge on the outer platform.

*Range*.—The species is recorded from the *Siphonodella-P. triangula inaequalis* Zone through the *Scaliognathus anchoralis* Zone in Germany (VOGES, 1959, table 1).

*Repository*.—Figured hypotypes, S.U.I. 10902, 10919.

**SIPHONODELLA QUADRUPPLICATA** (BRANSON & MEHL) 1934

Plate 2, figures 5-8; Plate 3, figures 9-12; Plate 4, figures 16, 20

*Siphonognathus quadruplicata* BRANSON & MEHL, 1934b, p. 295-296, pl. 24, figs. 18-20 (the specimen illustrated as fig. 18 is herewith selected as lectotype; *non* fig. 21 = *S. cooperi*).

*Polygnathus newalbanyensis* HUDDLE, 1934, p. 101, pl. 8, fig. 27 (*non* fig. 26 = *S. sexplicata*; *non* fig. 28 = *Siphonodella* sp. *indet.*).

*Siphonognathus isolopha* COOPER, 1939, p. 409, pl. 41, figs. 5, 6, 19, 20.

*Siphonognathus newalbanyensis* (Huddle), COOPER, 1939, p. 409, pl. 41, figs. 21, 22.

*Siphonognathus sexplicata* BRANSON & MEHL, COOPER, 1939, p. 410, pl. 41, figs. 38, 39.

*Siphonodella quadruplicata* (BRANSON & MEHL), BRANSON & MEHL, 1944, in Shimer & Shrock, p. 245, pl. 94, figs. 44, 45; YOUNGQUIST & PATTERSON, 1949, p. 70, pl. 16, fig. 11; THOMAS, 1949, p. 436, pl. 3, figs. 2, 3, 6; YOUNGQUIST & DOWNS, 1951, p. 790, pl. 111, fig. 22 (*non* figs. 23-25 = *S. obsoleta*); HASS, 1951, p. 2539, pl. 1, fig. 9; —, 1956, p. 25, pl. 2, fig. 29; CLOUD, BARNES, & HASS, 1957, p. 809, pl. 5, fig. 11; HASS, 1959, p. 370, 371, pl. 49, fig. 28 (same specimen as CLOUD, BARNES, & HASS, 1957); BEACH, 1961, p. 45, pl. 6, figs. 9, 15 (*non* fig. 13 = *S. obsoleta*); MÜLLER, 1962b, p. 1388, text-fig. 5.

*Siphonodella sexplicata* (BRANSON & MEHL), THOMAS, 1949, p. 436, pl. 3, fig. 1.

*Siphonodella duplicata* (BRANSON & MEHL) var. A HASS, 1951, p. 2539, pl. 1, fig. 8; —, 1956, p. 25, pl. 2, fig. 23 (*non* fig. 13); CLOUD, BARNES, & HASS, 1957, p. 809, pl. 5, fig. 8.

*Siphonodella duplicata* (BRANSON & MEHL), HASS, 1959, pl. 49, figs. 17, 18 (*non* fig. 25 = *S. duplicata*); BEACH, 1961, p. 54, pl. 6, fig. 12.

*Siphonodella crenulata* (COOPER), REXROAD & SCOTT, 1964, p. 44, pl. 3, fig. 26.

*Diagnosis*.—Nodes on inner side of platform, transverse ridges on outer side. Three to 5 rostral

**EXPLANATION OF PLATE 2**

All specimens are from the basal Lodgepole Limestone, Montana; all figures are unretouched photographs (×26).

FIGURE

- 1-4. *Siphonodella lobata* (BRANSON & MEHL).—1. Lower view.—4. Upper view of S.U.I. hypotype 10915 from loc. 7.—2. Lower view.—3. Upper view of S.U.I. hypotype 10916 from loc. 6. . . (p. 16)
- 5-8. *Siphonodella quadruplicata* (BRANSON & MEHL).—5. Lower view.—8. Upper view of S.U.I. hy-

- potype 10917 from loc. 5.—6. Lower view.—7. Upper view of S.U.I. hypotype 10918 from loc. 1. . . . . (p. 17)
- 9, 12. *Siphonodella obsoleta* HASS.—9. Lower view.—12. Upper view of S.U.I. hypotype 10919 from loc. 8. . . . . (p. 17)
- 10, 11. *Siphonodella cooperi* HASS.—10. Lower view.—11. Upper view of S.U.I. hypotype 10920 from loc. 6. . . . . (p. 16)

ridges, none extending posteriorly much beyond position of basal cavity. Longest (innermost) rostral ridge on outer side of platform not reaching lateral margin but terminating posteriorly near position of basal cavity.

*Remarks.*—*Siphonodella quadruplicata* is transitional with *S. cooperi*. As here interpreted both species may have 3 rostral ridges, although specimens of *S. quadruplicata* usually have 4 or 5. The number of rostral ridges is directly proportional to the size of the growth stage of the siphonodellid (Voges, 1959, p. 307) and thus should not be given absolute taxonomic significance. The posterior termination of the longest (innermost) rostral ridge, on the outer side of the platform, is about halfway between the carina and the lateral margin in *S. quadruplicata*, whereas it is at the lateral margin in *S. cooperi*. Thus defined, specimens designated as *S. duplicata* var. A (e.g., Cloud, et al., 1957, pl. 5, fig. 8) are logically interpreted as early growth stages of *S. quadruplicata*, which have not attained the full number of rostral ridges.

*Range.*—*S. quadruplicata* ranges from the middle part of the Hannibal Formation to within the upper part of the Chouteau Formation in the Mississippi Valley sequence (29, chart 2).

*Repository.*—Figured hypotypes, S.U.I. 10901, 10917, 10918, 10925, 10926.

#### SIPHONODELLA CRENULATA (Cooper), 1939

Plate 3, figures 5-8

*Siphonognathus crenulata* COOPER, 1939, p. 409, pl. 41, figs. 1, 2.

*Siphonodella crenulata* (Cooper), BISCHOFF & ZIEGLER, 1956, p. 165, pl. 12, figs. 15 (?), 16, 17; BISCHOFF, 1957, p. 54, pl. 6, figs. 3-5; VOGES, 1959, p. 307-308, pl. 35, figs. 23-30; ZIEGLER, 1960b, in Kronberg et al., pl. 3, fig. 11; FREYER, 1961, in Dvořák & Freyer, p. 894, pl. 2, fig. 12.

non *Siphonodella crenulata* (Cooper), REXROAD & SCOTT, 1964, p. 44, pl. 3, fig. 26 (= *S. quadruplicata*).

*Diagnosis.*—Strongly asymmetrical, with large, strongly convex outer side of platform, margin of which is crenulate. Sharp angular bend in inner margin about halfway between anterior and posterior ends in mature specimens. Outer side of platform bears ridges; inner side has nodes. Two or rarely 3 rostral ridges present.

*Remarks.*—The inner margin of the platform is slightly rounded in small specimens of *Siphonodella crenulata*, but larger specimens develop a characteristic angular bend. A row of nodes may form on the outer platform near and parallel to the carina. *S. crenulata* is distinguished from other species of the genus by its outline. The specimen illustrated by REXFORD & SCOTT (1964, pl. 3, fig. 26) has a well-rounded inner margin more characteristic of *S. quadruplicata*.

No specimen in the present material shows characteristics transitional between *S. crenulata* and *S. cooperi*. Thus, the statement of REXROAD & SCOTT (1964, p. 43, 44) is not supported. Furthermore, *S. cooperi* first occurs lower than *S. crenulata* in the Montana sequence; so it appears unlikely that *S. cooperi* could have evolved from *S. crenulata*.

*Range.*—The present species ranges from the base of the lower *S. crenulata* Zone through the *Scaliognathus anchoralis* Zone in Germany (Voges, 1959, table 1).

*Repository.*—Figured hypotypes, S.U.I. 10923, 10924.

#### SIPHONODELLA DUPLICATA (Branson & Mehl), 1934

Plate 4, figure 13

*Siphonognathus duplicata* BRANSON & MEHL, 1934b, p. 296-297, pl. 24, figs. 16, 17; BRANSON, 1934, p. 315, pl. 25, fig. 16.

*Pelygnathus plana* HUDDLE, 1934, p. 103-104, pl. 8, figs. 39-43.

*Siphonodella duplicata* (Branson & Mehl), HASS, 1951, p. 2538, pl. 1, figs. 12, 13; —, 1956, p. 25, pl. 2, figs. 8-11; CLOUD, BARNES, & HASS, 1957, p. 809, pl. 5, fig. 5; HASS, 1959, pl. 49, fig. 25 (same specimen as CLOUD, BARNES, & HASS, 1957; non figs. 17, 18 = *S. quadruplicata*).

*Diagnosis.*—Transverse ridges on both sides of platform. Two rostral ridges usually form margins of well-developed rostrum. Outer lateral lobe not developed.

*Remarks.*—*Siphonodella sulcata* (HUDDLE) is similar to *S. duplicata*, but the former has only an incipiently developed rostrum. These 2 species, together with *S. lobata*, are the only representatives of *Siphonodella* with transverse ridges on both sides of the platform.

The concept of *S. duplicata* was restricted by HASS (1959), but is further restricted here to exclude forms which HASS (1951) had formerly designated as *S. duplicata* var. A and which have nodes instead of ridges on the inner side of the platform. *S. duplicata* var. A of HASS is referred to *S. quadruplicata* in this report.

*Range.*—The species occurs in the Hannibal and Chouteau Formations in the Mississippi Valley (29, chart 2).

*Repository.*—Figured hypotype, S.U.I. 10900.

#### SIPHONODELLA SEXPLICATA (Branson & Mehl), 1934

Plate 4, figure 18

*Siphonognathus sexplicata* BRANSON & MEHL, 1934b, p. 296, pl. 24, figs. 22, 23; — & —, 1938b, p. 205, pl. 33, fig. 59; COOPER, 1939, p. 410, pl. 41, figs. 3, 4, 7, 8 (non figs. 38, 39 = *S. quadruplicata*).

*Polygnathus newalbanyensis* HUDDLE, 1934, p. 101, pl. 8, fig. 26.

*Diagnosis.*—Broad, with nodes on inner side of platform, transverse ridges on outer side. Six ros-

tral ridges extend posteriorly no farther than position of basal cavity.

*Remarks.*—Forms referred to *Siphonodella sexplicata* have 6 rostral ridges and possess a broader platform than *S. quadruplicata*. The rostral ridges on the outer side of the platform extend to near the posterior end in specimens of *S. sandbergi*.

*Range.*—The species ranges from the middle part of the Hannibal Formation to the lower part of the Chouteau Formation (29, chart 2).

*Repository.*—Figured hypotype, S.U.I. 10903.

**SIPHONODELLA SANDBERGI** Klapper, n. sp.

Plate 4, figures 6, 10-12, 14, 15

*Diagnosis.*—Broad, short, with nodes on inner side of platform. On outer side, at least one rostral ridge (usually the innermost) extends to near posterior end. Ornament weak to absent between this ridge and carina. Five to 6 rostral ridges present.

*Description.*—With extremely short free blade. Inner margin of platform straight or slightly rounded; outer margin convex. Two to 3 rostral ridges not extending posteriorly to position beyond basal cavity on inner platform, whereas they have 3 rostral ridges, extending much farther backward on outer platform. Innermost rostral ridge (or one next to it) on outer platform extending to near posterior end. Area immediately behind basal cavity flattened.

*Remarks.*—*Siphonodella sandbergi* is comparable to *S. obsoleta*, which also has at least one rostral ridge that extends to near the posterior end on the outer side of the platform. *S. obsoleta* is much narrower and more elongate in outline, has a longer free blade, and has fewer rostral ridges than does *S. sandbergi*. Although *S. sexplicata* has a comparable number of rostral ridges, none of those on the outer side extend as far posteriorly as in *S. sandbergi*. Furthermore, *S. sexplicata* has transverse ridges on the outer platform.

The species is named to honor CHARLES A. SANDBERG.

*Range.*—*Siphonodella sandbergi* occurs in *cuI* strata in Montana and Wyoming. I have also found the species at the Hönnetal railroad cut in strata equivalent to VOGES' sample 9 (1960, text, fig. 2; table 1), *i.e.*, at the top of the *Siphonodella-P. triangula inaequalis* Zone.

*Repository.*—Holotype, S.U.I. 10899; figured paratypes, S.U.I. 10895, 10898.

**Genus POLYGNATHUS** Hinde, 1879

*Polygnathus* HINDE, 1879, p. 361; Type species: *Polygnathus robusticostata* BISCHOFF & ZIEGLER, 1957 [pending decision on proposal to ICZN by ZIEGLER, KLAPPER, & LINDSTRÖM]. *Polygnathus* Hinde, MILLER,

1889, p. 520; *Polygnathus* Hinde, BRYANT, 1921, p. 23-24; *Polygnathus* Hinde, ROUNDY, 1926, p. 13. *Ctenopolygnathus* MÜLLER & MÜLLER, 1957, p. 1084.

*Remarks.*—*Ctenopolygnathus* was differentiated from *Polygnathus* by the posterior extent of the platform. In *Polygnathus* the platform always extends to the posterior tip; whereas it does not in *Ctenopolygnathus* according to the definitions of MÜLLER & MÜLLER (1957, p. 1084-1085). They regarded *Ctenopolygnathus* as morphologically intermediate between *Spathognathodus* and *Polygnathus* but not necessarily ancestral to the latter.

*Ctenopolygnathus* cannot be differentiated from *Polygnathus* on the basis of morphology of the lower side. Features of the lower side of platform genera are credited with greater taxonomic significance than those of the upper side, as stated under the discussion of *Siphonodella*. Furthermore, the extent of the platform toward the posterior is variable. One species discussed below, *Polygnathus longipostica*, includes forms in which the platform may or may not reach the posterior tip.

If both *Polygnathus* and *Ctenopolygnathus* are to be maintained, modification of MÜLLER & MÜLLER's concept of the latter genus is necessary. Some of the species referred by them to *Ctenopolygnathus* are not generically related to either *Polygnathus* or *Ctenopolygnathus*. *Polygnathus omala*, *P. oxyx*, and *P. xyncha*, all of COOPER, are considered herein as junior synonyms of *Pseudopolygnathus marginata*.

For discussion of the type species of *Polygnathus*, see ZIEGLER, *et al.* (1964).

*Range.*—Lower Devonian (at least as low as Emsian) to Lower Carboniferous (*cuIIIa*).

**POLYGNATHUS INORNATA** Branson, 1934

Plate 1, figures 7-14; Plate 4, figures 2-4

*Polygnathus inornata* BRANSON, 1934, p. 309, pl. 25, figs. 8, 26; BRANSON & MEHL, 1934b, p. 293, pl. 24, figs. 5-7; — & —, 1938b, p. 146, pl. 34, fig. 37; COOPER, 1939, p. 400, pl. 39, figs. 11, 12; YOUNGQUIST & PATTERSON, 1949, p. 64, pl. 17, figs. 4, 5, 9, 13; THOMAS, 1949, p. 436, pl. 3, fig. 36; YOUNGQUIST & DOWNS, 1951, p. 787-788, pl. 111, figs. 11, 17, 18; HASS, 1956, p. 25, pl. 2, figs. 14, 15; BISCHOFF & ZIEGLER, 1956, p. 157, pl. 12, fig. 4 (*non* fig. 5 = *P. symmetrica*); BISCHOFF, 1957, p. 42, pl. 2, figs. 17, 18, 20, 21; CLOUD, BARNES, & HASS, 1957, p. 813, pl. 5, fig. 6; KLAPPER, 1958, p. 1089, pl. 142, figs. 2, 3; HASS, 1959, p. 370, pl. 49, fig. 22 (same specimen as CLOUD, BARNES, & HASS, 1957); VOGES, 1959, p. 291, pl. 34, figs. 12-20; BEACH, 1961, d. 47-48, pl. 5, figs. 8, 13; REXROAD & SCOTT, 1964, p. 35, pl. 2, figs. 19, 20.

*Polygnathus abnormis* BRANSON, 1934, p. 313-314, pl. 25, fig. 22.

*Polygnathus distorta* BRANSON & MEHL, 1934b, p. 294, pl. 24, fig. 12.

*Polygnathus lobata* BRANSON & MEHL, 1938b, p. 146-147, pl. 34, figs. 44-47; COOPER, 1939, p. 401, pl. 39, figs.

