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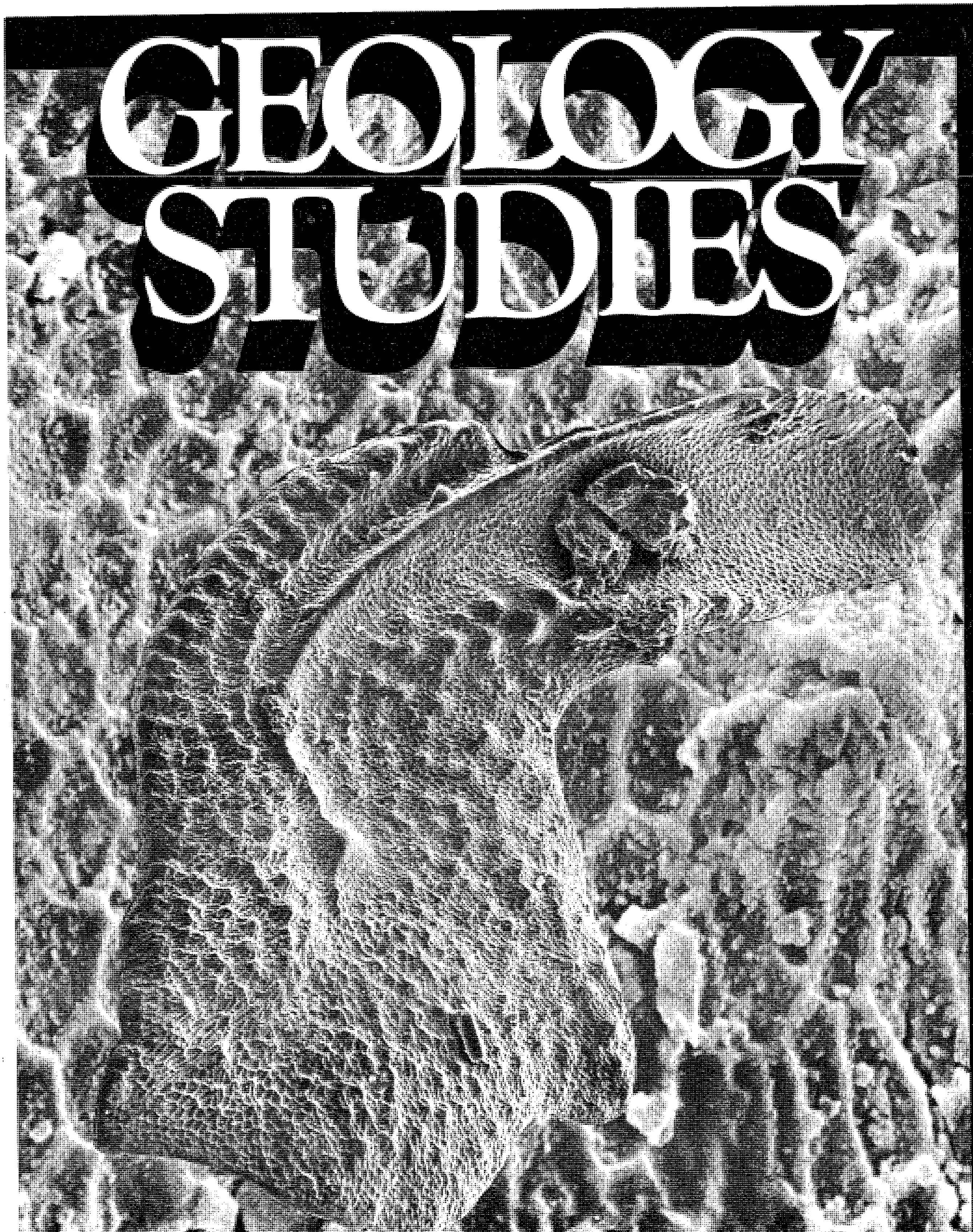

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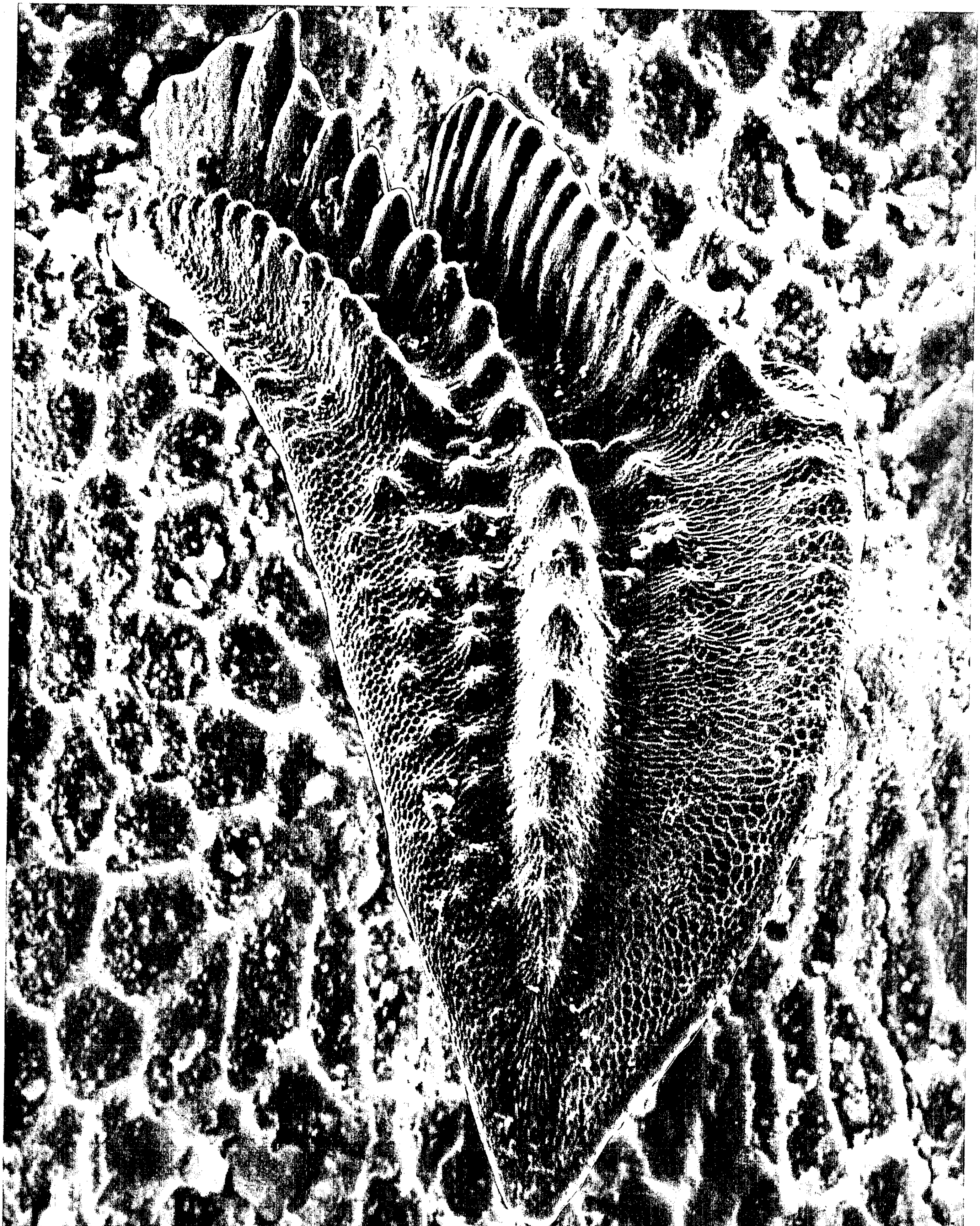

Brigham Young University Geology Studies

Volume 26, Part 3

Conodont Biostratigraphy of the Great Basin and Rocky Mountains

The proceedings of the Pander Society symposium, workshop, and post-meeting field trip held in conjunction with the Rocky Mountain section, Geological Society of America, at Brigham Young University, Provo, Utah, on April 28–May 2, 1978

Charles A. Sandberg and David L. Clark
Editors

Front cover: Late Devonian conodont Palmatolepis rugosa ampla.
Inside front cover: Early Mississippian conodont Siphonodella isosticha. *Both are SEM photomicrographs. See preface for details.*

THE GLORY OF GOD IS INTELLIGENCE

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PREFACE

The distribution of papers of this symposium volume among the various geologic systems is a good representation of the focus of regional conodont biostratigraphic work in the Great Basin and Rocky Mountains, with one notable exception. Work on the Cambrian System by J. F. Miller is not included because it either had been already published or was scheduled for publication elsewhere. Moreover, the guidebook for the Pander Society field trip on Cambrian and Ordovician rocks, held on April 26–27, 1978, immediately preceding the symposium at Provo, Utah, has already been published (Miller 1978). Judging by the numbers of papers published here and elsewhere, conodont work in the Great Basin and Rocky Mountain regions appears to be focused primarily on the Ordovician, Permian, and Triassic Systems, and secondarily on the Cambrian, Devonian, and Mississippian Systems. It is noteworthy that no papers in this volume are devoted to the Silurian and Pennsylvanian Systems. Although some work on these systems in the Great Basin has appeared in the past, the editors were unable to find workers actively enough engaged in studies of these systems on a regional basis to contribute to the present symposium. Hence the Silurian and Pennsylvanian Systems appear to offer fertile, uncrowded fields for future investigators.

In editing the papers of this symposium volume, an increasing awareness of conodont biofacies was noted among authors of all systems. Although there is still some indication that provinciality of conodont faunas existed in the western United States during limited intervals of geologic time, it is becoming evident that more and more seemingly provincial conodont faunas are being encountered as conodont studies extend westward off the former shelf into more offshore, deeper-water realms in central Nevada. Continued work on several systems in the Great Basin region may eventually discern as many lateral biofacies as the eight that have been recognized in the *Polygnathus styriacus* Zone of the Upper Devonian in the same region by Sandberg (1976) and Sandberg and Ziegler (1979). As demonstrated by Sandberg (1976), the combined Rocky Mountain and Great Basin regions offer an unparalleled opportunity for conodont workers to study faunas of the same age in a transect of environments, ranging from peritidal to far offshore pelagic—even including rises surrounding island arcs.

The front cover and inside front cover of this volume, which show the Late Devonian conodont *Palmatolepis rugosa ampla* and the Early Mississippian conodont *Siphonodella isosticha,* respectively, against a background of platform-conodont micro-ornamentation, were composited from SEM photomicrographs made at the Fachbereich Geowissenschaften, Philipps-Universität, Marburg, Federal Republic of Germany, under the direction of Prof. Dr. Willi Ziegler, to whom we are grateful for permission to use them.

REFERENCES

Miller, J. F. (ed.), 1978, Upper Cambrian to Middle Ordovician conodont faunas of western Utah; 1978 Pander Society field trip: Southwest Missouri State University, Geoscience Series, no. 5, 44p.

Sandberg, C. A., 1976, Conodont biofacies of Late Devonian *Polygnathus styriacus* Zone in western United States: In Barnes, C. R. (ed.), Conodont paleoecology: Geological Association of Canada Special Paper 15, p. 171–86.

Sandberg, C. A., and Ziegler, Willi, 1979, Taxonomy and biofacies of important conodonts of Late Devonian *styriacus*-Zone, United States and Germany: Geologica et Palaeontologica, v. 13, p. 173–212, 7 pls.

Devonian and Lower Mississippian Conodont Zonation of the Great Basin and Rocky Mountains

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ABSTRACT.—A total of 56 conodont zones are now recognized in the Devonian and Lower Mississippian: 10 zones in the Lower Devonian, 10 zones (excluding 1 as yet unzoned interval) in the Middle Devonian, 27 zones in the Upper Devonian, and 9 zones in the Lower Mississippian. Because of the wide range in paleoenvironmental settings from peritidal to pelagic that are represented by Devonian and Lower Mississippian rocks in the Rocky Mountain and Great Basin regions, a large part of this zonation has been proposed, refined, or critically tested in this huge area. Only 5 zones that are known in Europe have not been recognized as yet in the Western United States. The zonation of the lower half of the Lower Devonian is based on the first occurrence of species in several different lineages. The zonation of the upper half of the Lower Devonian, beginning with the first appearance of the genus *Polygnathus*, and of the Middle Devonian is based almost entirely on the phylogeny of this genus and related genera, *Tortodus* and *Schmidtognathus*. The zonation of the Upper Devonian is based mainly on the phylogeny of the genus *Palmatolepis* and its direct ancestor, *Polygnathus asymmetricus*. The zonation of the highest part of the Devonian and of the Kinderhookian is based mainly on the phylogeny of the genus *Siphonodella*. The highest part of the *Siphonodella* zonation and the lowest Osagean zone are based on the lineage of the genus *Gnathodus*. Two higher Osagean zones are based on first occurrences of *Doliognathus latus* and *Taphrognathus varians*.

The Late Devonian (late Famennian) *Polygnathus styriacus* Zone is divisible laterally into the 5 biofacies proposed by Sandberg (1976), as well as into three other possible nearshore biofacies. Adjacent Famennian zones probably can be divided into the same number of biofacies. Much older Devonian zones and Lower Mississippian zones can now be divided laterally into at least two biofacies—nearshore and pelagic—based on occurrences of the genera *Icriodus*, *Polygnathus*, *Siphonodella*, *Pandorinellina*, *Patrognathus*, and "*Spathognathodus*." Additional biofacies undoubtedly will be recognized with increased knowledge of faunal distribution.

