

CONODONT BIOSTRATIGRAPHY OF THE UPPER DEVONIAN  
IN THE GLOBE-MAMMOTH AREA, ARIZONA

by  
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## ABSTRACT

Conodont faunas from the Upper Devonian Martin and Percha Formations in the study area can be assigned to two Frasnian and two Famennian conodont zones. The Famennian faunas were recovered from strata that had previously been included within the Martin Formation, but have since been assigned to the Percha Formation. Three local zones are recognized in the Percha: 1) the Palmatolepis distorta Zone, 2) the Palmatolepis rugosa-Polygnathus semicostatus Zone, and 3) the Polygnathus communis Zone. The Percha faunas lacked standard zonal name taxa but can be assigned to the upper part of the Scaphignathus velifer Zone (Scaphignathus subserratus-Pelekysgnathus inclinatus Fauna) and the Upper Polygnathus styriacus Zone. These strata are the time and lithologic equivalent of the Box Member of the Percha Shale of New Mexico.

The Frasnian zones are the Lower and Upper Palmatolepis gigas Zones. The Frasnian faunas were recovered from the upper fossiliferous part of the Martin Formation.

The Frasnian-Famennian boundary in the study area is an unconformity with a hiatus spanning as many as twelve of the standard conodont zones and is locally characterized by a basal Percha (Late Famennian) lag deposit. Gluteus minimus, a phosphatic microfossil of unknown biological affinities, previously reported only from Iowa, is present in basal Percha strata in the study area.

## INTRODUCTION

### Purpose

This study was undertaken to determine the stratigraphic distribution of conodonts in the Upper Devonian Martin and Percha Formations in the Globe-Mammoth area of Gila and Pinal Counties, Arizona. A local conodont biostratigraphic zonation could then be established and compared to the refined zonations which have been erected for both Europe and North America. In this manner the Upper Devonian strata in the study area could be very precisely dated.

Based on corals and brachiopods, early workers (Kindle, 1916) assigned a Late Devonian age to the Devonian strata in the study area. Also based on brachiopods and corals, Teichert (1965) assigned a Late Frasnian age to the fossiliferous upper part of the Martin Formation. Teichert named these fossiliferous beds the "upper unit" of the Jerome Member of the Martin Formation. Earlier, Stoyanow (1936) had reported a rhynchonellid brachiopod fauna from the highest beds of the Martin Formation (highest beds of Teichert's upper unit) and suggested that these strata were quite younger than the rest of the Martin. Recently Schumacher and others (1976) assigned the upper part of Teichert's upper unit, which includes the beds from which Stoyanow reported the rhynchonellid brachiopod fauna, to the Percha Formation.

Ethington (1965) described a sparse conodont fauna from the Martin and confirmed the Late Frasnian age assignment. Ethington also

reported conodonts younger than Late Frasnian from the Martin near Bisbee, Arizona. These younger strata, now assigned to the Percha Formation, have remained unstudied to the present. In addition, since Ethington's work, a highly refined conodont biostratigraphic zonation has emerged for both Europe and North America. Therefore, the primary objectives of this study were: 1) to determine the age and conodont biostratigraphy of the Percha Formation in the study area, 2) to determine more precisely the age of the fossiliferous beds of the remainder (after removing the strata now assigned to the Percha Formation) of Teichert's upper unit of the Martin Formation, and 3) to compare the conodont zones found in the study area to the standard conodont zonations for North America and Europe.

Secondary objectives of this study were: 1) to study briefly the conodont paleoecology of the study area, 2) to examine closely the Frasnian-Famennian boundary beds in the study area, and 3) to study briefly the unique fossil, Gluteus minimus (Davis and Semken, 1975).

#### Location

Eleven stratigraphic sections were measured and sampled for conodonts. Six primary sections were systematically sampled on a bed-by-bed basis or every five feet (1.5 meters). Five supplementary sections were sampled at critical horizons. These sections are indicated by number on the Locality Map (Fig. 1).

1. Globe Hills: S1/2 NW1/4 sec. 13, T. 1 N., R. 15 E., Globe Quadrangle, Gila County.
2. Pinal Creek: W1/2 NW1/4 SE1/4 sec. 10, T. 1 N., R. 15 E., Globe Quadrangle, Gila County.

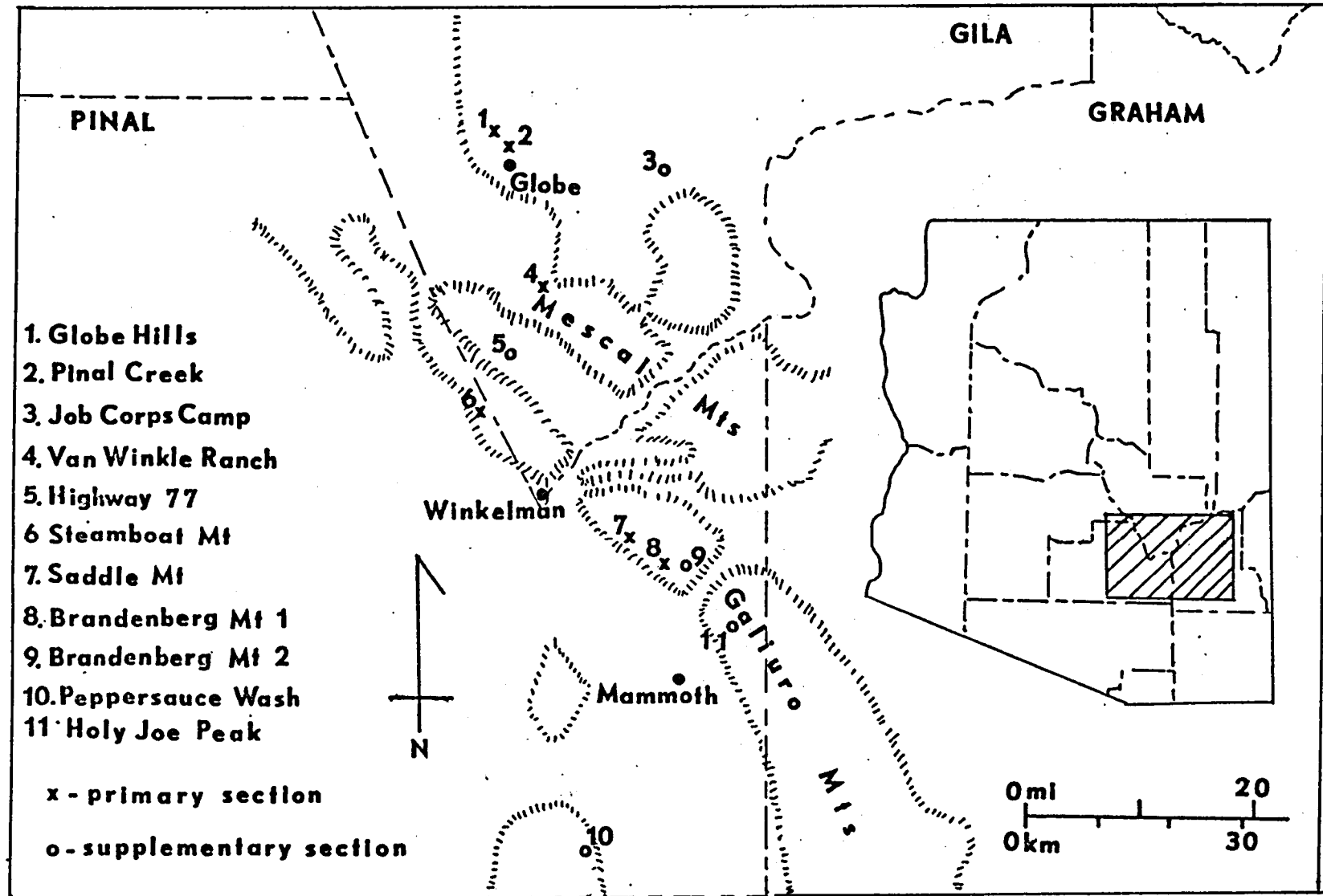


Figure 1. Map Showing Location of Study Area and Location of Measured Sections.

3. Job Corps Camp: NE1/4 SW1/4 sec. 35, T. 1 N., R. 17 E.,  
Dourine Canyon Quadrangle, Gila County.
4. Van Winkle Ranch: NW1/4 SE1/4 sec. 19, T. 2 S., R. 16 E.,  
Christmas Quadrangle, Gila County.
5. Highway 77: S1/2 SW1/4 NW1/4 and E1/2 NW1/4 SW1/4 sec. 10,  
T. 3 S., R. 15 E., El Capitan Mountain Quadrangle, Gila  
County.
6. Steamboat Mountain: E1/2 SE1/4 sec. 12, T. 4 S., R. 14 E.,  
Hayden Quadrangle, Pinal County.
7. Saddle Mountain: NE1/4 SW1/4 sec. 19, T. 5 S., R. 17 E.,  
Saddle Mountain Quadrangle, Pinal County.
8. Brandenburg Mountain 1: SW1/4 NW1/4 sec. 27, T. 6 S.,  
R. 17 E., Brandenburg Mountain Quadrangle, Pinal County.
9. Brandenburg Mountain 2: NE1/4 SW1/4 sec. 27, T. 6 S.,  
R. 17 E., Brandenburg Mountain Quadrangle, Pinal County.
10. Peppersauce Wash: SW1/4 SW1/4 sec. 21, T. 10 S., R. 16 E.,  
Peppersauce Wash Quadrangle, Pinal County.
11. Holy Joe Peak: SE1/4 sec. 7, T. 7 S., R. 18 E., Holy Joe  
Peak Quadrangle, Pinal County.

#### Field Methods and Laboratory Techniques

Sections were measured using a Brunton compass and a Jacob staff. Two to four kilogram samples were collected from each bed or at five foot (1.5 meters) intervals. 800-1000 grams of each carbonate sample were immersed in 10-15 percent glacial acetic acid for a period of five to seven days. In most cases not all of the sample dissolved. Productive samples were processed twice. "Quaternary O" was used to break down shales. "Quaternary O", when mixed with water and boiled, dis-aggregates most shales.

The insoluble residues were then washed, sieved, and dried. The dried residue was separated using heavy liquid (tetrabromoethane) as

described by Collinson (1963). The heavy fraction of the residue was examined for conodonts using a binocular microscope.

Thin sections, polished slabs, and acetate peels were used to identify lithologies. Dunham's (1962) classification was used to describe the rock types.

Photographs were taken with either Polaroid Type 55 P/N film, using an ALR Scanning Electron Microprobe Quantometer (SEMQ), or Kodak Panatomic X film, using a Polaroid MP-3 Land Camera.

## PREVIOUS WORK

### Stratigraphy

Blake (1901) was the first to report fossils of Devonian age from southern Arizona (from the Santa Rita Mountains). Williams (1903) compiled a faunal list of Devonian fossils from a section along Pinal Creek near Globe. Based on these fossils he suggested an early neo-Devonian age for these strata. Ransome (1904) proposed the name Martin Limestone for equivalent beds exposed at Mount Martin on Escabrosa Ridge, near Bisbee. In 1916, Ransome extended the Martin Limestone into the Globe area. Kindle (1916) examined fossils from this area and assigned a Late Devonian age to these strata. Huddle and Dobrovolsky (1952) studied Devonian and Mississippian strata in east-central Arizona. They proposed that the term Martin Formation should be used instead of Martin Limestone because of the varying lithology of the Devonian strata. They stated that faunal evidence indicate a Late Devonian age for the Martin Formation. Teichert (1965) and Pine (1968) studied the stratigraphy and paleogeography of Devonian strata in the study area. Teichert examined sections at Globe and to the north. Pine examined sections in Gila, Graham, Greenlee and Pinal Counties. Teichert assigned a late Frasnian age to the fossiliferous upper part of the Martin, and Pine assigned a Fingerlake and Chemung (Frasnian) age to this same upper part of the Martin.

Stoyanow (1936) reported the Famennian brachiopod Camerotoechia (=Paurorhyncha) endlichi (Meek) from the upper beds of the Martin along Pinal Creek. Based on this fossil, he correlated these strata with the lower part of the Ouray Limestone of Colorado. He proposed that the strata containing the Camerotoechia endlichi fauna, between the Martin and the Mississippian, be named the Lower Ouray Formation. As this unit was defined by its faunal characteristics rather than by its lithologic and stratigraphic characteristics, the name was never accepted and subsequent workers included these strata within the Martin Formation (Huddle and Dobrovlny, 1952; Wright, 1964; Teichert, 1965; Pine, 1968; Krieger, 1968a,b,c,d). Recently, Schumacher and others (1976) proposed the name Percha Formation for the sequence of slope-forming shales and overlying ledge-forming carbonates that occur above the Martin in much of southern Arizona and which contain the Paurorhyncha endlichi fauna. Gordon (1907) first introduced the name Percha when he assigned the Devonian strata in the Kingston-Hillsboro-Lake Valley district of southwestern New Mexico to the Percha Shale. Stevenson (1945) divided the Percha Shale into a lower Ready Pay Member consisting of fissile black shale and an upper Box Member composed of yellowish to greenish-gray shales with limestone nodules and shaly limestones near the top. Since Stoyanow's Lower Ouray name was invalid, the name Percha Formation was proposed for this unit because of its lithologic similarity to the Percha Shale of New Mexico with which it correlates (Schumacher and others, 1976).

### Conodonts

Devonian conodonts from Arizona were first reported by Sabins (1957) from the Portal Formation at Blue Mountain in the Chiricahua range in the southeastern corner of Arizona. Teichert (1965) reported a Late Frasnian conodont fauna from the "Island Mesa beds" of Stoyanow (1936) near the Verde River.

Ethington (1962, 1965) described a sparse conodont fauna from four localities in Arizona. He sampled sections of the Martin Formation at Globe, Superior and Bisbee, and the Portal Formation at Blue Mountain. Ethington (1965) reported Palmatolepis subrecta, Ancyrodella, and an abundance of Polygnathus from the Martin Formation and thereby confirmed its Late Frasnian age. He also reported fragments of Palmatolepis rugosa from Black Cap in the Bisbee area and noted that this species is younger than those found elsewhere in the Martin.

On a world-wide basis, Upper Devonian conodont biostratigraphy has been well studied in recent years and extremely refined zonations have been erected for both Europe and North America. Ziegler (1962, 1971), the pioneer of Upper Devonian conodont biostratigraphy, established a zonation consisting of 10 zones and 24 subzones for Europe. Most subsequent work has been directed toward extending or refining this zonation. In 1967, Clark and Ethington recognized and described conodonts from nine of Ziegler's ten major zones in the Upper Devonian of the Great Basin. In 1971, the Symposium on Conodont Biostratigraphy (Klapper and others) was published. In this volume Ziegler further refined his 1962 zonation and added the ranges of many new index taxa.

Klapper and others (1971), in this same volume, established a zonation for North America based on reference sections throughout the North American continent. Differences and similarities between European and North American zones are discussed.

The most recent refinement on the standard zonation was a modification of the Famennian zones by Sandberg and Ziegler (1973).

Figure 2 shows the correlations of the Upper Devonian conodont zonations for Europe and North America with the conodont zones recognized in the study area.

		CONODONT ZONES					
SERIES	STAGE	EUROPE <small>(After Ziegler, 1971, and Sandberg and Ziegler, 1973)</small>		NORTH AMERICA <small>(After Klapper and others, 1971, and Sandberg and Ziegler, 1973)</small>		PRESENT STUDY	
		UPPER DEVONIAN	FAMENNIAN	<i>Pretognathodus</i>			
? ?							
<i>Bl. costatus</i>	U			<i>Bl. costatus</i>	U		
	M				M		
	L				L	- - - ? - - - ? - - - ? - - -	
<i>Pa. styriacus</i>	U			<i>Pa. styriacus</i>	U	<i>Pa. communis</i>	
	M					<i>Pa. rugosa</i>	
	L					<i>Pa. semicostatus</i>	
<i>S. velfer</i>	U			<i>S. subserratus</i> - <i>Pa. inclinatus</i>		<i>Pa. distorta</i>	
	M			Fauna		- - - - -	
	L						
<i>Pa. marginifera</i>	U			<i>Pa. marginifera</i>	U		
	L				L		
<i>Pa. rhomboidea</i>	U			<i>Pa. rhomboidea</i>	U		
	L				L		
<i>Pa. crepida</i>	U			<i>Pa. crepida</i>	U		
	M				M		
	L				L		
<i>Pa. triangularis</i>	U	<i>Pa. triangularis</i>	U				
	M		M				
	L						
<i>Pa. gigas</i>	Uppermost	<i>Pa. gigas</i>	Uppermost				
	U		U	<i>Pa. gigas</i>	U		
	L		L		L		
FRASNIAN		<i>A. triangularis</i>		<i>A. triangularis</i>		<i>A. triangularis</i> (probable)	
		<i>Pa. asymmetricus</i>	U	<i>Pa. asymmetricus</i>	U	<i>Pa. asymmetricus</i> (probable, see Ethington, 1965)	
			M		M	- - - - -	
			L		L		
			Lowermost				
<i>Sc. hermanni</i>	U						
MIDDLE DEVONIAN	GIVETIAN	<i>Pa. cristatus</i>					

**EXPLANATION**

- U = Upper
- M = Middle
- L = Lower
- Bl = Bispathodus
- Pa = Palmatolepis
- Pe = Polygnathus
- S = Scaphignathus
- Pe = Pelekygnathus
- A = Ancyrognathus
- Sc = Schmidtegnathus

Figure 2. European and North American Standard Conodont Zonations. Zones recognized in the study area are to the right.

## STRATIGRAPHY

### Martin Formation

Teichert (1965) divided the Martin Formation into two members: the Beckers Butte Member and the Jerome Member. The Jerome Member was further divided into three informal "units": the fetid dolomite unit, the aphanitic dolomite unit, and the upper unit. Teichert included a slope-forming shale with overlying ledge-forming carbonates within the upper unit of the Martin. Schumacher and others (1976) assigned the name Percha Formation to this sequence and that terminology is followed here. Teichert's upper unit (restricted) (restricted = after removal of strata now assigned to the Percha Formation) consists of moderately fossiliferous thick and thin bedded limestones and dolomites. Figure 3 shows the approximate extent of Teichert's upper unit (restricted) between the overlying Percha Formation and the rest of the Martin. It was this part of the Martin Formation that was sampled for conodonts. In some places, Teichert's upper unit (restricted) is difficult to distinguish from the underlying evenly bedded aphanitic dolomite unit. So, at the primary sections of this study, sampling was begun at the first fossiliferous bed. The underlying units of the Martin Formation were sampled at Steamboat Mountain and all samples were devoid of conodonts. The upper unit (restricted) is overlain either by the thin basal sandstone beds of the Percha or, more commonly, by the slope-forming shale member of the Percha. Precambrian Troy Quartzite, the Cambrian Abrigo



Figure 3. Martin Formation, Upper Unit (Restricted) (Dmu) and Percha Formation (Dp), Steamboat Mountain.

Formation, or the aphanitic dolomite unit of the Martin, underlie the upper unit (restricted) in the study area. Fossils are relatively abundant in the upper unit (restricted) with crinoids and brachiopods dominating, and corals locally abundant. Species of Hexagonaria, Pachyphyllum, and Atrypa from this unit were originally used to assign a Late Frasnian age to the upper Martin Formation (Teichert, 1965). For a review of the stratigraphic nomenclature, lithology, thickness, and areal extent of the Martin Formation, see Pye (1959), Teichert (1965), Pine (1968), and Wright (1964).