- 29, 30; THOMAS, 1949, p. 436, pl. 3, fig. 11; BISCHOFF, 1957, p. 42, pl. 2, fig. 19; REXROAD & SCOTT, 1964, p. 35-36, pl. 2, figs. 15, 16.
- Polygnathus curta* COOPER, 1939, p. 400, pl. 39, figs. 37, 38, 49, 50.
- Polygnathus irregularis* COOPER, 1939, p. 400, pl. 39, figs. 57, 58.
- Polygnathus longipostica* BRANSON & MEHL, COOPER, 1939, p. 401, pl. 39, figs. 43, 44 (*non* figs. 31, 32 = *P. symmetrica*).
- Polygnathus subserrata* BRANSON & MEHL, COOPER, 1939, p. 404, pl. 40, figs. 1, 2.
- Polygnathus inaequilateralis* YOUNGQUIST & PATTERSON, 1949, p. 63, pl. 16, figs. 14, 15.
- ? *Siphonodella duplicata* (BRANSON & MEHL), THOMAS, 1949, p. 436, pl. 3, fig. 8 (fig. 8 = specimen is missing; *non* fig. 9 = *Siphonodella cooperi*).
- Pseudopolygnathus?* cf. *P. triangula* VOGES, MÜLLER, 1962b, p. 1388, text figs. 9a-c.
- Diagnosis.**—Lanceolate, with short, high blade; nearly straight to strongly incurved carina. Posterior end may be attenuate and sharply pointed or rounded. Lateral margins of anterior part of platform strongly upturned, usually to above level of carina. One anterolateral margin in many cases higher than other. "Rostral ridges" may be present. Basal cavity relatively large, circular to ovate, usually with prominent lips.
- Remarks.**—A characteristic constriction in the lateral margins, near the anterior end of the platform is present in most specimens. In front of this constriction the lateral margins are usually somewhat alate. Although no true rostrum is developed, ridges on the anterior part of the platform may be present, and these may simulate the rostral ridges of *Siphonodella*. The degree of arching of the platform ranges from unarched to highly arched.
- The specimens illustrated on Pl. 1, figs. 9, 13, and 11, in that order, represent a series terminating in an extreme morphologic variant of *Polygnathus inornata*, although the extreme form is quite common in the material at hand. A specimen somewhat similar to the extreme form of this series was designated as *P. abnormis* (BRANSON, 1934, pl. 25, fig. 22).
- Polygnathus lobata* BRANSON & MEHL was suppressed as a junior synonym of *P. inornata* by VOGES (1959, p. 291); the former falls well within the range of variation of *P. inornata*.
- Range.**—The oldest verified occurrence of *Polygnathus inornata* is in *toV* strata (BISCHOFF & ZIEGLER, 1956). The species also occurs in a lower *Spathognathodus costatus* Zone fauna in Wyoming (KLAPPER, 1958). The youngest occurrences are given as either the *Scaliognathus anchoralis* Zone (VOGES, 1959, table 1) or *culIIa* (BISCHOFF, 1957, table 2).
- Repository.**—Figured hypotypes, S.U.I. 10893-10894, 10907-10910.
- POLYGNATHUS LONGIPOSTICA** BRANSON & MEHL, 1934  
Plate 4, figures 1, 5
- Polygnathus longipostica* BRANSON & MEHL, 1934b, p. 294, pl. 24, figs. 8-11, 13; BRANSON, 1934, p. 311, pl. 25, fig. 18; YOUNGQUIST & PATTERSON, 1949, p. 65, pl. 15, figs. 16-20; ? BISCHOFF, 1956, p. 133, pl. 9, fig. 22; REXROAD & SCOTT, 1964, p. 36-37, pl. 2, fig. 26.
- Polygnathus lanceolata* BRANSON, 1934, p. 313, pl. 25, fig. 21; YOUNGQUIST & PATTERSON, 1949, p. 64-65, pl. 16, fig. 16.
- Polygnathus scapha* HUDDLE, 1934, p. 102, pl. 8, figs. 33-35, text-fig. 3, fig. 2; COOPER, 1939, p. 403, pl. 40, figs. 17, 18, 28, 29 (*non* figs. 19, 20 = *P. symmetrica*). *non Polygnathus lanceolata* BRANSON, BRANSON & MEHL, 1938b, p. 148, pl. 34, fig. 42 (= *P. flabella* BRANSON & MEHL).
- non Polygnathus longipostica* BRANSON & MEHL, COOPER, 1939, p. 401, pl. 39, figs. 31, 32, 43, 44 (figs. 31, 32 = *P. symmetrica*; figs. 43, 44 = *P. inornata*); YOUNGQUIST & MILLER, 1948, p. 448, pl. 68, fig. 12 (= *P. normalis* MILLER & YOUNGQUIST, 1947).
- Polygnathus ortha* COOPER, 1939, p. 401, pl. 39, figs. 3, 4.
- Polygnathus permarginata* BRANSON, COOPER, 1939, p. 402, pl. 40, figs. 61, 62.
- Polygnathus subserrata* BRANSON & MEHL, COOPER, 1939, p. 404, pl. 39, figs. 51, 52, 65, 66, 75, 76; pl. 40, figs. 9, 10, 42, 43 (*non* figs. 1, 2 = *P. inornata*).
- Polygnathus toxophora* COOPER, 1939, p. 404, pl. 39, figs. 67, 70.
- Polygnathus adunca* YOUNGQUIST & PATTERSON, 1949, p. 60-61, pl. 16, figs. 18, 19.
- Polygnathus cunulae* YOUNGQUIST & PATTERSON, 1949, p. 62, pl. 15, figs. 11-13 (transitional to *P. inornata*).
- Polygnathus cymbiformis* YOUNGQUIST & PATTERSON, 1949, p. 62-62, pl. 17, figs. 14, 15.
- Polygnathus inopinata* YOUNGQUIST & PATTERSON, 1949, p. 64, pl. 16, figs. 20, 21.
- Polygnathus* cf. *P. subserrata* BRANSON & MEHL, YOUNGQUIST & PATTERSON, 1949, p. 67, pl. 17, fig. 10.
- Polygnathus subtortilis* YOUNGQUIST & PATTERSON, 1949, p. 67, pl. 17, fig. 3.
- Polygnathus anida* COOPER, THOMAS, 1949, p. 436, pl. 3, figs. 10, 12.
- Polygnathus* aff. *symmetrica* BRANSON, YOUNGQUIST & DOWNS, 1951, p. 789, pl. 111, fig. 6.
- Diagnosis.**—Lanceolate, with relatively long free blade and attenuate posterior end. Platform may or may not reach posterior tip. Denticles of carina lowest near mid-length. Anterolateral margins of platform upturned to about level of carina. Basal cavity circular or ovate, relatively large, with or without lips.
- Remarks.**—BRANSON & MEHL (1934b, p. 293) listed the characteristics which differentiate *Polygnathus longipostica* from *P. inornata*. Chief among these is the degree of upturning of the anterolateral margins of the platform. *P. longipostica* stands more or less midway between *P. inornata* and *P. symmetrica*. A specimen like the one designated as *P. cunulae* (YOUNGQUIST & PATTERSON, 1949, pl. 15, figs. 11-13) is transitional between *P. longipostica* and *P. inornata*. *P. cunulae* is arbitrarily placed in *P. longipostica* because it has an-

terolateral margins upturned only to the level of the carina.

*Range*.—The species is restricted to the Lower Mississippian (Kinderhook) according to REXROAD & SCOTT (1964).

*Repository*.—Figured hypotype, S.U.I. 10892.

**POLYGNATHUS SYMMETRICA Branson, 1934**

Plate 4, figures 7, 9; Plate 6, figures 1, 5

- Polygnathus symmetrica* BRANSON, 1934, p. 310, pl. 25, fig. 11; BRANSON & MEHL, 1938b, p. 146, pl. 34, fig. 33; COOPER, 1939, p. 404, pl. 41, figs. 50, 51; YOUNGQUIST & PATTERSON, 1949, p. 67, pl. 15, figs. 14, 15; BISCHOFF, 1957, p. 44, pl. 2, fig. 22.
- Polygnathus spicata* BRANSON, 1934, p. 312-313, pl. 25, fig. 20; COOPER, 1939, p. 404, pl. 39, figs. 67, 68.
- Polygnathus anida* COOPER, 1939, p. 399, pl. 39, figs. 39, 40.
- Polygnathus flabellum* Branson & Mehl, COOPER, 1939, p. 400, pl. 39, figs. 13, 14.
- Polygnathus longipostica* Branson & Mehl, COOPER, 1939, p. 401, pl. 39, figs. 31, 32; THOMAS, 1949, p. 436, pl. 3, fig. 38; HASS, 1956, p. 25, pl. 2, fig. 28.
- Polygnathus macra* COOPER, 1939, 401, pl. 40, figs. 7, 8, 15, 16.
- Polygnathus scapha* Huddle, COOPER, 1939, p. 403, pl. 40, figs. 19, 20.
- Polygnathus biclarula* YOUNGQUIST & PATTERSON, 1949, p. 61-62, pl. 15, figs. 23, 24.
- Polygnathus perplana* Branson, YOUNGQUIST & PATTERSON, 1949, p. 65-66, pl. 17, figs. 11, 12.
- Polygnathus sagittaria* YOUNGQUIST & PATTERSON, 1949, p. 66, pl. 15, figs. 9, 10; pl. 16, figs. 13; YOUNGQUIST & DOWNS, 1951, p. 788-789, pl. 111, figs. 7-9 (specimen missing).
- Polygnathus scobiniiformis* Branson, YOUNGQUIST & PATTERSON, 1949, p. 66-67, pl. 17, figs. 6-8.
- Polygnathus undulosa* YOUNGQUIST & PATTERSON, 1949, p. 67, pl. 17, figs. 1, 2.
- Polygnathus inornata* Branson, BISCHOFF & ZIEGLER, 1956, p. 157, pl. 12, fig. 5 (non fig. 4 = *P. inornata*); ZIEGLER, 1957, in Flügel & Ziegler, p. 46, pl. 2, fig. 7.

*Diagnosis*.—Lanceolate, with relatively long free blade and straight carina; unit only slightly arched. Anterolateral margins of platform somewhat upturned. Both sides of platform about equally developed. Basal cavity usually deep and ovate but with groove projecting short distance posteriorly as slit in keel. Basal cavity usually without lips, because cavity is set deep into platform.

*Remarks*.—Many specimens are transitional between *Polygnathus symmetrica* and *P. longipostica*. Upturning of the anterolateral margins of the platform and attenuation of the posterior end of the platform typically are better developed in *P. longipostica*.

*Polygnathus symmetrica* COOPER (1939) is a homonym of *P. symmetrica* BRANSON and also a subjective junior synonym. The development of the two platform halves in a specimen referred to *P. scobiniiformis* BRANSON (YOUNGQUIST & PATTERSON, 1949, pl. 17, fig. 8) is more symmetrical than

is shown in their illustration; the specimen is assigned herein to *P. symmetrica*.

*Range*.—*Polygnathus symmetrica* has been recorded from toVI strata (BISCHOFF, 1957, table 2) and cull strata (NW Gossfelden, BISCHOFF & ZIEGLER, 1956, pl. 12, fig. 5) in Germany.

*Repos to y*.—Figured hypotypes, S.U.I. 10855, 10896.

**POLYGNATHUS COMMUNIS Branson & Mehl, 1934**

Plate 6, figures 6, 11

- Polygnathus communis* BRANSON & MEHL, 1934b, p. 293, pl. 24, figs. 1-4; BRANSON, 1934, p. 308, pl. 25, figs. 5, 6; BRANSON & MEHL, 1938b, p. 145, pl. 34, figs. 39-41; COOPER, 1939, p. 399, pl. 39, figs. 1, 2, 9, 10, 23, 24; MEHL & THOMAS, 1947, p. 15, pl. 1, fig. 37; YOUNGQUIST & PATTERSON, 1949, p. 62, pl. 15, figs. 7, 8; YOUNGQUIST & DOWNS, 1951, p. 787, pl. 111, figs. 4, 5, 19, 20; HASS, 1951, p. 2538, 2539, pl. 1, fig. 10; —, 1956, p. 25, pl. 2, figs. 2-5; BISCHOFF & ZIEGLER, 1956, p. 156-157, pl. 12, figs. 1-3; BISCHOFF, 1957, p. 42, pl. 2, figs. 24, 27 (non figs. 23, 25, 26 = *P. pura* VOGES); ZIEGLER, 1957, in Flügel & Ziegler, p. 46, pl. 2; fig. 15; HASS, 1959, p. 390, pl. 49, figs. 9-11, 13; VOGES, 1959, p. 288-289, pl. 34, figs. 1-7; SCOTT & COLLINSON, 1961, p. 130, pl. 1, figs. 6-10, pl. 2, fig. 30; BEACH, 1961, p. 49, pl. 6, figs. 1-4; FREYER, 1961, in Dvořák & Freyer, p. 892, pl. 1, figs. 15, 16; ZIEGLER, 1962b, p. 87-88; —, 1962c, p. 392, pl. 1, fig. 9; REICHSTEIN & SCHWAB, 1962, p. 24, pl. 1, figs. 2, 4, 11; REXROAD & SCOTT, 1964, p. 33.
- Polygnathus adola* COOPER, 1939, p. 399, pl. 39, figs. 33-36.
- Polygnathus communis bifurcata* HASS, 1959, p. 390, pl. 48, figs. 11, 12; SCOTT & COLLINSON, 1961, p. 130-131, pl. 1, fig. 11.
- Polygnathus communis carina* HASS, 1959, p. 391, pl. 47, figs. 8, 9; REXROAD & SCOTT, 1964, p. 34, pl. 2, figs. 24, 25.
- Polygnathus cf. styriaca* Ziegler, ZIEGLER, 1962c, p. 392, pl. 1, fig. 8.
- Polygnathus communis communis* Branson & Mehl, REXROAD & SCOTT, 1964, p. 33-34, pl. 2, figs. 17, 18.

*Diagnosis*.—Unornamented or weakly ornamented, lanceolate, or ovate platform. Carina straight to slightly incurved posteriorly. Shallow troughs present, at least anteriorly, on the upper side of the platform immediately adjacent to and on both sides of the carina. Basal cavity elliptical. Keel low lying in a depression immediately behind basal cavity.

*Remarks*.—HAAS (1959) and REXROAD & SCOTT (1964) recognized three subspecies of *Polygnathus communis* as shown in the synonymy above. All of the available material in the present study belongs in *P. communis communis*.

*Range*.—The nominate subspecies definitely ranges from the lower *Polygnathus styriaca* Zone (ZIEGLER, 1962b, p. 88) to the *Scaliognathus anchoralis* Zone (VOGES, 1959, table 1) but perhaps ranges as high as cuIIIa strata (BISCHOFF, 1957, table 2).

*Repository*.—Figured hypotype, S.U.I. 10858.

**POLYGNATHUS DELICATULA** Ulrich & Bassler, 1926  
Plate 6, figures 7, 9, 10

*Polygnathus delicatulus* ULRICH & BASSLER, 1926, p. 45, pl. 7, figs. 9, 10 (the specimen U.S.N.M. 10994a illustrated on pl. 7, as fig. 9 is herewith selected as lectotype).

non *Polygnathus delicatula* Ulrich & Bassler, COOPER, 1939, p. 400, pl. 40, figs. 37, 38 (= *P. radina* COOPER).

*Polygnathus rimulata* Ulrich & Bassler, BISCHOFF & ZIEGLER, 1956, p. 158, pl. 12, fig. 7.

*Polygnathus wyomingensis* KLAPPER, 1958, p. 1090-1091, pl. 142, figs. 5-8, THINGTON, FURNISH, & WINGERT, 1961, p. 765-766, pl. 10, figs. 1-3.

**Diagnosis.**—Narrow and lanceolate with a long free blade. Unit arched with the posterior end downcurved. Carina straight to slightly incurved posteriorly; sides of platform nearly symmetrical. Both margins of platform with transverse ridges or nodes and separated from carina by trough. Anterolateral margins upturned, usually to just below the level of carina. Keel sharp posteriorly. Basal cavity set in keel, elliptical and strongly attenuate posteriorly.

**Remarks.**—An examination of the types of *Polygnathus delicatula* revealed that at least the lectotype (ULRICH & BASSLER, 1926, pl. 7, fig. 9) agrees with the present concept of *P. wyomingensis*, which is therefore suppressed.

*Polygnathus delicatula* is distinguished from *P. symmetrica* chiefly by shape of the basal cavity and location of the cavity in the conspicuously raised keel in the former. The basal cavity is set into the platform in *P. symmetrica*. *P. delicatula* is more strongly arched than *P. symmetrica*.

**Range.**—The species is recorded from toV strata in Germany (BISCHOFF & ZIEGLER, 1956, p. 158).

**Repository.**—Figured hypotypes, S.U.I. 10859, 10861.

**POLYGNATHUS OBLIQUICOSTATA** Ziegler, 1962  
Plate 6, figures 2, 4

? *Polygnathus sanduskiensis* Stauffer, THOMAS, 1949, p. 434, pl. 1, fig. 24.

*Polygnathus obliquicostata* ZIEGLER, 1962b, p. 92-93, pl. 11, figs. 8-12.

**Diagnosis.**—Strongly incurved platform, carina not reaching posterior end. Behind carina platform crossed by oblique, transverse ridges. On inner side of middle portion of platform, ridges oblique to carina. Rostrum partially developed. Basal cavity elliptical, with lips.

**Remarks.**—The keel is present throughout the length of the unit; it is interrupted only by the basal cavity in the specimens of *Polygnathus obliquicostata* illustrated by ZIEGLER (1962b) and in the material from Wyoming. This species is similar to species of *Siphonodella* in the partial development of a rostrum. The character of the basal cavity, however, places *P. obliquicostata* in *Poly-*

*gnathus* (see the remarks on *Siphonodella*). *P. obliquicostata* is close to *P. semicostata*, which has a much narrower and less strongly incurved platform.

**Range.**—ZIEGLER (1962b, p. 93) recorded the species from the Lower and Middle *Polygnathus styriaca* Zone. *P. obliquicostata* occurs in Wyoming in a fauna referable to the lower *Spathognathodus costatus* Zone.

**Repository.**—Figured hypotype, S.U.I. 10856.

**Genus SPATHOGNATHODUS**  
**Branson & Mehl, 1941**

*Ctenognathus* PANDER [non FAIRMAIRE, 1843], 1856, p. 32.

*Spathodus* BRANSON & MEHL [non BOULENGER, 1900], 1933, p. 46.

*Pandorina* STAUFFER [non BORY, 1827], 1940, p. 428.

*Spathognathodus* BRANSON & MEHL, 1941b, p. 98 [*pro Spathodus* BRANSON & MEHL].

*Mehlina* YOUNGQUIST, 1945, p. 363.

*Ctenognathodus* FAY, 1959, p. 195 [*pro Ctenognathus* PANDER].

*Pandorinellina* HASS, 1959, p. 378-379 [*pro Pandorina* STAUFFER].

*Branmehla* HASS, 1959, p. 381.