CONTENTS

INTRODUCTION

This paper summarizes the present state of knowledge (to May 1978) of the Devonian and Lower Mississippian conodont zonation of the Great Basin and Rocky Mountain regions. The zonation of the Lower and Middle Devonian is merely a regional extension of the zonal scheme proposed by Klapper (1977) in central Nevada and hence is commented on only briefly. The standard Upper Devonian zonation was proposed by Ziegler (1962) and was amended or refined by several later authors, including Ziegler (1971) and Sandberg and Ziegler (1973). It was adopted for use in the Great Basin and Rocky Mountains by Sandberg and Poole (1977). The highest Devonian and Lower Mississippian (Kinderhookian) *Siphonodella* zonation was provisionally proposed by Sandberg and Ziegler (1976) and was formalized and amended by Sandberg, Ziegler, and others (1978). The upper Lower Mississippian (Osagean) zonation proposed herein is considered a tentative working zonation that may be amenable to further subdivision. It differs in being based primarily on shelf-margin and pelagic faunas from zonations (e.g., Collinson and others 1962) that originated in the Midcontinent region..

Early History of Conodont Studies

The literature on Devonian and Lower Mississippian conodont faunas and zonation in the Rocky Mountains and Great Basin covers only 40 years and is not extensive. In fact, the short selective bibliography of this report lists most, if not all, of the important references. Specifically excluded are abstracts that were superseded by formal papers and theses that subsequently were published in whole or in part.

The first discoveries of Devonian and Lower Mississippian conodonts in the Rocky Mountain region were reported in 1938. Upper Devonian conodonts in the Wind River Mountains, Wyoming, were mentioned by Branson and Mehl (1938) and later listed by Branson and Branson (1941). Lower Mississippian (Kinderhookian) conodonts from the Little Rocky Mountains, Montana, were listed by Knechtel and Hass (1938), and their listing was amended by Hass (1943). Cooper and Sloss (1943) illustrated the first Kinderhookian conodonts, and Cooper (1945) illustrated the first Upper Devonian conodonts from the Rocky Mountain region in western Montana. Between 1946 and 1957 no conodont papers were published on the Rocky Mountain region or on the Great Basin region. In 1958, Klapper recollected and illustrated the faunas from the Wind River Mountains that had been mentioned earlier by Branson and Mehl (1938).

Conodont studies were not extended into the Great Basin region until 1958, when Chapman completed a master's thesis on Frasnian conodonts in the Confusion Range, Utah. At about the same time, work on Upper Devonian conodonts was under way at Brigham Young University. The first informal Upper Devonian conodont zonation for the Great Basin was published by Clark and Becker (1960). Their zonation was expanded by Beach (1961), who first illustrated Upper Devonian conodonts from the Great Basin.

Conodont zonation of the Upper Devonian and Lower Mississippian in the Great Basin and Rocky Mountain regions reached maturity only after comprehensive zonal schemes were published in distant regions in 1962. Collinson, Scott, and Rexroad (1962) published a conodont zonation for the type Mississippian in the Upper Mississippi Valley region. Their zonation has provided the basis for all later conodont zonations of the Mississippian in North America. In the same year, Ziegler (1962) published a zonation of the Upper Devonian in Germany that rendered obsolete all previous zonal schemes, including the Upper Devonian zonation of Collinson, Scott, and Rexroad (1962). Clark and Ethington (1967) published the first comprehensive zonation of the Upper Devonian in the Great Basin and recognized 12 of Ziegler's (1962) zones there. Klapper (1966) and Sandberg and Klapper (1967) published zonations for the Upper Devonian and Lower Mississippian of the Northern Rocky Mountains that incorporated parts of the zonal schemes of Ziegler (1962) and Collinson, Scott, and Rexroad (1962). Upper Devonian conodont zonation was first applied to regional stratigraphic studies of the Rocky Mountains and Great Basin by Sandberg and Mapel (1967) and by Poole and others (1967), respectively. Lower Mississippian conodonts from the Idaho part of the Basin and Range province were first reported by Sandberg, Mapel, and Huddle (1967). In a paper on Lower Devonian conodonts in northern Canada, Klapper (1969) made comparisons with sequences in central Nevada and illustrated a few specimens from that area.

Development of Present Conodont Zonation

The Devonian conodont zonation presented herein was built on the North American Devonian zonation compiled by Gilbert Klapper and me in collaboration with seven other coauthors in 1968–69. Unfortunately, this zonation became obsolete in the short interval between its oral presentation at the Pander Society Symposium on Conodont Biostratigraphy at Columbus, Ohio, in May 1969 and its formal publication (Klapper, Sandberg, and others 1971) early in 1971. This obsolescence was caused by two factors. First, a much closer collaboration with Willi Ziegler, who had developed the European conodont zonation, began during the Columbus meeting and immediately led to a meshing of ideas on conodont species concepts and a realization that the differences in conodont ranges, as presented by Ziegler (1971) and Klapper, Sandberg, and others (1971), were not as great as they appeared. Second, the scope of conodont research in the Great Basin by Klapper on the Lower and Middle Devonian and by me on the Upper Devonian was just then beginning to expand rapidly. The close intercontinental collaboration and intensified research in the Great Basin produced these important developments during the 1970s:

1. A formal zonation for the Lower Devonian was proposed in central Nevada by Klapper (1977) to replace the informal subdivision into Faunas 1 to 9 by Klapper, Sandberg, and others (1971, p. 287–92).
2. A subdivision of the late Middle Devonian (Givetian) *Polygnathus varcus* Zone was proposed by Ziegler, Klapper, and Johnson (1976) on the basis of conodont ranges in both North America and Europe.
3. A formal zonation for the Middle Devonian was proposed in central Nevada by Klapper (1977) to replace the informal faunal scheme of Klapper, Sandberg, and others (1971, p. 293–99).
4. As knowledge of conodont faunas on both continents increased and as species that had been thought to be confined to one continent were discovered on the other, the apparent differences in ranges of almost all Upper Devonian species between North America and Europe were resolved. This resolution is exemplified by the establishment of a new zone, the Lower *Palmatolepis rhomboidea* Zone, which was based on the simultaneous discovery of new species of *Palmatolepis* in Nevada and West Germany (Sandberg and Ziegler 1973).
5. As conodont studies were extended progressively farther west in the Great Basin, many pelagic species of Upper Devonian conodonts that were unknown or scarce in the New York, Midcontinent, and Rocky Mountain regions were found. This produced a much closer match with the European conodont zonation than had been predicted by Klapper, Sandberg, and others (1971, p. 305) and led to adoption of the standard Upper Devonian conodont zonation, originally proposed in Germany, for the Western United States by Sandberg and Poole (1977).
6. As faunas of the same zone, the *Polygnathus styriacus* Zone, were collected in environments ranging westward from peritidal to pelagic, a recognition of at least 5 lateral conodont biofacies (Sandberg 1976) provided a third dimension to the Upper Devonian conodont zonation.
7. A zonal scheme for the highest Devonian and lower part of the Lower Carboniferous (Kinderhookian) was developed on the basis of ranges of species of *Siphonodella* in the Rocky Mountains, Great Basin, and West Germany (Sandberg and Ziegler 1976; Sandberg, Ziegler, and others 1978).

CONODONT ZONATION

Lower and Middle Devonian

The Lower and Middle Devonian conodont zonation was established by Klapper (1977) on the basis of lower plate limestone sequences in Eureka County and northern Nye County, central Nevada. The 10 Lower Devonian zones replace the 9 informal faunal units of Klapper, Sandberg, and others (1971). The Middle Devonian zones are virtually the same as those that have been recognized in Europe (Weddige and Ziegler 1977, Weddige 1977). The Lower and Middle Devonian zonation is repeated here (fig. 1), so that the zonation of the entire Devonian and Lower Mississippian will be available from a single source. Because of the excellence of Klapper's (1977) treatment, it is unnecessary to repeat a full discussion of the zonal boundaries, type sections, index conodonts, faunal associations, and ranges in central Nevada. Instead, a few brief, general comments will be followed by a mention of zonal occurrences in the Rocky Mountains and the Great Basin outside central Nevada.

General comments

It is important to note that the base of the lowermost Lower Devonian conodont zone, the *Icriodus woschmidti hesperius* Zone (fig. 1) does not mark the base of the Devonian. By international agreement, this boundary now is placed at the lowest occurrence of the graptolite *Monograptus uniformis.* Because the conodont *I. woschmidti hesperius* first appears a short distance below *M. uniformis* in the boundary stratotype in Czechoslovakia, the base of the *hesperius* Zone only approximates the Silurian-Devonian boundary.

The lower six Lower Devonian zones (fig. 1) are based on first occurrences of species or subspecies belonging to four different genera, because no single widely distributed phyletic lineage exists on which they could have been based. With the exception of the *Ozarkodina* n. sp. D Zone, the lower boundaries of these zones are defined by the lowest occurrence of the nominal species or subspecies. The *O.* n. sp. D Zone is based on the lowest occurrence of *O.* n. sp. C, but it is named for the more widely occurring *O.* n. sp. D. Unfortunately, neither species has been formally illustrated as yet by Klapper.

The upper 4 Lower Devonian conodont zones and all 10 Middle Devonian zones are better established, because they are based primarily on phyletic lineages within a single genus, *Polygnathus,* and two related genera, *Tortodus* and *Schmidtognathus.* The zonal-name-giving subspecies *kockelianus australis* and *kockelianus kockelianus* were transferred by Weddige (1977) from Polygnathus to the new genus, *Tortodus,* which is distinguished by its laterally curved and twisted platform and by its large pit, from *Polygnathus.* The zonal-name-giving species *hermanni* is assigned to the genus *Schmidtognathus,* which is distinguished mainly by its asymmetric basal pit from *Polygnathus.*

A possible improvement in the Lower Devonian zonation might be effected by extending the *Polygnathus*-based zonation one zone lower and replacing the *Eognathodus sulcatus* n. subsp. Zone with a zone based on the first occurrence of *Polygnathus pireneae* Boersma, the oldest currently known species of *Polygnathus.* The evolution of this species from a possible spathognathodan or eognathodan ancestor should provide an easily recognized worldwide event.

The *Polygnathus costatus patulus* Zone (fig. 1) was intentionally not tabulated by Klapper (1977, fig. 1), although he did discuss this zone in its proper sequence. The reason for his omission and my inclusion of this zone with an asterisk (*) is that this zone has not yet been identified in the Great Basin and Rocky Mountain regions although it is known in New York State and in Europe. With increased knowledge of faunas, it is a virtual certainty that this zone will be encountered in the Western United States. Although absent in the lower plate in central Nevada, the nominal subspecies of this zone has been found in the lower part of the next higher *Polygnathus costatus costatus* Zone in the lower member of the upper plate Milligen Formation in Idaho (Sandberg and others 1975, sample SAW-1, p. 711).

Following Klapper (1977), I show an unzoned interval on figure 1 between the *Tortodus kockelianus kockelianus* Zone and the Lower *Polygnathus varcus* Zone. Only an undiagnostic fauna has as yet been found by Klapper (1977, p. 47) in this insufficiently sampled interval.

The upper and lower subdivisions of the *Schmidtognathus hermanni-Polygnathus cristatus* Zone (fig. 1) are enclosed in quo-

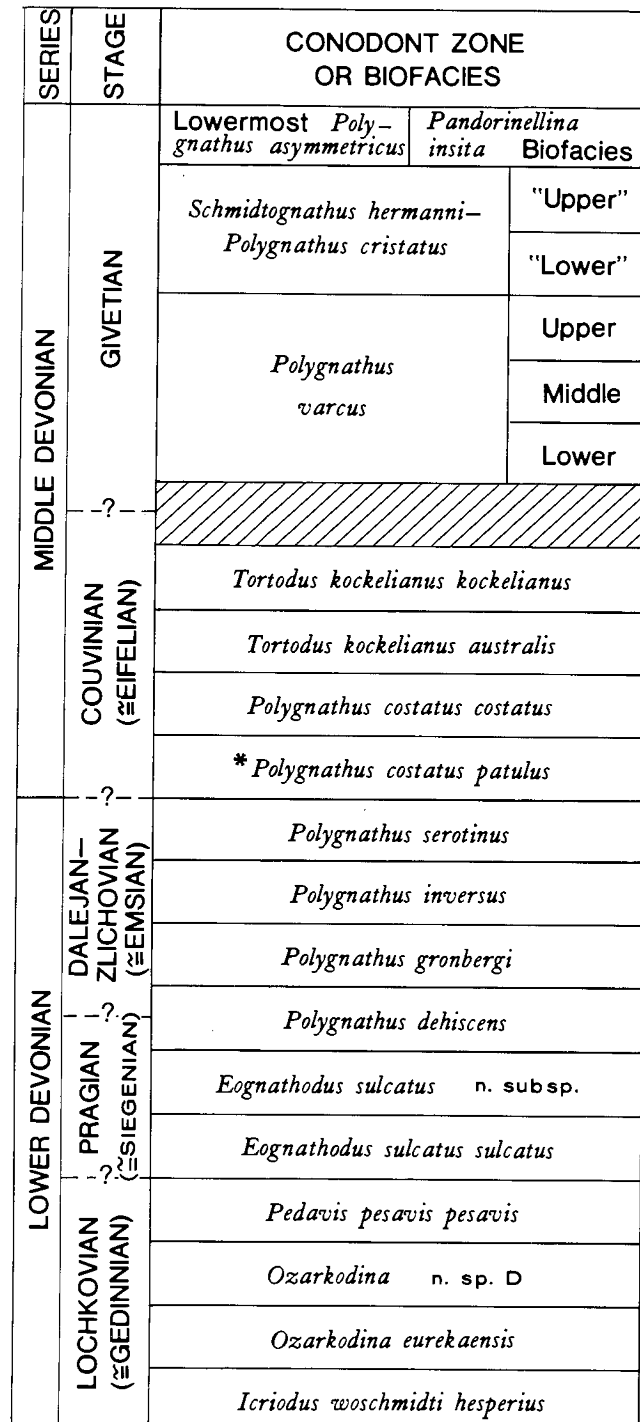

FIGURE 1.–Lower and Middle Devonian conodont zonation (modified from Klapper 1977). *, zone not yet identified in western United States; cross-hatching, unzoned interval lacking diagnostic conodonts.

tation marks to emphasize that these are still considered to be informal zones. All other usages of *Upper, Middle, Lower, Lowermost,* and *Uppermost* in this paper, are considered to be formal zones, and not subzones.