#### Percha Formation

The Percha Formation consists of two informal members: a slope-forming shale member and an overlying ledge-forming carbonate member (Schumacher and others, 1976). Figures 3 and 4 show the slope-forming topographic expression of the Percha Formation between the cliff-forming Mississippian Escabrosa Limestone and the Martin Formation. Locally the basal beds of the shale member contain a lag deposit that consists of coarse sand, quartz pebbles, fish bones and teeth, phosphatic material of unknown origin, abundant conodonts, and Gluteus minimus (Davis and Semken, 1975) in a hematite matrix or weakly cemented by dolomite. Where present, these basal beds grade upward into the shale member. The shale is unfossiliferous. Pine (1968) states that quartz and an illite-like clay are the most common minerals in the shale. The shale member grades upward into thin bedded calcareous and dolomitic siltstones and finally into the more massive limestones and dolomites of the carbonate member. The carbonate member is replete with fossils with crinoids,



Figure 4. Martin (Dm) and Percha (Dp) Formation, Brandenburg Mountain.

bryozoans, and brachiopods dominating. A sponge, Ensiferites, previously known only from the Middle Devonian of New York, is common in this unit (Sally Meader, personal communication, 1976). A middle to late Famennian age can be assigned to these beds based on the presence of the rhynchonellid brachiopods Paurorhyncha endlichi (Meek) and P. cooperi Stainbrook (Sartenaer, 1967).

The basal lag deposit or shale member of the Percha disconformably overlies the limestones and dolomites of the upper unit (restricted) of the Martin at all localities except Saddle Mountain (Fig. A.7), where the Percha overlies quartzites of the Cambrian Abrigo Formation. The Percha is overlain disconformably by the cliff-forming Mississippian Escabrosa Limestone. The uppermost beds of the carbonate member of the Percha are fossiliferous light-gray limestones and dolomites that resemble the basal beds of the Escabrosa. At Saddle Mountain and Steamboat Mountain, a thin sand unit is present at the base of the Escabrosa and the contact can be fairly precisely placed based on both lithologic and paleontologic evidence. At Holy Joe Peak, a 15 foot (4.5 m) thick sandstone bed marks the base of the Escabrosa. In the absence of this sandstone, the location of the contact is somewhat subjective.

Famennian strata of the Percha Formation are present throughout the study area and range to the north at least as far as Salt River Canyon (shale member present) and west as far as Roosevelt Dam. The shale member of the Percha extends to the south of Holy Joe Peak, and Famennian strata have been reported at Peppersauce Wash (Stoyanow, 1936)

and as far south as Bisbee (Ethington, 1965; Stainbrook, 1947). The Percha Formation reaches its maximum thickness of over 240 feet (75 m) in the northern Galiuro Mountains in the middle of the present study area.

## CONODONT BIOSTRATIGRAPHY

### Martin Formation

#### The Lower and Upper Palmatolepis gigas Zones

In the present study, two of the standard Frasnian conodont zones are recognized in the upper unit (restricted) of the Martin Formation: the Lower and Upper Palmatolepis gigas Zones (Fig. 2).

The Lower P. gigas Zone is defined by the joint occurrence of Palmatolepis gigas, P. foliacea, and Ancyrognathus triangularis (Klapper and others, 1971). This zone is present at the Van Winkle Ranch section (Fig. A.4) and at the Steamboat Mountain section (Fig. A.6).

The Upper P. gigas Zone is defined by the joint occurrence of P. gigas and Ancyrognathus asymmetricus before the first occurrence of Palmatolepis linguiformis (Klapper and others, 1971). This zone is present at the Van Winkle Ranch section, the Steamboat Mountain section, and the Holy Joe Peak section (Figs. A.4, A.6, and A.11). The entrance of P. linguiformis defines the Uppermost P. gigas Zone (Klapper and others, 1971). No specimens of P. linguiformis were found in this study.

P. gigas also occurs in the sections at Globe Hills and Job Corps Camp (Figs. A.1 and A.3), but these sections lacked other diagnostic species necessary for more precise assignment.

The sample from Holy Joe Peak (Fig. A.11) that yielded an Upper P. gigas Zone fauna, is mixed with an older Frasnian fauna because Palmatolepis transitans is present in abundance. In addition, an abundant

Lower Ordovician fauna was found in this sample. Scolopodus, Drepanodus and Acontiodus dominated this assemblage.

Eight Martin Formation upper unit (restricted) sections yielded Frasnian conodonts. In two sections (Van Winkle Ranch and Steamboat Mountain, Figs. Z.4 and A.6), the Lower and Upper P. gigas Zones could be recognized. At one section (Holy Joe Peak, Fig. A.11), only the Upper P. gigas Zone could be recognized. At four sections (Job Corps Camp, Globe Hills, Highway 77, and Pinal Creek, Figs. A.1, A.2, A.3 and A.5), the P. gigas Zone could be recognized. At Peppersauce Wash (Fig. A.10), only a Middle to Late Frasnian age could be assigned due to the absence of diagnostic palmatolepids.

In his study of the Martin, Ethington (1965) illustrated a specimen of Polygnathus asymmetricus ovalis from Superior, Arizona. Although no specimens of P. asymmetricus were found in this study, strata assignable to older Frasnian conodont zones are probably present in the study area. The Polygnathus asymmetricus Zone is present at Superior (Ethington, 1965), which is just to the west of the present study area. The presence of Palmatolepis transitans transitional to P. punctata, P. proversa, stratigraphically beneath P. gigas also indicates that older Frasnian strata, probably assignable to the Ancyrognathus triangularis Zone, are present in the study area. One specimen assigned to A. triangularis was found with P. gigas at the Van Winkle Ranch section.

A number of formations in North America have been assigned to the Lower and Upper P. gigas Zones and therefore are equivalent to the upper unit (restricted) of the Martin in the study area. Equivalent units

include: parts of the Pilot Shale and Devils Gate Limestone of Nevada and Utah (Clark and Ethington, 1967), part of the Sweetland Creek Shale of Iowa (Miller and Youngquist, 1947), the lower part of the Kettle Point Shale of Ontario (Winder, 1966), the Cerro Gordo Member of the Lime Creek Formation in Iowa (Anderson, 1966), the Amana beds of Iowa (Youngquist, 1945), the Independence Shale of Iowa (Müller and Müller, 1957), the Olentangy Shale of Ohio (Stauffer, 1938), part of the "Kenwood" Shale of Wisconsin (Schumacher, 1971), and formations of the Cohocton stage of New York (Angola Shale Member and West Hill Members of the West Falls Formation and Nunda Sandstone Member of the New Milford Formation) (Oliver and others, 1967).

#### Percha Formation

Three local conodont zones are recognized in the Percha Formation in this study. These zones, along with the ranges of the diagnostic species, are shown in Figure 5. Zones will be discussed in ascending stratigraphic order.

#### Palmatolepis distorta Zone

The limits of the Palmatolepis distorta Zone are defined by the range of P. distorta to just below the first occurrence of either Palmatolepis rugosa (any subspecies) or Polygnathus semicostatus. Associated species are Palmatolepis glabra, Polylophodonta confluens, Polylophodonta concentrica, Palmatolepis perlobata and Polygnathus perplexa.

This zone occurs in the basal lag deposit of the Percha at both Highway 77 and Holy Joe Peak (Figs. A.5 and A.11).

UPPER DEVONIAN			L. MISSISSIPPIAN	SERIES
FAMENNIAN			KINDERHOOKIAN	STAGE
PERCHA			ESCABROSA	FORMATION
<i>Palmatolepis distorta</i> Zone	<i>Palmatolepis rugosa</i> <i>Polygnathus semicostatus</i> Zone	<i>Polygnathus communis</i> Zone		CONODONT ZONE CONODONTS
				<i>Pa. distorta</i>
				<i>Pa. glabra</i> , (any subspecies)
				<i>Polylophadonta</i> sp.
				<i>Pa. perlobata</i>
				<i>Po. perplexa</i>
				<i>Pa. rugosa rugosa</i>
				<i>Pa. semicostatus</i>
				<i>Pa. rugosa postera</i>
				<i>Po. homoirregularis</i>
				<i>Bi. stabilis</i>
				<i>Po. communis</i>
				<i>Pelekysgnathus</i>
				<i>Siphonodella</i> sp.

Po.= Polygnathus  
Pa.= Palmatolepis  
Bi = Bispathodus

Figure 5. Percha Formation Conodont Zones and Ranges of Diagnostic Species.

The presence of Palmatolepis distorta and Polygnathus perplexa in this local zone suggests correlation with the Upper Scaphignathus velifer Zone and the Scaphignathus subserratus-Pelekysgnathus inclinatus Fauna (Fig. 2). In Europe, the S. velifer Zone is defined on the first occurrence of S. velifer (Ziegler, 1971). A conodont fauna in North America, which may be correlated with the upper half of the S. velifer Zone, is characterized by the first occurrence of Scaphignathus subserratus, Pelekysgnathus inclinatus, Polygnathus perplexa, and Polygnathus homoirregularis and the highest occurrence of Palmatolepis distorta and Palmatolepis glabra elongata (Klapper and others, 1971). The equivalent fauna in this study is characterized by the first occurrence of Polygnathus perplexa and the only occurrence of Palmatolepis distorta and Palmatolepis glabra. Conodonts of the underlying Palmatolepis gigas Zone were also found admixed with the Famennian conodonts at both localities.

Strata equivalent to the basal lag deposit of the Percha (Scaphignathus subserratus-Pelekysgnathus inclinatus Fauna) include the Maple Mill Shale in southeastern Iowa (Thomas, 1949; Beinert, 1968), the top bed of the Trident Member of the Three Forks Formation (Sandberg and Klapper, 1967) in southwestern Montana (Klapper and others, 1971), the top of the Beirdneau Formation in Utah (Klapper and others, 1971), part of the Saverton Formation of Missouri (Collinson and others, 1967), and part of the Pinyon Peak Limestone in Utah (Clark and Ethington, 1967).

#### Palmatolepis rugosa-Polygnathus semicostatus Zone

The limits of the Palmatolepis rugosa-Polygnathus semicostatus Zone are defined by either the range of P. rugosa (any subspecies) or

the range of P. semicostatus before the first occurrence of Polygnathus communis. Associated species are Palmatolepis perlobata, Polygnathus perplexa, Polygnathus homoirregularis, and Bispathodus stabilis.

This zone is present in the lower and middle parts of the carbonate member of the Percha at Saddle Mountain, Brandenburg Mountain 1, Brandenburg Mountain 2, and Steamboat Mountain (Figs. A.6, A.7, A.8, and A.9). A rhynchonellid brachiopod fauna, including Paurorhyncha endlichi and P. cooperi, is associated with the conodonts of this zone at all four sections. A single specimen provisionally assigned to P. semicostatus was found near the top of the Peppersauce Wash section (Fig. A.10).

The conodonts of the Palmatolepis rugosa-Polygnathus semicostatus Zone are assigned to the standard Upper Polygnathus styriacus Zone. The conodonts found in this local zone include Polygnathus semicostatus, Polygnathus perplexa, Polygnathus homoirregularis, Palmatolepis rugosa rugosa, Palmatolepis rugosa postera (strong lobe), Palmatolepis rugosa postera (weak lobe), Palmatolepis rugosa postera (no lobe), and Bispathodus stabilis. This list compares favorably with the faunal lists compiled by Sandberg and Klapper for both the Upper P. styriacus Zone and the lower part of the Bispathodus costatus Zone (Klapper and others, 1971). Klapper and others (1971) state that the diagnostic characteristic of the Upper P. styriacus Zone in North America is the presence of Clydagnathus ormistoni and the absence of Bispathodus aculeatus and Bispathodus costatus costatus. B. aculeatus and B. costatus costatus are indeed absent, but so is C. ormistoni.

The necessary conodont zonal indicators may be found in future studies, but based on Upper P. styriacus Zone conodonts found in the Box Member of the Percha Shale in New Mexico (Sandberg, 1976) and brachiopod evidence, the carbonate member of the Percha Formation (Palmatolepis rugosa-Polygnathus semicostatus Zone) is assigned to the Upper P. styriacus Zone. Rhynchonellid brachiopods of the genus Paurorhyncha have been found by Sandberg (1975, 1976) in strata containing P. styriacus Zone conodonts throughout the western United States. Rhynchonellid brachiopods of this genus have also been found by Stainbrook (1947) in the Percha Formation of New Mexico and Arizona, by Stoyanow (1936) at Pinal Creek, Peppersauce Wash, and Arivaipa Canyon, and by Meader (n.d.) in the carbonate member of the Percha at Saddle Mountain, Steamboat Mountain, Brandenburg Mountain 1, Brandenburg Mountain 2, and Holy Joe Peak sections of this study. The shale member of the Percha is bracketed between the upper part of the S. velifer Zone and the Upper P. styriacus Zone.

Upper Polygnathus styriacus Zone faunas have been reported by Sandberg (1976) from a variety of stratigraphic units in the western United States. Equivalent of the carbonate member of the Percha Formation include: part of the Box Member of the Percha Formation in New Mexico, the Ouray Limestone in Colorado, the lower part of the Crystal Pass Limestone Member of the Sultan Limestone in southern Nevada, the middle part of the Pilot Shale in Nevada and Utah, part of the Slaven Chert in central Nevada, the Mowitza Shale in Utah, part of the Pinyon Peak Limestone in Utah, the basal beds of the Leatham Formation in

northern Utah, the middle part of the Chaffee Group in Colorado, the basal bed of the Cottonwood Canyon Member of the Madison Limestone in Colorado, the lower black shales of the Sappington Member of the Three Forks Formation in Montana, and the lower black shale of the Exshaw Formation in Montana (Sandberg, 1976).

#### Polygnathus communis Zone

The Polygnathus communis Zone is defined by the first occurrence of P. communis to the first occurrence of the Mississippian species, Siphonodella isosticha. Associated with P. communis is Bispathodus stabilis and Pelekysgnathus.

This zone is present at Brandenburg Mountain 1 and Brandenburg Mountain 2 (Figs. A.8 and A.9) in the upper part of the carbonate member of the Percha Formation. This zone includes a maximum of 15 feet (4.5 m) of strata and occurs above the rhynchonellid brachiopod fauna associated with the P. rugosa-P. semicostatus Zone.

The P. communis Zone is probably post Upper P. styriacus Zone (possibly B. costatus Zone ?) because it occurs stratigraphically above the rhynchonellid brachiopod fauna and does not include any Upper P. styriacus Zone conodonts. Too few index taxa were found for more precise assignment.

## CONODONT BIOFACIES AND PALEOECOLOGY

For almost as long as conodonts have been studied it has been noted that the same species have not been equally distributed in rocks of the same age. In the Upper Devonian, Palmatolepis and Icriodus dominated assemblages have been recognized for some time. Recently, more and more workers (Seddon, 1970; Seddon and Sweet, 1971; Druce, 1973; Sandberg, 1976; Schumacher, 1976) have attempted to investigate the geologic or ecologic factors responsible for this unequal distribution. In this study recurring conodont associations were observed in both the Martin and Percha Formations.

### Martin Formation

Seddon (1970) showed that two distinct conodont biofacies are present in the lower Upper Devonian rocks of the Canning Basin of Australia: the Palmatolepis biofacies, confined to the basinal area, and the Icriodus biofacies found near reefs. Most of the elements of the Icriodus biofacies could be found in the Palmatolepis biofacies, but species dominating the Palmatolepis biofacies were not present in the Icriodus biofacies. Druce's (1973) observations in the Bonaparte Gulf Basin of northern Australia agreed with Seddon's and, in addition, Druce added a third biofacies, the Belodella biofacies, from the very shallow water, near-reef facies.

Seddon and Sweet (1971) proposed a general ecologic model for conodonts that suggests they were small planktonic animals, perhaps like

modern chaetognaths, with different species living at different depths. According to this model, conodonts of the Polygnathus-Icriodus biofacies are confined to a zone near the surface of the ocean and the Palmatolepis-Ancyrodella biofacies is confined to a deeper zone some meters below the surface. This depth-zonation model of Seddon and Sweet's (1971) offers a simple explanation that is consistent with most of the observations of Seddon (1970) and Druce (1973).

The conodont distribution in the Martin Formation generally agrees with the depth stratification model of Seddon and Sweet (1971). The Palmatolepis biofacies is generally found in deeper water facies but the distribution of Ancyrodella seems to be more restricted (Fig. 6). Polygnathus was by far the most abundant platform element found in this study as well as in Ethington's (1965) study. Abundant Polygnathus were found both with (Van Winkle Ranch) and without (Globe Hills and Pinal Creek) abundant Palmatolepis. This distribution is in agreement with the Seddon and Sweet (1971) model.

One significant difference between the Martin faunas found in this study and other Upper Devonian conodont faunas is the absence of an Icriodus biofacies. Out of more than 3000 conodonts studied, fewer than 30 are Icriodus. As suggested by Schumacher (1976), this would seem to indicate that although Polygnathus (narrow platform) and Icriodus both may have inhabited shallow water they both do not necessarily belong to the same biofacies.

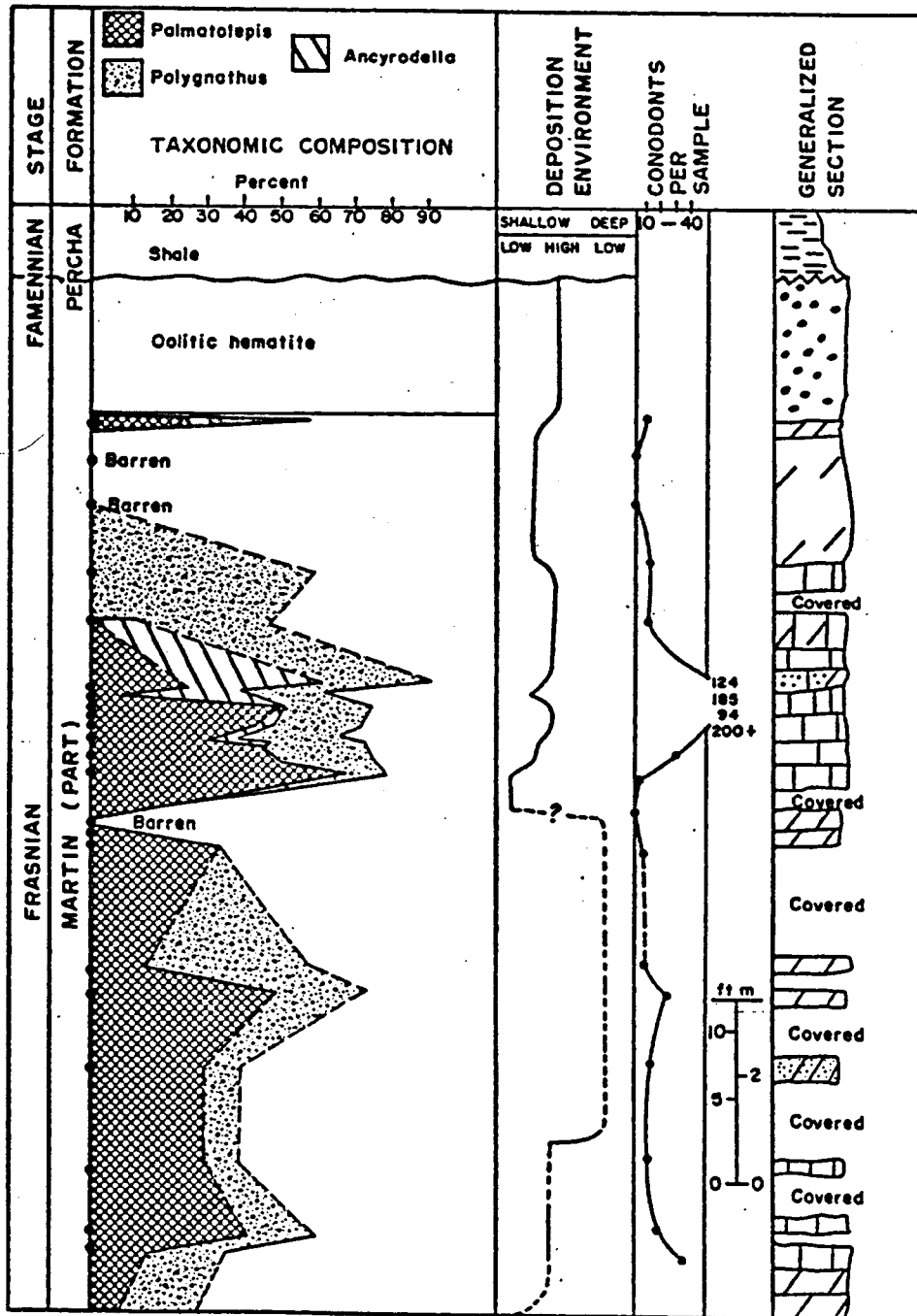


Figure 6. Martin Formation Conodont Distribution at Van Winkle Ranch.