*Spathognathodus* (*Bispathodus*) MÜLLER, 1962a, p. 114.

**Type-species.** *Spathodus primus* BRANSON & MEHL, 1933, p. 46, pl. 3, figs. 25-30 [OD].

**Range.**—*Spathognathodus* ranges from the Middle Ordovician (LINDSTRÖM, 1964, p. 165) into the Middle Triassic (BENDER & KOCKEL, 1963, pl. 1), but many short-ranged species are well known.

**SPATHOGNATHODUS ABNORMIS** (Branson & Mehl),  
1934

Plates 5, figures 5, 12, 13

*Spathodus abnormis* BRANSON & MEHL, 1934b, p. 277, pl. 22, fig. 20; BRANSON, 1934, p. 308, pl. 28, fig. 22; BRANSON & MEHL, 1938b, p. 138, pl. 34, fig. 11.

*Spathodus parvifossatus* BRANSON & MEHL, 1934b, p. 274-275, pl. 22, fig. 14; COOPER, 1939, p. 416, pl. 45, fig. 31.

non *Spathodus abnormis* Branson & Mehl, COOPER, 1939, p. 413, pl. 45, figs. 39, 42.

*Spathodus cyclus* COOPER, 1939, p. 413, pl. 45, fig. 32.

*Spathognathodus longus* HASS, 1959, p. 388, pl. 48, figs. 9, 13, 14.

**Diagnosis.**—Single-rowed, slightly incurved posteriorly. Unit arched with anterior end (both upper and lower margin) usually arched downward. Lower margin of posterior end usually arched upward slightly but may be arched downward. Apical denticle not much larger than other denticles, located above basal cavity. Upper margin of blade usually declines from apical denticle posteriorly. Basal cavity small and elliptical, located somewhat behind mid-length.

**Remarks.**—HASS (1959) proposed *Spathognathodus longus* for a form which has the upper margin of the anterior end of the blade angled down-



ward and which lacks an especially prominent apical denticle. In both respects, as well as others, *S. longus* is the same as *S. abnormis*.

**Range.**—Lower Mississippian (Kinderhook) of North America.

**Repository.**—Figured hypotypes, S.U.I. 10876, 10881, 10882.

**SPATHOGNATHODUS STABILIS (Branson & Mehl), 1934**

Plate 5, figures 6, 7

*Spathodus stabilis* BRANSON & MEHL, 1934a, p. 188-189, pl. 17, fig. 20.

*Spathodus macer* BRANSON & MEHL, 1934b, p. 276, pl. 22, fig. 19.

*Spathodus crassidentatus* BRANSON & MEHL, BRANSON, 1934, p. 303, pl. 27, fig. 12; COOPER, 1939, p. 413, pl. 45, fig. 19.

*Spathodus denticulatus* BRANSON, 1934, p. 305, pl. 27, fig. 17.

*Spathodus acidentatus* BRANSON, 1934, p. 306, pl. 27, figs. 21, 23; COOPER, 1939, p. 413, pl. 45, figs. 26, 28, 44.

*Spathodus strigilis* HUDDLE, 1934, p. 89-90, pl. 7, fig. 15; pl. 12, fig. 11; text-fig. 3, fig. 1.

*Spathodus parvus* HUDDLE, 1934, p. 90-91, pl. 7, fig. 16.

*Spathodus elongatus* BRANSON & MEHL, 1938b, p. 139, pl. 34, fig. 9 (non fig. 6).

*Spathodus pulcher* BRANSON & MEHL, 1938b, p. 139-140, pl. 34, figs. 7, 8 (transitional to *S. crassidentatus*).

*Spathodus chouteauensis* COOPER, 1939, p. 413, pl. 45, fig. 20.

*Spathognathodus acidentatus* (Branson), COOPER, 1943, in Cooper & Sloss, p. 174, pl. 28, fig. 2; YOUNGQUIST & PATTERSON, 1949, p. 71, pl. 15, fig. 3.

*Spathognathodus crassidentatus* (Branson & Mehl), COOPER, 1943, in Cooper & Sloss, p. 175, pl. 28, fig. 1; YOUNGQUIST & PATTERSON, 1949, p. 71-72, pl. 15, fig. 2; THOMAS, 1949, p. 435, pl. 2, fig. 16 (non fig. 24); p. 437, pl. 4, fig. 6; BISCHOFF & ZIEGLER, 1956, p. 166, pl. 13, figs. 13, 14; BISCHOFF, 1957, p. 56.

*Spathognathodus cyrius* (Cooper), COOPER, 1943, in Cooper & Sloss, p. 175, pl. 28, fig. 6.

*Spathognathodus strigilis* (Huddle), COOPER, 1943, in Cooper & Sloss, p. 175, pl. 28, figs. 3, 4, 10, 12.

*Spathognathodus quintidentatus* THOMAS, 1949, p. 429, pl. 4, figs. 8, 9.

*Spathognathodus macer* (Branson & Mehl), YOUNGQUIST & DOWNS, 1951, p. 791, pl. 111, figs. 1, 2.

non *Spathognathodus stabilis* Branson & Mehl [*sic*], GRAVES, 1952, p. 612, pl. 81, fig. 2.

*Spathognathodus stabilis* (Branson & Mehl), BISCHOFF & ZIEGLER, 1956, p. 167, pl. 13, fig. 11; BISCHOFF, 1957, p. 58; HELMS, 1959, p. 658, pl. 3, fig. 5; pl. 5, fig. 1; pl. 6, figs. 12, 13; ZIEGLER, 1962b, p. 112-114, pl. 13, figs. 1-10.

non *Spathognathodus acidentatus* (Branson), HASS, 1956, p. 25, pl. 2, fig. 26; CLOUD, BARNES, & HASS, 1957, p. 813, pl. 5, fig. 7; HASS, 1959, pl. 49, fig. 24 (same specimen as CLOUD, BARNES, & HASS, 1957).

*Spathognathodus jugosus* (Branson & Mehl), KLAPPER, 1958, p. 1091, pl. 141, fig. 14.

**Diagnosis.**—Single-rowed, straight to slightly incurved. Unit arched, especially from anterior end of basal cavity to posterior end of blade. Denticles usually 20 or more in large specimens, commonly many germ denticles. Symmetrical basal cavity

widest anteriorly, usually extending to near posterior end.

**Remarks.**—The forms regarded by HASS (1956, 1959) as belonging to *Spathognathodus acidentatus* have lateral denticles and therefore can not be included in *S. stabilis*. One specimen referred to *S. crassidentatus* (THOMAS, 1949, pl. 2, fig. 24) also has a lateral denticle.

Most of the specimens referred in the literature to *Spathognathodus crassidentatus* do not have the characteristics of the lectotype of that species. They are here regarded as representatives of *S. stabilis*, although some may not have as long a basal cavity as originally described for the latter.

**Range.**—BISCHOFF & ZIEGLER (1956) recorded the range of *Spathognathodus stabilis* as toIII to cuII in Germany. ZIEGLER (1962b) cited the earliest occurrence of the species in the middle *Scaphignathus velifera* Zone.

**Repository.**—Figured hypotypes, S.U.I. 10877, 10878.

**SPATHOGNATHODUS CRASSIDENTATUS (Branson & Mehl), 1934**

Plate 5, figs. 15-17

*Spathodus crassidentatus* BRANSON & MEHL, 1934b, p. 276, pl. 22, fig. 17 (the specimen illustrated as fig. 17 is herewith selected as lectotype; non fig. 18).

*Spathodus regularis* BRANSON & MEHL, 1938b, p. 137, pl. 34, figs. 1-3, 10.

non *Spathodus regularis* Branson & Mehl, COOPER, 1939, p. 415, pl. 45, fig. 38.

*Spathognathodus regularis* (Branson & Mehl), REXROAD & SCOTT, 1964, p. 49-50, pl. 3, figs. 1, 2.

**Diagnosis.**—Single-rowed, straight to incurved, and slightly arched. Two main denticles, markedly higher and wider than the others, located at anterior end of blade. Denticles form convex arc from position above basal cavity to posterior tip. Denticles usually 10 to 15, few germ denticles. Basal cavity extends from somewhat in front of mid-length to near posterior end. Nearly symmetrical cavity rounded anteriorly tapering sharply toward posterior end.

**Remarks.**—The 2 main denticles of *Spathognathodus crassidentatus* are terminal, but 1 or 2 smaller denticles usually appear about halfway up the side of the first large denticle. The lectotype of *S. crassidentatus* shows the diagnostic features of *S. regularis* and the latter species is therefore a junior synonym. Later references in the literature to *S. crassidentatus* are, for the most part, better assigned to *S. stabilis* which lacks the 2 prominent, wide anterior denticles of *S. crassidentatus* and generally has more denticles.

**Range.**—Lower Mississippian (Kinderhook) in North America.

**Repository.**—Figured hypotypes, S.U.I. 10884-10886.

**SPATHOGNATHODUS JUGOSUS (Branson & Mehl), 1934**

*Spathodus jugosus* BRANSON & MEHL, 1934a, p. 190-191, pl. 17, figs. 19, 22.

*Spathognathodus jugosus* (Branson & Mehl), BISCHOFF & ZIEGLER, 1956, p. 167, pl. 13, figs. 8-10; HASS, 1959, pl. 50, fig. 15; ZIEGLER, 1962b, p. 110, pl. 13, figs. 17-19.

non *Spathognathodus jugosus* (Branson & Mehl), KLAPPER, 1958, p. 1091, pl. 141, fig. 14 (= *S. stabilis*).

**Remarks.**—Double-rowed forms of *Spathognathodus* which have transverse ridges posteriorly and possess the other characteristics of *S. jugosus* are present in the material at hand.

**Range.**—ZIEGLER (1962b, p. 110) recorded the range of this species from the upper *Polygnathus styriaca* Zone through the lower *Spathognathodus costatus* Zone in Germany.

**SPATHOGNATHODUS PRAELONGUS Cooper, 1943**

Plate 6, figure 23

*Spathognathodus praelongus* COOPER, 1943, in Cooper & Sloss, p. 175, pl. 28, fig. 14.

*Spathognathodus exochus* (Cooper), COOPER, 1943, in Cooper & Sloss, p. 175, pl. 28, fig. 16.

*Spathognathodus mediocris* (Branson & Mehl), COOPER, 1943, in Cooper & Sloss, p. 175, pl. 28, fig. 5.

*Spathognathodus flexus* THOMAS, 1949, p. 429, pl. 2, fig. 20.

**Diagnosis.**—Single-rowed, with posterior end of blade incurved. Lower margin of posterior end of blade straight to slightly arched downward; anterior end of blade not significantly arched. Main denticle located above position of basal cavity and not much larger than other denticles. Upper margin declines posteriorly from main denticle. Basal cavity located near posterior end of blade.

**Remarks.**—*Spathognathodus praelongus* differs from *S. abnormis*, which has its anterior end arched downward and its basal cavity located nearer to mid-length.

**Range.**—Upper part of Upper Devonian in North America.

**Repository.**—Figured hypotype, S.U.I. 10871.

**SPATHOGNATHODUS ACULEATUS (Branson & Mehl), 1934**

Plate 6, figures 15-17

*Spathodus aculeatus* BRANSON & MEHL, 1934a, p. 186-187, pl. 17, figs. 11, 14 (fig. 11 = lectotype selected by ZIEGLER, 1962b, p. 105).

*Spathodus tridentatus* BRANSON, 1934, p. 307-308, pl. 27, fig. 26.

*Spathodus duplidens* HUDDLE, 1934, p. 91-92, pl. 12, figs. 1-4.

*Spathognathodus aculeatus* (Branson & Mehl), HASS, 1947, p. 134, 135, 140; —, 1956, p. 17, 22, 24; KLAPPER, 1958, p. 1091, pl. 141, fig. 13; HELMS, 1959, p. 657, pl. 3, fig. 8; ETHINGTON, FURNISH, & WINGERT, 1961, p. 766-767, pl. 90, figs. 5-9; ZIEGLER, 1962b, p. 105-106, pl. 13, figs. 27-36.

non *Spathognathodus aculeatus* Branson & Mehl [sic], GRAVES, 1952, p. 612, pl. 81, figs. 1, 3-5 (figs. 1, 4

= *S. frankenwaldensis* BISCHOFF & SANNEMANN; fig. 3 = *S. steinhornensis* ZIEGLER).

*Spathognathodus tridentatus* (Branson), SANNEMANN, 1955a, p. 331, pl. 24, fig. 13; BISCHOFF & ZIEGLER, 1956, p. 167, pl. 13, figs. 1, 2; HELMS, 1959, p. 658, pl. 3, fig. 7; FREYER, 1961, p. 89, pl. 6, fig. 150; ZIEGLER, 1962c, p. 393, pl. 3, figs. 8, 9 (preprint 1960).  
*Spathodus (Bispathodus) aculeatus* (Branson & Mehl), MÜLLER, 1962a, p. 114.

**Diagnosis.**—With lateral denticles on inner side of blade in region of basal cavity. Development of lateral denticles does not reach posterior tip. Unit nearly straight to slightly curved. Basal cavity located at mid-length, nearly circular in shape, and wide.

**Remarks.**—The lateral denticles of *Spathognathodus aculeatus* are usually joined to the denticles of the main row by transverse ridges. Most specimens in the material at hand have 3 to 5 lateral denticles, but some specimens have as many as 7 lateral denticles.

*Spathognathodus costatus costatus* (Branson) sensu ZIEGLER (1962b) has the offset lateral denticles developed completely to the posterior end. *S. anteposicornis* SCOTT has one lateral denticle, which is anterior to the basal cavity. The lateral denticles in *S. aculeatus* are developed both anterior and posterior to the basal cavity. Forms that have been referred to *S. tridentatus* in the literature do not differ sufficiently from *S. aculeatus* to warrant separation.

**Range.**—ZIEGLER (1962b, p. 40, 41, 106) recorded the range of the species from the middle part of the lower *Spathognathodus costatus* Zone to the top of the Middle *S. costatus* Zone.

**Repository.**—Figured hypotypes, S.U.I. 10865, 10866.

**Genus DINODUS Cooper, 1939**

*Dinodus* COOPER, 1939, p. 386.—Type species: *Dinodus leptus* COOPER, 1939, p. 386, pl. 47, figs. 63, 75, 76; OD.

**Diagnosis.**—Highly arched, strongly compressed blades composed of extremely thin, high denticles fused nearly to their tips and lacking distinct main cusp. Unit asymmetrical or nearly symmetrical consisting of either 2 or 3 processes. Surface covered with small pits. Conspicuous flange near lower margin.

**Remarks.**—*Dinodus* and *Elsonella* YOUNGQUIST, 1945 (type species, *E. prima* YOUNGQUIST) both have the surface of the blade entirely covered with small pits (75, p. 157). *Elsonella* possesses a conspicuous but more massive flange near the lower margin, has much broader denticles than *Dinodus*, and has a distinct main cusp. The lectotype of *E. prima* YOUNGQUIST (1945, pl. 56, fig. 5, selected by MÜLLER, 1956a, p. 825) is reillustrated here to show the median posterior process (Pl. 5, fig. 9).

*Dinodus* formerly included only the type species and *D. fragosus* (BRANSON), both of which possess 2 processes. The concept of the genus is expanded here to include a new form, *D. youngquisti*, which has three processes but is otherwise closely comparable to species of *Dinodus*.

*Range*.—Lower Mississippian (Kinderhook) of North America and Tournaisian of Germany.

**DINODUS LEPTUS** Cooper, 1939

Plate 5, figure 8

*Dinodus leptus* COOPER, 1939, p. 386, pl. 47, figs. 63, 75, 76; VOGES, 1959, p. 273, pl. 33, figs. 1, 2.

*Diagnosis*.—See VOGES, 1959, p. 273.

*Remarks*.—VOGES (125) emphasized the whirl-like arrangement of the denticles at the apex of *Dinodus leptus*. In contrast the denticles at the apex are straight in *D. fragosus*. The denticles of the anterior and posterior processes are low in *D. leptus*, in contrast to *D. fragosus* where they are high.

*Range*.—VOGES (125, table 1) recorded the present species from the *Siphonodella-Pseudopolygnathus triangula triangula* Zone (upper *cul*) in Germany.

*Repository*.—Figured hypotype, S.U.I. 10879.

**DINODUS YOUNGQUISTI** Klapper, n. sp.

Plate 5, figures 2, 3

*Scutula* cf. *venusta* Sannemann, VOGES, 1959, p. 306, pl. 35, figs. 14-18.

*Diagnosis*.—Composed of posterior process and arch formed by 2 lateral processes. Unit nearly symmetrical, one side of arch slightly more developed than other. Median posterior process projects through flange developed near lower margin; basal cavity developed under posterior process where it intersects flange, which has sharp keel on its lower side.

*Description*.—Compressed lateral processes highly arched, with their upper margins convex. From their junction, 2 processes are directed somewhat anteriorly, but recurve posteriorly at their margins. Denticles thin, high, fused nearly to their tips, and curving upward toward axis of symmetry. Main cusp not differentiated from other denticles. Median posterior process, when unbroken, is as long as either of the lateral processes and has the same type of denticulation.

Sharp keel paralleling lateral processes and median in position throughout lower side of flange. Basal cavity relatively prominent, lying immediately behind keel and directly under intersection of posterior process and flange. Flange built up from lower margin of lateral processes and more evident in posterior view.

*Remarks*.—The Montana specimens of *Dino-*

*dus youngquisti* are identical to specimens figured by VOGES (1959) who designated them as *Scutula* cf. *venusta*. This species cannot be confused with *S. venusta* which has a median anterior process and 2 lateral processes and which does not have a prominent flange developed near the lower margin.