Icriodus woschmidti hesperius *Zone*

The *Icriodus woschmidti hesperius* Zone has been recognized in the Roberts Mountains Formation at Fish Creek Reservoir in the Pioneer Mountains, Idaho (Skipp and Sandberg 1975, p. 702, samples FCR-8B and 8A).

Ozarkodina *n. sp. D Zone*

At three localities north of the Snake River Plain in Idaho, the *Ozarkodina* n. sp. D Zone has been found. It may be represented in the upper plate Roberts Mountains Formation at Fish Creek Reservoir in the Pioneer Mountains in my sample FCR-7, which contains an association of *Ozarkodina* n. sp. D and *O. stygia* (Skipp and Sandberg 1975, p. 703). It definitely is present in a shallow-water, lower plate, unnamed Lower Devonian unit at Upper Spar Canyon (Johnson and Sandberg 1977, p. 126–27, fig. 4), where *O.* n. sp. C occurs alone in my collection SPAR-11A and with *O. johnsoni* in a higher collection, USGS 9500-SD, from a sample of W. H. Hays. (The Upper Spar Canyon section is located on a ridge crest in the SW¼NW¼ sec. 26, T. 11 N, R. 19 E, Custer County, Idaho, in the Lone Pine Peak 1:24,000 quadrangle.) The *O.* n. sp. D Zone is also definitely present in my collection from sample T-SD-4 of C. M. Tschanz. This collection, which contains an association of *O.* n. sp. C, *O.* n. sp. D, *O. stygia,* and *O. johnsoni,* comes from the upper plate Milligen Formation on North Fork Big Lost River in the Boulder Mountains. (The sample locality is at lat 43°53'36" N, long 114°21'39" W in Custer County, Idaho, in the Meridian Peak 1:24,000 quadrangle.)

Eognathodus sulcatus *n. subsp. Zone*

The *Eognathodus sulcatus* n. subsp. Zone has been recognized in the lowest exposed limestone ledge of the upper plate Slaven Chert near the Hilltop Barite Mine, near Slaven Canyon, in the Shoshone Range, Nevada. It occurs in my collection SVN-4, which contains an association of the nominal subspecies and *Polygnathus pireneae* Boersma. (The sample locality is in the NW¼NE¼SE¼ sec. 10, T. 30 N, R. 46 E, Lander County, Nevada, in the Mt. Lewis 1:62,500 quadrangle.)

Polygnathus costatus costatus *Zone*

Recognized at three localities north of the Snake River Plain in Idaho, the *Polygnathus costatus costatus* Zone is present in several samples from the lower plate Carey Dolomite at Fish Creek Reservoir in the Pioneer Mountains. An updated list of the important taxa that were tabulated by Skipp and Sandberg (1975, table 1) comprises: the nominal subspecies, *Pandorinellina exigua expansa, Polygnathus serotinus, P.* cf. *P. dobrogensis, P. angustipennatus,* and *Tortodus intermedius.* Importantly, the coarser-textured beds that yield this fauna, which represents a polygnathid-pandorinellinid biofacies, are interbedded with finer-textured beds that contain a fauna of *Icriodus* cf. *I. angustus* and *I. corniger,* which represents an icriodid biofacies. The polygnathid-pandorinellinid biofacies is interpreted to be a shallower-water biofacies that was derived from reef or bioherm talus. Thus, as in the Late Devonian, *Pandorinellina* apparently occurs in shallower water than *Icriodus.* The *Polygnathus costatus costatus* Zone is also present in the Carey Dolomite at Upper Spar Canyon in my collections SPAR-13 and 14. The same zone is present in my collection SAW-1 from the upper plate lower member of the Milligen Formation in the Wood River area. In addition to most of the important taxa listed above, collection SAW-1 also contains *P. costatus patulus* and abundant *P. linguiformis linguiformis* (Sandberg and others 1975, p. 711).

The *Polygnathus costatus costatus* Zone is also recognized in the upper plate Woodruff Formation in the Piñon Range, Nevada. It occurs in my sample PNR-2, which yielded a prolific conodont fauna (~10,000 conodonts/kg) that includes *Icriodus latericrescens robustus* in addition to all the important taxa that occur at the three Idaho localities. This fauna is assigned to the polygnathid-pandorinellinid biofacies; the platform conodonts comprise 80 percent *Polygnathus,* 15 percent *Pandorinellina exigua expansa,* 4 percent *Icriodus,* and 1 percent other genera. (The sample locality is in the center NW¼ sec. 34, T. 32 N, R. 52 E, Elko County, Nevada, in the Carlin 1:62,500 quadrangle).

Tortodus kockelianus kockelianus *Zone*

The *Tortodus kockelianus kockelianus* Zone has been recovered from a limestone lens in an upper plate, unnamed Devonian, predominantly chert-greenstone sequence in the Adobe Range, Nevada. My collection, from sample 7044 of K. B. Ketner, contains a large, diversified fauna of this zone that includes the nominal subspecies, *Polygnathus* cf. *P. dobrogensis, P. parawebbi,* and *P. eiflius.* (The sample locality is in the NW¼NE¼SW¼ sec. 8, T. 38 N, R. 56 E, Elko County, Nevada, in the Coal Mine Basin 1:24,000 quadrangle.)

Lowermost Polygnathus asymmetricus *Zone*

A fauna that is believed to represent the pandorinellinid biofacies of the Lowermost *Polygnathus asymmetricus* Zone occurs in my collection POR–9 from 47 m above the base of the Hyrum Dolomite at Portage Canyon in the Blue Spring Hills, Utah (Sandberg and others 1975). This collection contains a primitive morphotype of *Pandorinellina insita* with a single large offset anterior denticle, whereas five higher collections from this biofacies are dominated by advanced morphotypes with one or more smaller denticles anterior to the main denticle.

Upper Devonian

The standard Upper Devonian conodont zonation, shown on figure 2, was adopted for use in the Great Basin and Rocky Mountains and applied to an interregional stratigraphic analysis based on depositional complexes by Sandberg and Poole (1977). This zonation is virtually unchanged from Ziegler's (1962) original proposal. His zonation has withstood critical testing because it was based on a condensed sequence of hemipelagic limestones that were deposited in a moderately deep-water setting on submarine rises (Schwellen). Thus, the zonation did not suffer from overlaps or gaps in the ranges of species, as might have occurred had it been pieced together from several different regions that represented different paleotectonic settings and hence different biofacies.

Over the years, Ziegler's (1962) zonation has experienced a few minor name changes, additions, and modifications. It should be noted, however, that Ziegler's original zonal nomenclature employed only specific names except in the case of the *Ancyrognathus triangularis* Zone (to avoid confusion with his *triangularis*-Zone). Here, I adhere to American practice and use exclusively binomial zonal nomenclature, as Ziegler (1971) himself was compelled to do when publishing in the United States. The *dubia*-Zones and *rhenana*-Zones automatically became the *Polygnathus asymmetricus* Zones and *Palmatolepis gigas*

Zones, respectively, when the species *dubia* and *rhenana* were synonymized. Ziegler (1971) added a Lowermost *Polygnathus asymmetricus* Zone, which is here included at the top of the Middle Devonian for the reasons given by Sandberg and others (1975, p. 712–13), and an Uppermost *Palmatolepis gigas* Zone. Sandberg and Ziegler (1973) added a Lower *Palmatolepis rhomboidea* Zone, changed the former *Pa. rhomboidea* Zone to Upper *Pa. rhomboidea* Zone, and changed the name of the *Pa. quadrantinodosa* Zone to *Pa. marginifera* Zone. Ziegler, Sandberg, and Austin (1974) monographed the *Bispathodus* group and changed the name of the *Spathognathodus costatus* Zones to *Bispathodus costatus* Zones. Sandberg and others (1975) recognized a *Pandorinellina insita* (or pandorinellinid) biofacies as being equivalent to all four *Polygnathus asymmetricus* Zones. Sandberg, Ziegler, and others (1978) added a *Siphonodella praesulcata* Zone, which partly overlaps and partly extends above the *B. costatus* Zone to the top of the Devonian, and recognized a *Protognathodus* (or protognathodid) biofacies equivalent of it.

SERIES	STAGE	CONODONT ZONE OR BIOFACIES		
UPPER DEVONIAN	FAMENNIAN	*Siphonodella praesulcata*	*Protognathodus* Biofacies	
			(cross-hatching)	
			*Upper	
		Bispathodus costatus	Middle	
			Lower	
		Polygnathus styriacus	Upper	
			*Middle	
			*Lower	
		Scaphignathus velifer	Upper	
			Middle	
			*Lower	
		Palmatolepis marginifera	Upper	
			Lower	
		Palmatolepis rhomboidea	Upper	
			Lower	
		Palmatolepis crepida	Upper	
			Middle	
			Lower	
		Palmatolepis triangularis	Upper	
			Middle	
	FRASNIAN		Lower	
		Palmatolepis gigas	Uppermost	
			Upper	
			Lower	
		Ancyrognathus triangularis		
		Polygnathus asymmetricus	Upper	*Pandorin. insita* Biofacies
			Middle	
			Lower	

FIGURE 2.—Standard Upper Devonian conodont zonation (Ziegler 1962; amended by Ziegler 1971; Sandberg and Ziegler 1973; Sandberg, Ziegler, and others 1978). *, zone not yet identified in western United States; cross-hatching, unzoned interval lacking conodonts.

A few general comments about the Upper Devonian zonation will be followed by a discussion of the boundaries, significant species and faunal associations, and important localities for each zone in the Great Basin and Rocky Mountain regions.

General comments

The standard Upper Devonian conodont zonation is based primarily on phyletic lineages within a single genus. *Palmatolepis,* and its direct ancestor, *Polygnathus asymmetricus.* Consequently, the zonation would be improved if the definition and names of the *Ancyrognathus triangularis* and *Scaphignathus velifer* Zones were changed to reflect this phylogeny. Also, the boundary between the Upper *Polygnathus asymmetricus* and *Ancyrognathus triangularis* Zones might be refined. The *P. asymmetricus* Superzone is a range zone defined by the lifespan of *P. asymmetricus,* whereas the *A. triangularis* Zone is an Oppelian zone, the base of which is defined by the lowest occurrence of its nominal species. It is difficult to conceive that the extinction of a pelagic species, *P. asymmetricus,* could have been synchronous with the first appearance of an unrelated, probably nearshore species, *A. triangularis.*

Only four zones of the standard zonation are as yet unrecognized in the Great Basin and Rocky Mountain regions. These zones, indicated by an asterisk (*) on figure 2, are the Lower *Scaphignathus velifer,* Lower and Middle *Polygnathus styriacus,* and Upper *Bispathodus costatus* Zones. The Lower *S. velifer* Zone could be difficult to find because of the widespread distribution of evaporitic rocks at the time of this zone in the Western United States. The Lower and Middle *P. styriacus* Zones could be scarce mainly because rocks of the Upper *P. styriacus* Zone generally overlie a major unconformity in Western North America. Locally, these two zones might be represented by lagoonal limestone, containing nearshore conodont biofacies with bizarre conodont species, in the lower member of the Pinyon Peak Limestone in Utah. The time of the Upper *B. costatus* Zone probably is represented by the *Siphonodella praesulcata* Zone in the Leatham Formation and equivalents in Utah and Montana. Perhaps all four missing zones will be encountered as conodont studies are extended westward into pelagic upper plate rocks in central Nevada and central Idaho.

Another point that deserves comment is the absence or rarity of the nominal species of the *Scaphignathus velifer* and *Polygnathus styriacus* Zones in the Great Basin and Rocky Mountain regions. *Scaphignathus velifer,* which belongs to a characteristically shallow-water genus, has not been reported anywhere in Western North America, although the shallow-water polygnathid-pelekysgnathid biofacies of the Middle and Upper *S. velifer* Zones is widely distributed. *Polygnathus styriacus* is a member of the *Polygnathus nodocostatus* group, which increases in abundance in offshore, pelagic settings. It is represented only by four questionable juvenile specimens from the *P. styriacus* Zone in the Great Basin and Rocky Mountain regions (Sandberg 1976, table 1), but it is unequivocally present in reworked faunas from the Llano area, Texas (Seddon 1970, pl. 16, figs. 13, 14). Perhaps the fortuitous moderately deep, far offshore setting of the submarine rises, where the zonation was erected in Germany, provided optimum living conditions for both species, and a matching setting has not yet been encountered in the Great Basin and Rocky Mountain regions. Noteworthy, however, is that two species of *Scaphignathus* that probably are descendant from *S. velifer* have been discovered in the Upper *P. styriacus* Zone in central Utah. They occur with pelagic species in areas that could have been submarine rises created by retarded subsidence of eroded and later inundated ancestral uplifts. Perhaps the nominal species, *S. velifer,* will be found eventually in areas of central Nevada and central Idaho that have not yet been intensively searched for conodonts.

A final comment is that regional stratotypes have been proposed for parts of the Upper Devonian conodont zonation in the Western United States by Sandberg and Poole (1977, p. 148). The stratigraphic section at Devils Gate, Nevada (Sandberg and Poole 1977, fig. 5), serves as the regional stratotype for nine conodont zones between the Upper *Polygnathus asymmetricus* and Lower *Palmatolepis crepida* Zones. The section at Bactrian Mountain, Nevada (Sandberg and Ziegler 1973), serves as the regional stratotype for five succeeding zones between the Middle *Pa. crepida* and Lower *Pa. marginifera* Zones.