### Percha Formation

Druce (1973) reports three biofacies in the Famennian: 1) Biofacies I, simple cones (Acodina), found in the shallowest facies, 2) Biofacies II, Icriodus, Pelekysgnathus, Spathognathodus, and Scaphignathus, found in facies interpreted to represent waters less than 50 meters in depth, and 3) Biofacies III, Palmatolepis, Polygnathus, and Polylophodonta, found in deep water facies. Sandberg (1975, 1976) recognizes five conodont biofacies in the Upper Polygnathus styriacus Zone of western North America: 1) a palmatolepid-bispathodid biofacies deposited on the continental slope, 2) a palmatolepid-polygnathid biofacies deposited on the continental shelf, 3) a polygnathid-icriodid biofacies of the outer cratonic platform, 4) a polygnathid-pelekysgnathid biofacies of the inner craton, and 5) a clydagnathid biofacies deposited on offshore banks and in lagoons.

No specimens of Acodina or Clydagnathus were recognized in this study. Only one specimen of Icriodus, one Pelekysgnathus and four Bispathodus were found in the course of this study.

In the study area, two biofacies can be recognized: a Polygnathus-n (n = narrow platform) biofacies and a Palmatolepis-Polygnathus-w (w = wide platform) biofacies. Polygnathus-n includes primarily P. semicostatus and P. communis. Polygnathus-w includes polygnathids of the P. nodocostatus group. Figure 7 shows the distribution of these genera for the Saddle Mountain and Brandenburg Mountain 1 sections.

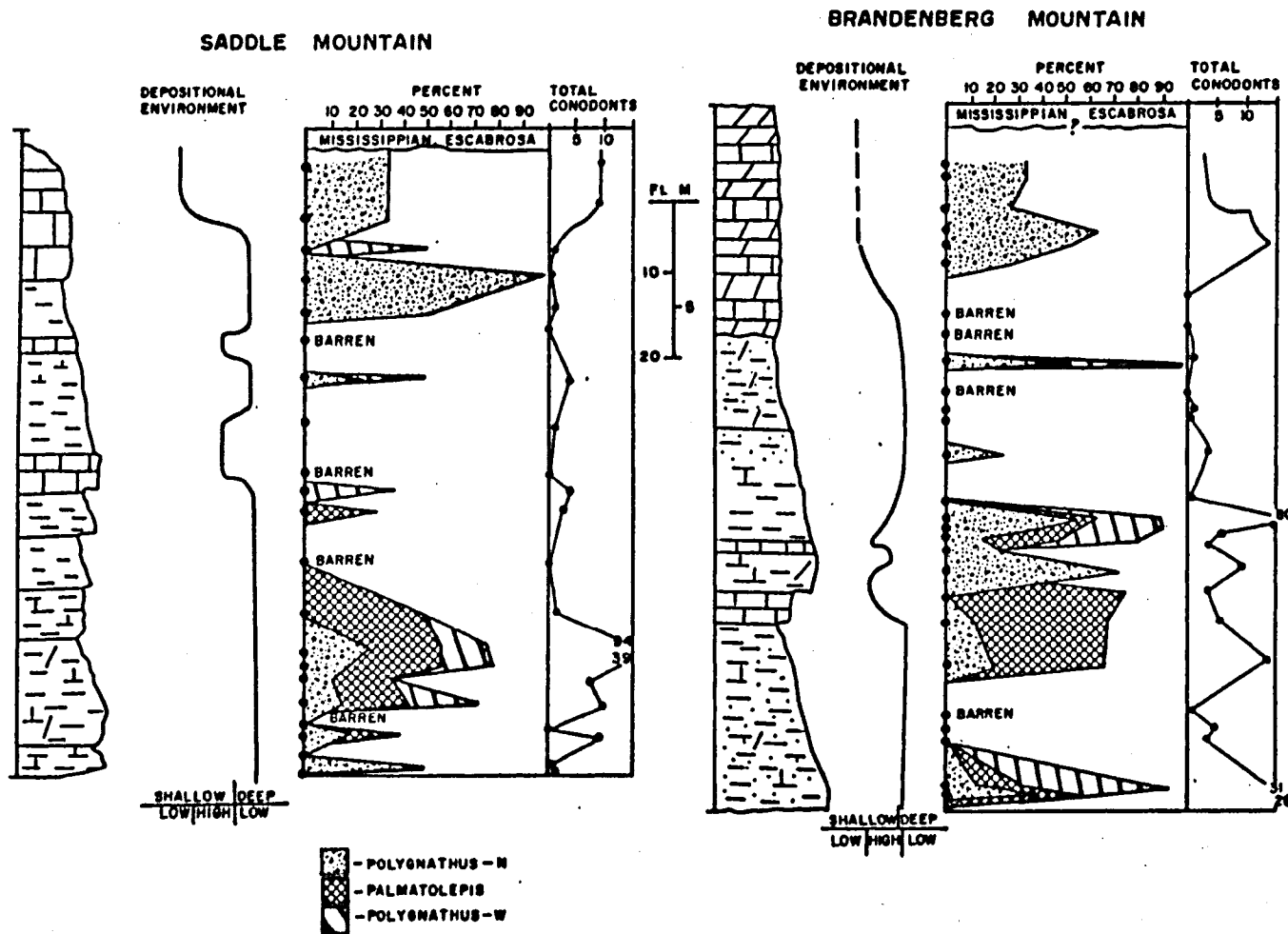


Figure 7. Percha Formation Conodont Distribution at Saddle Mountain and Brandenburg Mountain 1.

The Polygnathus-n biofacies is present wherever conodonts are found. This distribution agrees with the Seddon and Sweet (1971) depth stratification model. However, in the Percha as well as in the Martin, neither abundant Icriodus nor Pelekysgnathus were present, indicating that although Polygnathus may inhabit shallow water it doesn't have to be associated with Icriodus or Pelekysgnathus. Neither Druce (1973) nor Sandberg (1975, 1976) recognize a biofacies dominated solely by narrow platform polygnathids.

The Palmatolepis-Polygnathus-w biofacies is generally present in environments interpreted as representing deeper water which fits the Seddon and Sweet (1971) model. This biofacies compares favorably with Sandberg's palmatolepid-polygnathid biofacies and with Druce's Biofacies III. Sandberg (1976) found this biofacies in shallow to moderately deep water deposits on the continental shelf, but recovered most of the conodonts from lag deposits. In this study, the faunas came from mudstones and grainstones.

Although not part of this study, samples from two other localities bear mention here. One reconnaissance sample from a sandstone unit in the Percha at Salt River Canyon yielded a Pelekysgnathus and Polygnathus-n dominated fauna. Several well washed grainstone samples from the Upper Devonian Portal Formation at Blue Mountain in southeastern Arizona yielded an Icriodus and Polygnathus-n dominated fauna. The Pelekysgnathus-Polygnathus-n fauna belongs to Sandberg's polygnathid-pelekysgnathid biofacies and possibly to Druce's Biofacies II. The Icriodus-Polygnathus-n fauna belongs to Sandberg's polygnathid-icriodid biofacies and possibly to Druce's Biofacies II.

Apparently there are at least four distinct but contemporaneous biofacies in Famennian age strata of the Percha and Portal Formations of southeastern Arizona. If depth stratification were a major factor in species distribution it would seem that we should find Icriodus and Pelekysgnathus in greater abundance in deeper water facies. The presence of Icriodus and Pelekysgnathus in some abundance in deposits interpreted as near-shore facies indicates that proximity to shore is an important factor in conodont distribution (as suggested by Druce, 1973, and Schumacher, 1976).

#### Conclusions

For both the Martin and Percha Formations, the Seddon and Sweet (1971) depth stratification model generally holds true with a few exceptions. In the Martin Formation Ancyrodeella appears to be restricted by other factors than just depth. In both the Martin and Percha Formations an abundance of narrow platform Polygnathus with few or no Icriodus would indicate that even if these two genera both inhabited shallow water they do not necessarily belong to the same biofacies. The distribution of wide platform polygnathids in the Percha is closely tied to the distribution of Palmatolepis and both occur in deeper water facies. The distribution of Palmatolepis for both the Martin and Percha generally fits the ecologic model of Seddon and Sweet (1971).

## FRASNIAN-FAMENNIAN BOUNDARY

This study offers a unique opportunity for the examination of one of the most interesting boundaries in the geologic column--the Frasnian-Famennian boundary. This boundary has been discussed in the past with emphasis usually placed on the vast extinctions which took place at this time. McLaren (1970) suggested that a catastrophe caused the Frasnian-Famennian extinctions and observed that conodonts, ammonoids, fish, plants, and many molluscs pass through the Frasnian-Famennian boundary unaffected. Johnson (1974) suggested that relatively rapid regressions after prolonged periods of submergence caused the extinctions at the end of the Ordovician, Frasnian, and Permian. However, Johnson observes that in many places in the western United States, a Frasnian-Famennian unconformity is not obvious. In the midwestern United States, strata of early Frasnian to Kinderhookian age are present without an apparent break (Ham and Wilson, 1967). The documentation of widespread Famennian strata (of the Percha Formation), in most cases directly overlying late Frasnian strata (of the Martin Formation), permits the examination of the Frasnian-Famennian boundary in the study area.

In southern Arizona, the Frasnian-Famennian boundary is clearly an unconformity. The best place to examine the unconformity is the section at Highway 77 (Figs. 8 and 9). The top of the Martin here is a lag deposit consisting of a 3-4 foot (1-1.2 m) sequence of thinly bedded dolomitic siltstone and sandstone with minor shale interbeds. Figure 9 shows the massive yellow dolomite overlain by the thin bedded lag deposit.





Figure 9. Basal Beds of Percha Formation, Highway 77.

The lag deposit contains a mixed conodont fauna with Palmatolepis gigas Zone conodonts (Frasnian) admixed with abundant conodonts characteristic of the upper part of the Scaphignathus velifer Zone or the Scaphignathus subserratus-Pelekysgnathus inclinatus Fauna (Famennian -- see discussion of P. distorta Zone, p. 19). These beds also contain abundant fish bones and teeth, phosphatic pellets (possibly some fecal pellets), the phosphatic fossil Gluteus minimus (discussed elsewhere in this thesis), abraded specimens of Atrypa and Coenites, arthropod trails, residual chert, and sand to pebble sized quartz grains. All elements in this unit show evidence of reworking, sorting, and winnowing. Many conodonts are highly abraded or broken. The best preserved conodonts are large robust forms. One palmatolepid is 4mm long and much of the posterior tip is missing. I believe this deposit to be a concentrated transgressive lag similar to those described by Twenhofel (1936), McGugan (1965), Sandberg and Klapper (1967), and Sandberg (1969). Concentrated lag deposits are characterized by basal conglomerates, basal black shales, concretions, residual chert, glauconite, phosphatic pellets or nodules, manganiferous zones, pyritiferous zones, iron oxides, fish bones and teeth, and fossils from different biostratigraphic zones (McGugan, 1965). The Highway 77 lag deposit has many of these features and clearly represents a time of very slow sediment accumulation during a Famennian transgression over a mostly Martin (Frasnian) surface.

At Holy Joe Peak and Brandenburg Mountain 1 and 2 (Fig. 8), a 1-4 inch (2-10 cm) hematite "crust" or "pavement" (Fig. 10) is present at the same stratigraphic horizon as the Highway 77 lag deposit. Abundant



Figure 10. Basal Beds of Percha Formation, Brandenburg Mountain.

fish bones and teeth, quartz granules and pebbles, sand lenses, rare external molds of Gluteus minimus, and conodonts in the hematite suggest that this unit also represents a time of very slow sediment accumulation. This pavement is included within the basal beds of the Percha, and based on P. distorta, Polylophodonta, and Gluteus minimus found at Holy Joe Peak, is the same age as the Highway 77 lag. The top of the Martin at Holy Joe Peak is a sandy, fish bone-rich dolomite unit directly beneath the hematite pavement. Five conodont samples were taken at Holy Joe Peak: one from the fish bone bed 6 inches (15 cm) below the hematite pavement; one from a channel-like deposit about 1 foot (30 cm) below the hematite; and three lower in the dolomite unit (Fig. A.11). The hematite pavement was examined for conodonts in the field. The fish bone bed yielded abundant conodonts of both Late Frasnian (Upper Palmatolepis gigas Zone) and Early Ordovician age. This bed may represent a regressive lag which was not eroded away during the hiatus separating the Martin and Percha. The bed contains a mixed conodont fauna from at least one Ordovician Zone and from at least two Upper Devonian Zones (P. gigas and probably Ancyrognathus triangularis, see discussion on Martin conodont zones, p. 17). The channel deposit yielded a sparse mixed Devonian and Ordovician conodont fauna. The three samples lower in the section were devoid of conodonts but the sample 31 feet (9.5 m) below the hematite yielded fish bone fragments. Krieger (1968a) mapped these dolomite beds as part of the "Upper (brown sandy) Member" of the Cambrian Abrigo Formation. Based on conodonts, fish bones, and gross lithology, these beds are now assigned to the Devonian Martin Formation.

At Saddle Mountain, Frasnian strata are absent (Fig. 8). At Steamboat Mountain, the boundary is placed at the base of the shale member of the Percha. At Pinal Creek and Globe Hills (not figured), the shale unit of the Percha overlies Atrypa and/or Palmatolepis gigas-bearing carbonates of the Martin Formation.

At the Van Winkle Ranch and Job Corps Camp sections, the shale member of the Percha overlies an oolitic hematite unit. At Van Winkle Ranch, the oolitic hematite overlies a yellow coral-stromatolite dolomite which contains P. gigas Zone conodonts, Coenites, Pachyphyllum, and Hexagonaria. The corals appear to represent a small patch reef. It is tempting to correlate the oolitic hematite with the hematite pavement located to the south, but, since hematite oolites are found mixed with fossil debris in underlying beds and some fossils from underlying beds are replaced by hematite, the oolitic bed appears to be more closely associated with the Martin than the overlying shale member of the Percha. Thus, the Frasnian-Famennian boundary is placed at the top of the oolitic hematite.

The oolites probably formed in tidal bores between or among patch reefs in shallow water (Newell, Purdy and Imbrie, 1960). The formation of the hematite oolites is a complex problem in itself and will not be discussed here.

In summary, the evidence suggests that before the end of P. gigas time the sea regressed from the study area, probably to the east. After the regression, erosion took place during Palmatolepis triangularis through Scaphignathus velifer time or at least through Palmatolepis

marginifera time. Then a Percha transgression began over an older, mostly Martin surface of fairly low topographic relief. The Highway 77 lag and the hematite pavement were deposited at this time. The seas regressed to the east or southeast during the Frasnian and advanced again from the east or southeast to the west or northwest during the Famennian.

I feel that the Frasnian-Famennian boundary beds in the study area show the regression-transgression which Johnson (1971, 1974) discussed. The regression was probably rapid because P. gigas Zone strata underlies the Percha Formation at all sections except one (Saddle Mountain). The regression may have been fast enough to cause large-scale extinctions.

GLUTEUS MINIMUS (Davis and Semken, 1975)

Specimens of the enigmatic phosphatic fossil, Gluteus minimus (Davis and Semken, 1975), colloquially known as "horse collars", were found in the basal beds of the Percha Formation along Highway 77 (Fig. A.5). External molds of this fossil were also found at Brandenburg Mountain 2 and Holy Joe Peak (Figs. A.1 and A.11) at the same stratigraphic horizon in the hematite crust.

This fossil of unknown biological affinities was recently described by Davis and Semken (1975), and the Arizona occurrence documented here is the only report of this fossil outside Iowa (R. Davis, personal communication, 1975). Twelve complete and hundred of broken fragments of "horse collars" have been examined. All specimens are asymmetrical, bilobate, and consist of a smooth side and a side displaying concentric growth rings. All appear to be phosphatic, although some appear to be in the process of being replaced by an unknown substance. Most are broken and/or abraded and show signs of having been transported and sorted. All specimens generally resemble the holotype of Gluteus minimus, but are smaller. One larger fragment more closely resembles the holotype than any of the smaller complete specimens.

The Iowa occurrence of "horse collars" is in the Upper Devonian Maple Mill Shale. Beinert (1968) notes that the conodonts in the Maple Mill are reworked and the assemblage is a mixed one including specimens from six conodont zones (Palmatolepis triangularis Zone to Polygnathus

styriacus Zone). However, Klapper (in Davis and Semken, 1975) believes that the Maple Mill Shale belongs in the upper half of the Scaphignathus velifer Zone and that the reworking is less than one conodont zone in length. It is interesting that the Maple Mill Shale is of the same age and is also a concentrated deposit similar to the beds from which Gluteus minimus is obtained in Arizona.

If one combines the ranges of the conodonts associated with "horse collars" from the Iowa and Arizona localities, we find that they could range from the Palmatolepis gigas Zone to the Polygnathus styriacus Zone. I feel that it is unlikely that "horse collars" lived during P. gigas or P. triangularis time because no "horse collars" have been reported in the well preserved faunas of these zones throughout the Midwest. None were found in the P. gigas Zone faunas of this study. Also, Sandberg has not reported "horse collars" associated with the widespread P. styriacus Zone, conodont faunas in the western United States. It is therefore suggested that Gluteus minimus is a Famennian fossil that probably lived during the Scaphignathus velifer Zone.

No attempt is made here to discern the biological affinities of Gluteus minimus, and detailed morphologic and compositional analysis of the Arizona forms of this fossil are left for future studies.

## CONCLUSIONS

1. The age of Teichert's (1965) upper unit (restricted) of the Martin Formation in the study area is Middle to Late Frasnian. The age of the Percha Formation in the study area is Late Famennian.
2. Two conodont zones are recognizable in the upper unit (restricted) of the Martin Formation: the Lower and Upper Palmatolepis gigas Zones. Three local conodont zones are recognizable in the Percha Formation: the Palmatolepis distorta Zone, the Palmatolepis rugosa-Polygnathus semicostatus Zone, and the Polygnathus communis Zone. The P. distorta Zone can be correlated with the upper part of the standard Scaphignathus velifer Zone or the Pelekysgnathus inclinatus-Scaphignathus subserratus Fauna. The P. rugosa-P. semicostatus Zone can be correlated with the standard Upper Polygnathus styriacus Zone. The P. communis Zone is probably post P. styriacus Zone.
3. Widespread Famennian strata are documented for the first time in Arizona. Famennian age strata extend from at least Salt River Canyon on the north to Bisbee on the south and Roosevelt Dam on the west to the Clifton-Morenci area on the east.
4. The distribution of Palmatolepis and Polygnathus in both the Martin and Percha Formations generally fits the depth stratification model of Seddon and Sweet (1971). The distribution of

Ancyrodella does not. An Icriodus biofacies was not found in either the Martin or the Percha Formation. The ubiquitous distribution of Polygnathus (narrow platform) in both the Martin and Percha indicates that although Polygnathus may have inhabited shallow water, it is not necessarily part of the Icriodus biofacies.

5. A hiatus spanning as many as twelve of the standard conodont zones separates the Frasnian (Martin Formation) and the Famennian (Percha Formation) in southern Arizona.
6. The phosphatic microfossil, Gluteus minimus, is present in the basal beds of the Percha Formation. This is the first report of this fossil outside Iowa.

## SYSTEMATIC PALEONTOLOGY

Two methods of conodont taxonomy are in use today. Form species taxonomy, based on the morphology of individual elements, was established by Pander (1856). Multielement taxonomy, based on naturally occurring assemblages, was established by Hinde (1879). Until recently, most conodont workers have used the form species taxonomy. However, with more complete study, multielement taxonomy has gained wide acceptance. Consequently, a dual nomenclature now exists for conodont taxonomy--form species and multielement. The generic concept in conodont taxonomy has recently been discussed by Sweet and Bergstrom (1970), and Huddle (1972).