Although the 2 specimens illustrated here have the median process partially broken, a number of specimens are available from the Lodgepole Limestone which have a well-developed median process preserved. Some of these are included in the unfigured paratypes.

The species is named for WALTER YOUNGQUIST.

*Range*.—VOGES (1959, table 1) recorded the species from the *Siphonodella-Pseudopolygnathus triangula triangula* Zone (upper *cul*) in Germany. It occurs in Montana in *cul* and *culla* strata.

*Repository*.—Holotype, S.U.I. 10874; figured parat., pe. S.U.I. 10875; unfigured paratypes.

**Genus ELICTOGNATHUS** Cooper, 1939

*Solenognathus* BRANSON & MEHL, 1934b, p. 270-271 [non AGASSIZ, 1846].

*Elictognathus* COOPER, 1939, p. 386-387; COOPER, HASS, 1959, p. 386.—Type species: *Solenognathus bialata* BRANSON & MEHL, 1934, p. 273, pl. 22, fig. 11; OD COOPER, 1939, p. 387.

*Solenodella* BRANSON & MEHL, 1944, in Shimer & Shrock, p. 244; BRANSON & MEHL, 1948, p. 527 [pro *Solenognathus* BRANSON & MEHL, 1934].

non *Solenodella* Branson & Mehl, ELIAS, 1956, p. 113.

*Remarks*.—The first valid generic name to be applied to a species belonging to this taxon is *Elictognathus* COOPER.

All of the species referred to *Solenodella* by ELIAS (1956) lack the prominent ridges or shelves, near the lower edge, on both sides of the blade. These structures constitute features which are considered diagnostic of *Elictognathus* (= *Solenodella*). ELIAS' taxa are better referred to *Ozarkodina*. Three valid species of *Elictognathus* are recognized: *E. lacerata*, *E. bialata*, and *E. fulcrata*.

*Range*.—*Elictognathus* is restricted to the Tournaisian (*cul-culla*) in Germany (VOGES, 1959, table 1), and to Tournaisian equivalents in North America (e.g., Hannibal and Chouteau strata of the standard Mississippi Valley sequence, 29, chart 1).

**ELICTOGNATHUS BIALATA** (Branson & Mehl), 1934

Plate 5, figure 14

*Solenognathus bialata* BRANSON & MEHL, 1934b, p. 273, pl. 22, fig. 11.

*Solenognathus dicrocheila* BRANSON, 1934, p. 333, pl. 27, fig. 9; COOPER, 1939, p. 411, pl. 45, figs. 7, 8.

*Elictognathus bialata* (Branson & Mehl), COOPER, 1939, p. 387, pl. 45, figs. 1, 2; HASS, 1959, p. 370, pl. 49, fig. 21; VOGES, 1959, p. 277-278, pl. 33, figs. 18, 19.

*Solenognathus bidentata* COOPER, 1939, p. 410, pl. 45, figs. 9, 10.

*Solenodella bialata* (Branson & Mehl), BRANSON & MEHL,

- 1944, in Shimer & Shrock, p. 244, pl. 94, fig. 6; BISCHOFF, 1957, p. 55, pl. 6, figs. 11, 14.
- Solenodella* sp. cf. *S. bialata* (Branson & Mehl), THOMAS, 1949, p. 436, pl. 3, fig. 26.
- Solenodella dicrocheila* (Branson), BISCHOFF & ZIEGLER, 1956, p. 166, pl. 12, fig. 20.
- Diagnosis.**—Narrow ridge on outer side not reaching posterior end, and with shelf on inner side of blade, near lower margin. Shelf directed laterally from blade and folded upward at right angle into thin denticulate parapet parallel to blade. Posterior end of blade flexed inward to meet shelf. Basal cavity thin and elongate in direction of blade. Keel straight anteriorly, behind basal cavity curving inward to its termination at posterior end of lower side of shelf.
- Remarks.**—*Elictognathus bialata* differs from *E. lacerata* in possessing a parapet parallel to and nearly as high as the blade in some specimens. Fossils here referred to *E. bialata* are closely similar to original material on which the species was based.
- Range.**—The species ranges from the *Siphonodella-Pseudopolygnathus triangula triangula* Zone to the lower *Siphonodella crenulata* Zone, with questionable occurrence in the upper *S. crenulata* Zone (VOGES, 1959, table 1).
- Repository.**—Figured hypotype, S.U.I. 10883.
- ELICTOGNATHUS LACERATA** (Branson & Mehl), 1934  
Plate 5, figures 18-21
- Solenognathus lacerata* BRANSON & MEHL, 1934b, p. 271, pl. 22, figs. 5, 6; COOPER, 1939, p. 411, pl. 44, fig. 30.
- Solenognathus tabulata* BRANSON & MEHL, 1934b, p. 271-272, pl. 22, fig. 7; COOPER, 1939, p. 412, pl. 44, figs. 64-66.
- Solenognathus costata* BRANSON, 1934, p. 332, pl. 27, fig. 7; COOPER, 1939, p. 410-411, pl. 44, figs. 33-35.
- Solenognathus tenera* BRANSON, 1934, p. 332-333, pl. 27, fig. 8; BRANSON & MEHL, 1938b, p. 140, pl. 34, fig. 14; COOPER, 1939, p. 412, pl. 44, figs. 36, 37.
- Bryantodus camurus* HUDDLE, 1934, p. 68-69, pl. 2, figs. 6-9.
- Bryantodus microdens* HUDDLE, 1934, p. 69, pl. 2, fig. 10.
- Polygnathellus similis* HUDDLE, 1934, p. 93, pl. 7, fig. 20 (non fig. 21).
- Solenognathus amphelicta* COOPER, 1939, p. 410, pl. 44, figs. 10-12.
- Solenognathus anida* COOPER, 1939, p. 410, pl. 44, figs. 46-48.
- Solenognathus anomala* COOPER, 1939, p. 410, pl. 44, figs. 15-17.
- Solenognathus anomalodus* COOPER, 1939, p. 410, pl. 44, figs. 27-29.
- Solenognathus araiia* COOPER, 1939, p. 410, pl. 44, figs. 31, 32.
- Solenognathus camura* (Huddle), COOPER, 1939, p. 410, pl. 44, figs. 58-60.
- Solenognathus carinata* (Cooper), COOPER, 1939, p. 410, pl. 43, figs. 55-57.
- Solenognathus dicta* COOPER, 1939, p. 411, pl. 44, figs. 70-72.
- Solenognathus eura* COOPER, 1939, p. 411, pl. 44, figs. 7-9.
- Solenognathus eurynota* COOPER, 1939, p. 411, pl. 44, figs. 55-57.
- Solenognathus isomeces* COOPER, 1939, p. 411, pl. 44, figs. 4-6.
- Solenognathus macra* COOPER, 1939, p. 411-412, pl. 44, figs. 13, 14.
- Solenognathus micra* COOPER, 1939, p. 412, pl. 44, figs. 40, 41.
- Solenognathus oliga* COOPER, 1939, p. 412, pl. 44, figs. 21-23, 52-54.
- Solenognathus pecta* COOPER, 1939, p. 412, pl. 44, figs. 1-3.
- Solenognathus plecta* COOPER, 1939, p. 412, pl. 43, figs. 47-52, 58-60.
- Solenognathus syntyla* COOPER, 1939, p. 412, pl. 44, figs. 38, 39.
- Solenognathus trinodus* COOPER, 1939, p. 412, pl. 44, figs. 67-69.
- Solenognathus tyla* COOPER, 1939, p. 412, pl. 44, figs. 24-26, 42, 43.
- Solenognathus typica* COOPER, 1939, p. 412, pl. 44, figs. 18-20, 44, 45, 49-51; —, 1943, in COOPER & SLOSS, p. 171, pl. 28, fig. 13.
- Solenodella lacerata* (Branson & Mehl), BRANSON & MEHL, 1944, in SHIMER & SHROCK, p. 244, pl. 94, fig. 4.
- Pinacognathus? deflecta* YOUNGQUIST & PATTERSON, 1949, p. 60, pl. 15, fig. 5.
- Solenodella lateranodosa* THOMAS, 1949, p. 428-429, pl. 3, fig. 19.
- Solenodella tenera* (Branson), THOMAS, 1949, p. 436, pl. 3, figs. 18, 20.
- Solenodella tenera* (Branson)?, YOUNGQUIST & DOWNS, 1951, p. 790-791, pl. 111, fig. 3.
- Elictognathus lacerata* (Branson & Mehl), HASS, 1951, p. 2539, pl. 1, fig. 3; —, 1956, p. 25, 26, pl. 2, figs. 21, 22; CLOUD, BARNES, & HASS, 1957, p. 813, pl. 5, fig. 4; HASS, 1959, p. 386-387, pl. 49, figs. 1-8, 12; VOGES, 1959, p. 278-279, pl. 33, fig. 20; FREYER, 1961, in DVOŘÁK & FREYER, p. 894, pl. 2, figs. 4, 5; REXROAD & SCOTT, 1964, p. 26-27, pl. 3, figs. 18-20.
- Solenodella costata* (Branson), BISCHOFF & ZIEGLER, 1956, p. 166, pl. 12, figs. 18, 19; BISCHOFF, 1957, p. 55, pl. 6, fig. 15; BEACH, 1961, p. 51, pl. 5, fig. 1 (cited as *Solenognathus costata* on pl. 5).
- Elictognathus costata* (Branson), REXROAD & SCOTT, 1964, p. 25-26, pl. 3, fig. 24.
- Diagnosis.**—Narrow ridge on outer side, narrow ridge to prominent shelf on inner side of blade near lower margin. Posterior end of blade usually flexed inward. Basal cavity generally elliptical and elongate in direction of blade. Sharp keel anteriorly and posteriorly, grooved at both ends of basal cavity.
- Remarks.**—There may be only one prominent apical denticle, which is larger than the other denticles, or 2 or 3 prominent denticles in the apical region. In some specimens a few denticles near the anterior end of the blade are higher than the apical one. As emphasized by HASS (1959), details of denticulation are highly variable within this species and cannot be regarded as diagnostic.
- All morphological gradations ranging from a narrow ridge to a prominent shelf on the inner side of the blade near the lower margin are present in the basal 5 feet of the Lodgepole Limestone. The narrow-ridged forms could be referred to *Elictognathus lacerata* and those with a

prominent shelf to *E. tabulata* if the species were to be maintained separately. As there is a complete gradation in the material at hand, *E. tabulata* is suppressed. *E. fulcrata* has a conspicuously developed "buttress" rising from the shelf below the apical denticle (BRANSON & MEHL, 1934b, p. 272-273).

*Range*.—The species ranges from the *Siphonodella-Pseudopolygnathus triangula inaequalis* Zone to the lower *Siphonodella crenulata* Zone, with a questionable occurrence in the upper *S. crenulata* Zone of Germany (VOGES, 1959, table 1).

*Repository*.—Figured hypotypes, S.U.I. 10887-10890.

**Genus FALCODUS Huddle, 1934**

*Falcodus* HUDDLE, 1934, p. 87.—Type species: *Falcodus angulus* HUDDLE, 1934, p. 87-88, pl. 7, fig. 9; text-fig. 3,3; OD.

*Remarks*.—*Falcodus* differs from *Dinodus* by possession of a distinct main cusp and by lack of a prominent flange near the lower margin. Individual denticles in *Falcodus* are much broader than in *Dinodus*.

Valid species of *Falcodus*, as interpreted here, include *F. angulus*, *F. conflexus* (= *F. tortus*), all HUDDLE, and possibly *F. aculeatus* SANNEMANN. *F.?* *granulosus* HUDDLE should be referred to *Dinodus*; *F. ultimus* (BRANSON & MEHL) is based on a fragment which is specifically indeterminate; and *F. trypherus* COOPER and *F. variabilis* SANNEMANN do not belong in *Falcodus*. *F.?* *alatoides* REXROAD & BURTON (1961) was later referred to *Hindeodus* REXROAD & FURNISH (1964, p. 672).

*Elsonella secunda* YOUNGQUIST has been assigned to *Falcodus* by ETHINGTON & FURNISH (1962, p. 1266). This species has a prominent flange near the lower margin, a feature uncharacteristic of *Falcodus*. The blade of *E. secunda* is not as laterally compressed as in typical *Falcodus* and probably the species should be referred to a new genus. The species includes 3 of YOUNGQUIST's unfigured paralectotypes of *E. prima*, but a 4th unfigured specimen, which possesses a median posterior process, is correctly assigned to *Elsonella*.

*Range*.—*Falcodus* is known from the Lower Mississippian (Kinderhook) and the Upper Devonian, provided that *F. aculeatus* is regarded as properly allocated to this genus.

**FALCODUS ANGULUS Huddle, 1934**

Plate 5, figures 1, 4

*Falcodus angulus* HUDDLE, 1934, p. 87-88, pl. 7, fig. 9; text-fig. 3, fig. 3.

*Diagnosis*.—Blade set with high, thin denticles, fused almost throughout their length. Lower margin of posterior process angled downward from basal cavity to posterior end. Ridge on inner side

of posterior process straight, except near posterior end where it is turned down; it may be only weakly developed, however. Anterior process projecting downward at right angles to posterior process, usually in same plane, but incurved in some specimens. Two highest points along blade are at posterior end and at main cusp. Small basal cavity beneath main cusp.

*Remarks*.—*Falcodus angulus* and *F. conflexus* HUDDLE are closely related; HUDDLE (1934) distinguished them on the basis of relative lengths of the anterior and posterior processes. They are differentiated here by the fact that in *F. angulus* the lower margin of the posterior process angles downward from the basal cavity to the posterior end and it is not paralleled by the ridge on the inner side. In *F. conflexus* the lower margin of the posterior process is straight for most of its length except near the posterior end where it is turned down, and it is paralleled throughout its length by the ridge on the inner side. The material from the Lodgepole Limestone agrees with HUDDLE's types of *F. angulus* except in the weaker development of the ridge on the inner side of the posterior process.

The specimen which BRANSON & MEHL (1934, pl. 23, fig. 21) designated as *Palmatodella ultima* should be referred to *Falcodus*, but it is too fragmentary for positive reference to either *F. angulus* or *F. conflexus*. The same statement applies to the specimens which COOPER (1939, p. 387) referred to *F. conflexus*.

*Range*.—Lower Mississippian (Kinderhook).

*Repository*.—Figured hypotypes, S.U.I. 10872, 10873.

**PINACOGNATHUS Branson & Mehl, 1944**

*Pinacodus* BRANSON & MEHL [non DAVIS, 1883], 1934b, p. 269.

*Pinacognathus* BRANSON & MEHL, 1944, in Shimer & Shrock, p. 244 [pro *Pinacodus* BRANSON & MEHL].—Type species: *Pinacodus profundus* BRANSON & MEHL, 1934b, p. 269-270, pl. 22, fig. 1; OD.

*Pinacognathus (sic)* BRANSON & MEHL, 1948, p. 527-528.

*Range*.—Lower Mississippian (Kinderhook) of North America and Tournaisian of Germany.

**PINACOGNATHUS PROFUNDA (Branson & Mehl), 1934**

Plate 5, figure 22

*Pinacodus profundus* BRANSON & MEHL, 1934b, p. 269-270, pl. 22, fig. 1; COOPER, 1939, p. 399, pl. 45, figs. 29, 35.

*Pinacodus profundus* Branson & Mehl?, BRANSON & MEHL, 1934b, p. 335, pl. 22, figs. 2-4.

*Pinacodus anomius* COOPER, 1939, p. 398, pl. 45, figs. 36, 41.

*Pinacodus brachys* COOPER, 1939, p. 398-399, pl. 45, fig. 43.

*Pinacognathus profunda* (Branson & Mehl), BRANSON & MEHL, 1944, in Shimer & Shrock, p. 244, pl. 94, fig. 3; HASS, 1956, p. 25, pl. 2, fig. 17; CLOUD, BARNES, & HASS, 1957, p. 813, pl. 5, fig. 3; HASS, 1959, pl. 49, figs. 15, 19, 20; VOGES, 1959, p. 288, pl. 33, fig. 45.

**Remarks.**—*Pinacognathus*, as well as the only valid species, *P. profunda*, is based on relatively few specimens and is generally a rare faunal element. For example, of over 22,000 conodont specimens from the Chappel Limestone (HASS, 1959, table 1) only one specimen of *P. profunda* was reported (the other two specimens illustrated by HASS (1959) are from the Houy Formation).

*Pinacognathus* differs from *Elictoagnathus* in lacking a development of ridges or shelves on sides of the blade which is shorter and higher than in *Elictoagnathus* relative to length. *P. profunda* has an elliptical, shallow basal cavity extending from below the apical denticle to the posterior end. In front of the basal cavity the blade is keeled. The unit is slightly arched. The upper margin declines steeply from the apical denticle to the posterior end.

The specimens which BRANSON & MEHL (1934b) doubtfully referred to *Pinacognathus profunda* are regarded as within the range of variation of the species. The single specimen from the Lodgepole Limestone agrees well with the holotype, as well as with subsequent references to the species.

**Range.**—VOGES (1959, table 1) recorded the species from the *Siphonodella-Pseudopolygnathus triangula inaequalis* Zone and the *Siphonodella-P. triangula triangula* Zone in Germany.

**Repository.**—Figured hypotype, S.U.I. 10891.

### Genus APATOGNATHUS Branson & Mehl, 1934

*Apatognathus* BRANSON & MEHL, 1934a, p. 201.—Type species: *A. varians* BRANSON & MEHL, 1934a, p. 201-202, pl. 17, figs. 1-3; OD [original designation].

**Remarks.**—Following revisions of *Apatognathus* (75, 82, 109), the only form referable to the genus is the type species. *A. varians* differs from forms assigned with question to *Apatognathus*

in the St. Louis (95, p. 7-8), by possession of a diagonal offset of the denticles on both processes. The St. Louis forms lack such a characteristic denticulation and are referred to a new genus (109, p. 113-116).