Pandorinellina insita *(pandorinellinid) biofacies*

The Lower, Middle, and Upper *Polygnathus asymmetricus* Zones are known mainly from upper plate rocks west of the Roberts Mountains thrust system in central Nevada and central Idaho. To the east, only the Upper *P. asymmetricus* Zone has been recognized at two localities. It is present at Devils Gate, Nevada (Sandberg and Poole 1977, fig. 5), and possibly at Ward Mountain, south of Ely, Nevada, in samples of W. W. Niebuhr. With these two exceptions, all known occurrences that represent the time of the Lower, Middle, and Upper *P. asymmetricus* Zones on the continental shelf and cratonic platform, either in the lower plate beneath or in the area east of the Roberts Mountains thrust system, contain conodont faunas that are dominated by *Pandorinellina insita* and that lack *P. asymmetricus.* This *P. insita* (pandorinellinid) biofacies of the Lower, Middle, and Upper *P. asymmetricus* Zones is recognized at Portage Canyon (in my collections POR-10, 11, 12, 13, and 14, above POR-9) and at the 10 other localities from Nevada to Montana, named by Johnson and Sandberg (1977, fig. 8). Paleotectonic evidence provided by Johnson and Sandberg (1977) and Sandberg and Poole (1977), considered together with the shallow-water features of the sediments and their biota (which includes trochiliscids, plant debris, and fresh- or brackish-water fish remains), conclusively demonstrates that beds containing the pandorinellinid biofacies were deposited across a very shallow shelf and in long embayments, where the water depth is estimated to have been 10 m or less. This provides compelling evidence of the shallow-water origin of the pandorinellinid biofacies. In such shallow settings, the living habits of *P. insita,* whether it was planktic or nektobenthic, must have been controlled to some extent by bottom conditions, as well as by such factors as salinity, currents, temperature, and food supply.

Lower Polygnathus asymmetricus *Zone*

The base of the Lower *Polygnathus asymmetricus* Zone was defined by the first occurrence of *Ancyrodella rotundiloba* by Ziegler (1971, p. 267, chart 5), who recognized two subspecies at this position. Consequently, I consider *A. rotundiloba rotundiloba,* the progenitor of *A. rotundiloba alata,* to be the sole definitive subspecies for the base of the zone. In North America, the top is considered to be at the first occurrence of *A. gigas* (Klapper, Sandberg, and others 1971). Besides *A. rotundiloba rotundiloba,* important elements of the fauna are *A. rotundiloba alata, Polygnathus asymmetricus asymmetricus, P. asymmetricus ovalis, P. dengleri, P. xylus, Pandorinellina insita, Icriodus symmetricus,* and *Nothognathella klapperi.* The zone occurs in upper plate, transitional-assemblage, unnamed Devonian rocks in north central and central Nevada at Marys Mountain in the Tuscarora Mountains (Clark and Ethington 1967) and in the northern Sulphur Springs Range (my sample NSS-1 in the SW¼SW¼SW¼ sec. 11, T. 27 N, R. 52 E, Eureka County, Nevada, in the Mineral Hill 1:62,500 quadrangle). Either the Lower or Middle *P. asymmetricus* Zone is represented by two samples of D. B. Johnson (1972, p. 41) with *A. rotundiloba alata* from the lower plate Devils Gate Limestone in the Cortez Mountains, Nevada. The Lower *P. asymmetricus* Zone is definitely present in four of my samples from the upper plate, deep-water, transitional-assemblage Milligen Formation in the Wood River area, Idaho (Sandberg and others 1975, table 1).

Middle Polygnathus asymmetricus *Zone*

In North America, the base of the Middle *Polygnathus asymmetricus* Zone is recognized by the lowest occurrence of *Ancyrodella gigas,* which is below the first occurrence of *Palmatolepis punctata* (Klapper and others 1971). In Europe, Ziegler (1971) defined the base solely by the first occurrence of *Pa. punctata,* but he showed that *A. gigas, A. lobata,* and *Pa. proversa* first appeared at exactly the same position. Two parts of the Middle *P. asymmetricus* Zone are represented by my samples C-189 and C-58 from the type Milligen Formation in central Idaho (Sandberg and others 1975). The lower sample, C-189, contains *A. gigas*; and the upper sample, C-58, contains both *A. gigas* and *Pa. punctata.* Thus, in Idaho and elsewhere in North America, this zone may be divided on the basis of this order of occurrence into lower and upper parts. Other important elements of the fauna include both subspecies of *P. asymmetricus, P. xylus, Icriodus symmetricus,* and *Nothognathella klapperi.*

Upper Polygnathus asymmetricus *Zone*

The base of the Upper *Polygnathus asymmetricus* Zone is defined by the first occurrence of *Ancyrodella curvata* and the top by the last occurrence of *Polygnathus asymmetricus asymmetricus* and *P. ancyrognathoideus* (Ziegler 1962, p. 19). This original definition is inadvertently erroneous, because Ziegler correctly defined the base of the overlying zone by the first occurrence of *Ancyrognathus triangularis.* Following the latter definition would avoid the difficulty that is produced where an overlap or gap exists between this species and *P. asymmetricus asymmetricus* in a sequence of samples.

A succession of 13 samples from Devils Gate, Nevada, illustrates the difficulty caused by a gap in the two ranges. The Upper *Polygnathus asymmetricus* Zone is believed to be represented by six of my samples (DVG-18B, 18C, 19, 19A, 19B, and 19C) from Devils Gate, Nevada (Sandberg and Poole 1977, fig. 5). These contain the nominal subspecies together with *Ancyrodella buckeyensis.* Other important elements of the fauna are *Polygnathus xylus, P. angustidiscus, P. webbi, P. dubius, Icriodus symmetricus, I. cf. I. brevis,* and *I. expansus?.* Three higher samples (DVG-17, 18, and 18A) that lack the nominal subspecies are tentatively assigned to the ancyrodellid-polygnathid biofacies of this zone, because they contain *A. rugosa,* which extends into the lower part of the zone in Europe (Willi Ziegler oral commun. 2 May 1977). If only the occurrences of *A. buckeyensis* and *A. rugosa* were considered, and not the succession of faunas, an assignment to the Middle *P. asymmetricus* Zone would be equally tenable for all nine samples mentioned above. However, the three succeeding samples (DVG-14, 15, and 16) contain a very different, more pelagic fauna with *Palmatolepis punctata* and *Polygnathus?* (more likely *Ancyrognathus*) *ancyrognathoideus* but without *P. asymmetricus asymmetricus* (even though this subspecies would be expected to occur with *Palmatolepis*), and the next higher sample (DVG-13) contains the lowest occurrence of *Ancyrognathus triangularis.* By the first definition of the zonal boundary, samples DVG-14, 15, and 16 belong to the *A. triangularis* Zone, because they are above the range of *P. asymmetricus asymmetricus.* However, if the lowest occurrence of *A. triangularis* were used, they would have to be assigned to the Upper *P. asymmetricus* Zone.

Ancyrognathus triangularis *Zone*

The base of the *Ancyrognathus triangularis* Zone is defined by the first occurrence of *Ancyrognathus triangularis*; the top is defined by the first occurrence of *Palmatolepis gigas* (Ziegler 1962). Besides *A. triangularis,* important constituents of the zone in the Great Basin region are *Palmatolepis punctata, Pa. subrecta* (both coarsely and smoothly ornamented morphotypes), *Pa. proversa, Pa. hassi, Ancyrodella lobata, A. curvata, A. nodosa, A. buckeyensis, Polygnathus angustidiscus, P. webbi* s.s., *P. webbi* smooth morphotype, *P. decorosus* s.l., *P. xylus, P.? ancyrognathoideus, "Spathognathodus" gradatus, Icriodus* cf. *I. brevis, Nothognathella klapperi, Belodella devonica,* and *Coelocerodontus* sp. *Palmatolepis foliacea* first occurs in the upper part of this zone and may provide a basis for its subdivision. *Ancyrodella ioides* and *Pa. unicornis* also appear in the upper part of the zone. The *A. triangularis* Zone is best displayed in the type Devils Gate Limestone, Nevada (Sandberg annd Poole 1977, fig. 5). It is also present elsewhere in Nevada in the upper parts of the Guilmette Formation and Devils Gate Limestone and in the lower member of the Pilot Shale at A-1 Canyon, Red Hills, Water Canyon, and Phillipsburg Mine (Sandberg and Poole 1977, fig. 7).

Lower Palmatolepis gigas *Zone*

The base of the Lower *Palmatolepis gigas* Zone is defined by the first occurrence of *Palmatolepis gigas,* and the top is defined by the first occurrence of *Ancyrognathus asymmetricus.* Both *Pa. gigas gigas* and *Pa. gigas semichatovae* Ovnatanova as well as *A. triangularis* are found in this zone together with *Pa. foliacea,* which does not range above the zone. *Polygnathus brevis* and *P. webbi→brevis* have not been noted below this zone. The other important zonal constituents in the Great Basin region are identical to those that occur in the upper part of the *A. triangularis* Zone. The Lower *Pa. gigas* Zone has been recognized in the upper parts of the Devils Gate Limestone and Guilmette Formation and in the lower member of the Pilot Shale in 18 collections from 6 localities in Nevada and Utah (Sandberg and Poole 1977, fig. 7).

Upper Palmatolepis gigas *Zone*

The base of the Upper *Palmatolepis gigas* Zone in Germany is defined dually by the extinction of *Palmatolepis foliacea* and by the first appearance of *Ancyrognathus asymmetricus* (Ziegler 1962). As *A. asymmetricus,* which may be a shallow-water species descendant from *Pandorinellina,* is scarce, having been found only in collection RUB-10 (Sandberg and Poole 1977, fig. 7), only the first criterion is generally employed in the Great Basin. The top of the zone is defined by the first occurrence of *Pa. linguiformis* in Germany (Ziegler 1971) and is similarly delimited in the Great Basin. An important conodont of this zone is an unnamed new species, *Pa. foliacea→linguiformis,* which bridges the former gap between these two index species of the Lower and Uppermost *Pa. gigas* Zones, respectively. *Polygnathus? ancyrognathoideus* occurs uncommonly in the Upper *Pa. gigas* Zone, above its highest occurrence in Germany. A species of *Palmatolepis* that evolved from *Pa. subrecta* and is very close to, if not cospecific with, *Pa. delicatula delicatula* occurs commonly in this zone, although Ziegler (1971) did not record that subspecies below the Middle *Pa. triangularis* Zone in Germany. The lowest occurrence of *Icriodus alternatus,* which Ziegler (1971) did not record below the Upper *Pa. triangularis* Zone in Germany, may be in the top of the Upper *Pa. gigas* Zone. *Palmatolepis unicornis* and *Ancyrodella ioides* apparently become extinct within this zone. Other important faunal constituents of this zone are: *Ancyrodella nodosa, Ancyrognathus triangularis, Pa. gigas gigas, Pa. gigas semichatovae, Pa. subrecta* (both coarsely and finely ornamented morphotypes), *Polygnathus angustidiscus, P. brevis, P. decorosus* s.l., *P.* cf. *P. xylus, P. webbi* s.s., *P. webbi* smooth morphotype, *P. webbi→inornatus, P. webbi→amanus* (with regular, thin transverse ridges). *P.? sinuosus, Pelekysgnathus planus, "Spathognathodus" gradatus, Belodella devonica, Neopanderodus* sp., and *Icriodus* cf. *I. brevis.* The Upper *Pa. gigas* Zone is present in the upper parts of the Devils Gate Limestone and Guilmette Formation and in the lower member of the Pilot Shale in 11 collections from 7 localities in Nevada and Utah (Sandberg and Poole 1977, fig. 7).

Uppermost Palmatolepis gigas *Zone*

The base of the Uppermost *Palmatolepis gigas* Zone is defined by the lowest occurrence of *Palmatolepis linguiformis,* and the top is defined by the lowest occurrence of *Pa. triangularis* (Ziegler 1971). *Polygnathus brevis* is present throughout the zone, but apparently does not range much higher. *Ancyrodella nodosa* and a few specimens of *P.? ancyrognathoideus* are still present, well above their ranges in Germany. *Icriodus alternatus* is definitely present, well below its first occurrence in Germany. All the other species and subspecies, including *Neopanderodus* sp., that are listed as occurring to the top of the Upper *Pa. gigas* Zone extend into this zone. The Uppermost *Pa. gigas* Zone, which is readily identified by the presence of *Pa. linguiformis* (apparently restricted to the zone), is present in 5 collections from 4 localities in lower plate formations–the upper part of the Devils Gate Limestone and the lower member of the Pilot Shale–in eastern Nevada (Sandberg and Poole 1977, fig. 7). It is also present in upper plate rocks of north central Nevada in two collections made from samples of limestone debris-flow lenses in a predominantly chert-greenstone sequence collected by K. B. Ketner: collection 7051 from the Adobe Range and collection 7117 from the Independence Mountains. Collection 7051 comes from the center of the north line of sec. 10, T. 38 N, R. 56 E, Elko County, Nevada, in the Coal Mine Basin 1:24,000 quadrangle; collection 7117 comes from the E½NW¼ sec. 21, T. 37 N, R. 53 E, Elko County, Nevada, in the Blue Basin 1:24,000 quadrangle.)

Lower Palmatolepis triangularis *Zone*

The base of the Lower *Palmatolepis triangularis* Zone was defined by the first occurrence of *Palmatolepis triangularis* and the top by the first occurrence of *Pa. delicatula delicatula* and *Pa. delicatula clarki* (Ziegler 1962). However, because *Pa. delicatula delicatula* is possibly cospecific with a form that occurs as low as the Middle *Pa. gigas* Zone in the Great Basin, only the latter subspecies is used as a criterion there. As no distinctive species of *Palmatolepis* characterizes this zone, the zone is recognized in the Great Basin and Rocky Mountains either by the occurrence of *Pa. triangularis* in sequences below the first occurrence of *Pa. delicatula clarki* or by the overlap of *Pa. triangularis* with the highest range of any of these four species that become extinct in this zone: *Pa. gigas, Polygnathus brevis, Ancyrodella nodosa,* and *Ancyrognathus asymmetricus.* A distinctive new species, *Icriodus* cf. *I. alternatus,* first occurs in this zone and ranges only as high as the Middle *Pa. triangularis* Zone. In this species the center-row denticles are weak or absent, and the posterior cusp is aligned with either of the lateral row of denticles. A similar form was illustrated as *I.* cf. *nodosus,* a form transitional between *I. nodosus* and *I. alternatus,* by Helms (1959, pl. 4, fig. 8). Because of its limited range, *I.* cf. *I. alternatus* may be important in determining an approximate zonal assignment of Late Devonian faunas of the polygnathid-icriodid biofacies that lack *Palmatolepis.* Other important species of the Lower *Pa. triangularis* Zone are *Pa. subrecta, Ancyrodella curvata, Polygnathus angustidiscus, P. webbi* s.s., *P. webbi→amanus, P.* cf. *P. xylus, Acodina* sp., and *"Spathognathodus" gradatus.* The zone is recognized in the Devils Gate Limestone at Devils Gate, Nevada, and in the lower member of the Pilot Shale at Tule Valley, Utah (Sandberg and Poole 1977, fig. 7). It also is present in my collection RHO-3 from the basal part of the Thoroughgood Formation of Flower (1958) at Rhodes Canyon in the San Andres Mountains, New Mexico (in the center of the west line of sec. 9, T. 13 S, R. 4 E, Sierra County, in the Black Top Mountain 1:62,500 quadrangle.)