Although Devonian multielement taxa have been established (Klapper and Phillip, 1971, 1972), most Devonian conodont workers have used form species taxonomy. The standard Devonian conodont zones are based on form species not multielement taxa. The conodont faunas recovered in this study were of relatively low abundance and diversity and did not lend themselves to the use of multielement taxonomy. Therefore, I have chosen to use form species taxonomy.

Since most of the bar and blade taxa in the Upper Devonian have little biostratigraphic value and are seldom illustrated in publications, only the platform species are described in this study. The genera are listed alphabetically and the synonymies are limited to the original citation, the most recent reference with a complete synonymy, and any

new additions. Descriptions of better known species are abbreviated. The total number of specimens studied is listed under "material". The stratigraphic distribution of important species is shown in Appendix A. Figured specimens are repositied in the Paleontology collection of the Department of Geosciences, The University of Arizona, numbers UA 52900-52994.

Figure 11. Ancyrodella, Ancyrognathus, Icriodus.

All specimens from the Martin Formation except nos. 8-9 which are from the Percha Formation.

1-3--Ancyrodella buckeyensis Stauffer: 1, oblique view of UA52900, x 37; 2, top view of UA52901, x 36; 3, oblique view of UA52902, x 36.

4-7--Ancyrodella curvata (Branson and Mehl): 4, top view of UA52903, x 36; 5, top view of UA52904, x 35; 6, 7, aboral views of UA52903 and UA52905 respectively, x 28.

8--Ancyrodella sp.: 8, aboral view of UA52906, x 35.

9-12--Ancyrognathus asymmetricus (Ulrich and Bassler): 9, top view of UA52907, x 35; 10, top view of UA52908, x 45; 11, top view of UA52909, x 45; 12, top view of UA52910, x 46.

13, 17--Ancyrognathus triangularis Youngquist: 13, top view of UA52911, x 45; 17, close-up of UA52911, x 600.

14-16, 18, 19--Icriodus alternatus Branson and Mehl: 14, top view of UA52912, x 44; 15, top view of UA52913, x 44; 16, top view of UA52914; 18, top view of UA52915, x 172; 19, aboral view of UA52915, x 172.

20--Icriodus symmetricus Branson and Mehl: 20, top view of UA52916, x 46.

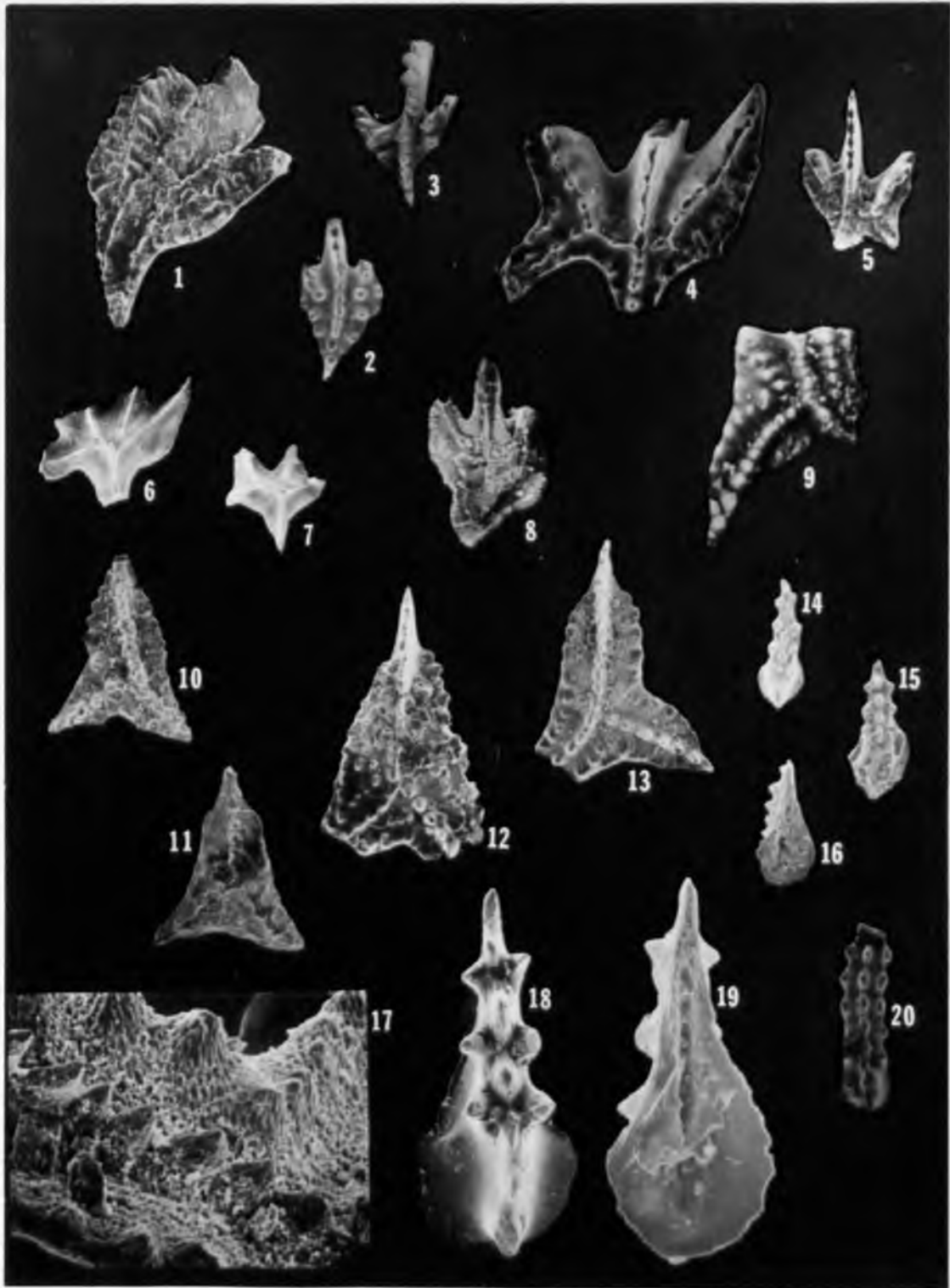


Figure 11. Ancyrodella, Ancyrognathus, Icriodus.

Genus Ancyrodella Ulrich and Bassler, 1926

Type species: A. nodosa Ulrich and Bassler, 1926

Ancyrodella buckeyensis Stauffer, 1938

Fig. 11, nos. 1-3

Ancyrodella buckeyensis Stauffer, 1938, p. 418, Pl. 52, Figs. 17, 19  
23, 24.

Ancyrodella buckeyensis Stauffer, Ethington, 1965, p. 570, Pl. 68,  
Fig. 3.

Ancyrodella buckeyensis Stauffer, Szulczewski, 1971, p. 11, Pl. 2,  
Fig. 1.

Diagnosis.--A species of Ancyrodella with a fairly short triangular platform. The platform is ornamented with nodes and ridges which run perpendicular to the edges of the platform. The posterior tip is pointed.

Remarks.--A. buckeyensis specimens found in this study displayed a wide range of variability from juvenile specimens ornamented only by nodes to mature specimens ornamented by nodes and ridges. On mature specimens ornamentation is reduced to more randomly oriented nodes with ribs normal to platform edges only partly retained.

Occurrence.--Ziegler (1971) records A. buckeyensis from the Middle P. asymmetricus Zone to the lower part of the Upper P. gigas Zone. In my study, A. buckeyensis was found in the Martin Formation at Pinal Creek, Job Corps Camp, Van Winkle Ranch, Steamboat Mountain, and Holy Joe Peak.

Material.--28 specimens.

Figured Specimens.--UA52900-UA52902 (hypotypes).

Ancyrodella curvata (Branson and Mehl), 1934

Fig. 11, nos. 4-7

Ancyrognathus curvata Branson and Mehl, 1934, p. 241, Pl. 19, Figs. 6,  
11.

Ancyrodella curvata (Branson and Mehl), Glenister and Klapper, 1966, p. 798, Pl. 86, Figs. 13-15.

Ancyrodella curvata (Branson and Mehl), Schumacher, 1971, p. 100, Pl. 12, Figs. 4-6.

Ancyrodella curvata (Branson and Mehl), Szulczewski, 1971, p. 11, Pl. 3, Fig. 5; Plt. 4, Figs. 4-5.

Diagnosis.--In this species of Ancyrodella a strongly pronounced posterolateral lobe, in addition to the normal number of lobes, has developed. This lobe bears a distinct secondary carina and keel.

Occurrence.--Ziegler (1971) records the range of A. curvata from the base of the Upper P. asymmetricus Zone to the top of the Lower P. triangularis Zone. In my study, A. curvata was present in the Martin Formation at Globe Hills, Van Winkle Ranch, and Holy Joe Peak.

Material.--29 specimens.

Figured Specimens.--UA52903-UA52905 (hypotypes).

Ancyrodella sp.  
Fig. 11, no. 8

Remarks.--Aboral view of an Ancyrodella which could be one of several species. This specimen was found in the basal beds of the Percha Formation at Highway 77 with a Palmatolepis distorta dominated fauna. It was probably reworked from the beds of the underlying Martin Formation.

Material.--1 specimen.

Figured Specimen.--UA52906.

Genus Ancyrognathus Branson and Mehl, 1934  
Type species: Ancyrognathus symmetrica Branson and Mehl, 1934

Ancyrognathus asymmetricus (Ulrich and Bassler), 1926  
Fig. 11, nos. 9-12

Palmatolepis asymmetrica Ulrich and Bassler, 1926, p. 50, Pl. 7,  
Fig. 18..

Ancyrognathus asymmetricus (Ulrich and Bassler), Glenister and Klapper,  
1966, p. 801, Pl. 87, Figs. 1-5.

Ancyrognathus asymmetricus (Ulrich and Bassler), Szulczewski, 1971,  
p. 18, Pl. 6, Figs. 6-7.

Diagnosis.--A nearly symmetrical species of Ancyrognathus.

Outer and inner margins of platform are normally concave to straight or rarely slightly convex. Carina and secondary carina are normally distinct posterior of their junction.

Occurrence.--Ziegler (1971) records A. asymmetricus only on the Upper and Uppermost P. gigas Zones. Klapper and others (1971) find A. asymmetricus in the Upper P. gigas Zone. In my study, A. asymmetricus was found in the Martin Formation at Van Winkle Ranch, Highway 77, Pinal Creek and Holy Joe Peak. One specimen assigned to A. asymmetricus was found in the basal lag deposit of the Percha Formation at Highway 77.

Material.--9 specimens.

Figured Specimens.--UA52907-UA52910 (hypotypes).

Ancyrognathus triangularis Youngquist, 1945  
Fig. 11, no. 13, 17

Ancyrognathus irregularis Branson and Mehl, 1934, p. 242, Pl. 19, Figs. 1, 2, 10 (non pl. 19, Figs. 4, 16)..

Ancyrognathus triangularis Youngquist, 1945, p. 356-357, Pl. 54, Fig. 7.

Ancyrognathus triangularis Youngquist, Glenister and Klapper, 1966,  
p. 802, Pl. 87, Figs. 10, 13.

Ancyrognathus triangularis Youngquist, Mound, 1968, p. 471-472, Pl. 65,  
Figs. 19-22..

Ancyrognathus triangularis Youngquist, Szulczewski, 1971, p. 19-20,  
Pl. 6, Figs. 3-5.

Diagnosis.--A generally triangular species of Ancyrognathus having a relatively low blade which diminishes in height toward the posterior end. Platform inner and outer edges are more or less straight or concave. The angle which is formed between the main keel on the outer (posterior) lobe and the secondary keel on the inner lateral lobe is 90 degrees or more.

Occurrence.--Ziegler (1971) records the range of A. triangularis from the base of the A. triangularis Zone to the lowest part of the Upper P. gigas Zone. Klapper and others (1971) find A. triangularis in the A. triangularis Zone and in the Lower P. gigas Zone. In my study, a single specimen assigned to A. triangularis was found at Van Winkle Ranch in the Martin Formation.

Material.--1 specimen.

Figured Specimen.--UA52911 (hypotype).

Genus Icriodus Branson and Mehl, 1938

Type species: Icriodus expansus Branson and Mehl, 1938

Icriodus alternatus Branson and Mehl, 1934

Fig. 11, nos. 14-16, 18, 19

Icriodus alternatus Branson and Mehl, 1934, p. 225-226, Pl. 13, Figs. 4-6.

Icriodus alternatus Branson and Mehl, Mound, 1968, p. 486-487, Pl. 66, Figs. 13, 15, 19, 24.

Icriodus alternatus Branson and Mehl, Szulczewski, 1971, p. 21, Pl. 7, Fig. 2.

Diagnosis.--A species of Icriodus where the denticles of the outer row alternate with the denticles of the middle row. The middle row of denticles continues posteriorly beyond the outer rows for one or two teeth.

Occurrence.--Ziegler (1962) records I. alternatus from the A. triangularis Zone to the Upper P. marginifera Zone. Ethington (1965) found I. alternatus common at Pinal Creek, but in my study I. alternatus was absent at Pinal Creek and rare elsewhere. I. alternatus was found in the Martin Formation at Van Winkle Ranch, Highway 77, Steamboat Mountain, and Globe Hills. One specimen of I. alternatus was found in the basal beds of the Percha Formation at Highway 77.

Material.--21 specimens.

Figured Specimens.--UA52912-UA52915 (hypotypes).

Icriodus symmetricus Branson and Mehl, 1934  
Fig. 11, no. 20

Icriodus symmetricus Branson and Mehl, 1934, p. 226, Pl. 13, Figs. 1-3.

Icriodus symmetricus Branson and Mehl, Glenister and Klapper, 1966,  
p. 805, Pl. 95, Figs. 4,5.

Icriodus symmetricus Branson and Mehl, Szulczewski, 1971, p. 23, Pl. 7,  
Figs. 4,5.

Diagnosis.--A slender icriodid with three rows of discrete, regularly rounded denticles with the denticles of the middle row located just opposite or slightly anterior of those in the side rows.

Occurrence.--Ziegler (1958) records I. symmetricus from the Lower P. Asymmetricus Zone to the Upper P. gigas Zone. In this study, a single specimen was found at Steamboat Mountain and several specimens were found at Holy Joe Peak in the Martin Formation.

Material.--8 specimens.

Figured Specimen.--UA52916 (hypotype).

Genus Palmatolepis Ulrich and Bassler, 1926

Type species: Palmatolepis perlobata Ulrich and Bassler, 1926

Palmatolepis foliacea Youngquist, 1945

Fig. 12, no. 1

Palmatolepis foliaceus Youngquist, 1945, p. 364-365, Pl. 56, Figs. 11, 12.

Palmatolepis foliacea Youngquist, Glenister and Klapper, 1966, p. 810.

Palmatolepis foliacea Youngquist, Schumacher, 1971, p. 147, Pl. 14, Fig. 16.

Diagnosis.--A small narrow species of Palmatolepis with little ornamentation and with an inner lateral lobe that is either very weakly developed or absent.

Occurrence.--The range of P. foliacea is recorded by Ziegler (1971) from the higher part of the A. triangularis Zone to the top of the Lower P. gigas Zone. In North America, Klapper and others (1971) find P. foliacea in the A. triangularis and the Lower P. gigas Zones. In my study, P. foliacea was found in the Martin Formation at Van Winkle Ranch and Steamboat Mountain.

Material.--25 specimens.

Figured Specimens.--UA52917 (hypotype).

Palmatolepis subrecta Miller and Youngquist, 1947

Fig. 12, nos. 2-6

Palmatolepis subrecta n. sp., Miller and Youngquist, 1947, p. 513, Pl. 75, Figs. 7-11.

Palmatolepis subrecta Miller and Youngquist, Anderson, 1966, p. 409, Pl. 49, Figs. 11-15, 17, 19.

Palmatolepis subrecta Miller and Youngquist, Glenister and Klapper, 1966, p. 823-824, Pl. 88, Figs. 1-3.

Palmatolepis subrecta Miller and Youngquist, Szulczewski, 1971, p. 41, Pl. 10, Figs. 8-9; Pl. 12, Figs. 4-8.

Figure 12. Palmatolepis.

All specimens from the Martin Formation except 7, 16 and 17-21 which are from the Percha Formation.

- 1--Palmatolepis foliacea Youngquist: 1, top view of UA52917, x 25.
- 2-6--Palmatolepis subrecta Miller and Youngquist: 2, top view of UA52918, x 30; 3, top view of UA52919, x 30; 4, top view of UA52920, x 30; 5, aboral view of UA52921, x 30; 6, top view of UA52922, x 30.
- 7--Palmatolepis punctata (Hinde): 7, top view of UA52923, x 35.
- 8--Palmatolepis proversa Ziegler: 8, top view of UA52924, x 30.
- 9-16--Palmatolepis gigas Miller and Youngquist: 9, top view of UA52925, x 32; 10, top view of UA52926, x 30; 11, oblique view of UA52926, x 26; 12, top view of UA52927, x 25; 13, top view of UA52928, x 30; 14, top view of UA52929, x 25; 15, aboral view of UA52930, x 30; 16, top view of UA52931, x 35.
- 17-20--Palmatolepis distorta Branson and Mehl: 17, top view of UA52932, x 35; 18, top view of UA52935, x 35; 19, top view of UA52934, x 35; 20, top view of UA52935, x 35.
- 21--Palmatolepis glabra pectinata Ziegler: 21, top view of UA52936, x 25.



Figure 12. Palmatolepis.

Palmatolepis transitans Müller, 1956

Palmatolepis (Manticolepis) transitans, Müller, 1956, p. 18-19, Pl. 1, Figs. 1-2.

Palmatolepis transitans Müller, Szulczewski, p. 42-43, Pl. 9, Figs. 1-4, 7, 9.

Diagnosis.--A species of Palmatolepis with a straight blade carina and a poorly developed inner lateral lobe. Ornamentation is coarse and usually concentrated along the outer edge of the platform.

Remarks.--Samples from the fish bone-rich dolomite at the top of the Martin Formation at Holy Joe Peak yielded a rich fauna of palmatolepids which were transitional from P. transitans to P. punctata.

Specimens were assigned to P. transitans on the basis of a poorly developed to nearly absent inner lobe and a straight blade carina. Denticles on the blade carina were generally fused until the azygous node, then two or three discrete nodes continued beyond the azygous node either aligned with the blade carina or at a very slight angle.

Occurrence.--Ziegler (1971) records the range of P. transitans from the base of the Lower P. asymmetricus Zone to the middle of the A. triangularis Zone. In my study, specimens assigned to P. transitans were found at Holy Joe Peak mixed with Upper P. gigas Zone and Lower Ordovician conodonts.

Material.--36 specimens.

Unfigured Specimens.--UA52994.

Palmatolepis punctata (Hinde), 1879  
Fig. 12, no. 7

Polygnathus punctatus, Hinde, 1879, p. 367, Pl. 17, Fig. 14.

Palmatolepis punctata (Hinde), Glenister and Klapper, 1966, p. 879,  
Pl. 88, Figs. 8,9.

Palmatolepis punctata (Hinde), Szulczewski, 1971, p. 38, Pl. 9, Fig. 8;  
Pl. 10, Figs. 1-4.

Diagnosis.--A more or less triangular species of Palmatolepis with coarse ornamentation on the upper surface. The inner lateral lobe is anterior of the azygous node and the blade carina extends to a downward flexed posterior tip.

Remarks.--P. punctata differs from P. transitans primarily in having a more markedly differentiated inner lateral lobe.

Occurrence.--Ziegler (1971) records the range of P. punctata from the base of the Middle P. asymmetricus Zone to the Lower P. gigas Zone. In my study, P. punctata was found in the Martin Formation at Van Winkle Ranch, Steamboat Mountain and Holy Joe Peak. One specimen of P. punctata was found in the basal lag deposit of the Percha Formation at Highway 77.