*Apatognathus lipperti* BISCHOFF has been transferred to *Gnamptognathus* ZIEGLER (75, p. 155) and to *Enantiognathus* (82, p. 559). It is questionably assigned to *Gnamptognathus* by GLENNISTER & KLAPPER (1966).

**Range.**—The genus as presently defined is restricted to the Upper Devonian.

### APATOGNATHUS VARIANS Branson & Mehl, 1934 Plate 6, figures 12-14

*Apatognathus varians* BRANSON & MEHL, 1934a, p. 201-202, pl. 17, figs. 1-3; BISCHOFF & ZIEGLER, 1956, p. 145, pl. 14, fig. 3; KLAPPER, 1958, p. 1085, pl. 141, figs. 6, 8; ETHINGTON, FURNISH, & WINGERT, 1961, p. 763, pl. 90, fig. 11.

non *Apatognathus?* *variens* BRANSON & MEHL, COOPER, 1939, p. 385, pl. 47, fig. 30 (non *Apatognathus*).

non *Apatognathus varians* BRANSON & MEHL, FREYER, 1961, p. 36, pl. 1, fig. 13 (= *Gnamptognathus?* *lipperti*).

**Description.**—See ETHINGTON, *et al.*, 1961, p. 763.

**Remarks.**—ETHINGTON, *et al.* (39) were first to note the diagonal offset of the denticles in cycles of 3 along the inner side of the 2 processes of *Apatognathus varians*. In most specimens available for this study the diagonal offset is in cycles of 2 near the apex of the arch; farther from the apex the offset is in cycles of 3. This characteristic denticulation is unique to *A. varians* and distinguishes it from *A.?* *gemina* (HINDE) *sensu* REXROAD & COLLINSON (1963) which has a similar configuration of the 2 processes and a similar basal cavity.

Of 37 specimens of the species from the Englewood Formation, 7 have a large cusp developed on one process in addition to the main cusp at the apex (comparable to BRANSON & MEHL, 1934, pl. 17, fig. 3). These forms are regarded as intraspecific variants.

### EXPLANATION OF PLATE 3

All specimens are from the basal Lodgepole Limestone, Montana and Wyoming; all figures are unretouched photographs (×26).

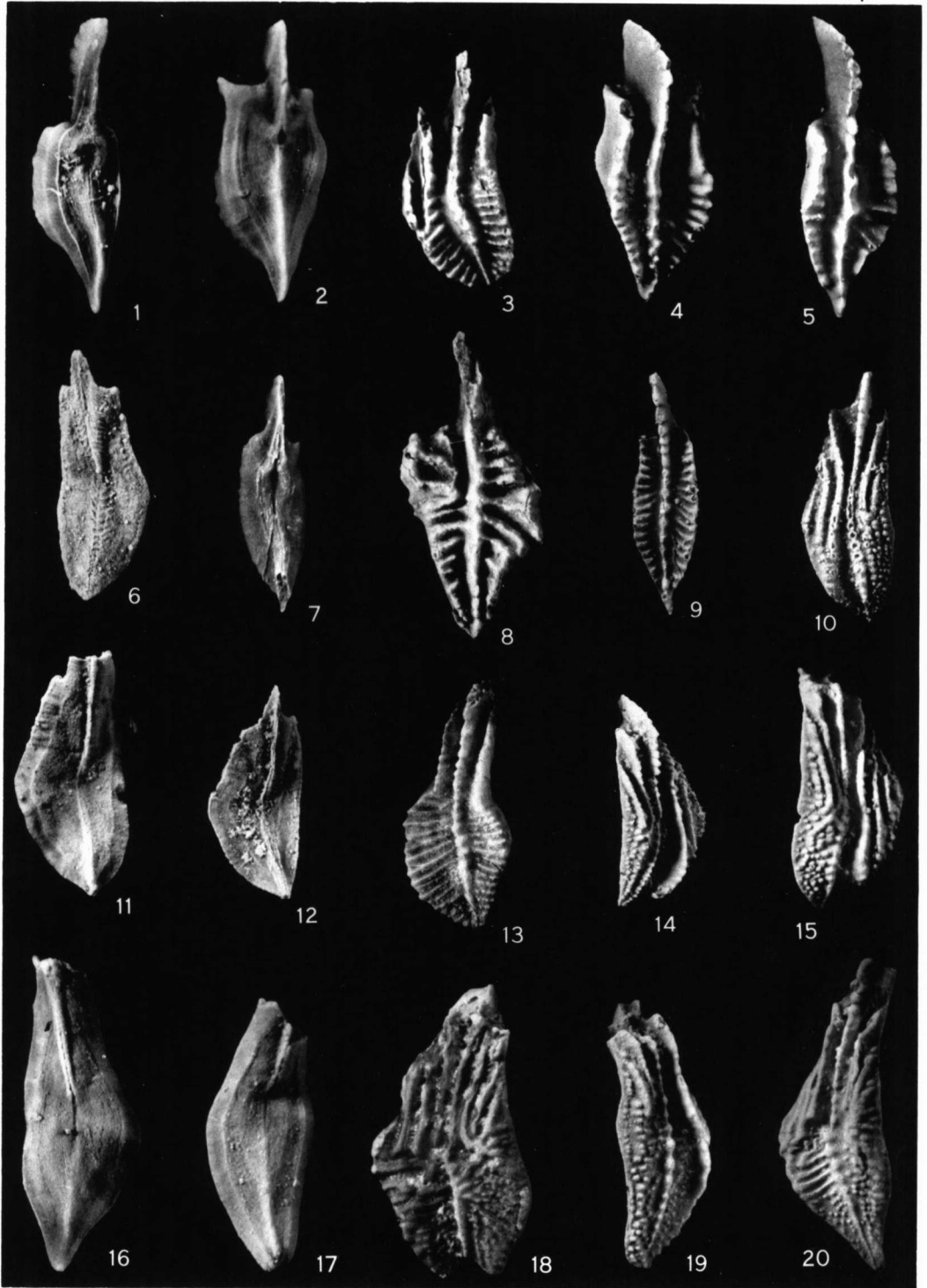
#### FIGURE

1-4. *Siphonodella cooperi* HASS.—1. Upper view.—4. Lower view of S.U.I. hypotype 10921 from loc. 7.—2. Upper view.—3. Lower view of S.U.I. hypotype 10922 from loc. 4. .... (p. 16)  
5-8. *Siphonodella crenulata* (COOPER).—5. Upper

view.—8. Lower view of S.U.I. hypotype 10923 from loc. 6.—6. Upper view.—7. Lower view of S.U.I. hypotype 10924 from loc. 4. .... (p. 18)  
9-12. *Siphonodella quadruplicata* (BRANSON & MEHL).—9. Upper view.—12. Lower view of S.U.I. hypotype 10925 from loc. 5.—10. Upper view.—11. Lower view of S.U.I. hypotype 10926 from loc. 14. Both specimens are transitional to *S. cooperi*. .... (p. 17)



Klapper--Devonian and Mississippian Conodont Zones



Klapper--Devonian and Mississippian Conodont Zones



*Range.*—*Apatognathus varians* ranges from the *Palmatolepis quadrantinodosa* Zone to the *Spathognathodus costatus* Zone in Western Australia (44). In North America it is apparently restricted to the *S. costatus* Zone.

*Repository.*—Figured hypotypes, S.U.I. 10862-10864.

**Genus ICRIODUS Branson & Mehl, 1938**

*Icriodus* BRANSON & MEHL, 1934a, p. 225 (*nomen nudum*).  
*Icriodus* BRANSON & MEHL, 1938a, p. 159.—Type species:  
*Icriodus expansus* BRANSON & MEHL, 1938a, p. 160-161,  
 pl. 26, figs. 18-21; OD.

*Remarks.* — *Icriodus* and *Pelekysgnathus* THOMAS are closely related, an opinion emphasized by LINDSTRÖM (1964, p. 10, 163) but obscured by HASS' (1962) classification. Inasmuch as the 2 genera possess nearly identical basal cavities and are linked by at least the transitional *I. costatus* (THOMAS), HASS' reference of *Pelekysgnathus* to the Prioniodinidae is doubtful.

According to present interpretation, *Pelekysgnathus* differs from *Icriodus* in having only a single row of denticles on the upper surface. *Icriodus* normally has 3 rows of denticles on the upper surface. Thus interpreted, *P. costata* THOMAS belongs in *Icriodus*. Forms with only 2 rows of denticles were diagnosed by MÜLLER & MÜLLER (1957, p. 1105) as belonging to *Icriodus*, although they are stated to be rare. VOGES (1959, pl. 33, fig. 44) illustrated a form with 2 rows of denticles on the upper surface, which he designated as

*Pelekysgnathus* sp. A. Such forms with 2 rows are better placed in *Icriodus*.

ETHINGTON, *et al.* (1961) differentiated *Pelekysgnathus* from *Icriodus* on the basis of the more prominent inclined main cusp and the greater degree of arching in *Pelekysgnathus*. A prominent, inclined main cusp, however, is a feature encountered at different times in the evolutionary development of *Icriodus* (e.g., *I. woschmidti* ZIEGLER, Gedinnian, and especially *I. angustus* STEWART & SWEET, Eifelian), and therefore is not unique to *Pelekysgnathus*. Degree of arching does not seem to be a character of sufficient value for generic differentiation in platform conodonts. *I. costatus*, according to the criteria of ETHINGTON, *et al.* (1961), should be assigned to *Pelekysgnathus* even though this species has 3 rows of denticles. *I. costatus* has its lateral rows connected to the median row by transverse ridges. This is a characteristic seen in several other species of *Icriodus* (e.g., some specimens of *I. latericrescens* BRANSON & MEHL, 9, pl. 12, figs. 5, 8, and *I. symmetricus* BRANSON & MEHL, = *I. curvatus* BRANSON & MEHL, 1938a, pl. 26, fig. 26).

BRANSON & MEHL (17) oriented *Icriodus* with the main cusp as posterior; THOMAS (1949, p. 424) oriented *Pelekysgnathus* in exactly the same manner. This orientation is followed herein for reasons stated by ZIEGLER (1960a, p. 186) and LINDSTRÖM (1964, p. 12, 21, 178, text fig. 5).

**EXPLANATION OF PLATE 4**

All specimens are from the Mississippian part of the dark shale unit of SANDBERG, Montana and Wyoming, except figs. 7, 9; all figures are unretouched photographs (×26).

FIGURE

- 1, 5. *Polygnathus longipostica* BRANSON & MEHL.—1. Lower view.—5. Upper view of S.U.I. hypotype 10892 from basal 6 in. of dark shale unit, loc. 12. (p. 20)
- 2-4. *Polygnathus inornata* BRANSON.—2. Lower view.—4. Upper view of S.U.I. hypotype 10893 from basal 6 in. of dark shale unit, loc. 12.—3. Upper view of S.U.I. hypotype 10894 from the basal 2 in. of dark shale unit, loc. 9. (p. 19)
- 6, 10-12, 14, 15.—*Siphonodella sandbergi* KLAPPER, n. sp.—6. Lower view.—10. Upper view of S.U.I. paratype 10895 from 0-1 ft. below top of dark shale unit, loc. 11.—11. Lower view.—15. Upper view of S.U.I. paratype 10898 from basal 6 in. of dark shale unit, loc. 12.—12. Lower view.—14.

- Upper view of S.U.I. holotype 10899 from basal 6 in. of dark shale unit, loc. 12. (p. 19)
- 7, 9. *Polygnathus symmetrica* BRANSON.—7. Lower view.—9. Upper view of S.U.I. hypotype 10896 from basal Lodgepole Limestone, loc. 7. (p. 21)
- 8. *Pseudopolygnathus prima* BRANSON & MEHL.—Upper view of S.U.I. hypotype 10897 from basal 2 in. of dark shale unit, loc. 9. (p. 13)
- 13. *Siphonodella duplicata* (BRANSON & MEHL).—Upper view of S.U.I. hypotype 10900 from basal 2 in. of dark shale unit, loc. 9. (p. 18)
- 16, 20. *Siphonodella quadruplicata* (BRANSON & MEHL).—16. Lower view.—20. Upper view of S.U.I. hypotype 10901 from basal 6 in. of dark shale unit, loc. 12. (p. 17)
- 17, 91. *Siphonodella obsoleta* HASS.—17. Lower view.—19. Upper view of S.U.I. hypotype 10901 from basal 6 in. of dark shale unit, loc. 12. (p. 17)
- 18. *Siphonodella sexplicata* (BRANSON & MEHL).—Upper view of S.U.I. hypotype 10903 from basal 6 in. of dark shale unit, loc. 12. (p. 19)

*Range.*—*Icriodus* is known in the *Mono-graptus ultimus* Zone of the Carnic Alps (*I. latialatus* Zone of WALLISER, 1964), and from the Gedinnian through the *Spathognathodus costatus* Zone (to V-VI).

#### ICRIODUS CONSTRICTUS Thomas, 1949

Plate 6, figure 18

*Icriodus constrictus* THOMAS, 1949, p. 416, pl. 1, fig. 25; KLAPPER, 1962, p. 58-60, pl. 1, fig. 18; ANDERSON, 1964, p. 57-59, pl. 6, figs. 14-16.

*Icriodus mehli* KLAPPER, 1958, p. 1086-1087, pl. 141, figs. 2, 3.

*Diagnosis.*—Weakly developed main cusp. Unit slightly arched. Median row a series of small nodes connected by ridge throughout length of unit or merely a thin longitudinal ridge. From each node of median row, transverse ridges are developed which bifurcate toward margins. Unit tapers anteriorly. Basal cavity widens and deepens posteriorly and has flaring margins.

*Remarks.*—The holotype of *Icriodus mehli* is fragmentary, and the flaring margins of its basal cavity are broken. The original description of the lower side is no longer tenable in the light of the specimen illustrated here, which shows the characteristics of *I. constrictus*. Since THOMAS' species is apparently based on a single specimen and only 2 specimens are now known from Wyoming, the range of intraspecific variation of *I. constrictus* cannot be defined. From THOMAS' holotype, as well as the specimen illustrated here, the holotype of *I. mehli* departs with respect to details of upper surface ornamentation. *I. mehli* should not be maintained as a separate species based on only its holotype, however. The procedure of establishing a conodont species based on only one specimen is a highly dubious practice, as some Upper Devonian species are represented by thousands of specimens. Even after the holotype of *I. mehli* is referred to *I. constrictus*, the latter species is of doubtful significance because only 3 published specimens are as yet referable to it.

*Range.*—Upper part of Upper Devonian (Maple Mill Shale of Iowa and dark shale unit of Sandberg, 1963, in Wyoming).

*Repository.*—Figured hypotype, S.U.I. 10867.

#### ICRIODUS COSTATUS (Thomas), 1949

Plate 6, figures 19-22

*Pelekyognathus costata* THOMAS, 1949, p. 424, pl. 2, fig. 9.

*Icriodus* cf. *I. rectus* Youngquist & Peterson (1947), THOMAS, 1949, p. 434, pl. 1, figs. 17, 18.

*Icriodus darbyensis* KLAPPER, 1958, p. 1086, pl. 141, figs. 9, 11, 12.

*Pelekyognathus darbyensis* (Klapper), ETHINGTON, FURNISH, & WINGERT, 1961, p. 765, pl. 90, figs. 12-17; LINDSTRÖM, 1964, p. 53, 161, text-figs. 17A, 56h.

*Diagnosis.*—Arched, with prominent main cusp inclined posteriorly and distinctly set off from other denticles. Unit may be incurved at both ends. Nodes of lateral rows aligned with and connected to those of median row by transverse ridges. Basal cavity widest posteriorly, with flaring margins.

*Remarks.*—As stated by ETHINGTON, *et al.* (1961), *Icriodus costatus* is morphologically intermediate between *Icriodus* and *Pelekyognathus*. Several small specimens are available which have only one lateral denticle developed on each side of the median row. *I. costatus* is placed in *Icriodus* because of the presence of three rows of denticles in mature specimens.

*Icriodus costatus* and *I. darbyensis* agree in all essential details; therefore, the latter is suppressed. *I. costatus* is closest to *I. cornutus* SANNEMANN (1955b) from which it was probably derived. *I. cornutus* has the median and lateral rows in alternating series and does not have the lateral rows joined to the median row by transverse ridges.

*Range.*—Upper part of the Upper Devonian (Maple Mill Shale of Iowa, Devonian part of the Englewood Formation of South Dakota, and the Devonian part of the dark shale unit of Sandberg, 1963, in Wyoming).

*Repository.*—Figured hypotypes, S.U.I. 10868-10870.

#### Genus PALMATOLEPIS Ulrich & Bassler, 1926

*Panderodella* BASSLER, 1925, p. 220 (*nomen dubium*).

*Palmatolepis* ULRICH & BASSLER, 1926, p. 49.—Type species:

*Palmatolepis perlobata* ULRICH & BASSLER, 1926, p. 49-50, pl. 7, fig. 22 (=lectotype selected by MÜLLER, 1956b, p. 15; non figs. 19-21, 23); OD.

*Remarks.*—The reader is referred to reviews of the nomenclatorial problem of *Panderodella* vs. *Palmatolepis* given by CLARK & BECKER (1960) and ZIEGLER (1962c). These authors regard the type species of *Panderodella* (*P. truncata* BASSLER) as a *nomen dubium*. HASS' (1959, p. 369) partition of *Palmatolepis* into 2 genera is untenable, as pointed out by ZIEGLER (1962c, p. 396).

*Range.*—Lower *Polygnathus asymmetrica* Zone (to Ia) to upper *Spathognathodus costatus* Zone (to VI).