Middle Palmatolepis triangularis *Zone*

In the Great Basin and Rocky Mountain regions, the base of Ziegler's (1962) zone is recognized by the lowest occurrence of *Palmatolepis delicatula clarki,* and the top is recognized by the lowest occurrence of either *Pa. tenuipunctata* or *Pa. minuta minuta.* Besides *Pa. triangularis, Pa. delicatula clarki,* and abundant *Pa. delicatula delicatula,* the other common constituents of the zone are *Pa. triangularis→quadrantinodosalobata, Polygnathus brevilaminus, Icriodus alternatus, I.* cf. *I. alternatus, I.* cf. *I. brevis, I. cornutus, Acodina* sp., and *Nothognathella reversa.* The occurrence of *I. cornutus* is slightly below its lowest occurrence in Germany. I use *P. brevilaminus* instead of the possibly cospecific *P. angustidiscus* for this and higher Famennian occurrences of polygnathids with a short, narrow platform that does not reach the posterior tip of the blade. Large specimens of the Famennian forms tend to have broader platforms than those of the older species, and the Famennian forms display an ontogenetic development of the platform similar to that of *Scaphignathus? subserratus* (Beinert and others 1971). The Middle *Pa. triangularis* Zone is present in the Devils Gate Limestone at Devils Gate, Nevada, and in the lower member of the Pilot Shale at Tule Valley, Utah (Sandberg and Poole 1977, fig. 7). It is also present in my collection SLY-2 from the middle of the Thoroughgood Formation of Flower (1958) in the San Andres, Mountains, New Mexico (in the NE¼SE¼ sec. 25, T. 11 S, R. 5 E, Socorro County, in the Capitol Peak 1:62,500 quadrangle).

Upper Palmatolepis triangularis *Zone*

In the Great Basin the base of Ziegler's (1962) zone is recognized by the lowest occurrence of *Palmatolepis tenuipunctata,* or of *Pa. minuta minuta* where *Pa. tenuipunctata* is absent, and the top is recognized by the lowest occurrence of *Pa. crepida,* or of *Pa. quadrantinodosalobata* s.s. where *Pa. crepida* is absent. Besides *Pa. triangularis, Pa. minuta minuta,* and *Pa. tenuipunctata,* other important faunal constituents of the zone are *Pa. triangularis→wolskajae* (which Ziegler [1962] may have included in *Pa. perlobata*), *Pa. triangularis→quadrantinodosalobata, Polygnathus webbi?, P. brevilaminus, P. procerus, P.? sinuosus, Icriodus alternatus, I.* cf. *I. brevis, I. cornutus, I. iowaensis, Acodina* sp., *Apatognathus* sp., *Pelekysgnathus planus,* and *"Spathognathodus" gradatus.* The lowest occurrences of *Polylophodonta* sp. and of *Ancyrolepis cruciformis,* which does not occur below the Lower *Pa. crepida* Zone in Germany (Ziegler 1971), are in this zone. The Upper *Pa. triangularis* Zone is present in the highest part of the type Devils Gate Limestone and in the middle of the lower member of the Pilot Shale in 10 collections from 5 localities in Nevada and Utah (Sandberg and Poole 1977, fig. 7). It is best represented in my collection NGS-4, which might serve as a regional stratotype for the zone, from 50 m above the base of the lower member of the Pilot Shale at Nevada Governors Spring in the Pancake Range, Nevada (Sandberg and Poole 1977, locality register, p. 181).

Lower Palmatolepis crepida *Zone*

The base of the Lower *Palmatolepis crepida* Zone is defined by the first occurrence of *Palmatolepis crepida,* and the top is defined by the first occurrence of *Pa. termini* (Ziegler 1962). The fauna of this zone is virtually identical to that of the Upper *Pa. triangularis* Zone, from which it is difficult to distinguish in the absence of *Pa. crepida,* which is rare to absent in the eastern part of the Great Basin. There the zone can be recognized by the presence of *Pa. quadrantinodosalobata* s.s. (with a short outer lobe) and by the diminished abundance of *Pa. triangularis* and *Pa. triangularis→quadrantinodosalobata.* Other important faunal constituents of this zone are *Pa. triangularis→wolskajae, Pa. perlobata, Pa. delicatula delicatula, Pa. delicatula clarki, Pa. minuta minuta, Pa. minuta loba, Pa. tenuipunctata, Polygnathus brevilaminus, P. procerus, I. cornutus, I.* cf. *I. brevis, I. iowaensis, I. alternatus, Pelekysgnathus planus, Acodina* sp., *Apatognathus* sp., and *"Spathognathodus" gradatus.* A few specimens of *Belodella devonica* have been recorded from this zone, well above the next highest occurrence in the Uppermost *Pa. gigas* Zone. The Lower *Pa. crepida* Zone is present in the lower member of the Pilot Shale and in the West Range Limestone in 6 collections from 3 localities in Nevada and Utah (Sandberg and Poole 1977, fig. 7).

Middle Palmatolepis crepida *Zone*

The base of the Middle *Palmatolepis crepida* Zone is defined by the first occurrence of *Palmatolepis termini,* and the top is defined by the first occurrence of *Pa. glabra prima* (Ziegler, 1962). The important faunal constituents in the Great Basin are *Pa. termini, Pa. quadrantinodosalobata* (including forms with a much longer outer lobe than those in the Lower *Pa. crepida* Zone), *Pa. wolskajae* (called *Pa.* aff. *P. circularis* by Sandberg and Ziegler 1973), *Pa. delicatula clarki, Pa. delicatula protorhomboidea, Pa. perlobata, Pa. subperlobata, Pa. tenuipunctata, Ancyrognathus* cf. *A. sinelaminus, Polylophodonta* sp., *Polygnathus brevilaminus, Icriodus cornutus, I. iowaensis, Pelekysgnathus planus, Apatognathus* sp., and *"Spathognathodus" gradatus.* Also, the highest occurrence of *Pa. triangularis* is in this zone. The Middle *Pa. crepida* Zone is present in the West Range Limestone in 6 collections from Bactrian Mountain, Nevada (Sandberg and Ziegler 1973, table 1) and in 2 collections from the South Burbank Hills (Sandberg and Poole 1977, fig. 7). In these collections, *Pa. termini* and *Pa. crepida* are scarce. The zone is also present in 2 collections from the lower member of the Pilot Shale at Phillipsburg Mine in the Diamond Mountains, Nevada (Sandberg and Poole 1977, fig. 7); in these collections *Pa. termini* and *Pa. crepida* are abundant. As the Pilot Shale occurrence represents a deep-water, starved basin setting, whereas the West Range Limestone occurrences represent moderately deep-water shelf carbonates, it would appear that these two species favored a more offshore pelagic setting than the other species of *Palmatolepis* in this zone.

Upper Palmatolepis crepida *Zone*

The base of the Upper *Palmatolepis crepida* Zone is defined by the lowest occurrence of *Palmatolepis glabra prima* s.s., and the top is defined by the lowest occurrence of *Pa. rhomboidea* (Ziegler 1962). The zone can be subdivided into a lower part that contains only the oldest member of the *Pa. glabra* species, *Pa. glabra prima* s.s., and an upper part that contains this subspecies plus six other subspecies and morphotypes of *Pa. glabra*. This explosive genetic outburst that characterizes the upper part of the zone is illustrated by Sandberg and Ziegler (1973, fig. 3). The important faunal constituents of the lower part of the Upper *Pa. crepida* Zone are *Pa. glabra prima* s.s., *Pa. crepida*, *Pa. quadrantinodosalobata*, *Pa. wolskajae* (called *Pa. aff. Pa. circularis* by Sandberg and Ziegler 1973), *Pa. tenuipunctata*, *Pa. subperlobata*, *Pa. perlobata perlobata*, *Pa.* cf. *Pa. regularis*, *Pa. minuta minuta*, *Pa. minuta loba*, *Polylophodonta* sp., *Polygnathus brevilaminus*, *P. nodocostatus* s.l., *Icriodus cornutus*, *I.* cf. *I. brevis*, *Pelekysgnathus planus*, *Apatognathus* sp., *Nothognathella sublaevis*, and *"Spathognathodus" gradatus*. In the upper part of the zone the following fauna is added to that listed above: *Pa. glabra lepta* (early form), *Pa. glabra prima* Morphotypes 1 and 2, *Pa. glabra acuta*, *Pa. glabra pectinata* s.s. and Morphotype 1, *Pa. quadrantinodosalobata* Morphotype 1, and *Polygnathus glaber glaber*. In addition *Pa.* sp. A Sandberg and Ziegler, which is restricted to the lower *Pa. rhomboidea* Zone at Bactrian Mountain, occurs in the highest part of the Upper *Pa. crepida* Zone at other localities. The Upper *Pa. crepida* Zone had been recognized in the lower member of the Pilot Shale and in the West Range Limestone in 13 collections from 5 localities in Nevada and Utah (Sandberg and Poole 1977, fig. 7).

Lower Palmatolepis rhomboidea *Zone*

The base of the Lower *Palmatolepis rhomboidea* Zone is defined by the lowest occurrence of *Palmatolepis rhomboidea*, and the top is defined by the highest occurrence of *Pa. poolei* (Sandberg and Ziegler 1973). *Palmatolepis rhomboidea* is scarce in this zone, and in its absence the zone can be recognized by the presence of *Pa. poolei*, which first appears at about the same time as *Pa. rhomboidea* and is restriced to the zone. *Palmatolepis klapperi* and *Pa. quadrantinodosa inflexa* also have their first occurrences at the base of the Lower *Pa. rhomboidea* Zone, but they range upward through the Lower *Pa. marginifera* Zone. *Palmatolepis crepida*, *Pa. wolskajae*, *Pa. tenuipunctata*, *Pa. quadrantinodosalobata* s.s. and Morphotype 1, *Pa.* sp. A Sandberg and Ziegler, and *Pa. glabra prima* Morphotypes 1 and 2 became extinct at different levels within the Lower *Pa. rhomboidea* Zone. With the above-listed exceptions, the fauna of this zone is identical to that of the upper part of the Upper *Pa. crepida* Zone. The Lower *Pa. rhomboidea* Zone has been recognized in Nevada in four collections from the West Range Limestone at Bactrian Mountain (Sandberg and Ziegler 1973, table 1) and in two collections from the lower member of the Pilot Shale at Phillipsburg Mine in the Diamond Mountains (Sandberg and Poole 1977, fig. 7).

Upper Palmatolepis rhomboidea *Zone*

The base of the Upper *Palmatolepis rhomboidea* Zone is defined by the highest occurrence of *Palmatolepis poolei*, and the top is defined by the lowest occurrence of *Pa. marginifera marginifera*. The fauna is identical to that of the Lower *Pa. rhomboidea* Zone except for the absence of *Pa. poolei* and the eight taxa that are mentioned as becoming extinct within the Lower *Pa. rhomboidea* Zone. In the Great Basin, *Polygnathus semicostatus* has its local first occurrence in the Upper *Pa. rhomboidea* Zone, but this species has been reported as low as the Middle *Pa. crepida* Zone in Belgium (Dreesen and Dusar 1974). *Palmatolepis stoppeli* has its first occurrence in the upper part of the Upper *Pa. rhomboidea* Zone. This zone has been recognized in the West Range Limestone in six collections at Bactrian Mountain, Nevada (Sandberg and Ziegler 1973), in one collection at South Burbank Hills (Sandberg and Poole 1977, fig. 7), and in my collection SI-3 from Side Hill Pass in the southern Schell Creek Range, Nevada (in sec. 17, T. 6 N, R. 64 E, unsurveyed, Lincoln County, in the Sidehill Spring 1:24,000 quadarangle).

Lower Palmatolepis marginifera *Zone*

The base of the Lower *Palmatolepis marginifera* Zone is defined by the lowest occurrence of *Palmatolepis marginifera marginifera*, and the top is defined by the extinction of all three subspecies of *Pa. quadrantinodosa: inflexa*, *inflexoidea*, and *quadratinodosa*. *Palmatolepis quadrantinodosa quadrantinodosa*, *P. quadrantinodosa inflexoidea*, *Pa. marginifera duplicata*, *Pa. glabra distorta*, and *Pa. glabra lepta* (typical form) have their first occurrences near the base of this zone, whereas *Pa. marginifera* n. subsp. Sandberg and Ziegler first appears at or near the top. Important conodonts that range up into the Lower *Pa. marginifera* Zone are *Pa. rhomboidea*, *Pa. klapperi*, *Pa. stoppeli*, and *Pa. quadrantinodosa inflexa*. Other common conodonts of this zone are *Pa. subperlobata*, *Pa. perlobata perlobata*, *Pa. perlobata schindewolfi*, *Pa. minuta minuta*, *Pa. glabra pectinata*, *Pa. glabra acuta*, *Polylophodonta* sp., *Icriodus cornutus*, *Polygnathus brevilaminus*, *P. nodocostatus* s.l., *P. glaber glaber*, *P. semicostatus*, *Apatognathus varians*, and *"Spathognathodus" gradatus*. The Lower *Pa. marginifera* Zone is one of the most widely recognized zones in the Great Basin and Rocky Mountains regions. It is represented by more than 35 collections from 18 localities in Nevada, Utah, and Idaho: 7 localities in the lower member of the Pilot Shale and 3 localities in the West Range Limestone in Nevada and Utah; 1 locality in the Slaven Chert, near Hilltop Barite Mine in the Shoshone Range, Nevada; and 7 localities in the upper part of the Birdbear Member of the Jefferson Formation in the Lost River and Lemhi Ranges and Beaverhead Mountains, Idaho. Locations for most of these sections are given by Sandberg and Poole (1977), Sartenaer and Sandberg (1974), and Klapper, Sandberg, and others (1971).