Material.--19 specimens.

Figured Specimen.--UA52923 (hypotype).

Palmatolepis proversa Ziegler, 1958

Fig. 12, no. 8

Palmatolepis proversa, Ziegler, 1958, p. 62-63, Pl. 3, Figs. 11, 12;  
Pl. 10, Figs. 1-14.

Palmatolepis proversa Ziegler, Mound, 1968, p. 500, Pl. 68, Figs. 14,  
16, 21; Pl. 7, Figs. 15, 19.

Palmatolepis proversa Ziegler, Szulczewski, 1971, p. 38, Pl. 9, Fig. 8;  
Pl. 10, Figs. 1-4.

Diagnosis.--A more or less triangular shaped species of Palmatolepis with a well developed inner lateral lobe which is directed

anteriorly at 45° to the carina. The margins of the platform are commonly built up with coarse ornamentation.

Occurrence.--Ziegler (1971) records the range of P. proversa from the base of the Middle P. asymmetricus Zone to the Lower P. gigas Zone. In my study, P. proversa was found in the Martin Formation at Globe Hills, Pinal Creek, Van Winkle Ranch, and Holy Joe Peak.

Material.--7 specimens.

Figured Specimens.--UA52924 (hypotype).

Palmatolepis gigas Miller and Youngquist, 1947  
Fig. 12, nos. 9-16

Palmatolepis gigas, Miller and Youngquist, 1947, p. 512-513, Pl. 75,  
Fig. 1

Palmatolepis gigas Miller and Youngquist, Anderson, 1966, p. 408, Pl. 49,  
Figs. 1-2, 4-10, 16, 20.

Palmatolepis gigas Miller and Youngquist, Glenister and Klapper, 1966,  
p. 810, Pl. 88, Fig. 12.

Palmatolepis gigas Miller and Youngquist, Mound, 1968, p. 499, Pl. 68,  
Figs. 1, 2.

Palmatolepis gigas Miller and Youngquist, Szulczewski, 1971, p. 31,  
Pl. 10, Fig. 7; Pl. 11, Figs. 1-5; Pl. 12, Fig. 3.

Diagnosis.--A species of Palmatolepis with a very strongly elongate inner lateral lobe.

Remarks.--P. gigas is a very variable species. Apparently two general morphotypes are now recognized (Dr. Charles Sandberg, personal communication, 1975). One has a fairly short roundish platform with an extremely long inner lateral lobe (Fig. 12, nos. 10-16). The other has a longer, narrower platform with high anterior denticles on the blade, a hint of a parapet on the outer edge of the "shoulder" area, and/or a fairly well developed inner lateral lobe (Fig. 12, no. 9).

Occurrence.--Ziegler (1971) records P. gigas from the bottom of the P. gigas Zone to the Lower P. triangularis Zone. In North America, Klapper and others (1971) report P. gigas from the bottom to the top of the P. gigas Zone. In my study, P. gigas was found in the Martin Formation at Globe Hills, Job Corps Camp, Van Winkle Ranch, Highway 77, Steamboat Mountain, and Holy Joe Peak. One specimen assigned to P. gigas was found in the basal Percha beds at Highway 77.

Material.--More than 150 specimens.

Figured Specimens.--UA52925-UA52931 (hypotypes).

Palmatolepis distorta Branson and Mehl, 1934

Fig. 12, nos. 17-20

Fig. 13, nos. 1, 2, 15

Palmatolepis distorta Branson and Mehl, 1934, p. 237-238, Pl. 18, Figs. 13, 14.

Palmatolepis distorta Branson and Mehl, Glenister and Klapper, 1966, p. 809, Pl. 89, Fig. 8; Pl. 91, Figs. 2, 4.

Palmatolepis distorta Branson and Mehl, Dressen and Duser, 1974, Pl. 7, Fig. 4.

Diagnosis.--A narrow, elongate, strongly sigmoidal species of Palmatolepis. The blade-carina is strongly sigmoidal and an inner lobe is absent. A well developed outer margin parapet which lies close to and parallels the blade is present. The anterior inner platform is convex upward.

Remarks.--Glenister and Klapper (1966) say that P. distorta forms a continuous transitional series with P. glabra pectinata. The essential difference between these two is that P. distorta displays a convex arching of the anterior inner platform in contrast to P. glabra pectinata which is flat or concave in this same area (Ziegler, 1962).

Figure 13. Palmatolepis, Pelekysgnathus.

All specimens are from the Percha Formation.

1,2,15--Palmatolepis distorta Branson and Mehl: 1, aboral view of UA52937, x 35; 2, aboral view of UA52938, x 35; 15, top views of UA52950 and UA52951, x 35.

3,4--Palmatolepis glabra elongata Holmes: 3, oblique view of destroyed specimen, x 35; 4, oblique view of UA52939, x 35.

5,6,7,14,16--Palmatolepis perlobata perlobata Ulrich and Bassler: 5, oblique view of UA52941, x 25; 7, aboral view of UA52942, x 25; 14, aboral view of UA52949, x 35; 16, aboral view of UA52952, x 35.

8--Palmatolepis perlobata sigmoidea Ziegler: 8, top view of UA52943, x 35.

9--Palmatolepis marginifera marginifera (?) Helms: 9, aboral view of UA52944, x 30.

10,11--Palmatolepis rugosa rugosa Branson and Mehl: 10, top view of UA52945, x 25; 11, aboral view of UA52946, x 30.

12,13--Palmatolepis rugosa postera Ziegler: 12, top view of UA52947, x 30; 13, top view of UA52948, x 30.

17--Pelekysgnathus sp. Thomas: 17, side view of UA52953, x 30.



Figure 13. Palmatolepis, Pelekysgnathus.

Because of weathering specimens assigned to P. distorta in this study did not display the shagreen upper surface described by many others.

Occurrence.--P. distorta is recorded by Ziegler (1971) from the Lower P. marginifera Zone to the Middle S. velifer Zone. In North America, P. distorta is found from the Lower P. marginifera Zone to the S. subserratus-P. inclinatus Fauna (upper part of the S. velifer Zone). In my study, P. distorta was found in the basal lag deposit of the Percha Formation at Highway 77 and Holy Joe Peak.

Material.--P. distorta was extremely abundant on bedding planes--more than 500 specimens were examined.

Figured Specimens.--UA52932-UA52935, UA52937, UA52938, UA52950, UA52951 (hypotypes).

Palmatolepis glabra Ulrich and Bassler, 1926

Palmatolepis glabra pectinata Ziegler, 1962  
Fig. 12, no. 21

Palmatolepis sp. Branson and Mehl, 1941, p. 192, Pl. 7, Fig. 11.

Palmatolepis glabra Ulrich and Bassler, 1926, p. 51, Pl. 9, Figs. 18-20.

Palmatolepis glabra pectinata Ziegler, 1962, p. 398-399, Pl. 2, Fig.

3 5.

Palmatolepis glabra pectinata Ziegler, Sandberg and Ziegler, 1973,  
p. 104, Pl. 2, Figs. 4, 12-15; Pl. 5, Fig. 14.

Diagnosis.--A long slender sigmoidal species of Palmatolepis closely related to P. distorta but not as strongly sigmoidal and displaying a flat or concave anterior inner platform rather than a convex inner platform.

Remarks.--This broken specimen does not closely resemble Ziegler's lectotypes (1962) but is not as sigmoidal as specimens of P. distorta and does have a flat inner platform.

Occurrence.--Ziegler (1971) reports P. glabra pectinata from the Upper P. crepida Zone through the Upper P. marginifera Zone. Sandberg and Ziegler (1973) find P. glabra pectinata in the Upper P. crepida Zone to the top of the Upper P. rhomboidea Zone. The figured specimen was found in the basal lag deposit of the Percha at Highway 77. One other specimen was found in the basal beds of the Percha at Holy Joe Peak.

Material.--2 specimens.

Figured Specimens.--UA52936 (hypotype).

Palmatolepis glabra elongata Holmes, 1928  
Fig. 13, nos. 3-4

Palmatolepis elongata, Holmes, 1928, p. 133, Pl. 11, Fig. 33.

Palmatolepis glabra elongata Holmes, Ziegler, 1962, p. 58, Pl. 5, Figs. 6,7.

Palmatolepis glabra elongata Holmes, Glenister and Klapper, 1966, p. 811-814, Pl. 95, Fig. 1

Diagnosis.--A subspecies of Palmatolepis glabra that is extremely narrow and elongate and whose anterior outer platform is triangular in outline.

Remarks.--The two figured specimens generally resemble P. glabra elongata but were photographed on a bedding surface and no parapet was visible. The specimen illustrated in Figure 13, no. 3, was destroyed while being removed from the rock.

Occurrence.--Ziegler (1962) records the range of P. glabra elongata from the Lower P. marginifera Zone to the Upper S. velifer Zone. Klapper and others (1971) record the last occurrence of P. glabra elongata in the S. subserratus-P. inclinatus Fauna. In my study, P.

glabra elongata was found in the basal beds of the Percha Formation at Highway 77.

Material.--2 specimens.

Figured Specimen.--UA52939 (hypotype).

Palmatolepis perlobata perlobata Ulrich and Bassler, 1926  
Fig. 13, nos. 5,6,7,14,16

Palmatolepis perlobata, Ulrich and Bassler, 1926, p. 49, Pl. 7, Fig. 22.

Palmatolepis perlobata perlobata Ulrich and Bassler, Glenister and Klapper, 1966, p. 818, Pl. 92, Figs. 8, 13; Pl. 93, Figs. 1-6.

Palmatolepis perlobata Ulrich and Bassler, Huddle, 1968, p. 32-33, Pl. 15, Figs. 2,5,8.

Palmatolepis perlobata perlobata Ulrich and Bassler, Szulczewski, 1971, p. 37-38, Pl. 14, Figs. 3-4.

Diagnosis.--See Ziegler (1962).

Remarks.--This is a very highly variable form of Palmatolepis. Figure 13, nos. 14 and 16 were photographed on the bedding surface and an oral view was not available.

Occurrence.--Ziegler (1962) records the range of P. perlobata perlobata from the Upper P. triangularis Zone to the Lower P. costatus Zone. In my study, P. perlobata perlobata was found in both the basal beds and carbonate member of the Percha Formation.

Material.--Over 25 specimens.

Figured Specimens.--UA52940-UA52942, UA52949, UA52952 (hypotypes).

Palmatolepis perlobata sigmaidea Ziegler, 1962  
Fig. 9, no. 8

Palmatolepis (Palmatolepis) schindewolfi, Müller, 1956, S. 27, Taf. 8, Figs. 22, 24, 28(?), 31.

Palmatolepis perlobata sigmoidea subsp., Ziegler, 1962, p. 71-72, Pl. 8, Figs. 7, 9-11.

Diagnosis.--See Ziegler (1962).

Remarks.--This palmatolepid displays many of the characteristics of Ziegler's types but is not quite as sigmoidal.

Occurrence.--Ziegler (1971) records the range P. perlobata sigmoidea from the Lower P. marginifera Zone to the Upper P. styriacus Zone. In my study, one specimen was found in the basal beds of the Percha Formation at Highway 77.

Material.--1 specimen.

Figured Specimen.--UA52943 (hypotype).

Palmatolepis marginifera Helms, 1959

Palmatolepis marginifera marginifera Helms, 1959  
Fig. 13, no. 9

Palmatolepis quadrantinodosa marginifera Ziegler, Helms, 1959, p. 649, Pl. 5, Figs. 22, 23.

Palmatolepis quadrantinodosa marginifera Helms, Glenister and Klapper, 1966, p. 820, Pl. 91, Figs. 6-15.

Palmatolepis marginifera marginifera Helms, Sandberg and Ziegler, 1973, p. 104-105, Pl. 3, Figs. 13,14.

Palmatolepis marginifera Helms, Dreesen and Duser, 1974, p. 28, Pl. 5, Figs. 26-28.

Remarks.--This specimen was photographed on a bedding surface and closely resembles an aboral P. marginifera marginifera illustrated by Glenister and Klapper (1966). However, this specimen could be one of several roundish oblong palmatolepids. One other specimen, tentatively assigned to P. marginifera marginifera, was lost.

Occurrence.--Sandberg and Ziegler (1973) record the range of P. marginifera marginifera through the Lower and Upper P. marginifera Zones. In my study, P. marginifera marginifera was present only in the basal beds of the Percha Formation at Highway 77.

Material.--1 specimen.

Figured Specimen.--UA52944.

Palmatolepis rugosa Branson and Mehl, 1934

Palmatolepis rugosa rugosa Branson and Mehl, 1934  
Fig. 13, nos. 10-11

Palmatolepis rugosa, Branson and Mehl, 1934, p. 236, Pl. 18, Figs. 15, 16, 18, 19.

Palmatolepis rugosa, Branson and Mehl, Müller, 1956, p. 29, Pl. 9, Fig. 34.

Diagnosis.--A species of Palmatolepis with a strongly sigmoidal plate. The posterior tip is blunt and the inner lateral lobe is well developed. The surface is ornamented with coarse nodes, scattered generally around the surface but in rows on the inner lobe, inner edge, and outer edge. The blade carina is smooth with no denticles.

Remarks.--Ziegler (1962) subdivided P. rugosa into four subspecies. P. rugosa rugosa in this study most closely resembles P. rugosa ampla illustrated by Ziegler (1962).

Occurrence.--The range of P. rugosa is recorded by Ziegler (1971) as from the Upper P. marginifera Zone to the Upper P. styriacus Zone. In North America, Klapper and others (1971) find P. rugosa rugosa in the Upper P. styriacus Zone and the Lower and Middle B. costatus Zones. Sandberg (1976) has found P. rugosa rugosa s.l. in rocks of the P. styriacus Zone throughout much of the western United States. In my

study, P. rugosa rugosa was found in the carbonate member of the Percha Formation at Saddle Mountain, Brandenburg Mountain 1, and Brandenburg Mountain 2.

Material.--50 specimens.

Figured Specimens.--UA52945-UA52946 (hypotypes).

Palmatolepis rugosa postera Ziegler, 1960  
Fig. 9, nos. 12-13

Palmatolepis rugosa postera, Ziegler, 1960, in Kronberg and others, S. 39, Taf. 2, Figs. 10, 11, Abb. 12, 13.

Palmatolepis rugosa postera Ziegler, 1962, p. 79, Pl. 8, Figs. 12-14.

Diagnosis.--See Ziegler (1962).

Remarks.--Ziegler (1962) illustrates P. rugosa postera with a strong, weak, and no lobe. All three varieties were found in this study.

Occurrence.--Ziegler (1971) records the range of P. rugosa postera from the Lower to the Upper P. styriacus Zone. Klapper and others (1971) find P. rugosa postera in both the Upper P. styriacus and Lower B. costatus Zones. In my study, P. rugosa postera was found in the carbonate member of the Percha Formation at Saddle Mountain, Brandenburg Mountain 1 and Brandenburg Mountain 2.

Material.--7 specimens.

Figured Specimens.--UA52947-UA52948 (hypotypes).

Genus Pelekysgnathus Thomas, 1949

Type species: Pelekysgnathus inclinata Thomas, 1949

Pelekysgnathus sp.  
Fig. 13, no. 17

Remarks.--One fragmental specimen of Pelekysgnathus, showing the characteristic row of denticles and part of the basal plate, was found

in this study. The specimen was too incomplete for specific assignment.

Occurrence.--One broken specimen was found in the Percha Formation at Brandenburg Mountain 1.

Material.--1 specimen.

Figured Specimen.--UA52953.

Genus Polygnathus Hinde, 1879

Type species: Polygnathus robusticostata Bischoff and Ziegler, 1957  
Polygnathus dubius Hinde, 1879

Polygnathus normalis Miller and Youngquist, 1947  
Fig. 14, nos. 1-4

Polygnathus normalis, Miller and Youngquist, 1947, p. 515, Pl. 74, Fig. 4.

Polygnathus normalis Miller and Youngquist, Druce, 1969, p. 102, Pl. 19, Figs. 7-10.

Polygnathus normalis Miller and Youngquist, Szulczewski, 1971, p. 49-50, Pl. 19, Figs. 2-5.

Diagnosis.--See Miller and Youngquist (1947).

Remarks.--In this study P. normalis was quite abundant and displayed wide morphological variability. Most specimens were arched with transverse ridges running perpendicular to the blade carina.

Occurrence.--P. normalis ranges from the upper part of the Middle Devonian to as high as the Lower P. marginifera Zone. In this study, P. normalis was found in the Martin Formation at Pinal Creek, Globe Hills, Van Winkle Ranch, Job Corps Camp, and Highway 77.

Material.--More than 200 specimens.

Figured Specimens.--UA52954-UA52957 (hypotypes).

Figure 14. Polygnathus.

Numbers 1-4 are from the Martin Formation. Number 5 is from the Escabrosa Limestone. Numbers 6-17 are from the Percha Formation.

- 1-4--Polygnathus normalis Miller and Youngquist: 1, oblique view of UA52954, x 30; 2, oblique view of UA52955, x 30; 3, oblique view of UA52956, x 25; 4, oblique view of UA52957, x 27.
- 5--Polygnathus communis Branson and Mehl: oblique view of UA52958, x 30.
- 6--Polygnathus sp. A: 6, top view of UA52959, x 35.
- 7,8--Polygnathus sp. B: 7, top view of UA52960, x 35; 8, aboral view of UA52961, x 27.
- 9--Polygnathus sp. C: 9, top view of UA52962, x 35.
- 10--Polygnathus perplexus Thomas: 10, oblique view of UA52963, x 35.
- 11--Polygnathus sp. D: 11, aboral view of UA52964, x 35.
- 12,13--Polygnathus sp. E: 12, side view of UA52965, x 25; 13, side view of UA52966, x 25.
- 14--Polygnathus brevilaminus Branson and Mehl: 14, oblique view of UA52967, x 25.
- 15-17--Polygnathus semicostatus Branson and Mehl: 15, oblique view of UA52968, x 25; 16, oblique view of UA52969, x 25, 17, side view of UA52970, x 30.