#### PALMATOLEPIS GRACILIS Branson & Mehl, 1934

*Palmatolepis gracilis* BRANSON & MEHL, 1934a, p. 238, pl. 18, figs. 2, 8 (*non* fig. 5); MEHL & ZIEGLER, 1963, p. 200-205, pl. 1, figs. 1, 2 (fig. 1 = neotype).

*Diagnosis.*—Straight in lateral view with reduced platform. Deflection of carina about at the position of the azygous node. Inner lateral lobe more strongly developed than outer part of platform, which usually does not develop an outer

lateral lobe. Keel high anteriorly and posteriorly, offset in a semicircle by following the margin of the inner lobe in the typical subspecies. Secondary carinae and keels lacking; crimp may be present.

*Remarks.*—*Palmatolepis gracilis* as based on the neotype established by MEHL & ZIEGLER (1963) is a senior synonym of *P. deflectens* MÜLLER. Two subspecies of *P. gracilis* are recognized; the justification of such a procedure is purely of a practical nature. Such subspecies are stratigraphic entities, i.e. distinct parts of a chronocone. Morphologically they fall within the limits generally regarded as allowable for variation within a conodont species. The designation of them as subspecies seems preferable to the use of morphotypes. The synonymies and diagnoses of the two subspecies of *P. gracilis* follow:

**PALMATOLEPIS GRACILIS GRACILIS** Branson & Mehl, 1934

Plate 6, figure 3

*Palmatolepis gracilis* BRANSON & MEHL, 1934a, p. 238, pl. 18, figs. 2, 8 (*non* fig. 5); SANNEMANN, 1955a, p. 331, pl. 24, fig. 15 (*non* fig. 17 = *P. minuta schleizia* HELMS); BISCHOFF & ZIEGLER, 1956, p. 154, pl. 12, figs. 8, 9; BISCHOFF, 1957, p. 41-42, pl. 6, figs. 6-10; ZIEGLER, 1957, in FLÜGEL & ZIEGLER, p. 57, pl. 1, fig. 4; FREYER, 1961, p. 64, text-fig. 83 a, b; SCOTT & COLLINSON, 1961, p. 129, pl. 1, fig. 5; FREYER, 1961, in DVOŘÁK & Freyer, p. 892, pl. 1, figs. 9, 10; MEHL & ZIEGLER, 1962, p. 200-205, pl. 1, figs. 1, 2.

*Polygnathus basilicus* STAUFFER, 1938, p. 438, pl. 53, figs. 42, 43.

*Palmatolepis (Deflectolepis) deflectens* MÜLLER, 1956b, p. 32, pl. 11, figs. 28-39.

*Palmatolepis (Palmatolepis) gonioclymeniae* MÜLLER, 1956b, p. 26-27, pl. 7, fig. 18 (*non* figs. 12, 16, 17, 19 = *P. gonioclymeniae*); KLAPPER, 1958, p. 1088, pl. 142, figs. 10, 11, 13.

*Palmatolepis deflectens* Müller, HELMS, 1959, p. 648, pl. 6, fig. 20; —, 1961b, p. 990, pl. 1, fig. 5; REICHSTEIN & SCHWAB, 1962, p. 24, pl. 1, fig. 13.

*Palmatolepis deflectens deflectens* Müller, ZIEGLER, 1962b, p. 56, pl. 3, figs. 17-22.

*Palmatolepis (Deflectolepis) gracilis deflectens* Müller, HELMS, 1963, text-fig. 2, figs. 37, 38.

*Diagnosis.*—Gently to strongly curved blade-carina. Platform may be greatly reduced or more fully developed in some larger specimens. Keel offset to semicircle by following margin of inner lateral lobe.

*Remarks.*—*Palmatolepis gracilis gracilis* differs from *P. gonioclymeniae* chiefly in that the latter has a sharply uparched posterior end. The de-

flexion of the carina is sharper in *P. gonioclymeniae* and occurs farther forward than in *P. gracilis gracilis*. According to these differences, the specimens referred to *P. gonioclymeniae* (65, pl. 142, figs. 10, 11, 13; 84, pl. 7, fig. 18) should be assigned to *P. gracilis gracilis*.

The semicircular offset of the keel along the margin of the inner lobe is a diagnostic characteristic of *P. gracilis gracilis* which serves to distinguish it from all specimens of *P. minuta* BRANSON & MEHL. The keel of *P. basilica* (STAUFFER) corresponds exactly to that of *P. gracilis gracilis*; therefore the former is suppressed.

*Range.*—ZIEGLER (1926b, p. 56) recorded the range of the present subspecies from the *Palmatolepis rhomboidea* Zone to the upper *Spathognathodus costatus* Zone.

*Repository.*—Figured hypotype, S.U.I. 10857.

**PALMATOLEPIS GRACILIS SIGMOIDALIS** Ziegler, 1962

Plate 6, figure 8

*Palmatolepis glabra* Branson & Mehl, COOPER, 1943, in Cooper & Sloss, p. 170, pl. 29, fig. 5 (*non* fig. 36).

*Palmatolepis gracilis* Branson & Mehl, CLOUD, BARNES, & HASS, 1957, p. 809, pl. 4, fig. 7; FREYER, 1961, p. 64, text-fig. 83 c.

*Panderodella gracilis* (Branson & Mehl), HASS, 1959, p. 369, pl. 50, fig. 1 (same specimen as CLOUD, BARNES, & HASS, 1957).

*Palmatolepis deflectens sigmoidalis* ZIEGLER, 1962b, p. 56-57, pl. 3, figs. 24-28.

*Diagnosis.*—Strongly sigmoidal carina and platform. Platform always much reduced.

*Remarks.*—*Palmatolepis gracilis sigmoidalis* is distinguished from the typical subspecies by possession of a sigmoidal blade-carina. This subspecies lacks the conspicuous offset of the keel described for *P. gracilis gracilis*.

Many specimens of *Palmatolepis gracilis sigmoidalis* available from Wyoming were too small to be photographed satisfactorily. They are more strongly sigmoidal than the specimen illustrated (Pl. 6, fig. 8); this specimen is also sigmoidal, but the curvature is somewhat obscured by the oblique angle of the photography. The material available from Wyoming agrees well with the specimens illustrated by ZIEGLER (1962b), as well as with specimens which Ziegler sent to me for comparison.

*Range.*—*Spathognathodus costatus* Zone.

*Repository.*—Figured hypotype, S.U.I. 10860.

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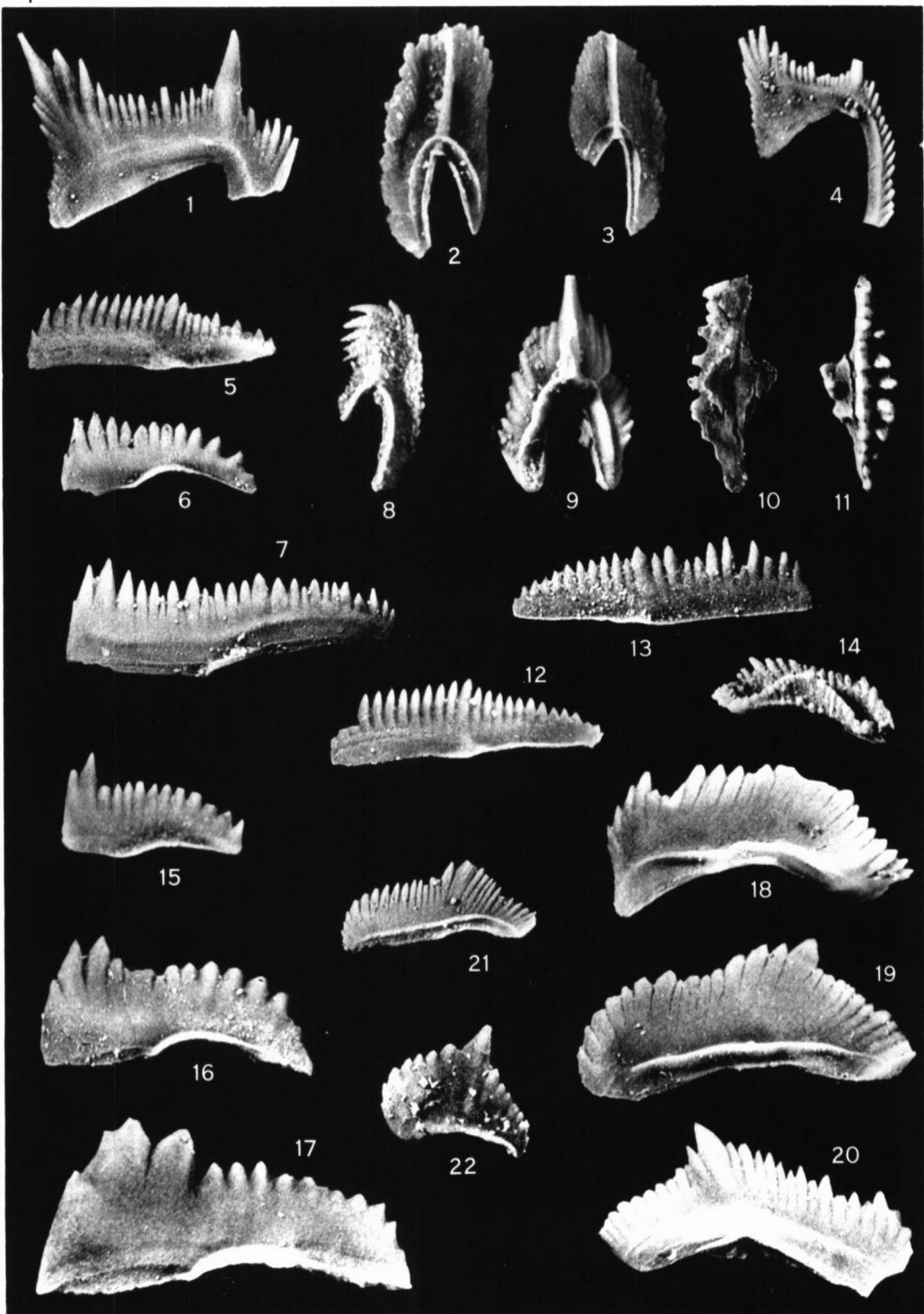
## EXPLANATION OF PLATE 5

All specimens are from the basal Lodgepole Limestone, Montana and Wyoming, or from the Mississippian part of the dark shale unit of SANDBERG, Montana and Wyoming, except fig. 9; all figures are unretouched photographs ( $\times 34$ , unless otherwise noted).

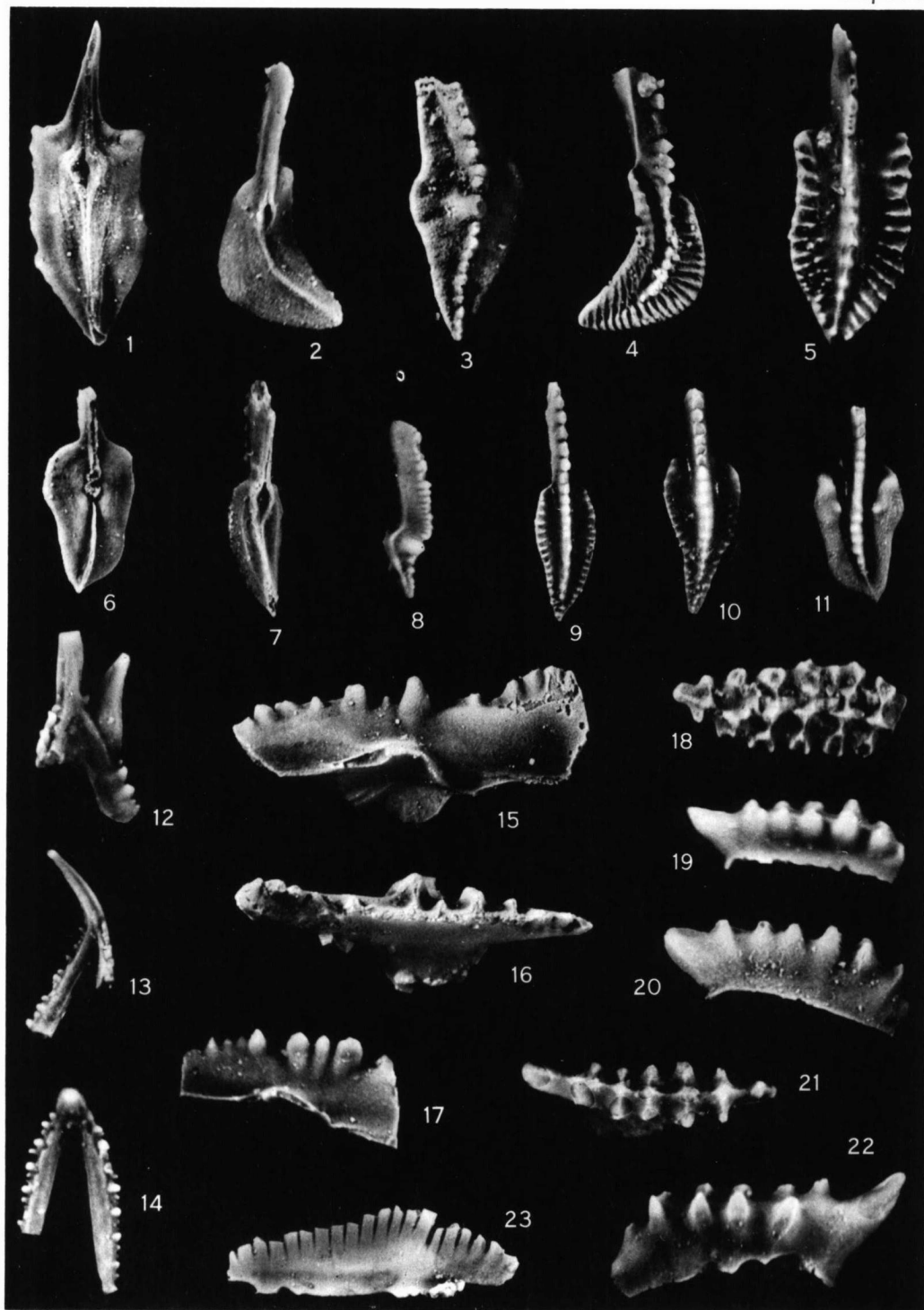
## FIGURE

- 1, 4. *Falcodus angulus* HUDDLE.—Inner lateral views of S.U.I. hypotypes 10872-10873 from basal Lodgepole Limestone, loc. 6. .... (p. 27)
- 2, 3. *Dinodus youngquisti* KLAPPER n. sp.—2. Posterior view of S.U.I. holotype 10874,  $\times 44$ .—3. Posterior view of S.U.I. paratype 10875,  $\times 44$ . Both from basal Lodgepole Limestone, loc. 6. .... (p. 25)
- 5, 12 13. *Spathognathodus abnormis* (BRANSON & MEHL).—5, 12. Inner lateral views of S.U.I. hypotypes 10876 and 10881 from basal Lodgepole Limestone, loc. 1.—13. Inner lateral view of S.U.I. hypotype 10882 from basal Lodgepole Limestone, loc. 6. .... (p. 22)
- 6, 7. *Spathognathodus stabilis* (BRANSON & MEHL).—6. Outer lateral view of S.U.I. hypotype 10877 from 0-1 ft. below top of dark shale unit, loc. 11.—7. Outer lateral view of S.U.I. hypotype 10878 from basal Lodgepole Limestone, loc. 1. .... (p. 23)
8. *Dinodus leptus* COOPER.—Inner lateral view of S.U.I. hypotype 10879,  $\times 44$  from 0-1 ft. below top of dark shale unit, loc. 11. .... (p. 25)
9. *Elsonella prima* YOUNGQUIST.—Posterior view of S.U.I. lectotype 2915 from Independence Formation, Middle Amana, Iowa. .... (p. 24)
- 10, 11. *Pseudopolygnathus dentilineata* BRANSON.—10. Lower view.—11. Upper view of S.U.I. hypotype 10880 from basal 2 in. of dark shale unit, loc. 9. .... (p. 14)
14. *Elictognathus bialata* (BRANSON & MEHL).—Inner lateral view of S.U.I. hypotype 10883 from 0-1 ft. below top of dark shale unit, loc. 11. .... (p. 25)
- 15-17. *Spathognathodus crassidentatus* (BRANSON & MEHL).—15. Outer lateral view of S.U.I. hypotype 10884 from basal Lodgepole Limestone, loc. 1.—16. Outer lateral view of S.U.I. hypotype 10885 from basal Lodgepole Limestone, loc. 6.—17. Outer lateral view of S.U.I. hypotype 10886 from basal Lodgepole Limestone, loc. 9. .... (p. 23)
- 18-21. *Elictognathus lacerata* (BRANSON & MEHL).—18, 20. Outer lateral views of S.U.I. hypotypes 10887 & 10889 from basal Lodgepole Limestone, loc. 1.—19. Inner lateral view of S.U.I. hypotype 10888 from basal Lodgepole Limestone, loc. 14.—21. Inner lateral view of S.U.I. hypotype 10890 from 0-1 ft. below top of dark shale unit, loc. 11. .... (p. 26)
22. *Pinacognathus profunda* (BRANSON & MEHL).—Inner lateral view of S.U.I. hypotype 10891 from basal Lodgepole Limestone, loc. 1. .... (p. 27)





Klapper--Devonian and Mississippian Conodont Zones



Klapper--Devonian and Mississippian Conodont Zones

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### EXPLANATION OF PLATE 6

All specimens are from the Devonian part of the Englewood Formation, South Dakota; from the Devonian part of the dark shale unit of SANDBERG, Wyoming; or from the Devonian part of the Madison Limestone, Wyoming; all figures are unretouched photographs (×34, unless otherwise noted).