Upper Palmatolepis marginifera *Zone*

The base of the Upper *Palmatolepis marginifera* Zone is marked by the highest occurrences of *Pa. quadrantinodosa quadrantinodosa*, *Pa. q. inflexa*, and *Pa. q. inflexoidea*, and in Germany the top is defined by the lowest occurrence of *Scaphignathus velifer*. The zone is characterized in the Great Basin by the joint occurrence of abundant *Pa. marginifera marginifera* and *Pa. marginifera* n. subsp. Sandberg and Ziegler (1973, pl. 3, figs. 20, 26), some specimens of which display a trend toward *Pa. perlobata grossi* and *Pa. rugosa trachytera*. *Palmatolepis perlobata grossi* and *Pa. rugosa* cf. *ampla*, which occur sporadically in this zone in Germany, have not been found in the Western United States. All the common conodonts of the Lower *Pa. marginifera* Zone range upward into this zone, except for *Pa. marginifera duplicata* and the three subspecies of *Pa. quadrantinodosa*. The Upper *Pa. marginifera* Zone is not well known because rocks of this zone are only partly preserved in the Great Basin. In Nevada and Utah a few remnants are present at the top of the lower member of the Pilot Shale beneath a widespread regional unconformity (Sandberg and Poole 1977, fig. 7). In Idaho, the zone is tentatively identified at several localities in the highest part of the Birdbear Member of the Jefferson Formation, just below a thick sequence of nonfossiliferous beds in the lower part of the Three Forks Formation (Sartenaer and Sandberg 1974, p. 759).

Lower Scaphignathus velifer *Zone*

The Lower *Scaphignathus velifer* Zone has not yet been recognized in the Great Basin and Rocky Mountain regions.

Middle Scaphignathus velifer *Zone*

In Germany, the base of the Middle *Scaphignathus velifer* Zone is defined by the lowest occurrence of *Palmatolepis rugosa trachytera,* and the top is defined by the lowest occurrence of *Pseudopolygnathus granulosus* (Ziegler 1962). Because neither of these conodonts nor *Scaphignathus velifer* has been found as yet in the Great Basin and Rocky Mountain regions, the Middle *S. velifer* Zone can be recognized only on circumstantial evidence provided by regional biostratigraphy and other conodont species. Occurrences in Utah that are tentatively assigned to this zone are based on four samples from the middle part of the "contact ledge" at the top of the Beirdneau Formation at Leatham Hollow in the Bear River Range and at the base of an unnamed siltstone unit at Buckhorn Canyon in the Dugway Range (Sandberg and Poole 1977, fig. 11, p. 163). These occurrences overlie a regional unconformity or disconformity that bounds the lower depositional complex of Sandberg and Poole (1977), which ranges upward through the Upper *Pa. marginifera* Zone. By means of brachiopod faunas and physical stratigraphy, these occurrences can be correlated to beds in Montana that contain *Scaphignathus? subserratus,* which does not range below the Lower *S. velifer* Zone in Germany (Beinert and others 1971). The conodont faunas assigned to the Middle *S. velifer* Zone in Utah comprise: *Pa. glabra distorta* s.s. and an advanced morphotype that lacks a central node, *Pa. marginifera marginifera, Polygnathus subirregularis* Sandberg and Ziegler 1979, *Polygnathus semicostatus, P. brevilaminus, P.* cf. *P. inornatus, Polylophodonta* sp., *Pelekysgnathus inclinatus, Bispathodus stabilis, Apatognathus varians,* and *Nothognathella sublaevis.* The highest recorded occurrences of *Pa. glabra distorta* and of *Pa. marginifera marginifera* are within the Middle *S. velifer* Zone in Germany (Ziegler 1971) and Belgium (Dreesen and Dusar 1974), respectively. The advanced morphotype of *Pa. glabra distorta* has not been recorded at the upper range of this species in Germany. Hence, its occurrence in the Utah faunas is believed to represent a position as high as, if not higher than, the middle of the Middle *S. velifer* Zone. *Polygnathus subirregularis,* which occurs at Buckhorn Canyon, has not been recorded below the Middle *S. velifer* Zone.

Upper Scaphignathus velifer *Zone*

In Germany, the base of the Upper *Scaphignathus velifer* Zone is defined by the first occurrence of *Pseudopolygnathus granulosus* (Ziegler 1962), and the top is defined by the first appearance of forms of *Polygnathus styriacus* that are transitional from *P. granulosus* (Ziegler 1971). In the absence of any of these species in the Great Basin and Rocky Mountain regions, the zone is recognized by several conodonts, the ranges of which overlap only in this zone. Conodont faunas assigned to the Upper *S. velifer* Zone are present mainly in 16 collections from 10 localities in the upper part of the Trident Member of the Three Forks Formation in Montana and east central Idaho, and in the equivalent "contact ledge" at the top of the Beirdneau Formation in southeastern Idaho and in the Bear River Range, Utah. Locations of the more important collections were given by Sandberg and Klapper (1967), Klapper, Sandberg, and others (1971), and Sandberg and Poole (1977). The faunas contain mainly the same conodonts as the Middle *S. velifer* Zone, and in addition *"Spathognathodus" strigosus, "S." inornatus,* and *Polygnathus communis communis.* However, these faunas are assignable mainly to the shallow polygnathid-pelekysgnathid biofacies and generally lack *Palmatolepis,* except in east central Idaho. The fauna of this zone at Leatham Hollow, Utah (Sandberg and Poole 1977, fig. 11) also contains a new species, *Icriodus? raymondi,* which was named by Sandberg and Ziegler (1979). The faunas from the Trident Member in Montana also contain an early form of *Polygnathus homoirregularis,* which ranges only as low as the Upper *S. velifer* Zone, and *P. perplexus.* Those from the Trident in Idaho contain *Pa. glabra lepta,* which ranges as high as the Upper *S. velifer* Zone in Germany (Ziegler 1962, p. 58–59). Collection BHN-2A from the upper part of an unnamed siltstone unit at Buckhorn Canyon in the Dugway Range, Utah, contains *P. perplexus* and the early form of *P. homoirregularis* and hence is probably assignable to this zone.

Lower and Middle Polygnathus styriacus *Zones*

The Lower and Middle *Polygnathus styriacus* Zones have not yet been recognized in the Great Basin and Rocky Mountain regions. They may be represented, however, by some of the collections of shallow-water faunas lacking zonal indicators that are included in the count of Upper *Polygnathus styriacus* Zone collections.

Upper Polygnathus styriacus *Zone*

The base of the Upper *Polygnathus styriacus* Zone is defined by the first occurrence of *Pseudopolygnathus brevipennatus,* and the top is defined by the first occurrence of *Bispathodus costatus.* Because these two species are scarce in the Great Basin and Rocky Mountain regions, the zone is recognized mainly by the association of *Palmatolepis rugosa rugosa, Pa. gracilis sigmoidalis, Pseudopolygnathus marburgensis marburgensis,* and *B. jugosus* before the first occurrence of *B. aculeatus.* Because the first occurrence of *B. aculeatus* is slightly above the base of the Lower *B. costatus* Zone in Germany, some of the occurrences ascribed to the higher part of the Upper *P. styriacus* Zone might actually represent the lowest part of the Lower *B. costatus* Zone.

The Upper *Polygnathus styriacus* Zone is the most widely studied Devonian conodont zone in the Great Basin and Rocky Mountain regions. It was reported by Sandberg (1976) to be present in 38 collections from 19 localities. Since then, the zone has been recognized in an additional 30 collections from 13 localities. The Upper *P. styriacus* Zone is now recognized in 11 different stratigraphic units from northern Montana to southern Arizona. Sandberg (1976, fig. 1) showed 13 units, but the units at localities formerly ascribed to the Mowitza Shale and lower part of the Crystal Pass Limestone Member of the Sultan Limestone were reidentified as Pinyon Peak Limestone by Sandberg and Poole (1977).

In the Upper *Polygnathus styriacus* Zone Sandberg (1976) has recognized these five laterally segregated biofacies, in a landward direction: the palmotolepid-bispathodid, palmatolepid-polygnathid, polygnathid-icriodid, polygnathid-pelekysgnathid, and clydagnathid biofacies. (See Sandberg 1976 for a full discussion of these biofacies and their faunal content.) In addition, three more biofacies may be found in nearshore settings comparable to that of the clydagnathid biofacies; these biofacies, which are as yet theoretical for this zone although recognized in other zones, are the scaphignathid, pandorinellinid, and patrognathid biofacies (Sandberg and Ziegler 1979).

The fauna of the Upper *Polygnathus styriacus* Zone in the Great Basin and Rocky Mountain regions is large and diverse. A faunal list of the important and common conodonts of this zone, updated from Sandberg (1976, table 1) and listed in the same order, includes the following: *Bispathodus jugosus, B. stabilis, Clydagnathus ormistoni, Palmatolepis gracilis gracilis, Pa. gracilis sigmoidalis, Pa. perlobata postera, Pa. rugosa ampla, Pa. rugosa rugosa, Icriodus* cf. *I. costatus, Pelekysgnathus inclinatus, Polygnathus nodocostatus* s.l., *P. granulosus, P. praehassi, P. homoirregularis, P. pennatuloideus, P. perplexus, P. styriacus?* (scarce), *P. obliquicostatus, P. semicostatus* (s.s. and Morphotypes 1, 2, and 3), *Apatognathus varians, P. communis communis, P. communis carina, P. triangularis, Pseudopolygnathus brevipennatus* (scarce), *Ps. marburgensis marburgensis, "Spathognathodus" fissilis, "S." inornatus, "S." strigosus, Hemilistrona* sp., *Nothognathella ziegleri, N.* n. sp. B Sandberg, *Ps.* cf. *Ps. dentilineatus,* and *Scaphignathus ziegleri.* In addition, these conodonts, listed by Sandberg (1976) but not repeated above, were formally named by Sandberg and Ziegler (1979): *Pa. gracilis gracilis* (wide form), *I.* cf. *I. costatus* (in part), *Patrognathus* n. sp., *Polygnathus* cf. *P. perplexus, Scaphignathus* n. sp., and new genus (cf. *Nothognathella*). The new formal names, respectively, are: *Pa. gracilis expansa, I.? raymondi, Patrognathus ourayensis, Polygnathus experplexus, Scaphignathus peterseni,* and *Nothognathella? cerebriformis.* Also, a new taxon, *Icriodus?* similar to Early Devonian *Pedavis,* was formally named *I.? mowitzaensis* by Sandberg and Ziegler (1979). *Polygnathus extralobatus, P. delicatulus,* and *I. costatus* first appear in the highest part of this zone or in the lowest, pre-*Bispathodus aculeatus* part of the Lower *B. costatus* Zone.

Lower Bispathodus costatus *Zone*

The base of the Lower *Bispathodus costatus* zone is defined by the lowest occurrence of *Bispathodus costatus,* and the top is defined by the lowest occurrence of *B. ultimus* (Ziegler 1962). Because *B. costatus* is relatively scarce and *B. ultimus* is unknown in the Great Basin and Rocky Mountain regions, in practice the base is defined there by the lowest occurrence of *B. aculeatus,* and the top is defined by the lowest occurrence of *Pseudopolygnathus marburgensis trigonicus, Polygnathus vogesi,* or *Protognathodus meischneri.* All the conodonts listed as being present in the highest part of the Upper *P. styriacus* Zone range into the Lower *B. costatus* Zone except for: *P. styriacus, P. granulosus, P. pennatuloideus, Scaphignathus peterseni, S. ziegleri,* and *Icriodus? mowitzaensis.* In addition, these conodonts have their first occurrence in this zone: *B. costatus costatus, B. spinulicostatus, B. aculeatus, P. "symmetricus", P. inornatus,* and new genus Q, n. sp. A Klapper and Sandberg (cf. *Gondolella*). *Pandorinellina* cf. *P. insita,* which occurs in the *Scaphignathus velifer* Zone in Belgium, also is present in the Lower *B. costatus* Zone with *Pseudopolygnathus vogesi* in Colorado (Sandberg and Poole 1977, p. 175). The first occurrence of *Patrognathus variabilis* probably is within the Lower *B. costatus* Zone in Utah (Sandberg and Poole 1977, p. 173). This zone is present in 5 collections from 3 localities in the lower tongue of the Cottonwood Canyon Member of the Madison Limestone in Wyoming, in 31 collections from 10 localities in the lower part of the Fitchville Formation in Utah, and in 1 collection from the upper part of the Dyer Dolomite in Colorado. The locations of most of these occurrences were given by Sandberg and Klapper (1967), Klapper, Sandberg, and others (1971), and Sandberg and Poole (1977, figs. 13–16, locality register on p. 181–82).