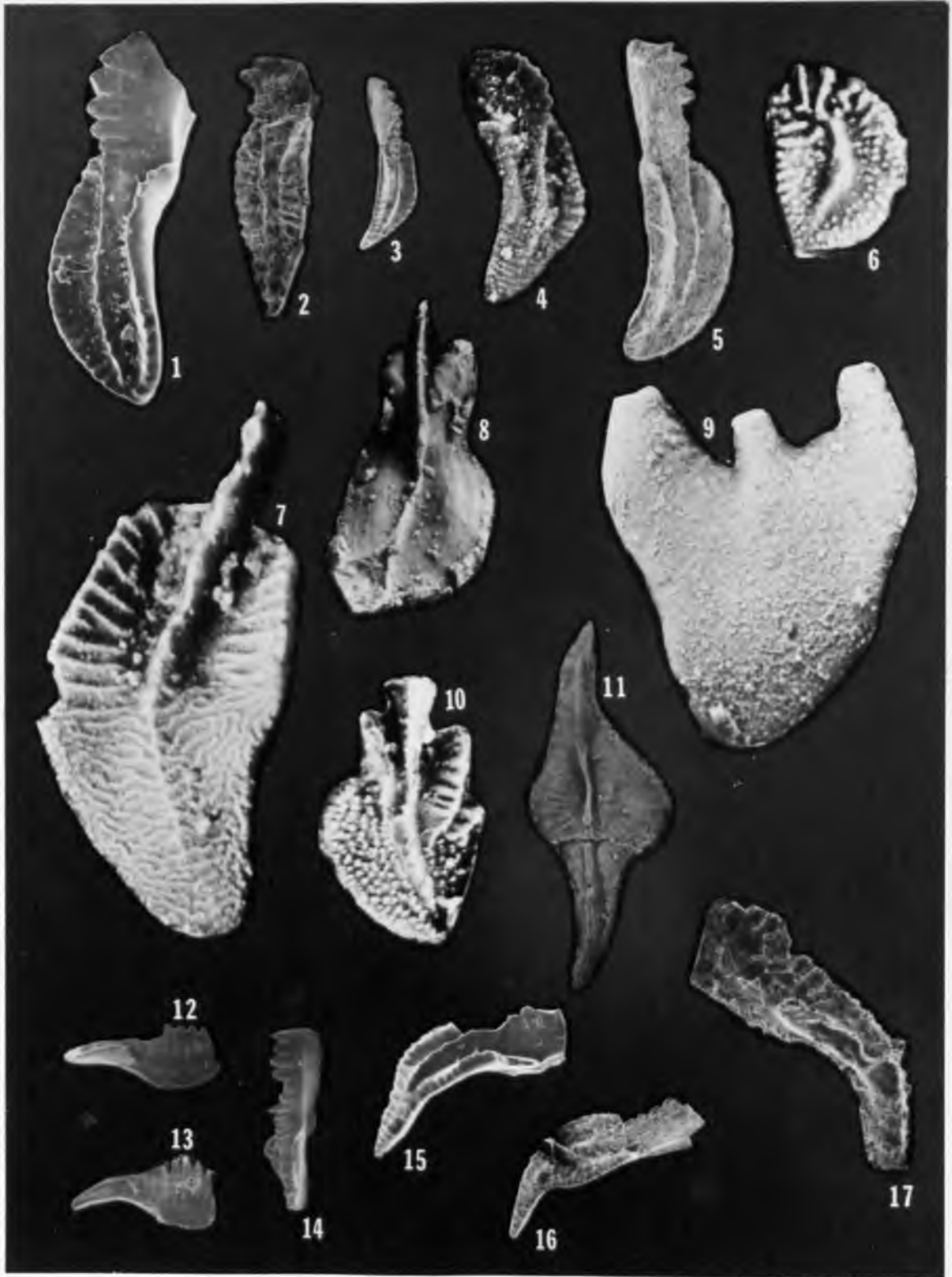


Figure 14. Polygnathus.

Polygnathus brevilaminus Branson and Mehl, 1934  
Fig. 14, no. 14

Polygnathus brevilaminus, Branson and Mehl, 1934, p. 246, Pl. 21, Figs. 3-6.

Polygnathus brevilaminus Branson and Mehl, Mound, 1968, p. 504-505, Pl. 69, Figs. 6,7.

Polygnathus brevilaminus Branson and Mehl, Szulczewski, p. 46-47, Pl. 18, Figs. 5,6, 10.

Remarks.--Specimens of P. brevilaminus found in this study generally conformed with the type specimens of Branson and Mehl.

Occurrence.--P. brevilaminus was found in the Percha Formation at Brandenburg Mountain 1 and Brandenburg Mountain 2.

Material.--5 specimens.

Figured Specimens.--UA52967 (hypotype).

Polygnathus communis Branson and Mehl, 1934  
Fig. 14, no. 5

Polygnathus communis Branson and Mehl, 1934, p. 293, Pl. 24, Figs. 1-4.

Polygnathus communis Branson and Mehl, Mound, 1968, p. 505, Pl. 69, Figs. 12, 13, 18 (Gives synonymy).

Polygnathus communis communis Branson and Mehl, Dreesen and Duser, 1974, p. 13, Pl. 1, Figs. 21-29; Pl. 4, Figs. 3-9; Text Figs. 9, 10.

Remarks.--P. communis is a smooth, essentially unornamented polygnathid, with a bowed, moderately arched platform.

Occurrence.--Dreesen and Duser (1974) extended the range of P. communis down to the Middle P. crepida Zone. P. communis ranges through the rest of the Upper Devonian and into the Mississippian. In my study, P. communis was found in the top part of the carbonate member of the Percha Formation at Brandenburg Mountain 1 and Brandenburg Mountain 2. P. communis also occurs in the Mississippian Escabrosa Limestone at Steamboat Mountain.

Material.--10 specimens.

Figured Specimen.--UA52958 (hypotype).

Polygnathus homoirregularis (Thomas, 1949)  
Fig. 15, nos. 1, 2, 5, 6

Palmatolepis ? irregularis, Thomas, 1949, p. 416-417, Pl. 2, Fig. 27.

Polygnathus irregularis (Thomas), Helms, 1961, p. 485-486, Taf. 3, Bild. 3, 5-7.

Diagnosis.--See Helms (1961).

Remarks.--Ziegler (1971) agreed with Helms' (1961) assignment of Palmatolepis ? irregularis Thomas to Polygnathus, but points out that Polygnathus irregularis is occupied. He proposes that Polygnathus homoirregularis be used for Palmatolepis ? irregularis Thomas.

Most specimens closely resemble the holotype illustrated by Thomas (1949). However, a few were somewhat different (Fig. 15, no. 2) and probably represent transitional forms. Figure 15, nos. 5-6 are probably P. homoirregularis transitional to Polygnathus hassi (Charles A. Sandberg, personal communication, 1975).

Occurrence.--Ziegler (1971) records the range of P. homoirregularis from the Lower to the Upper P. styriacus Zone. Klapper and others (1971) find P. homoirregularis in the S. subserratus-P. inclinatus Fauna, in the Upper P. styriacus Zone, and in the lower part of the B. costatus Zone. In my study, P. homoirregularis was present in the carbonate member of the Percha Formation at Brandenburg Mountain 1.

Material.--6 specimens.

Figured Specimens.--UA52971, UA52972, UA52975 (hypotypes).

Figure 15. Polygnathus, Polylophodonta, Siphonodella, Bispathodus.

All specimens are from the Percha Formation except Nos. 13 and 14, which are from the Escabrosa Limestone.

1,2--Polygnathus homoirregularis (Thomas): 1, oblique view of UA52971, x 30; 2, top view of UA52972, x 30.

3,4--Polygnathus perplexus Thomas: 3, oblique view of UA52973, x 30; 4, oblique view of UA52974, x 32.

5,6--Polygnathus homoirregularis (Thomas) transitional to Polygnathus hassi Helms: 5, top view of UA52975, x 30; 6, oblique view of UA52975, x 30.

7-9--Polylophodonta confluens (Ulrich and Bassler): 7, top view of UA52976, x 35; 8, top view of UA52977, x 35; 9, oblique view of UA52978, x 27.

10-12--Polylophodonta concentrica (Ulrich and Bassler): 10, oblique view of UA52979, x 27; 11, top view of UA52980, x 27; 12, oblique view of UA52981, x 25.

13,14--Siphonodella isosticha Cooper: 13, close-up of platform of UA52982, x600; 14, oblique view of UA52982, x 30.

15,16--Bispathodus stabilis (Branson and Mehl): 15, side view of UA52983, x 30; 16, oblique view of UA52984, x 25.

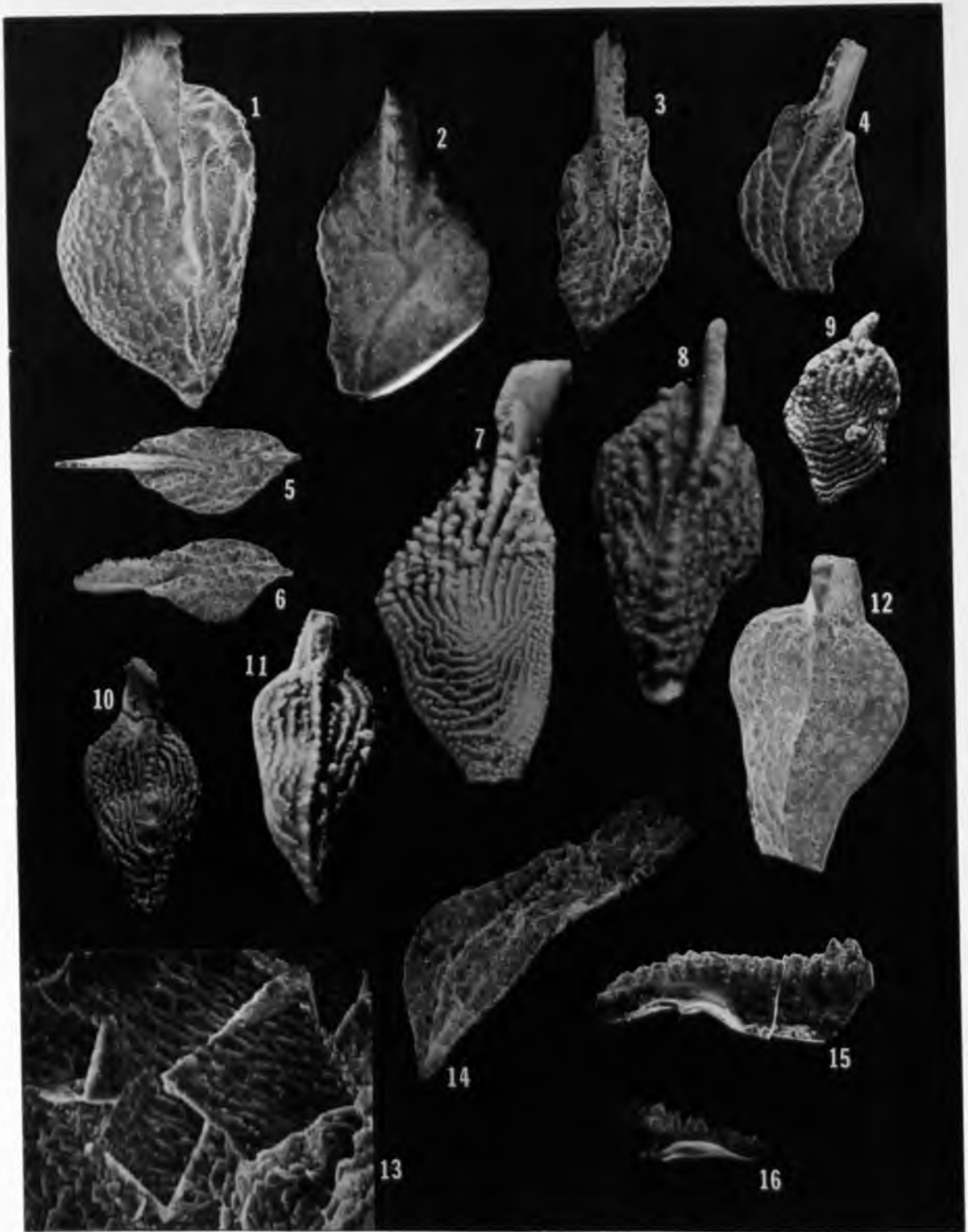


Figure 15. Polygnathus, Polylophodonta, Siphonodella, Bispathodus.

Polygnathus perplexus Thomas, 1949  
Fig. 14, no. 10; Fig. 15, nos. 3-4

Polygnathus perplexa, Thomas, 1949, p. 418, Pl. 2, Fig. 23.

Polygnathus perplexa Thomas, Helms, 1959, Pl. 6, Fig. 27.

Polygnathus perplexa Thomas, Helms, 1961, Pl. 1, Figs. 18, 19; Pl. 4,  
Figs. 1-3, 5; Text Fig. 10.

Polygnathus perplexus Thomas, Dreesen and Duser, 1974, p. 17, Pl. 3,  
Fig. 25.

Diagnosis.--See Helms (1961).

Remarks.--Two morphotypes of P. perplexus were found in this study. The first displayed a broad platform and was highly ornamented with coarse nodes and displayed the characteristic rostrum on the anterior part of the platform. The second was longer and narrower and was ornamented by ridges and fused nodes and also displayed the characteristic rostrum.

Occurrence.--Dreesen and Duser (1974) record the range of P. perplexa from the basal part of the Upper P. marginifera Zone into the S. velifer Zone. Ziegler (1971) records the range from the Upper S. velifer Zone to the Upper P. styriacus Zone. Klapper and others (1971) find P. perplexa in the S. subserratus-P. inclinatus Fauna, in the Upper P. styriacus Zone, and in the lower part of the B. costatus Zone. In my study, the first morphotype was found in the basal beds of the Percha Formation at Highway 77 and the second morphotype in the carbonate member of the Percha Formation at Saddle Mountain, Brandenburg Mountain 1, and Brandenburg Mountain 2.

Material.--10 specimens.

Figured Specimens.--UA52963, UA52973-UA52974 (hypotypes).

Polygnathus semicostatus Branson and Mehl, 1934  
Fig. 14, nos. 15-17

Polygnathus semicostata Branson and Mehl, 1934, p. 247-248, Pl. 21,  
Figs. 1, 2.

Polygnathus semicostatus Branson and Mehl, Szulczewski, p. 51, Pl. 19,  
Fig. 6.

Polygnathus semicostatus Branson and Mehl, Dreesen and Orchard, 1974,  
p. 3, Pl. 1, Figs. 1-8; Pl. 2, Figs. 1-5.

Diagnosis.--See Dreesen and Orchard (1974).

Occurrence.--Dreesen and Orchard (1974) record the range of P. semicostatus from the Middle P. crepida Zone to the S. velifera Zone. Klapper and others (1971) report P. semicostatus from as high as the B. costatus Zone. In my study, P. semicostatus was abundant in the carbonate member of the Percha Formation at Steamboat Mountain, Saddle Mountain, Brandenburg Mountain 1, and Brandenburg Mountain 2. One specimen from Peppersauce Wash was tentatively assigned to P. semicostatus.

Material.--71 specimens.

Figured Specimens.--UA52968-UA52970 (hypotypes).

Polygnathus sp. A  
Fig. 14, no. 6

Remarks.--This unknown species may have affinities to Palmatolepis or possibly to Polygnathus homoirregularis.

Occurrence.--Basal beds of the Percha Formation at Highway 77.

Material.--1 specimen.

Figured Specimen.--UA59259.

Polygnathus sp. B  
Fig. 14, nos. 7, 8

Remarks.--This unknown polygnathid could be a gerontic form of one of several common polygnathis species. P. planirostratus (Dreesen and Dusar, 1974, Pl. 2, Figs. 13-20), P. normalis (Szulczewski, 1971, Pl. 19, Fig. 3), and Polygnathus sp. A (Druce, 1969, Pl. 21, Fig. 3), all show affinities to this strange form. The ornamentation of the posterior half of the platform bears close resemblance to polylophodontid ornamentation.

Specimen no. 8 was photographed on a bedding plane and appears to be the aboral view of specimen no. 7.

Occurrence.--Basal beds of the Percha Formation at Highway 77.

Material.--10 specimens.

Figured Specimens.--UA52960, UA52961.

Polygnathus sp. C  
Fig. 14, no. 9

Remarks.--This heart-shaped polygnathid displays very fine transverse polylophodontid-like ridges on the entire oral surface when the specimen is moistened.

Occurrence.--Basal beds of the Percha Formation at Highway 77.

Material.--1 specimen.

Figured Specimen.--UA52962.

Polygnathus sp. D  
Fig. 14, no. 11

Remarks.--Aboral view of unknown specimen photographed on a bedding plane.

Occurrence.--Basal beds of the Percha Formation at Highway 77.

Material.--1 specimen.

Figured Specimen.--UA52964.

Polygnathus sp. E  
Fig. 14, nos. 12, 13

Remarks.--Juvenile polygnathids too young to be identified specifically.

Occurrence.--Carbonate member of the Percha Formation, Brandenburg Mountain 1 and Brandenburg Mountain 2.

Material.--15 specimens.

Figured Specimens.--UA52965-UA52966.

Genus Polylophodonta Branson and Mehl, 1934

Type species: Polygnathus gyratilineata Holmes, 1928  
Polylophodonta confluens (Ulrich and Bassler, 1926)  
Fig. 15, nos. 7-9

Polylophodonta confluens Ulrich and Bassler, 1926, p. 46-47, Pl. 7, Figs. 14, 15.

Polylophodonta confluens (Ulrich and Bassler), Glenister and Klapper, 1966, p. 831-832, Pl. 94, Figs. 10, 11.

Polylophodonta confluens (Ulrich and Bassler), Huddle, 1968, p. 42, Pl. 17, Figs. 1, 2, 8, 9, 11.

Polylophodonta confluens (Ulrich and Bassler), Dreesen and Duser, 1974, Pl. 4, Fig. 21.

Remarks.--A species of Polylophodonta with rows of nodes and ridges which parallel the free blade at the anterior end of the platform and with transverse ridges on the posterior part of the platform.

Occurrence.--Helms (1961) reported P. confluens from the Lower S. velifer Zone. Ziegler (1971) reports Polylophodonta from the Upper P. rhomboidea and Lower P. marginifera Zones. In my study, Polylophodonta was present in the basal beds of the Percha Formation at Highway 77 and Holy Joe Peak.

Material.--More than 20 specimens.

Figured Specimens.--UA59276-UA59278 (hypotypes).

Polylophodonta concentrica Ulrich and Bassler, 1926  
Fig. 15, nos. 10-12

Polygnathus concentricus Ulrich and Bassler, 1926, p. 47, Pl. 8, Figs. 6, 7.

Polylophodonta concentrica (Ulrich and Bassler), Huddle, 1968, p. 41, Pl. 17, Figs. 3-7, 10.

Remarks.--A species of Polylophodonta with a short free blade, and a tongue-shaped platform. Ridges and nodes are arranged in a variety of ways on the platform but are always in a concentric pattern.

Occurrence.--P. concentrica was present in basal beds of the Percha Formation at Highway 77.

Material.--More than 15 specimens.

Figured Specimens.--UA52979-UA52981 (hypotypes).

Genus Siphonodella Branson and Mehl, 1948  
Siphonodella isosticha (Cooper), 1939  
Fig. 15, nos. 13, 14

Siphonognathus isosticha Cooper, 1939, p. 409, Pl. 41, Figs. 9, 10.

Siphonodella isosticha (Cooper), Ethington, 1965, p. 587, Pl. 67, Figs. 15, 17.

Siphonodella isosticha (Cooper), Rexroad, 1969, p. 43, Pl. 3, Figs. 1-4.

Remarks.--A species of Siphonodella which is unornamented except for a carina and rostral ridges. This species was used to locate the Devonian-Mississippian contact where there was no obvious lithologic contact. Figure 15, no. 13 is a close-up of the platform of no. 14.

Occurrence.--S. isosticha was found in the basal beds of the Mississippian Escabrosa Limestone at Pinal Creek (from a thin platy unit

reported by Ethington, 1965), Highway 77, Van Winkle Ranch, Steamboat Mountain, Brandenburg Mountain 1, and Saddle Mountain.

Material.--53 specimens.

Figured Specimen.--UA52982.

Genus Bispathodus (Müller, 1962)

Type species: Spathodus spinulicostatus, Branson, 1934

Bispathodus stabilis (Branson and Mehl, 1934)

Fig. 15, nos. 15, 16; Fig. 16, nos. 1-3

Spathodus stabilis, Branson and Mehl, p. 188, Pl. 17, Fig. 20.

Bispathodus stabilis (Branson and Mehl), Ziegler, Sandberg, and Austin, 1974a, p. 100, Fig. 10; Pl. 3, Figs. 1-3.

Diagnosis.--A species of Bispathodus that has only one row of denticles and relatively small, narrow basal cavity that does not extend to the posterior end.

Remarks.--Ziegler, Sandberg, and Austin (1974a, 1974b) recognize two morphotypes of B. stabilis. The Bispathodus branch (Morphotype 2) has a large basal cavity that extends to the posterior end, and the aculeatus branch (Morphotype 1) has a smaller basal cavity that does not reach to the posterior end. Specimens of morphotype 1 were found in this study.

Occurrence.--Ziegler, Sandberg, and Austin (1974a) record the range of B. stabilis from the Upper P. marginifera Zone to the Lower Carboniferous. B. stabilis was found in my study in the Percha Formation at Saddle Mountain, Brandenburg Mountain 1, and Brandenburg Mountain 2.

Material.--8 specimens.

Figured Specimens.--UA52983, UA52985, UA52984 (hypotypes).

Figure 16. Spathognathodus, Bispathodus, Ostracod, Molluscs, Gluteus.