#### FIGURE

- 1, 5. *Polygnathus symmetrica* BRANSON.—1. Lower view.—5. Upper view of S.U.I. hypotype 10855 from 32-33 ft. below top of Englewood Formation, loc. 13. .... (p. 21)
- 2, 4. *Polygnathus obliquicostata* ZIEGLER.—2. Lower view.—4. Upper view of S.U.I. hypotype 10856 from 0-1 ft. above base of Madison Limestone, loc. 15. .... (p. 22)
3. *Palmatolepis gracilis gracilis* BRANSON & MEHL.—Upper view of S.U.I. hypotype 10857 from 11 ft., 9 in., to 12 ft., 7 in., below top of dark shale unit, loc. 11. .... (p. 31)
- 6, 11. *Polygnathus communis* BRANSON & MEHL.—6. Lower view.—11. Upper view of S.U.I. hypotype 10858 from 8 ft., 8 in., to 8 ft., 11 in., below top of dark shale unit, loc. 11. .... (p. 21)
- 7, 9, 10. *Polygnathus delicatula* ULRICH & BASSLER.—7. Lower view.—9. Upper view of S.U.I. hypotype 10859 from 8 ft., 8 in., to 8 ft., 11 in., below top of dark shale unit, loc. 11.—10. Upper view of S.U.I. hypotype 10861 from 8 in. to 1 ft., 8 in., below top of dark shale unit, loc. 15. .... (p. 22)
8. *Palmatolepis gracilis sigmoidalis* ZIEGLER.—Upper view of S.U.I. hypotype 10860 from 8 ft., 8 in., to 8 ft., 11 in., below top of dark shale unit, loc. 11, ×44. .... (p. 31)
- 12-14. *Apatognathus varians* BRANSON & MEHL.—12, 14. S.U.I. hypotypes 10862, 10864 from 24-25 ft. below top of Englewood Formation, loc. 13, ×44.—13. S.U.I. hypotype 10863 from 0-1 ft. above base of Madison Limestone, loc. 15, ×44. .... (p. 28)
- 15-17. *Spathognathodus aculeatus* (BRANSON & MEHL).—15. Inner lateral view.—16. Upper view of S.U.I. hypotype 10865 from 6 ft., 7 in., to 7 ft., 7 in., below top of dark shale unit, loc. 11.—17. Inner lateral view of S.U.I. hypotype 10866 from 10-11 ft. below top of Englewood Formation, loc. 13. ... (p. 24)
18. *Icriodus constrictus* THOMAS.—Upper view of S.U.I. hypotype 10867 from 8 in. to 1 ft., 8 in., below top of dark shale unit, loc. 15; specimen broken at posterior end; ×44. .... (p. 29)
- 19-22. *Icriodus costatus* (THOMAS).—19. Inner lateral view of S.U.I. hypotype 10868 from 10-11 ft. below top of Englewood Formation, loc. 13, ×44.—20. Outer lateral view.—21. Upper view of S.U.I. hypotype 10869 from 0-1 ft. above base of Madison Limestone, loc. 15, ×44.—22. Outer lateral view of S.U.I. hypotype 10870 from 8 ft., 8 in., to 8 ft., 11 in., below top of dark shale unit, loc. 11, ×44. .... (p. 30)
23. *Spathognathodus praelongus* COOPER.—Inner lateral view of S.U.I. hypotype 10871, from 7 ft., 8 in., to 8 ft., 8 in., below top of dark shale unit, loc. 11. .... (p. 24)

APPENDIX

MEASURED SECTIONS

Color designations are from the Rock Color Chart (GODDARD *et al.*, 1948) and were determined in the laboratory.

LOCALITY 1

Crystal Lake Road Cut, north side of road, Big Snowy Mountains, sec. 8, T. 12 N., R. 18 E., Roundup sheet (Army Map Service), Montana.

MISSISSIPPIAN

Lodgepole Limestone (basal)  
Dolomitic calcarenite, pale yellowish brown, weathers grayish orange, v. fine sand size particles, calcite vugs, authigenic pyrite cubes up to 2 mm., glauconitic in upper 2 ft. Residue (acetic acid): conodonts (lower *S. crenulata* Zone), fish fragments, phosphatic brachiopods, glauconitic steinkerns of ostracodes. .... 5

Dark shale unit of SANDBERG  
Shale, dark gray, platy, quartzose, non-calcareous, conodonts visible (14x) on parting surfaces. Residue (gasoline method): fragmentary conodonts. .... 9.5  
Conglomerate, very pale orange dolomite pebbles in a dark gray shale matrix, abundant conodonts, fish fragments, quartz and phosphate grains. Irregular surface with underlying formation. Residue (hydrofluoric acid): conodonts (lower Carboniferous—*cul*). .... 0.5  
Total dark shale unit: ..... 10.0

Unconformity

DEVONIAN

Jefferson Formation  
Dolomitic calcilitute, very pale orange, coarse silt-size particles, characterizes upper 1 ft., 1 in.; dolomite, light brown and medium light gray, v. fine sand size particles, characterizes lower 8 ft. to base of exposure at road level. Residue (acetic acid): no conodonts. .... 9 7

LOCALITY 2

Dry Hollow, SW ¼ NE ¼ sec. 3, T. 1 N., R. 1 W., Three Forks quadrangle (15 min.), Montana.

MISSISSIPPIAN

Lodgepole Limestone (basal):  
Calcarenite, same as basal Lodgepole at loc. 7. Residue (acetic acid): conodonts (lower *S. crenulata* Zone), crinoid columnals, fish fragments, ostracodes, argillaceous material. .... 3

MISSISSIPPIAN and DEVONIAN

Sappington Member, Three Forks Formation  
Siltstone, same as upper massive siltstone at loc. 7. .... 20 4  
Shale, same as middle gray shale at loc. 7. .... 14 10  
Siltstone, same as lower siltstone at loc. 7. .... 12 0  
Calcilitute, same as shaly nodular limestone at loc. 7. .... 3 0

Shale, same as lower black shale at loc. 7.  
Shale can be uncovered. Residue (gasoline method): extremely fragmentary conodonts which are undiagnostic. .... 1 6  
Total Sappington Member ..... 51 8

DEVONIAN

Trident Member, Three Forks Formation  
Calcarenite, light olive gray, weathers very pale orange, otherwise same as top limestone bed of Trident Member at loc. 7. Upper 4 ft. sampled.

LOCALITY 3

Milligan Canyon, NE ¼ SW ¼ sec. 36, T. 2 N., R. 1 W., Three Forks quadrangle (15 min.), Montana.

MISSISSIPPIAN

Lodgepole Limestone (basal)  
Calcarenite, same as basal Lodgepole at loc. 7. Residue (acetic acid): conodonts (lower *S. crenulata* Zone), fish fragments, holothurian sclerites, glauconite including steinkerns of gastropods, argillaceous material. .... 3

MISSISSIPPIAN and DEVONIAN

Sappington Member, Three Forks Formation  
Same units present as at loc. 7, member was not measured. Lower black shale can be uncovered and is 1 ft. thick.

DEVONIAN

Trident Member, Three Forks Formation:  
Calcarenite, light olive gray, weathers pale grayish orange, otherwise same as top limestone bed of Trident Member at loc. 7. Upper 6 ft. sampled.

LOCALITY 4

Rekap Station, SW ¼ SE ¼ sec. 27, T. 3 N., R. 2 E., Manhattan quadrangle (15 min.), Montana.

MISSISSIPPIAN

Lodgepole Limestone (basal)  
Calcarenite, same as basal Lodgepole at loc. 7. Residue (acetic acid): conodonts (lower *S. crenulata* Zone), crinoid columnals, glauconite, argillaceous material. .... 5 0

Dark shale unit of SANDBERG  
Siltstone, brownish gray, weathers very pale orange, coarse silt size particles, quartzose, calcareous. .... 1 0

MISSISSIPPIAN and DEVONIAN

Sappington Member, Three Forks Formation  
Same units present as at loc. 7. Lower black shale is exposed and is 8 ft. thick. ... 52 0

DEVONIAN

Trident Member, Three Forks Formation  
Calcarenite, olive gray, weathers very pale orange, otherwise same as top limestone bed of Trident Member at loc. 7. Upper 4 ft. sampled.

**LOCALITY 5**

Ingleside Quarry, NW¼ SW¼ sec. 4, T. 1 S., R. 1. W., Three Forks quadrangle (15 min.), Montana.

	Thickness (feet, inches)	
<b>MISSISSIPPIAN</b>		
Lodgepole Limestone (basal) Calcareenite, same as basal Lodgepole at loc. 7. Residue (acetic acid): conodonts (lower <i>S. crenulata</i> Zone), brachiopods, crinoid columnals, fish fragments, gastropods, glauconite, argillaceous material. ....	3	0
Dark shale unit of <b>SANDBERG</b>		
Siltstone, pale yellowish brown to grayish orange, weathers very pale orange, coarse silt-size particles, quartzose, calcareous, impressions of <i>Taonurus</i> on weathered surface. ....	..	10
Siltstone, dark yellowish brown, same as above unit except lacks <i>Taonurus</i> impressions. ....	1	5
Total dark shale unit .....	2	3

**MISSISSIPPIAN and DEVONIAN**

Sappington Member, Three Forks Formation  
Same units present as at loc. 7. Lower black shale can be uncovered.

**LOCALITY 6**

Logan, SW¼ SE¼ sec. 25, T. 2 N., R. 2 E., Manhattan quadrangle (15 min.), Montana.

	Thickness (feet, inches)	
<b>MISSISSIPPIAN</b>		
Lodgepole Limestone (basal) Calcareenite, same as basal Lodgepole at loc. 7. Residue (acetic acid): conodonts (lower <i>S. crenulata</i> Zone), agglutinated foraminifers, brachiopods, bryozoans, crinoid columnals, fish fragments, gastropods, holothurian sclerites, rugose corals, glauconite, pyrite, argillaceous material. ....	5	0
Dark shale unit of <b>SANDBERG</b>		
Siltstone, brownish black, weathers pale yellowish brown, coarse silt-size particles, quartzose, calcareous. ....	1	0
Siltstone, brownish black, weathers pale grayish orange, otherwise same as above unit. ....	..	4
Shale, dark gray, weathers pale yellowish brown, platy, quartzose. ....	2	0
Total dark shale unit .....	3	4

**MISSISSIPPIAN and DEVONIAN**

Sappington Member, Three Forks Formation  
Same units present as at loc. 7. Lower black shale can be uncovered and is 1 ft. thick. ....

**DEVONIAN**

Trident Member, Three Forks Formation  
Calcareenite, olive gray, weathers pale yellowish brown, otherwise same as top limestone bed of Trident Member at loc. 7. Upper 4 ft. sampled.

**LOCALITY 7**

Nixon Gulch, NE¼ SW¼ sec. 14, T. 2 N., R. 3 E., Manhattan quadrangle (15 min.), Montana.

	Thickness (feet, inches)	
<b>MISSISSIPPIAN</b>		
Lodgepole Limestone (basal) Calcareenite, light olive gray, weathers pale grayish orange, medium sand-size particles, fragmental texture, abundant crinoid columnals. Residue (acetic acid): conodonts (lower <i>S. crenulata</i> Zone), brachiopods, rugose corals, crinoid columnals, fish fragments, gastropods, glauconite, argillaceous material. ....	5	..
Dark shale unit of <b>SANDBERG</b>		
Siltstone, yellowish brown, weathers very pale orange, coarse silt-size particles, quartzose, calcareous. ....	1	5
Shale, dark gray, platy, quartzose, slightly calcareous. ....	..	3
Siltstone, brownish gray to black, weathers very pale orange, coarse silt-size particles, quartzose, calcareous, impressions of <i>Taonurus</i> on weathered surface. Residue (acetic acid): conodont fragments, including <i>Siphonodella</i> sp. ....	..	4
Shale, dark gray, platy, quartzose, slightly calcareous. ....	2	..
Total dark shale unit .....	4	..

**MISSISSIPPIAN and DEVONIAN**

Sappington Member, Three Forks Formation  
Siltstone (upper massive siltstone), grayish orange, coarse silt-size particles, quartzose, calcareous cement, flaggy to massive bedding. ....

	27	..
Shale (middle gray shale), medium light gray, quartzose, slightly calcareous. ....	14	5
Siltstone (lower siltstone), grayish orange, coarse silt-size particles, quartzose, calcareous, thin-bedded, gradational with underlying unit. ....	18	..
Calclutite (shaly nodular limestone), pale yellowish brown, weathers pale grayish orange, coarse silt-size particles, argillaceous, fossiliferous-brachiopods, crinoid columnals, algal and sponge nodules. Residue (acetic acid): agglutinated foraminifers, argillaceous material, silt-size quartz grains. ....	7	..
Shale (lower black shale), medium dark gray, platy, quartzose, slightly calcareous in upper 8 in.; shale, brownish black, weathers light brown, fissile surfaces show slickensides in lower 1 ft., 11 in. Unit well exposed. ....	2	7
Total Sappington Member .....	69	..

**DEVONIAN**

Trident Member, Three Forks Formation  
Calcareenite, pale yellowish brown, weathers very pale orange, v. fine sand-size particles, brachiopods, crinoid columnals. Residue (acetic acid): argillaceous material. ....

	4	..
Shale, olive gray, platy, quartzose, slightly calcareous, brachiopods. About 10 ft. of this unit exposed to base of exposure at creek level.		

**LOCALITY 8**

Peak 9559, Bridger Ranger, SE ¼ SE ¼ sec. 21, T. 2 N., R. 6 E., Sedan quadrangle (15 min.), Montana.

	Thickness (feet, inches)
<b>MISSISSIPPIAN</b>	
Lodgepole Limestone (basal)	
Calcarenite, same as basal Lodgepole at loc. 7. Residue (acetic acid): conodonts (lower <i>S. crenulata</i> Zone), brachiopods, crinoid columnals, fish fragments, glauconite including steinkerns of ostracodes, pyrite, argillaceous material. ....	5 ..
Dark shale unit of <b>SANDBERG</b>	
Siltstone, brownish black, coarse silt-size particles, quartzose, calcareous. Residue (hydrofluoric acid): conodonts (lower Carboniferous— <i>cul</i> ). ....	.. 2
Shale, dark gray, platy, quartzose, slightly calcareous. Residue (gasoline method): conodont fragments including <i>Siphonodella</i> sp. ....	3 ..
Total dark shale unit .....	3 2

**MISSISSIPPIAN and DEVONIAN**

**Sappington Member, Three Forks Formation**  
Same units present as at loc. 7. Lower black shale is exposed and is 7 ft. thick. Basal 1 ft. of lower black shale yields conodonts, including reworked specimens of *Palmatolepis glabra*, and undiagnostic bar forms. ....

67 ..

**DEVONIAN**

**Trident Member, Three Forks Formation**  
Calcarenite, light olive gray, weathers grayish orange, fine sand-size particles, fragmental texture, crinoid columnals, ostracodes. Upper 2 ft. sampled. Residue (acetic acid): conodonts (*Scaphignathus velifera* Zone), crinoid columnals, glauconite, argillaceous material.

**LOCALITY 9**

Baker Mountain, Beartooth Mountains, NW ¼ SW ¼ NW ¼ sec. 35, T. 3 S., R. 12 E., McLeod Basin quadrangle (7-½ min.), Montana.

	Thickness (feet, inches)
<b>MISSISSIPPIAN</b>	
Lodgepole Limestone (basal)	
Dolomitic calcilitute, pale yellowish brown, with thin streaks of medium dark gray, weathers grayish orange, coarse silt-size particles, crinoid columnals. Residue (acetic acid): conodonts (lower <i>S. crenulata</i> Zone), crinoid columnals, fish fragments, glauconite, silt size quartz grains, argillaceous material. ....	5 ..
Dark shale unit of <b>SANDBERG</b>	
Shale, dark gray, platy, quartzose, non-calcareous. ....	2 11
Quartzitic conglomeratic sandstone, dark gray to olive gray, weathers pale orange, quartz grains are fine sand-size, pebbles of orange siltstone up to 15 mm., non-calcareous, abundant conodonts, fish fragments, and phosphate pebbles all visible on weathered surface. Contact with under-	

lying formation irregular. Residue (hydrofluoric acid): conodonts (lower Carboniferous—*cul*), fish fragments. ....

2

Total dark sale unit .....	3	1
<b>Unconformity</b>		
<b>DEVONIAN</b>		
Logan Gulch Member, Three Forks Formation		
Dolomitic siltstone, weathers grayish orange.		

**LOCALITY 10**

Clarks Fork Canyon, NE ¼ NE ¼ sec. 7, T. 56 N., R. 103 W., Deep Lake quadrangle (15 min.), Wyoming. Section described by **SANDBERG** (1963, p. C17). **SANDBERG's** sample CF169 from the basal 1 in. of the Madison Limestone at this locality contains lower Carboniferous—*cul* conodonts.

**LOCALITY 11**

Cottonwood Canyon, north wall of canyon, Big Horn Mountains, sec. 34, T. 57 N., R. 93 W., Cody sheet (Army Map Service), Wyoming.

	Thickness (feet, inches)
<b>MISSISSIPPIAN</b>	
Madison Limestone (basal)	
Calcarenite, light olive gray, weathers very pale orange, v. fine sand-size particles, fragmental texture, abundant crinoid columnals especially in upper 1 ft. Residue (acetic acid): conodonts, including <i>Siphonodella obsoleta</i> , <i>Spathognathodus crassidentatus</i> , and <i>Polygnathus inornata</i> ; agglutinated foraminifers, dolomite rhombs. ....	5 ..