Middle Bispathodus costatus *Zone*

In Germany, the base of the Middle *Bispathodus costatus* Zone is defined by the lowest occurrence of *Bispathodus ultimus,* and the top is defined by the highest occurrence of *Palmatolepis gonioclymeniae* (Ziegler 1962). Neither species has been recognized, however, in the Great Basin and Rocky Mountain regions. Consequently, in practice the lower boundary is recognized by the first appearance of *Pseudopolygnathus marburgensis trigonicus, Polygnathus vogesi,* or *Protognathodus meischneri,* and the top is recognized by the first occurrence of *Siphonodella praesulcata.* All conodonts present in the Lower *B. costatus* Zone have also been found in the Middle *B. costatus* Zone except for *Hemilistrona* sp., *Palmatolepis rugosa ampla, Polygnathus praehassi, P. perplexus, P. homoirregularis, P. extralobatus, P. obliquicostatus,* and possibly *Pa. perlobata postera* and *Pa. rugosa rugosa.* In addition, conodonts that first appear in the Middle *B. costatus* Zone are *Ps. marburgensis trigonicus, P. vogesi, Pr. meischneri, "Spathognathodus" culminidirectus,* and *"S." disparilis.* This zone is present in 9 collections from the Leatham Formation at Leatham Hollow, Spring Hollow, and Porcupine Dam in the Bear River Range, Utah (Sandberg and Poole 1977, fig. 11; Sandberg and Gutschick 1978 and 1979, figs. 10, 11), and in the equivalent middle member of the Pilot Shale at Bactrian Mountain, Nevada (Klapper, Sandberg, and others 1971, fig. 5; Sandberg and Ziegler 1973, fig. 2) and in the Confusion Range, Utah, and southern Ruby Mountains, Nevada (Sandberg and Poole 1977, locality register, p. 181–82).

Upper Bispathodus costatus *Zone*

Although the Upper *Bispathodus costatus* Zone has not yet been identified in the Great Basin and Rocky Mountain regions, the time of this zone is represented by part of the *Siphonodella praesulcata* Zone (fig. 2).

Siphonodella praesulcata *Zone*

The base of the *Siphonodella praesulcata* Zone is defined by the first occurrence of *Siphonodella praesulcata,* and the top is defined by the first occurrence of *S. sulcata.* At Porcupine Dam, Utah (Sandberg and others 1972, p. 186, 195; Sandberg and Gutschick 1978 and 1979, fig. 10), the lowest part of this zone is dominated by *S. praesulcata* but also contains *Palmatolepis gracilis sigmoidalis, "Spathognathodus" culminidirectus, Protognathodus meischneri, Polygnathus communis communis, P. delicatulus, Apatognathus varians,* and *Bispathodus stabilis.* A presumably higher part of the zone at Lick Creek Road in the Little Belt Mountains, Montana (Sandberg and others 1972, p. 186, 194; Sandberg and Poole 1977, fig. 8), contains in addition *B. costatus costatus, B. aculeatus aculeatus, B. aculeatus anteposicornis, Protognathodus collinsoni,* and *"S." inornatus.* At most other localities, *S. praesulcata* occurs in sparse faunas by itself or with long-ranging conodonts such as *B. stabilis* and *P. communis communis.* The *S. praesulcata* Zone has been identified in units 5 and 6 (Sandberg and others 1972, fig. 2) of the Sappington Member of the Three Forks Formation in 10 collections from 6 localities in western Montana, and in units 5 and 6 of the Leatham Formation in 5 collections from Leatham Hollow, Porcupine Dam, and Spring Hollow, in the Bear River Range, Utah (Sandberg and Poole 1977, fig. 11; Sandberg and Gutschick 1978 and 1979, figs. 10, 11). A *Protognathodus* (protognathodid) biofacies of this zone is recognized in West Germany (fig. 2; Sandberg and others 1978).

Kinderhookian

The zonation of the Lower Mississippian (Kinderhookian) of the Great Basin and Rocky Mountain regions (fig. 3) is based on the *Siphonodella* zonation, which is applicable worldwide. This zonation was provisionally proposed by Sandberg and Ziegler (1976) and formalized by Sandberg, Ziegler, and others (1978). The *Siphonodella* zonation is based primarily on the first occurrences of species of *Siphonodella* that in most cases are the nominal species of zones. The base of the Mississippian in North America and the base of the Carboniferous worldwide can be defined in offshore marine sequences within the *Siphonodella* phylogeny by the evolutionary change from *S. praesulcata* to *S. sulcata* at the base of the *S. sulcata* Zone. To make the *Siphonodella* zonation correspond to the lifespan of the genus, the lower boundary of the highest zone has to be defined by the first occurrence of the earliest species of *Gnathodus*, *G. delicatus*, which probably evolved from *Protognathodus kockeli*. At that time, the phylogeny of *Siphonodella* was on the wane, no new species were evolving, and only simple species that display conservative characteristics lingered. The top of the *Siphonodella* zonation is defined by the last occurrence of the genus. This extinction marks the top of the Kinderhookian in North America and an important biostratigraphic break worldwide. Fortuitously, this extinction occurred almost simultaneously with the evolution of a new gnathodid species, *G. typicus*, from *G. delicatus*. Thus the highest *Siphonodella* zone is also definable within the phylogeny of *Gnathodus*, which is an important genus in the younger, Osagean zonation.

The range and identification of all known species of *Siphonodella* are shown in a phylogenetic chart (fig. 4) that was originally illustrated by Sandberg, Ziegler, and others (1978, fig. 1).

SERIES		CONODONT ZONE OR BIOFACIES		
LOWER MISSISSIPPIAN	OSAGEAN	*Taphrognathus varians* (Lower part)		"*Spathognathodus*" Biofacies
		Doliognathus latus		
		Gnathodus typicus		
	KINDERHOOKIAN	*Siphonodella isosticha* — Upper *Siphonodella crenulata*		*Patrognathus–Pandorinellina* Biofacies
		Lower *Siphonodella crenulata*		
		Siphonodella sandbergi		
		Siphonodella duplicata	Upper	
			Lower	
		Siphonodella sulcata		

FIGURE 3.—Lower Mississippian conodont zonation. Kinderhookian zonation after Sandberg, Ziegler, and others (1978).

Siphonodella sulcata *Zone*

The base of the *Siphonodella sulcata* Zone is defined by the first occurrence of *Siphonodella sulcata*, and the top is defined by the first occurrence of *S. duplicata* Morphotype 1. The zone is well developed in 11 collections from 3 localities in the Great Basin and Rocky Mountain regions. It is present in the middle part of the type Fitchville Formation in the East Tintic Mountains, Utah (Sandberg and Poole 1977, fig. 13); in the top 5 m of the upper member of the Pilot Shale in the South Ruby Mountains, Nevada (Sandberg and Poole 1977, p. 182); and in the upper tongue of the Cottonwood Canyon Member of the Madison Limestone at Windy Gap, in the Washakie Range, Wyoming (Sandberg and Klapper 1967, p. B51–B52). The abundant, diverse faunas at these localities are dominated by these conodonts: *S. sulcata, S. praesulcata, B. aculeatus aculeatus, B. aculeatus anteposicornis, B. stabilis, Patrognathus variabilis, Protognathodus kockeli, P. kuehni, Pseudopolygnathus dentilineatus, Polygnathus communis communis, P. inornatus,* and *P. longiposticus.* The zone has also been found in collection 22550-PC, from a sample of W. J. Sando, taken from the base of a 19-foot unit at the top of the Cottonwood Canyon Member at Clarks Fork Canyon, Wyoming (Sandberg 1963, p. C17). Although this collection consists mainly of broken conodonts, largely *S. sulcata*, it helps position the base of the upper tongue of the Cottonwood Canyon and the Devonian-Mississippian boundary at the base of this upper slope-forming unit in this important reference section (Sandberg and Klapper 1967, fig. 4, col. 4).

Lower Siphonodella duplicata *Zone*

The base of this zone is defined by the first occurrence of *Siphonodella duplicata* Morphotype 1, and the top is defined by the first occurrence of *S. cooperi* Morphotype 1. The fauna of this zone is identical to that of the *S. sulcata* Zone with the addition of *S. duplicata* Morphotype 1 and, slightly above the base, Morphotype 2, and of *Pseudopolygnathus primus* (including *Ps. triangulus inequalis* as a possible junior synonym). This zone has been recognized mainly from sandstones and siltstones, and hence faunas had to be obtained by crushing or hydrofluoric acid dissolution of quartzose rock, or else they had to be identified on rock surfaces. The largest and most diverse fauna is in my collection CON-13F from 14 m above the base of the upper member of the Pilot Shale at Little Mile-and-a-Half Canyon in the Confusion Range, Utah (Sandberg and Poole 1977, p. 181). Two other collections BCS-3BF and PD-2B, come from the Cottonwood Canyon Member of the Lodgepole Limestone in Utah, at Broad Canyon on Stansbury Island, and at Porcupine Dam in the Bear River Range (Sandberg and Gutschick 1978 and 1979, figs. 9, 10).

Upper Siphonodella duplicata *Zone*

The base of the Upper *Siphonodella duplicata* Zone is defined by the first occurrence of *Siphonodella cooperi* Morphotype 1, and the top is defined by the first occurrence of *S. sandbergi*. The fauna is nearly identical to that of the Lower *S. duplicata* Zone with the addition of *S. cooperi* Morphotype 1, *S. duplicata* sensu Hass, and, higher in the zone, *S. obsoleta* and *S. cooperi* Morphotype 2. *Patrognathus variabilis* and *Pandorinellina* cf. *P. insita* are uncommon but important faunal constituents. *Siphonodella carinthiaca*, which first appears in this zone in Europe, has not been recognized in the Western United States. The Upper *S. duplicata* Zone is represented by large faunas in the upper tongue of the Cottonwood Canyon Member of the Madison Limestone in Wyoming in collections HC-7F from Horse Creek in the Washakie Range and WS-1F from Warm Spring

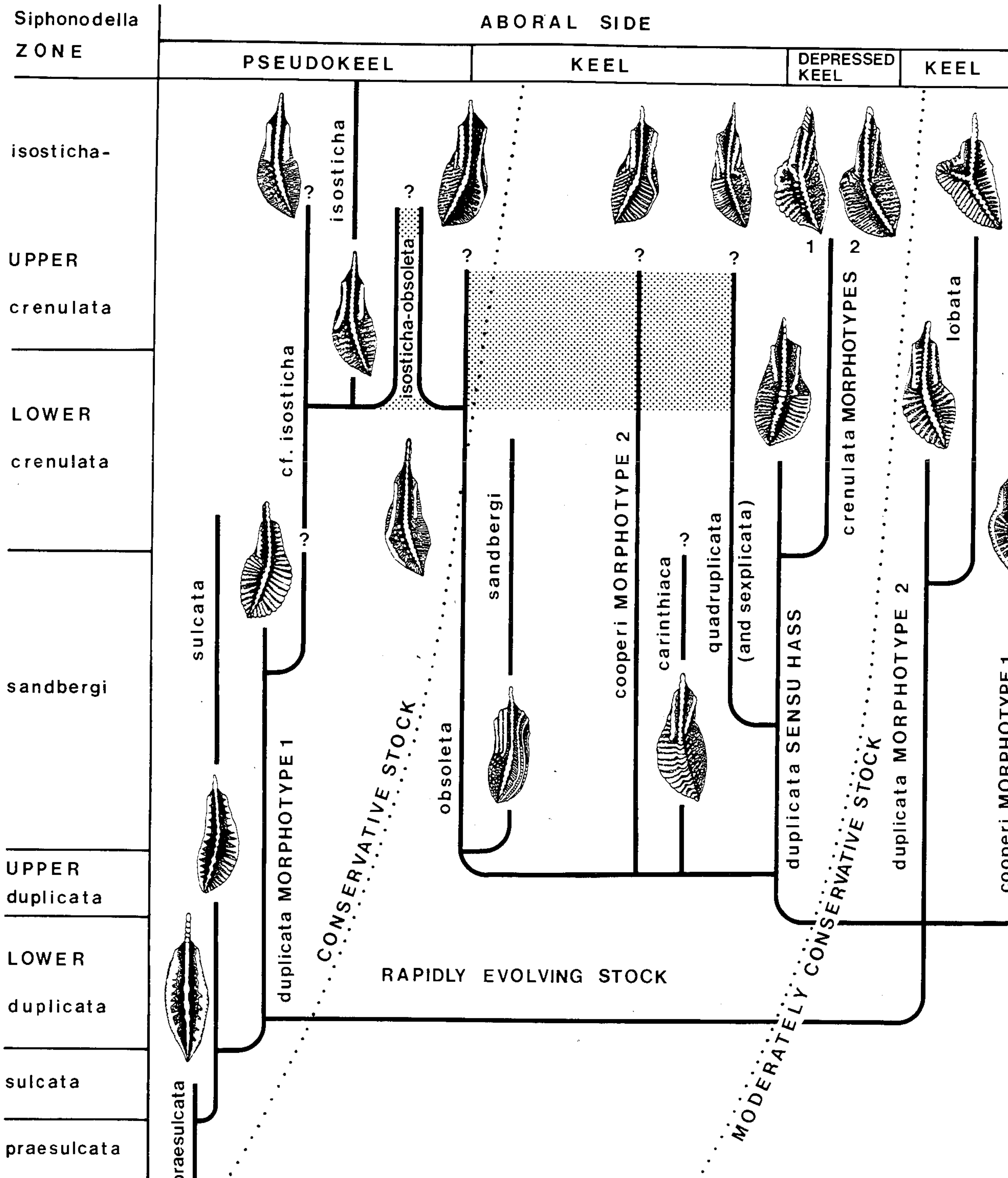

FIGURE 4.—*Siphonodella* range and identification chart (originally illustrated by Sandberg, Ziegler, and others 1978, fig. 1). Height of zonal boxes does not indicate true length of zones.

Canyon in the Wind River Range (Sandberg and Klapper 1967, p. B52–B53).