All specimens from the Percha Formation.

- 1-3--Bispathodus stabilis Branson and Mehl: 1, close-up of basal cavity of UA52985, x 600; 2, aboral oblique view of UA52985, x 30; 3, side view of UA52985, x 30.
- 4,5--Spathognathodus inornatus (Branson and Mehl): 4, aboral oblique view of UA52986, x 30; 5, side view of UA52986, x 30.
- 6-8--Ostracods from P. styriacus Zone of the Percha Formation: 6, UA52987; 7, UA52988; 8, UA52989, all x 25.
- 9--Gastropod from the P. styriacus Zone of the Percha Formation: 9, UA52990, x 25.
- 10-14--Gluteus minimus Davis and Semken: 10, smooth side view of UA52991, x 19; 11, growth line side view of UA52991, x 19; 12, smooth side view of UA52992, x 19; 13, growth line side view of UA52992, x 19; 14, external mold of growth line side, UA52993, x 19.

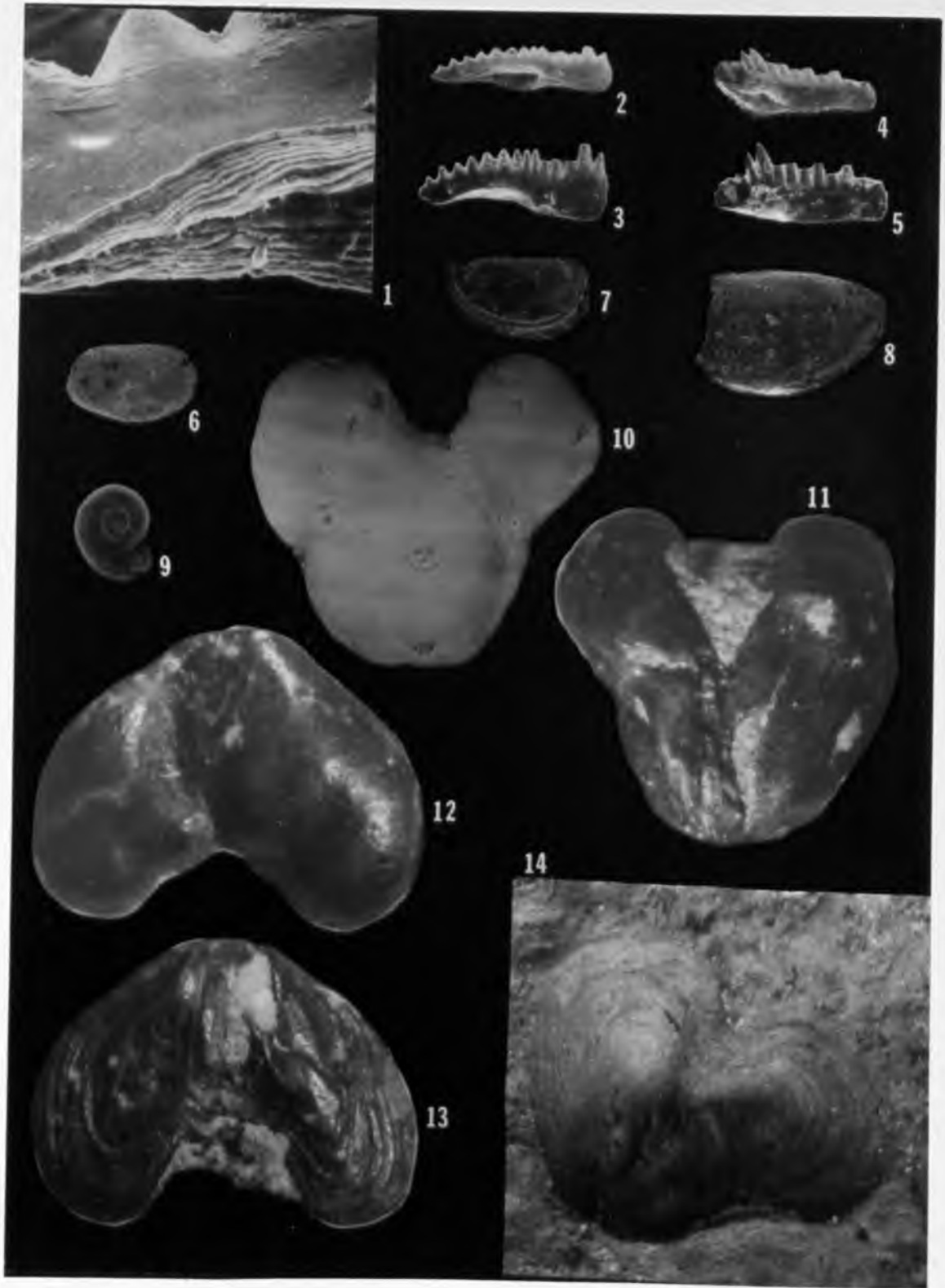


Figure 16. Spathognathodus, Bispathodus, Ostracod, Molluscs, Gluteus.

Genus Spathognathodus Branson and Mehl, 1941

Type species: Spathodus primus Branson and Mehl, 1933

Spathognathodus inornatus (Branson and Mehl, 1934)  
Fig. 12, nos. 4, 5

Spathognathodus inornatus Branson and Mehl, 1934, p. 185, Pl. 17,  
Fig. 23.

Spathognathodus inornatus (Branson and Mehl), Rexroad, 1969, p. 47,  
Pl. 6, Figs. 1, 2.

Remarks.--A species of Spathognathodus with oral and aboral margins subparallel. This specimen has 12 denticles, most of which are broken near their tips. The basal cavity is elongate and extends to the posterior end.

Occurrence.--In this study, S. inornatus is present in the lower part of the carbonate member of the Percha Formation at Brandenburg Mountain 1 and Brandenburg Mountain 2.

Material.--3 specimens.

Figured Specimens.--UA52986 (hypotype).

Other Microfossils

Molluscs  
Fig. 16, no. 9

Gastropod from the Percha Formation at Saddle Mountain.

Material.--5 specimens.

Figured Specimens.--UA52990.

Ostracods  
Fig. 16, nos. 7, 8

Ostracods found in the lower part of the carbonate member of the Percha Formation at Saddle Mountain.

Material.--20 specimens.

Figured Specimens.--UA52987-UA52989.

Genus Gluteus Davis and Semken, 1975

Type species: Gluteus minimus Davis and Semken, 1975

Gluteus minimus Davis and Semken, 1975  
Fig. 16, nos. 10-14

Gluteus minimus, Davis and Semken, 1975, p. 251-252, Figs. 2, A-D.

Diagnosis.--This fossil of unknown biological affinities is small, bilobate, asymmetrical and displays a smooth side and a side with concentric growth rings. All specimens found in my study generally resemble the holotypes of G. minimus, but are smaller.

Occurrence.--Davis and Semken (1975) report this fossil from four localities in the Maple Mill Shale of Iowa. Based on conodonts, the Maple Mill Shale was assigned to the Pelekysgnathus inclinatus-Scaphignathus subserratus Fauna (upper part of the Scaphignathus velifer Zone) by Beinert in Klapper and others (1971). In my study, Gluteus minimus was found in the basal beds of the Percha Formation at Highway 77, Brandenburg Mountain 2, and Holy Joe Peak. Conodonts found with G. minimus in the Percha Formation allow assignment to the same P. inclinatus-S. subserratus Fauna as the Maple Mill Shale.

Material.--More than 100 complete or partial specimens.

Figured Specimens.--UA52991-UA52993 (hypotypes).

## APPENDIX A

### CONODONT DISTRIBUTION AND STRATIGRAPHIC COLUMNS

#### Figures A.1-A.11--Explanation

Atry	= atrypid brachiopods
inart	= inarticular brachiopods
rhy	= rhynchonellid brachiopods
brach	= brachiopods
fish	= fish bones and/or teeth
coral	= corals, colonial or solitary
coen	= <u>Coenites</u>
pachy	= <u>Pachyphyllum</u>
hex	= <u>Hexagonaria</u>
syring	= <u>Syringopora</u>
snails	= gastropods
tenta	= tentaculitids
ost	= ostracods
phos pel	= phosphatic pellets
traisl	= trails
HC	= "Horse collars", <u>Gluteus minimus</u>
bry	= bryozoan
clams	= bivalves
sponge	= sponges (spicules or specimens)

- strom = stomatoperoids
- crin = crinoids
- C = common, over 15 specimens observed on bedding planes
- EA = extremely abundant, over 100 specimens observed on bedding planes
- NC = not counted, abundant conodonts on bedding planes studied but not counted



SYSTEM	MISSISSIPPIAN	DEVONIAN	FORMATION	FOSSILS	ROCK TYPE	FEET	METERS	SAMPLE LOCATION	
	MISSISSIPPIAN								
	LOWER MISSISSIPPIAN								
			KINDERHOOKIAN	Crin.	Grainstone				
			ESCARBOSA		Calclitic dolomite				16 14
			FAMENNIAN		Shale	250-76.25			
			PERCHA	Brach.	Dolomite				1 33
				Crin. Brach. Coral	Dolomitic grainstone				40 1
				Atrp.	Calclitic dolomite				8
				Crin. Brach.	Calclitic dolomite				1 1 1
				Crin.	Dolomitic grainstone	200-61.0			1 1 1
					Silty calclitic dolomite				1 1 2
			FRASNIAN	Crin.	Sandy grainstone				
			MARTIN (PART)		Orthoquartzite				
					Dolomite				
					Dolomite	150-45.75			21
					Dolomite				
				Crin.	Dolomitic grainstone				3 16 1 2 1 2
					Orthoquartzite				
					Dolomite				
				Crin.	Grainstone				
					Orthoquartzite				
						100-30.5			
								Base of creek bottom	

Figure A.2. Conodont Distribution and Stratigraphic Column, Pinal Creek. (Lithologies after Pine, 1968)

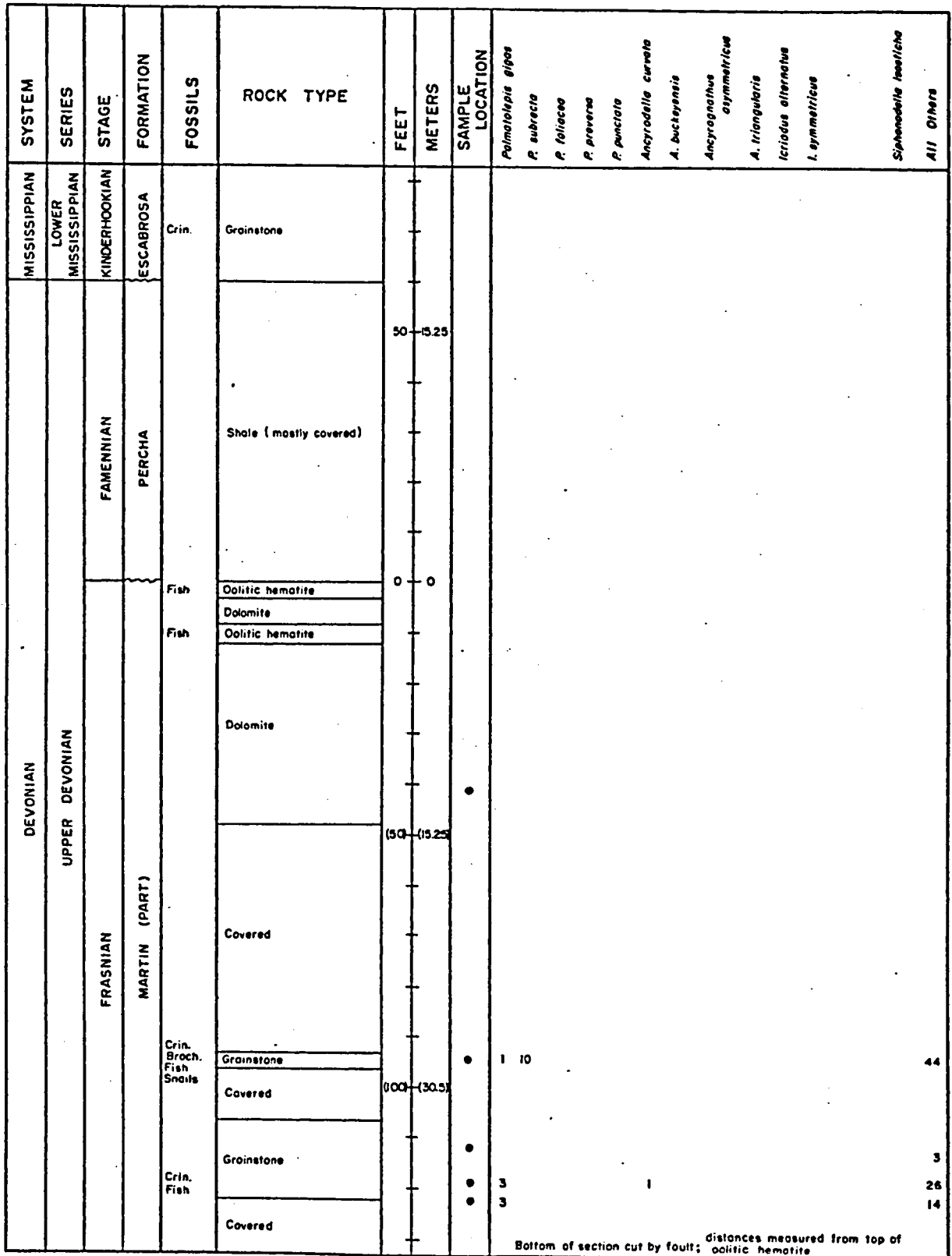


Figure A.3. Conodont Distribution and Stratigraphic Column, Job Corps Camp.









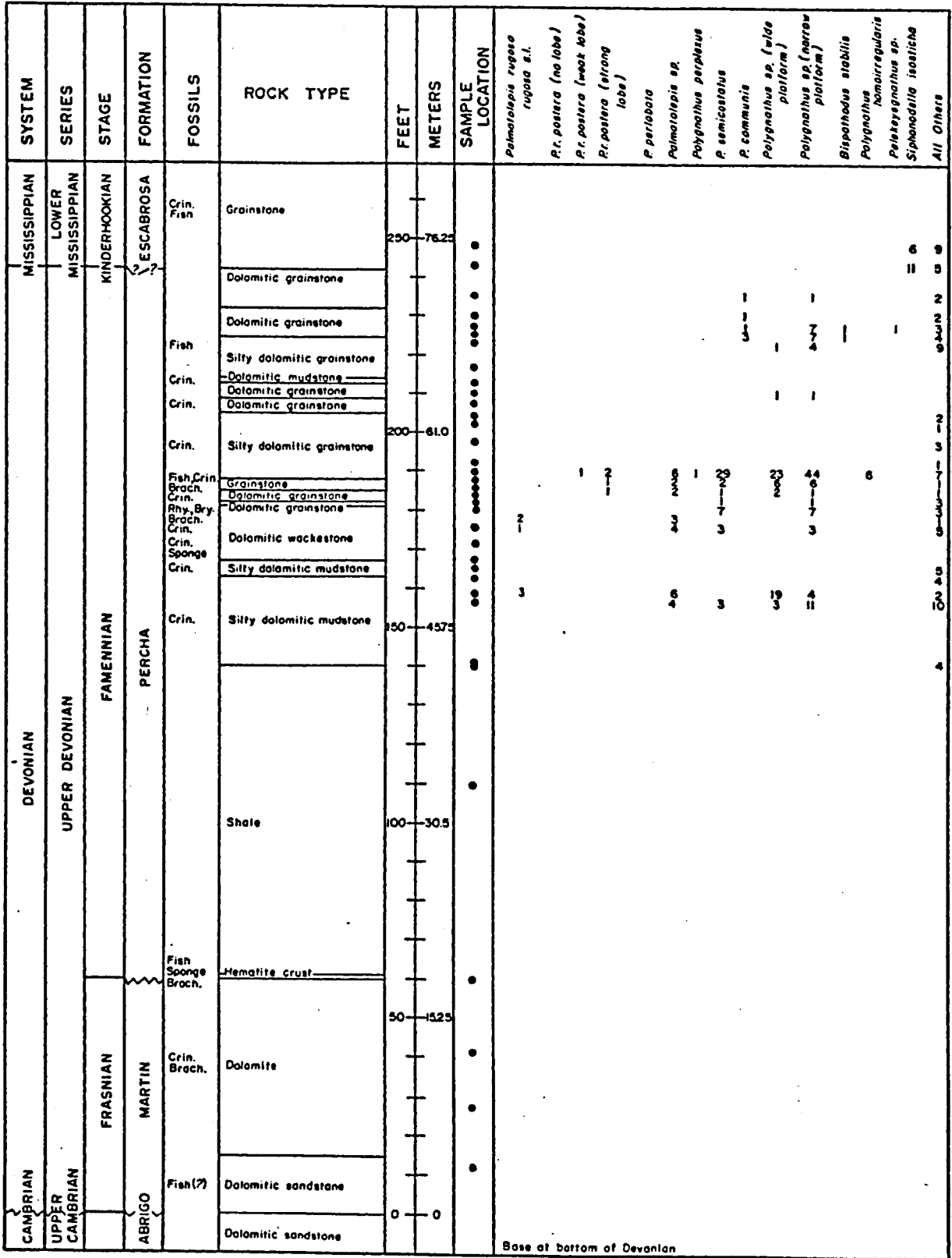


Figure A.8. Conodont Distribution and Stratigraphic Column, Brandenburg Mountain 1.



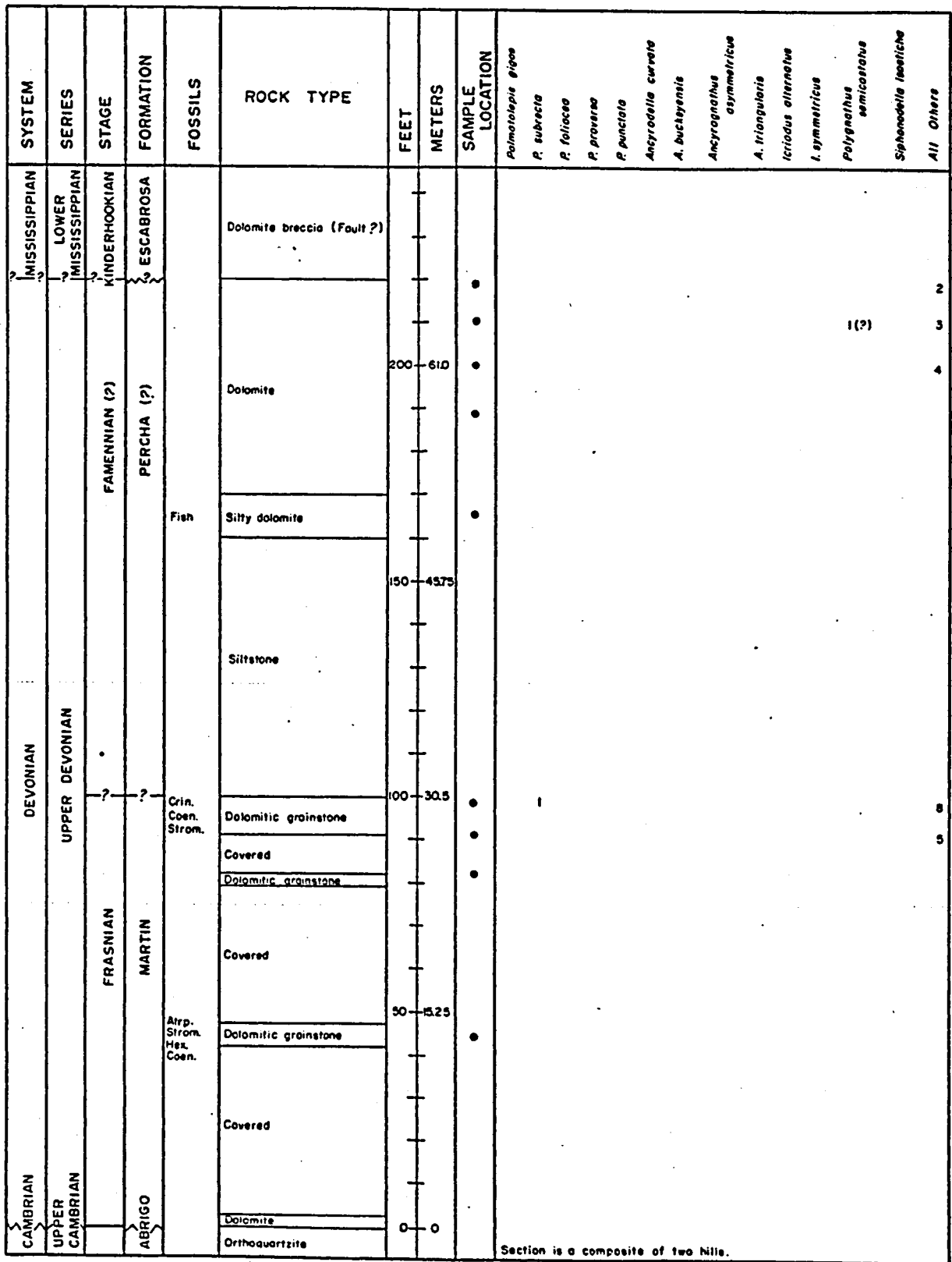


Figure A.10. Conodont Distribution and Stratigraphic Column, Peppersauce Wash.