Dark shale unit of **SANDBERG** (in part)

Dolomitic calcilitute, very pale orange, weathers grayish orange, coarse silt-size particles, molds remain where fossils have been leached. Separated from underlying unit by a distinct discontinuity surface. Calcite vugs developed just above this surface. Residue (acetic acid) from upper 3 ft. only: conodonts (lower Carboniferous—*cul*), dolomite rhombs, pyrite. ....

3 7

**DEVONIAN**

Dark shale unit of <b>SANDBERG</b>	
Dolomitic calcilitute, pale grayish orange, weathers grayish orange, coarse silt-size particles. Residue (acetic acid), from lower 1 ft. only: conodonts (lower <i>S. costatus</i> Zone), fish fragments, dolomite rhombs. ....	1 8
Dolomitic calcilitute, very pale orange, weathers grayish orange, coarse silt-size particles. Residue (acetic acid): conodonts (lower <i>S. costatus</i> Zone), fish fragments, dolomite rhombs. ....	1 1
Dolomitic calcilitute, at top is 3-in. medium dark gray shale bed. Conodonts from this 3-in. bed were described by <b>ETHINGTON, et al.</b> (1961). Middle (2 ft., 1 in.) is a dolomitic calcilitute, very pale orange, weathers grayish orange, coarse silt-size particles. Base is a 3-in. dark gray shale bed. Residues from the two shales and the dolomite (gasoline method and acetic acid): conodonts	

(lower *S. costatus* Zone), fish fragments, megaspores, silt-size quartz grains, dolomite rhombs. .... 2 7

Dolomitic calcilitite, pale grayish orange, weathers grayish orange, coarse silt-size particles, some subrounded "floating" quartz sand grains (0.5-1.0 mm.), fish fragments. Base (8 in.) is a conglomerate, pale yellowish brown and dark gray, weathers grayish orange, matrix is dolomitic calcarenite, v. fine sand-size particles, abundant "floating" quartz sand grains (0.5-1.0 mm.), phosphatic pebbles, white dolomite clasts (up to 20 mm.), fish fragments and conodonts visible in matrix. Residue (acetic acid): conodonts (lower *S. costatus* Zone), fish fragments, quartz. .... 4 4

---

Total dark shale unit ..... 13 3

Unconformity

DEVONIAN

Jefferson Formation

LOCALITY 12

South Fork Rock Creek, north side of creek, Big Horn Mountains, SW ¼ sec. 25, T. 52 N., R. 84 W., Sheridan sheet (Army Map Service), Wyoming.

Thickness  
(feet, inches)

MISSISSIPPIAN

Madison Limestone (basal)

Dolomitic calcilitite, very pale orange, weathers grayish orange, coarse silt-size particles, molds remain where fossils, (e.g., crinoid columnals) have been leached. .... 4 4

Dark shale unit of SANDBERG

Dolomitic calcilitite, very pale orange, streaked with grayish red, weathers pale grayish orange, coarse silt-size particles. 1 2

Conglomerate, upper 4 in. is dolomitic calcilitite, very pale orange, coarse silt-size particles, abundant "floating" quartz sand grains (0.5-1.0 mm.); lower 2 in. is conglomerate, grayish red, weathers moderate reddish orange, with subrounded quartz sand grains (1-2 mm.), fish plates (up to 5 mm.), and conodonts visible in a hematitic dolomitic matrix. Residue (acetic acid): conodonts (lower Carboniferous—*cul*). .... .. 6

Total dark shale unit ..... 1 8

Unconformity

DEVONIAN

Jefferson Formation

LOCALITY 13

Boxelder Canyon, Black Hills, SE ¼ SW ¼ SE ¼ sec. 7, T. 2 N., R. 6 E., Piedmont quadrangle 7-½ min.), South Dakota. Section described by KLAPPER & FURNISH (1962, p. 2074-2075).

LOCALITY 14

Teton Canyon, south wall of canyon (approx. sec. 32, T. 44 N., R. 117 W., unsurveyed), and west wall of

canyon (approx. sec. 5, T. 43 N., R. 117 W., unsurveyed), Teton Range, Driggs sheet (Army Map Service), Wyoming.

Thickness  
(feet, inches)

MISSISSIPPIAN

Lodgepole Limestone (basal)

Dolomitic calcarenite, light olive gray to medium gray, weathers pale yellowish brown, v. fine sand-size particles, fragmental texture. Residue (acetic acid): conodonts (lower *S. crenulata* Zone), crinoid columnals, glauconite including gastropod steinkerns, dolomite rhombs. .... 5 ..

Dark shale unit of SANDBERG

Siltstone, medium light gray, weathers moderate brown, coarse silt-size particles, quartzose, slightly calcareous, impressions of *Taonurus* on weathered surface. .. 9 10

Shale, medium dark gray, platy, quartzose, slightly calcareous. Residue (gasoline method): conodonts (lower Carboniferous—*cul*). .... .. 4

Total dark shale unit ..... 10 2

Unconformity

DEVONIAN

Logan Gulch Member, Three Forks Formation(?)

Covered interval of 50-60 ft. may be referable to the Logan Gulch Member. Below this covered interval is brown fetid dolomite typical of the Jefferson Formation.

LOCALITY 15

Dinwoody Canyon, Wind River Range, SW ¼ NW ¼ NW ¼ sec. 12, T. 4 N., R. 6 W., Hays Park quadrangle (7-½ min.), Wyoming.

Thickness  
(feet, inches)

DEVONIAN

Madison Limestone (basal)

Dolomitic calcilitite, light brownish gray, streaked with pale red, weathers grayish orange pink and pale yellowish brown, coarse silt-size particles. Residue (acetic acid): conodonts (lower *S. costatus* Zone), fish fragments, dolomite rhombs. .... 4 ..

Dark shale unit of SANDBERG

Quartzose sandstone, pale red, weathers light greenish gray and moderate orange pink, medium sand-size particles, calcite cement, fish fragments and conodonts visible with hand lens (14x). Residue (acetic acid): conodonts (lower *S. costatus* Zone). .. 2

Dolomite, pale red, weathers light brown, v. fine sand-size particles, "floating" quartz sand grains (0.25-0.5 mm.), calcite cement. .... 6

Shale, grayish red, platy, quartzose, slightly calcareous. Residue (gasoline method): conodonts (lower: *S. costatus* Zone). .... 2 6

Total dark shale unit ..... 3 2

Unconformity

Darby Formation of BLACKWELDER (1918), upper part only

Dolomite, light brownish gray, weathers

very pale orange, coarse silt-size particles, abundant "floating" quartz sand grains (0.5-1 mm.), calcite cement. ....	1	--
Dolomite, yellowish gray, mottled with grayish red, weathers moderate reddish orange, coarse silt-size particles, calcite cement. ....	2	7
Total Darby Formation measured .....	3	7

## LOCALITY 16

South side of Bull Lake Creek, Wind River Range, SW¼ NE¼ NE¼ sec. 10, T. 2 N., R. 4 W., Bull Lake West quadrangle (7-½ min.), Wyoming. Section described by KLAPPER (1958, p. 1083). Bed number 1 is now assigned to the Madison Limestone, beds number 2 to 5 are now assigned to the dark shale unit of SANDBERG and the remaining beds to the Darby Formation of BLACKWELDER (1918).

## INDEX

[Rejected names enclosed within square brackets]

- Apatognathus*, 28  
*A. varians*, 11, 28  
 Bakken Formation, 8  
 [*Bispathodus*], 22  
 [*B. aculeatus*], 24  
 [*Branmehla*], 22  
 [*Bryantodus camurus*], 26  
 [*B. microdens*], 26  
 Bushberg Sandstone, 13  
 Cassadaga Stage, 4  
 Champ Clark Group, 4  
 Chattanooga Shale, 4  
*Cheiloceras Stufe*, 4  
 Chouteau Formation, 4, 16, 18, 19, 25  
*Clymenia Stufe*, 4  
 conodont zones, 11  
 [*Ctenognathodus*], 22  
 [*Ctenognathus*], 22  
 [*Ctenopolygnathus*], 19  
*Cymaclymenia*, 4  
*Cyrtoclymenia*, 4  
 Darby Formation, 5  
 dark shale unit, 8  
 Devonian-Mississippian boundary, 2  
*Dinodus*, 24  
*D. fragosus*, 24, 25  
*D. leptus*, 25  
*D. youngquisti*, 25  
*Elictoognathus*, 25  
*E. bialata*, 25  
 [*E. costata*], 26  
*E. fulcrata*, 25  
*E. lacerata*, 25, 26  
 Ellicott Shale, 4  
 Englewood Formation, 10, 30  
 English River Siltstone, 4  
*Falcodus*, 27  
*F. angustus*, 27  
*F. conflexus*, 27  
 Gassaway Member (Chattanooga), 4  
*Gattendorfia Stufe*, 2, 11, 15  
 Germany, 2, 14, 17, 21, 22, 24, 27  
*Gnathodus kockeli* Zone, 11  
 Gowanda Shale, 4  
 Hannibal Formation, 4, 16, 18, 19, 25  
*Ieriodus*, 2, 28  
*I. angustus*, 29  
*I. constrictus*, 29  
*I. costatus*, 29  
*I. curvatus*, 29  
 [*I. darbyensis*], 30  
*I. gracilis*, 11  
*I. latericrescens*, 29  
*I. latialatus*, 29  
 [*I. mehli*], 29, 30  
*I. symmetricus*, 29  
*I. woschmidti*, 29  
 Jefferson Formation, 4  
 Kinderhook Group, 2, 21, 23, 27  
 Lodgpole Limestone, 10  
 [*Macropolygnathus*], 13  
 Madison Limestone, 8  
 Maple Mill Shale, 4, 30  
 [*Mehlina*], 22  
 Montana, 25  
 [*Palmatodella ultima*], 27  
*Palmatolepis*, 30  
 [*P. deflectens*], 31  
*P. glabra*, 12  
 [*P. gonioclymeniae*], 31  
*P. gracilis*, 30  
*P. gracilis gracilis*, 31  
*P. gracilis sigmoidalis*, 11, 31  
*P. perlobata*, 30  
*P. quadrantinodosa* Zone, 29  
*P. rhomboidea* Zone, 31  
*P. rugosa postera*, 11  
*P. rugosa rugosa*, 12  
 [*Pandorina*], 22  
 [*Pandorinellina*], 22  
 [*Pandorodella*], 30  
*Pelekysgnathus*, 2, 29  
 [*P. costata*], 30  
 [*P. darbyensis*], 30  
*Pericyclus Stufe*, 11  
 Perrysburg Formation, 4  
 [*Pinacodus*], 27  
 [*P. anomius*], 27  
 [*P. brachys*], 27  
 [*P. profundus*], 27  
*Pinacognathus*, 27  
 [*P. ? deflecta*], 26  
*P. p. ojunda*, 27, 28  
*Polygnathus*, 19  
 [*P. abnormis*], 20  
 [*P. adola*], 21  
 [*P. anida*], 20, 21  
 [*P. basilicus*], 31  
 [*P. biclavula*], 21  
 [*P. cunulae*], 20  
*P. communis*, 21  
 [*P. communis bifurcata*], 21  
 [*P. communis carina*], 21  
 [*P. curta*], 20  
 [*P. cymbiformis*], 20  
*P. delicatula*, 22  
 [*P. distorta*], 20  
 [*P. flabellum*], 21  
*P. hassi*, 15  
 [*P. inaequidateradis*], 20  
 [*P. inopinata*], 20  
*P. inornata*, 15, 19, 20  
 [*P. inornata*], 21  
 [*P. irregularis*], 20  
 [*P. lanceolata*], 20  
 [*P. lobata*], 20  
*P. longipostica*, 20  
 [*P. longipostica*], 20, 21  
 [*P. marera*], 21  
 [*P. newalbanyensis*], 19  
*P. nodocostata*, 15  
*P. obliquicostata*, 22  
 [*P. ortha*], 20  
 [*P. permarginata*], 20  
 [*P. perplana*], 21  
*P. perplexa*, 11, 15  
*P. rhomboidea*, 15  
 [*P. rimulta*], 22  
*P. robusticostata*, 19  
 [*P. sagittaria*], 21  
 [*P. sanduskiensis*], 22  
 [*P. scapha*], 20, 21  
 [*P. scobiniformis*], 21  
 [*P. spicata*], 21  
 [*P. scobiniformis*], 21  
 [*P. spicata*], 21  
*P. styriaca* Zone, 2, 11, 15, 21, 22, 24  
 [*P. subserrata*], 20  
 [*P. subtortilis*], 20  
*P. symmetrica*, 21, 22  
 [*P. toxophora*], 20  
 [*P. undulosa*], 21  
 [*P. wyomingensis*], 22  
*Polylophodonta*, 12  
*Pseudopolygnathus*, 12  
 [*P. apetodus*], 14  
 [*P. asymmetrica*], 14  
 [*P. aurita*], 14  
 [*P. brevimarginata*], 14  
 [*P. carinata*], 14  
 [*P. constricticarinata*], 14  
 [*P. corrugata*], 14  
 [*P. costata*], 14  
 [*P. crenulata*], 14  
*P. dentilincatus*, 2, 11, 14  
 [*P. distorta*], 14  
 [*P. exostyla*], 14  
 [*P. foliacea*], 14  
*P. granulosa*, 13  
 [*P. inaequicostata*], 14  
 [*P. irregularis*], 14  
 [*P. itha*], 13  
 [*P. laciniata*], 13  
 [*P. lobata*], 14



- P. marginata*, 13  
*P. micropunctata*, 13  
*P. multistriata*, 15  
*P. prima*, 13  
 [*P. projecta*], 14  
 [*P. striata*], 14  
 [*P. subrugosa*], 14  
 [*P. sulcifera*], 14  
*P. triangula inaequalis*, 11, 14  
*P. triangula inaequalis* Zone, 15, 19, 27, 28  
*P. triangula pinnata*, 13  
*P. triangula triangula*, 12, 13  
*P. triangula triangula* Zone, 13, 17, 26, 28  
 [*P. varicostata*], 14  
 Rockford Limestone, 13  
 Sappington Member (Three Forks Formation), 6  
*Scaliognathus anchoralis* Zone, 13, 15, 17, 18  
*Scaphignathodus velifera* Zone, 2, 11, 13, 23  
*Siphonodella*, 11, 15  
*S. cooperi*, 16, 17  
*S. crenulata*, 18  
*S. crenulata* Zone, 12, 13, 17, 18, 26  
*S. duplicata*, 11, 18  
*S. isosticha*, 17  
*S. lobata*, 12, 16  
*S. obsoleta*, 17  
*S. quadruplicata*, 12, 17  
*S. sandbergi*, 11, 17, 19  
 [*S. sexplicata*], 18  
*S. sulcata*, 18  
 [*Siphonognathus*], 15  
 [*S. crenulata*], 18  
 [*S. duplicata*], 18  
 [*S. isolopha*], 17  
 [*S. newalbanyensis*], 17  
 [*S. quadruplicata*], 17  
 [*Scolenodella*], 25  
 [*S. ocostata*], 16  
 [*S. lacerata*], 26  
 [*S. lateranodosa*], 26  
 [*S. tenera*], 26  
 [*Solenognathus*], 25  
 [*S. amphelicta*], 26  
 [*S. anida*], 26  
 [*S. anomala*], 26  
 [*S. anomaloides*], 26  
 [*S. araiia*], 26  
 [*S. bialata*], 25  
 [*S. bidentata*], 25  
 [*S. camura*], 26  
 [*S. carinata*], 26  
 [*S. costata*], 26  
*S. dichia*, 26  
 [*S. dicrocheila*], 25  
 [*S. eura*], 26  
 [*S. eurynota*], 26  
 [*S. isomeces*], 26  
 [*S. lacerata*], 26  
 [*S. macra*], 26  
 [*S. micra*], 26  
 [*S. oliga*], 26  
 [*S. pecta*], 26  
 [*S. plecta*], 26  
 [*S. syntyla*], 26  
 [*S. tabulata*], 26  
 [*S. tenera*], 26  
 [*S. trinodus*], 26  
 [*S. tyla*], 26  
 [*S. typica*], 26  
 South Dakota, 30  
 [*Spathodus*], 22  
 [*S. abnormis*], 22  
 [*S. aciedentatus*], 23  
 [*S. chouteauensis*], 23  
 [*S. crassidentatus*], 23  
 [*S. cycclus*], 22  
 [*S. denticulatus*], 23  
 [*S. elongatus*], 23  
 [*S. jugosus*], 24  
 [*S. macer*], 23  
 [*S. parvijossatus*], 22  
 [*S. parvus*], 23  
 [*S. pulchellus*], 23  
 [*S. regularis*], 23  
 [*S. stabilis*], 23  
*Spathognathodus*, 22  
*S. abnormis*, 22  
*S. aculeatus*, 2, 4, 11, 24  
*S. costatus* Zone, 2, 4, 8, 11, 20, 22, 24, 28, 29, 31  
*S. crassidentatus*, 23  
 [*S. crassidentatus*], 23  
 [*S. cyrius*], 23  
 [*S. duplcata*], 16  
 [*S. exochus*], 24  
 [*S. flexus*], 24  
*S. jugosus*, 24  
 [*S. jugosus*], 24  
 [*S. longus*], 22  
 [*S. macer*], 23  
 [*S. mediocris*], 24  
 [*S. perlobata*], 16  
*S. praelongus*, 24  
 [*S. quadruplicata*], 16  
 [*S. quintidentatus*], 23  
 [*S. sexplicata*], 19  
*S. stabilis*, 23  
 [*S. strigilis*], 23  
 [*S. tridentatus*], 24  
 Strunian, 2  
 Sweetland Creek Shale, 4  
 Three Forks Formation, 6  
 Tournaisian, 25  
 Trident Member (Three Forks, 6  
 Western Anstralia, 28  
*Wocklumeria Stufe*, 2  
 Wyoming, 20, 22, 30