## REFERENCES

- Anderson, W. I., 1966, Upper Devonian conodonts and the Devonian-Mississippian boundary of north-central Iowa: *Jour. Paleontology*, v. 40, p. 395-415.
- Beinert, R. J., 1968, Conodonts of Maple Mill Shale, southeast Iowa: M. Sc. thesis, University of Iowa, 100 p.
- Bischoff, G. and Ziegler, W., 1957, Die Conodontenchronologie des Mitteldevons und das tiefsten Oberdevons: *Hess. L.-Amt Bodenf. Abh.*, v. 22, 136 p.
- Blake, W. P., 1901, Some salient features in the geology of Arizona with evidence of shallow seas in Paleotectonic time: *Am. Geol.*, v. 27, p. 160-167.
- Branson, E. B. and Mehl., M. G., 1934, Conodonts from the Grassy Creek Shale of Missouri: *Univ. of Missouri Studies*, v. 8 (1933), p. 169-260.
- \_\_\_\_\_, 1938, The conodont genus *Icriodus* and its stratigraphic distribution: *Jour. Paleontology*, v. 12, p. 156-166.
- \_\_\_\_\_, 1941, New and little known Carboniferous conodont genera: *Jour. Paleontology*, v. 15, p. 97-106.
- \_\_\_\_\_, 1948, Conodont homonyms and names to replace them: *Jour. Paleontology*, v. 22, p. 527-528.
- Clark, D. L. and R. L. Ethington, 1967, Conodonts and zonation of the Upper Devonian of the Great Basin: *Geol. Soc. America, Mem.* 103, 94 p.
- Collinson, C., 1963, Collection and preparation of conodonts through mass production techniques: *Ill. Geol. Survey Circ.* 343, 16 p.
- Collinson, C., Becker, L. E., Carlson, M. P., Dorheim, F. H., James, G. W., Koenig, J. W., and Swann, D. H., 1967, Devonian of the north-central region, United States, in *Symposium on the Devonian System, Calgary, Alberta, Sept., 1967*: *Alberta Soc. Petrol. Geologists*, v. 1, p. 933-971.
- Cooper, C. L., 1939, Conodonts from a Bushberg-Hannibal horizon in Oklahoma: *Jour. Paleontology*, v. 13, p. 379-421.

- Davis, R. A. and Semken, H. A., 1975, Fossils of uncertain affinity from the Upper Devonian of Iowa: *Science*, v. 187, p. 251-254.
- Dreesen, R. and Dusar, M., 1974, Refinement of Conodont-Biozonation in the Famenne-type Area: International Symposium on Belgium Micropaleontological Limits, Pub. No. 13, 36 p.
- Dreesen, R. and Orchard, M., 1974, "Intraspecific" morphological variation within Polygnathus semicostatus Branson and Mehl: International Symposium on Belgium Micropaleontological Limits, Pub. No. 21, 26 p.
- Druce, E. C., 1969, Devonian and Carboniferous conodonts from the Bonaparte Gulf Basin, Northern Australia and their use in international correlation: Bureau of Mineral Resources, Geology and Geophysics, Commonwealth of Australia, Bull. 98, 243 p.
- \_\_\_\_\_, 1973, Upper Paleozoic and Triassic conodont distribution and the recognition of biofacies, in *Conodont Paleozoology*, Geol. Soc. of America, Special Paper 141, p. 191-237.
- Dunham, R. J., 1962, Classification of carbonate rocks according to depositional texture, in Ham, W. H., ed., *Classification of carbonate rocks - a symposium*: A.A.P.G. Mem. 1, p. 108-121.
- Ethington, R. L., 1962, Devonian conodonts in Arizona: *New Mexico Geol. Soc. Guidebook*, 13th Field Conf., p. 72-76.
- \_\_\_\_\_, 1965, Late Devonian and Early Mississippian conodonts from Arizona and New Mexico: *Jour. Paleontology*, v. 39, p. 566-589.
- Glenister, B. F. and Klapper, G., 1966, Upper Devonian conodonts from the Canning Basin, Western Australia: *Jour. Paleontology*, v. 40, p. 777-842.
- Gordon, C. H., 1907, Mississippian (Lower Carboniferous) formations in the Rio Grande Valley, New Mexico: *Am. Jour. Science*, v. 24, p. 60-62.
- Ham, W. E. and Wilson, J. L., 1967, Paleozoic epeirogeny and orogeny in the central United States: *Am. Jour. Science*, v. 265, p. 332-407.
- Helms, J., 1959, Conodonten aus dem Saalfelder Oberdevon (Thüringen): *Geologie*, v. 8, p. 634-677.
- \_\_\_\_\_, 1961, Die "nodocostata-Gruppe" der Gattung Polygnathus (Oberdevonische Conodonten): *Geologie*, v. 10, p. 674-711.

- Hinde, G. J., 1879, On conodonts from the Chazy and Cincinnati Groups of the Cambro-Silurian, and from the Hamilton and Genesee division of the Devonian, in Canada and the United States: *Quart. Jour. Geol. Soc. London*, v. 35, p. 351-368.
- Holmes, G. B., 1928, A bibliography of the conodonts with descriptions of Early Mississippian species: *U. S. Mat. Mus. Proc.*, v. 72, art. 5, p. 1-38.
- Huddle, J. W., 1968, Redescription of Upper Devonian conodont genera and species proposed by Ulrich and Bassler in 1926: *U. S. Geol. Soc. Prof. Paper* 578, 55 p.
- \_\_\_\_\_, 1972, Historical introduction to the problem of conodont taxonomy, in Lindstrom, M., and Ziegler, W., eds., *Symposium on conodont taxonomy: Geol. et Paleont. SBI*, p. 3-16.
- Huddle, J. W. and Dobrovolsky, E., 1952, Devonian and Mississippian rocks in central Arizona: *U. S. Geol. Survey Prof. Paper* 233-D, 122 p.
- Johnson, J. G., 1971, Timing and coordination of orogenic, epeirogenic, and eustatic events: *Geol. Soc. America Bull.*, v. 82, p. 3263-3298.
- \_\_\_\_\_, 1974, Extinction of Perched Faunas: *Geology*, v. 2, no. 10, p. 479-482.
- Kindle, E. M., 1916, Some Paleozoic sections in Arizona and their correlation, in Ransome, F. L.: *U. S. Geol. Survey Prof. Paper* 98-K, p. 141-142 and 161.
- Klapper, G. and Furnish, W. M., 1962, Conodont zonation of the early Upper Devonian in eastern Iowa: *Iowa Acad. Sci. Proc.*, v. 69, p. 400-410.
- Klapper, G. and Phillip, G. M., 1971, Devonian conodont apparatuses and their vicarious skeletal elements: *Lethaia* 4, p. 429-452, Oslo.
- \_\_\_\_\_, 1972, Familial classification of reconstructed Devonian conodont apparatuses: *Geol. Palaeontol. SBI*:97-114.
- Klapper, G., Sandberg, C. A., Collinson, C., Huddle, J. W., Orr, R. W., Rickard, L. V., Schumacher, D., Seddon, G., and Uyeno, T. T., 1971, North American conodont biostratigraphy, in Sweet, W., and Bergstrom, S., eds., *Symposium on conodont biostratigraphy: Geol. Soc. America Mem.* 127, p. 285-316.
- Krieger, M. H., 1968a, Geologic map of the Brandenburg Mountain Quadrangle, Pinal County, Arizona: *U. S. Geol. Survey, Map* GQ-668.

- Krieger, M. H., 1968b, Geologic map of the Holy Joe Peak Quadrangle, Pinal County, Arizona: U. S. Geol. Survey, Map GQ-669.
- \_\_\_\_\_, 1968c, Geologic map of the Lookout Mountain Quadrangle, Pinal County, Arizona: U. S. Geol. Survey, Map. GQ-670.
- \_\_\_\_\_, 1968d, Geologic map of the Saddle Mountain Quadrangle, Pinal County, Arizona: U. S. Geol. Survey, Map GQ-671.
- McGugan, Alan, 1965, Occurrence and persistence of thin shelf deposits of uniform lithology: Geol. Soc. America Bull., v. 76, no. 1, p. 125-130.
- McLaren, D. J., 1970, Presidential Address: Time, life, and boundaries: Jour. Paleontology, v. 44, no. 5, p. 801-815.
- Meader, S., n.d., Paleoecology of the Upper Devonian Percha Formation, south-central Arizona, The University of Arizona, Master's Thesis in preparation.
- Miller, A. K. and Youngquist, W., 1947, Conodonts from the type section of the Sweetland Creek Shale in Iowa: Jour. Paleontology, v. 21, p. 501-517.
- Mound, M., 1968, Upper Devonian conodonts from Southern Alberta: Jour. Paleontology, v. 42, p. 444-524.
- Müller, K. J., 1956, Zur Kenntnis der Conodonten-fauna des europäischen Devons, 1. Die Gattung Palmatolepis: Abh. Senckenb. Naturf. Ges., v. 494, p. 1-70.
- \_\_\_\_\_, 1962, Zur systematischen Einteilung der Conodontophorida: Palaont. Z., v. 36, p. 109-117.
- Müller, K. J. and Müller, E. M., 1957, Early Upper Devonian (Independence) conodonts from Iowa, part I: Jour. Paleontology, v. 31, p. 1069-1108.
- Newell, N. D., Purdy, E. G. and Imbrie, J., 1960, Bahamian oolitic sand: Jour. Geology, v. 68, p. 481-497.
- Oliver, W. A., Jr., DeWitt, W., Jr., Dennison, J. M., Hoskins, D. M., and Huddle, J. W., 1967, Devonian of the Appalachian Basin, United States, in Int. Symposium on the Devonian System, Calgary, Alberta, Sept., 1967: Alberta Soc. Petrol. Geol., v. 1, p. 1001-1040.
- Pander, C. H., 1856, Monographia der fossilen fische de Silurischen Systems der Russian-Batischen Gouvernements: K. Akad. Wiss. St. Petersburg, 91 p.

- Pine, G. L., 1968, Devonian stratigraphy and paleogeography in Gila, Graham, Greenlee, and Pinal Counties, Arizona: Unpub. Ph.D. dissertation, The University of Arizona, 305 p.
- Pye, W. D., 1959, Silurian and Devonian stratigraphy, southeastern Arizona and southwestern New Mexico, in Arizona Geol. Soc. Guidebook II: p. 25-30.
- Ransome, F. L., 1904, The geology and ore deposits of the Bisbee Quadrangle, Arizona: U. S. Geol. Survey Prof. Paper 21, 168 p.
- \_\_\_\_\_, 1916, Some Paleozoic sections in Arizona and their correlation: U. S. Geol. Survey Prof. Paper 98, p. 133-166.
- Rexroad, C. B., 1969, Conodonts from the Jacob Chapel Bed (Mississippian) of the New Albany Shale in Southern Indiana: Department of Natural Resources Geol. Survey Bull. 41, State of Indiana, 55 p.
- Sabins, F. F., Jr., 1957, Stratigraphic relations in Chiricahua and Dos Cabezas Mountains, Arizona: Am. Assoc. Petrol. Geol. Bull., v. 41, p. 466-510.
- Sandberg, C. A., 1969, Conodont-rich lag deposits: a tool for dating Late Devonian and Early Mississippian structural movements and oil migration in the northern Rocky Mountains Region (abs.): Geol. Soc. America, Spec. Paper 121, p. 633.
- \_\_\_\_\_, 1975, Conodont biofacies of Late Devonian Polygnathus styriacus Zone in western United States, (abs.): Geol. Soc. America Ann. Mtg., Waterloo, Ontario, p. 847.
- \_\_\_\_\_, 1976, Conodont biofacies of Late Devonian Polygnathus styriacus Zone in western United States, in Barnes, C. R., ed., Symposium on conodont paleoecology: Geol. Assoc. Canada Sp. Paper (in press).
- Sandberg, C. A. and Klapper, G., 1967, Stratigraphy, age and paleotectonic significance of the Cottonwood Canyon Member of the Madison Limestone in Wyoming and Montana: U. S. Geol. Survey Bull. 1251-B, p. 1-70.
- Sandberg, C. A. and Ziegler, W., 1973, Refinement of standard Upper Devonian conodont zonation based on sections in Nevada and West Germany: Geologic et Palaeontologica, v. 7, p. 97-122.
- Sartenaer, P.J.M.J., 1967, Famennian Rhynchonellid Brachiopod genera as a tool for correlation, in Int. Symposium on the Devonian System, Calgary, Alberta, Sept., 1967: Alberta Soc. Petrol. Geol., v. II, p. 1043-1060.

- Schumacher, D., 1971, Conodonts and biostratigraphy of the "Kenwood" Shale (Upper Devonian), in Conodonts and Biostratigraphy of the Wisconsin Paleozoic: Geol. and Nat. Hist. Surv., The Univ. of Wisconsin, Information Circular 19, p. 68-77.
- \_\_\_\_\_, 1976, Conodont biofacies and paleoenvironments in Middle Devonian-Upper Devonian boundary beds, Central Missouri, U.S.A., in Symposium on Conodont Paleocology: Geol. Assoc. Canada Sp. Paper (in press).
- Schumacher, D., Witter, D. P., Meader, S. J., and Keith, S. B., 1976, Late Devonian tectonism in southeastern Arizona, in Wilt, J. C., and Jenney, J. P., eds., Tectonic Digest, Az. Geol. Soc. Digest, v. X, p. 59-70.
- Seddon, G., 1970, Frasnian conodonts from the Sadler Ridge-Bugle Gap area, Canning Basin, Western Australia: Jour. Geol. Soc. Australia, v. 10, p. 723-753.
- Seddon, G. and Sweet, W. C., 1971, An ecologic model for conodonts: Jour. Paleontology, v. 45, p. 869-880.
- Stainbrook, M. A., 1947, Brachiopoda of the Percha Shale of New Mexico and Arizona: Jour. Paleontology, v. 21, p. 297-328.
- Stauffer, C. R., 1938, Conodonts of the Olentangy Shale: Jour. Paleontology, v. 12, p. 411-443.
- Stevenson, F. V., 1945, Devonian of New Mexico: Jour. Geol., v. 53, p. 217-245.
- Stoyanow, A. A., 1936, Correlation of Arizona Paleozoic formations: Geol. Soc. America Bull., v. 47, p. 459-540.
- Sweet, W. C. and Bergstrom, S. M., 1970, The generic concept in conodont taxonomy: North America Paleont. Convention 1969, Proc. C., p. 157-173.
- Szulczewski, M., 1971, Upper Devonian conodonts, stratigraphy, and facial development in the Holy Cross Mountains: Acta. Geol. Polonica, v. 21, p. 1-130.
- Teichert, C., 1965, Devonian rocks and paleogeography of central Arizona: U. S. Geol. Surv. Prof. Paper 464, 181 p.
- Thomas, L. A., 1949, Devonian-Mississippian formations of southeast Iowa: Geol. Soc. America Bull., v. 60, p. 403-437.

- Twenhofel, W. H., 1936, Marine unconformities, marine conglomerates, and thicknesses of strata: *Am. Assoc. Petrol. Geol. Bull.*, v. 20, no. 6, p. 677-703.
- Ulrich, E. O. and Bassler, R. S., 1926, A classification of the tooth-like fossils, conodonts, with descriptions of American Devonian and Mississippian species: *U. S. Nat. Mus. Proc.*, v. 68, Art. 12, p. 1-63.
- Williams, H. S., 1903, Devonian fossils of the Globe Quadrangle, in Ransome, F. L., *Geology of the Globe Copper District, Arizona*: U. S. Geol. Survey Prof. Paper 12, p. 40-42.
- Winder, C. G., 1966, Conodont zones and stratigraphic variability in Upper Devonian rocks, Ontario: *Jour. Paleontology*, v. 40, p. 1275-1293.
- Wright, J. J., 1964, Petrology of the Devonian rocks in eastern Pima and Cochise Counties, Arizona: Unpub. Ph.D. dissertation, The University of Arizona, 153 p.
- Youngquist, W., 1945, Upper Devonian conodonts from the Independence shale (?) of Iowa: *Jour. Paleontology*, v. 19, p. 355-367.
- Ziegler, W., 1958, Conodontenfeinstratigraphische Untersuchungen an der Grenze Mitteldevon/Oberdevon und in der Adorfstufe: *Notizbl. Hess. L.-Amt Bodenforsch.*, v. 87, p. 7-77.
- \_\_\_\_\_, 1962, Taxionomie und Phylogenie Oberdevonischer Conodonten und ihre stratigraphische Bedeutung: *Hess. Landesamt Bodenforschung Abh.*, v. 38, 166 p.
- \_\_\_\_\_, 1971, Conodont stratigraphy of the European Devonian: *Geol. Soc. America Mem.* 127, p. 227-284.
- Ziegler, W., Sandberg, C. A. and Austin, R. L., 1974a, Revision of Bispathodus group (Conodonta) in the Upper Devonian and Lower Carboniferous: *Geologica et Palaeontologica*, v. 8, p. 97-113.
- \_\_\_\_\_, 1974b, The Bispathodus group (Conodonta) in the Upper Devonian and Lower Carboniferous: *Int. Symposium on Belgium Micropaleontological Limits*, Pub. No. 20, 8 p.

Journal of the Entomological Society of America, vol. 45, p. 107-108, 1952.

Wright, E. O. and Sessler, R. J., 1952. A classification of the leafhoppers of the suborder Fulgoroidea with descriptions of new species. Entomological Society of America, vol. 45, p. 1-61.

Wright, H. S., 1901. Revision of the leafhoppers of the suborder Fulgoroidea. Entomological Society of America, vol. 1, p. 1-100.

Wright, H. S., 1902. Descriptions of new species of leafhoppers. Entomological Society of America, vol. 1, p. 101-110.

Wright, H. S., 1903. Descriptions of new species of leafhoppers. Entomological Society of America, vol. 1, p. 111-120.

Wright, H. S., 1904. Descriptions of new species of leafhoppers. Entomological Society of America, vol. 1, p. 121-130.

Wright, H. S., 1905. Descriptions of new species of leafhoppers. Entomological Society of America, vol. 1, p. 131-140.

Wright, H. S., 1906. Descriptions of new species of leafhoppers. Entomological Society of America, vol. 1, p. 141-150.

Wright, H. S., 1907. Descriptions of new species of leafhoppers. Entomological Society of America, vol. 1, p. 151-160.

Wright, H. S., 1908. Descriptions of new species of leafhoppers. Entomological Society of America, vol. 1, p. 161-170.

Wright, H. S., 1909. Descriptions of new species of leafhoppers. Entomological Society of America, vol. 1, p. 171-180.