Siphonodella sandbergi *Zone*

The base of the *Siphonodella sandbergi* Zone is defined by the lowest occurrence of *Siphonodella sandbergi,* and the top is defined by the lowest occurrence of *S. crenulata.* Many species of *Siphonodella* are found in this zone in the Great Basin and Rocky Mountain regions: *S. sandbergi, S. sulcata, S. duplicata* Morphotypes 1 and 2, *S. duplicata* sensu Hass, *S. obsoleta, S. cooperi* Morphotypes 1 and 2, *S. quadruplicata,* and *S.* cf. *S. isosticha.* Other important conodonts are *Pseudopolygnathus dentilineatus, Ps. primus, Polygnathus communis communis, P. inornatus, P. longiposticus, "Spathognathodus" crassidentatus, Bispathodus stabilis, B. aculeatus, Protognathodus kuehni,* and *Pr. kockeli.* In addition, *Elictognathus laceratus, E. bialatus, Dinodus leptus,* and *D. fragosus* have their lowest occurrence in this zone. Other uncommon but important constituents of the zone are *Patrognathus variabilis, Pandorinellina* cf. *P. insita,* and *Polygnathus communis carina.* The *S. sandbergi* Zone is widely distributed in the Rocky Mountain and Great Basin regions. It is present at most localities where the upper tongue of the Cottonwood Canyon Member of the Madison Limestone has been sampled for conodonts in Wyoming, including the five localities, the collections from which were tabulated by Sandberg and Klapper (1967, table 2). The zone may be represented by a sparse fauna in collection PD-4 from the same member at Porcupine Dam in the Bear River Range, Utah (Sandberg and Gutschick 1978 and 1979, fig. 10). It is definitely present in the middle part of the type Fitchville Formation in the East Tintic Mountains, Utah (Sandberg and Poole 1977, fig. 13). In Nevada, the *S. sandbergi* Zone is present in collection BCT-41 from 17 m above the base of the upper member of the Pilot Shale at Bactrian Mountain (Sandberg and Poole 1977, p. 181). Either this zone or the overlying Lower *S. crenulata* Zone is present in the basal part of the Joana Limestone at most localities in Nevada and Utah that were sampled for conodonts; however, because of the absence of *S. crenulata* and other diagnostic species from the sparse faunas in this stratigraphic position, the two zones are difficult to differentiate.

Lower Siphonodella crenulata *Zone*

The base of the Lower *Siphonodella crenulata* Zone is defined by the first occurrence of *Siphonodella crenulata,* and the top is defined by the first occurrence of *Gnathodus delicatus.* The genus *Siphonodella* attains its maximum speciation in the middle of this zone. Species that range through most of the zone in the Great Basin and Rocky Mountain regions are *S. crenulata, S. lobata, S. isosticha, S.* cf. *S. isosticha, S. isosticha→obsoleta, S. cooperi* Morphotype 2, *S. quadruplicata,* and *S. obsoleta.* Four other species die out within this zone: *S. sulcata, S. sandbergi, S. duplicata* sensu Hass, and *S. duplicata* Morphotype 2. All the other conodonts listed for the *S. sandbergi* Zone also occur in this zone except for *Patrognathus variabilis* and *Protognathodus kuehni.* Important new conodonts that appear in this zone are *Pseudopolygnathus marginatus, Ps. triangulus triangulus, Ps. radinus, Patrognathus andersoni,* and *Anchignathodus penescitulus.* Together with *S. lobata,* they help to differentiate the Lower *S. crenulata* Zone, in the absence of the nominal species, from the *S. sandbergi* Zone.

The Lower *Siphonodella crenulata* Zone is the most widely documented and best known Lower Mississippian conodont zone. It is ubiquitous in the basal encrinitic limestone beds of the Paine Member of the Lodgepole Limestone and is commonly recoverable from lag deposits of the underlying Cottonwood Canyon Member. The zone has been identified in the basal part of the Lodgepole at more than 35 localities in Montana, western Wyoming, eastern Idaho, and northern Utah. Yields from many collections exceed 10,000 conodonts/kg. Locations and faunal lists for about half the sections where the zone has been recovered were given by Klapper (1966), Sandberg and Klapper (1967), and Sandberg and Gutschick (1978, 1979). The Lower *S. crenulata* Zone also is present near the top of the middle part of the Fitchville Formation at its type section in the East Tintic Mountains (Sandberg and Poole 1977, fig. 13) and at several other localities in Utah. The zone is present in the lower part of the McGowan Creek Formation in the Lost River Range, east central Idaho (Sandberg 1975, p. E7–E8). Also, it may be present in my collections from basal beds of these formations: the Chainman Shale at Devils Gate, Nevada (Sandberg and Poole 1977, fig. 5); the Joana Limestone at Buckhorn Canyon in the Dugway Range, Utah; and the Mercury Limestone, near Portuguese Mountain, in the Pancake Range, Nevada. The absence of *S. crenulata* and other diagnostic species creates difficulty in positively identifying the zone in basal beds of the Joana and Mercury Limestones. This absence may be due to biofacies differences between these shallow-water beds and the more open marine basal beds of the Lodgepole.

Siphonodella isosticha–*Upper* S. crenulata *Zone*

The base of the *Siphonodella isosticha*–Upper *S. crenulata* Zone is defined by the first occurrence of *Gnathodus delicatus,* and the top is defined by the last occurrence of the genus *Siphonodella.* In sequences where the extinction of *Siphonodella* cannot be observed, the first occurrence of *G. typicus* may be used to define the top. *Siphonodella isosticha* ranges throughout this zone, whereas *S. crenulata* dies out within it. Other species of *Siphonodella* that range through part of this zone before extinction are: *S. lobata, S. quadruplicata, S. cooperi* Morphotype 2, *S.* cf. *S. isosticha,* and *S. isosticha→obsoleta. Gnathodus delicatus* and *G. punctatus* range through and above this zone. Other important species that occur throughout this zone in the Great Basin and Rocky Mountain regions are *Polygnathus communis communis, P. communis carina, P. inornatus, P. longiposticus, Bispathodus stabilis, Patrognathus andersoni, Anchignathodus penescitulus, Dinodus fragosus, D. leptus, D. youngquisti, Elictognathus bialatus, E. laceratus,* and *Falcodus angulus. Pseudopolygnathus marginatus* apparently terminates within this zone, whereas *Ps. multistriatus* first appears in it and ranges higher. The lower part of the *S. isosticha*–Upper *S. crenulata* Zone, which contains an association of *S. isosticha, G. delicatus,* and *G. punctatus* with scarce *S. crenulata,* is exemplified by my collection LCD-22 from the McGowan Creek Formation in the Lost River Range, Idaho (Sandberg 1975, table 1). In that collection, four specimens of *S. crenulata* make up only 1.3 percent of the total specimens of *Siphonodella* and 0.6 percent of the total fauna.

The *Siphonodella isosticha*–Upper *S. crenulata* Zone is widely distributed in the Rocky Mountain and Great Basin regions, but at most localities it is represented by faunas that are dominated by *S. isosticha, Gnathodus punctatus,* and *G. delicatus* and that contain few specimens of other species. The zone is present in the Paine Member of the Lodgepole Limestone, except for the basal beds, throughout Montana, western Wyoming, eastern Idaho, and northern Utah. The time-equivalent interval, where the zone would be expected to occur, between the basal and upper parts of the Joana Limestone in western Utah and eastern Nevada is apparently devoid of conodonts, judging by the nonproductive, closely spaced samples of Newman (1972a) at several sections.

Farther west, in the east central and central Idaho and in northeastern and north central Nevada, the *Siphonodella isosticha*-Upper *S. crenulata* Zone is presently in largely calcareous Antler flysch deposits. It has been found in east central Idaho in the lower part of the McGowan Creek Formation in the Lost River Range (Sandberg 1975, table 1, collections LCD-22 and DH-16), Lemhi Range (my collection MID-2 from Middle Canyon), and Beaverhead Mountains (Sandberg and Poole 1977, fig. 9, samples LNG-5, 6). It also is present in the Drummond Mine Limestone of Paull and others (1972) in the Pioneer Mountains, central Idaho, in my collection LCO-1 from Little Copper Creek and at several other localities (Sandberg 1975, table 1, p. E8). The zone is present in northeastern Nevada in all but the upper part of the Tripon Pass Limestone of Oversby (1973). My resampling of his type section indicates that the conodont identified by him as *Taphrognathus* sp. (?) is actually *Gnathodus cuneiformis* and that the *Siphonodella* fauna in the upper part of the formation has been reworked into the Osagean. Similarly, several of my collections from the Dale Canyon Formation in the Diamond Mountains, central Nevada, consist of reworked Frasnian, Famennian, and Kinderhookian conodonts together with the Osagean *Gnathodus typicus.* The *S. isosticha*-Upper *S. crenulata* Zone undoubtedly is present in the Webb Formation, of enigmatic origin, in the Carlin-Piñon Range area, north central Nevada, on the basis of conodonts listed by Smith and Ketner (1968, table 2).

Osagean

Unlike the Kinderhookian and Upper Devonian zonations, the Osagean zonation for the Great Basin and Rocky Mountain regions (fig. 3) is still in a formative state. A succession of five faunal assemblages is recognized, but they can be reduced to three first-occurrence zones because two of the assemblages represent conodont biofacies lacking in diversity as well as in diagnostic species. In naming the lowest Osagean zone, it would have been expedient to employ some index conodont, such as *Polygnathus communis carina* or *Pseudopolygnathus multistriatus,* that is employed in zonal nomenclature of the Midcontinent region (e.g., Collinson and others 1962, 1971; Thompson and Fellows 1970). However, studies of faunas in the Great Basin disclosed that these conodonts, as well as *Anchignathodus penescitulus* (='*Spathognathodus pulcher* sensu Thompson, 1967, pl. 1, figs. 1, 4), have ranges that extend below the base of the Osagean. As shown on the range chart (fig. 5), only *Gnathodus typicus,* among all the important Osagean conodonts, has a range that begins at or near the Kinderhookian-Osagean boundary. For the two higher Osagean zones, it was possible to choose names somewhat similar to those employed in the Midcontinent region. The two higher Osagean zones are based on first occurrences of *Doliognathus latus* and the cryptogene, *Taphrognathus varians.* Work now in progress with H. R. Lane and Willi Ziegler on a worldwide post-*Siphonodella* Lower Carboniferous zonation may be useful in expanding the present threefold Osagean zonation in the Great Basin and Rocky Mountain regions into five or more zones.

Gnathodus typicus *Zone*

The base of the *Gnathodus typicus* Zone is defined by the lowest occurrence of *Gnathodus typicus,* and the top is defined by the lowest occurrence of *Doliognathus latus.* The *G. typicus* Zone is correlative with faunal unit 3 of Lane (1974, p. 277) in southeastern New Mexico and western Texas. Common and important species of this zone in the Great Basin and Rocky Mountain regions are: *G. typicus, G. bulbosus, G. delicatus, G. typicus*→*cuneiformis, G. cuneiformis, Anchignathodus penescitulus, Bispathodus stabilis* (or possibly a homeomorph of the older *B. stabilis*), *Doliognathus dubius, Hindeodella segaformis, Pelekysgnathus bultyncki, Polygnathus communis communis, P. longiposticus, P.* cf. *P. longiposticus* (with a large basal cavity), *Pseudopolygnathus multistriatus* and three descendent species—*Ps.* cf. *Ps. multistriatus* (with a slightly flaring left anterior platform margin), *Ps.* cf. *Ps. lobatus* (with a flaring anterior platform margin), and *Ps. nudus* (with slightly flaring anterior margins and a weakly ornamented platform), *Scaliognathus anchoralis, S.* n. sp. (with one normal and one very short lateral limb, as illustrated by Groessens and Noël 1974, pl. 7, fig. 8), and "*Spathognathodus*" *elongatus* (sensu Thompson 1967). It will be noted that many of these species are left in open nomenclature pending formal taxonomic treatment. *Polygnathus communis carina* is very rare indeed in this zone. *Bactrognathus minutus* and *Eotaphrus burlingtonensis* first occur in the upper part of this zone. The *G. typicus* Zone is widely distributed and is represented by one or more collections at five or more localities from each of the listed formations. The zone has been identified in the upper beds of the Joana, Gardison, and Lodgepole limestones in Utah, Nevada, and Idaho. It also is present in the lowest beds of the overlying phosphatic member that is shared by the Deseret Limestone, Little Flat Formation and equivalents, Brazer Dolomite, and Woodman Formation and equivalents. Locations of some of the important stratigraphic sections are given by Sando and others (1976) and Sandberg and Gutschick (1978, 1979).

Doliognathus latus *Zone*

The base of the *Doliognathus latus* Zone is defined by the lowest occurrence of *Doliognathus latus,* and the top is defined by the lowest occurrence of *Taphrognathus varians.* The *D. latus* Zone is correlative with faunal units 4 and 5 of Lane (1974, p. 277–78) in southeastern New Mexico and western Texas. All the common and important species present in the upper part of the *Gnathodus typicus* Zone have been found in this zone with the exception of *G. delicatus* s.s. and *Polygnathus longiposticus* s.s. *Polygnathus communis carina* is again present rarely and in small numbers. *Eotaphrus burlingtonensis* occurs only in the more shoreward, eastern localities. Important new conodonts found in this zone are *D. latus, D.* n. sp. (without a platform either on the main blade or on the posteriorly directed lateral limb), *Anchignathodus penescitulus* n. subsp. (with a single large side denticle), *Apatognathus* sp., *Bactrognathus distortus, B. excavatus, B.* cf. *B. hamatus, Bispathodus aculeatus aculeatus* (or possibly a homeomorph of the older subspecies), *G. antetexanus, G. delicatus* (sensu Groessens and Noël 1974, pl. 7, fig. 24), *Metalonchodina* sp., *Pelekysgnathus* cf. *P. bultyncki, Polygnathus communis communis* (with a tiny platform as in *P. varcus*), and *Pseudopolygnathus* cf. *Ps. triangulus pinnatus* (probably a homeomorph in the *Ps. multistriatus* phyletic lineage). The *D. latus* Zone has been recognized in Utah in 21 collections, every one containing the nominal species, from limestone interbeds, lenses, or concretions in the phosphatic member of the Deseret Limestone at 11 localities, of the Woodman Formation at Buckhorn Canyon in the Dugway Range, and of the Little Flat Formation at Old Laketown Canyon. Locations and names of some of the important stratigraphic sections are given by Sando and others (1976) and Sandberg and Gutschick (1978, 1979). The zone is probably present in the Middle Canyon Formation at Long Canyon, in the Beaverhead Mountains, Idaho (Sandberg and Poole 1977,

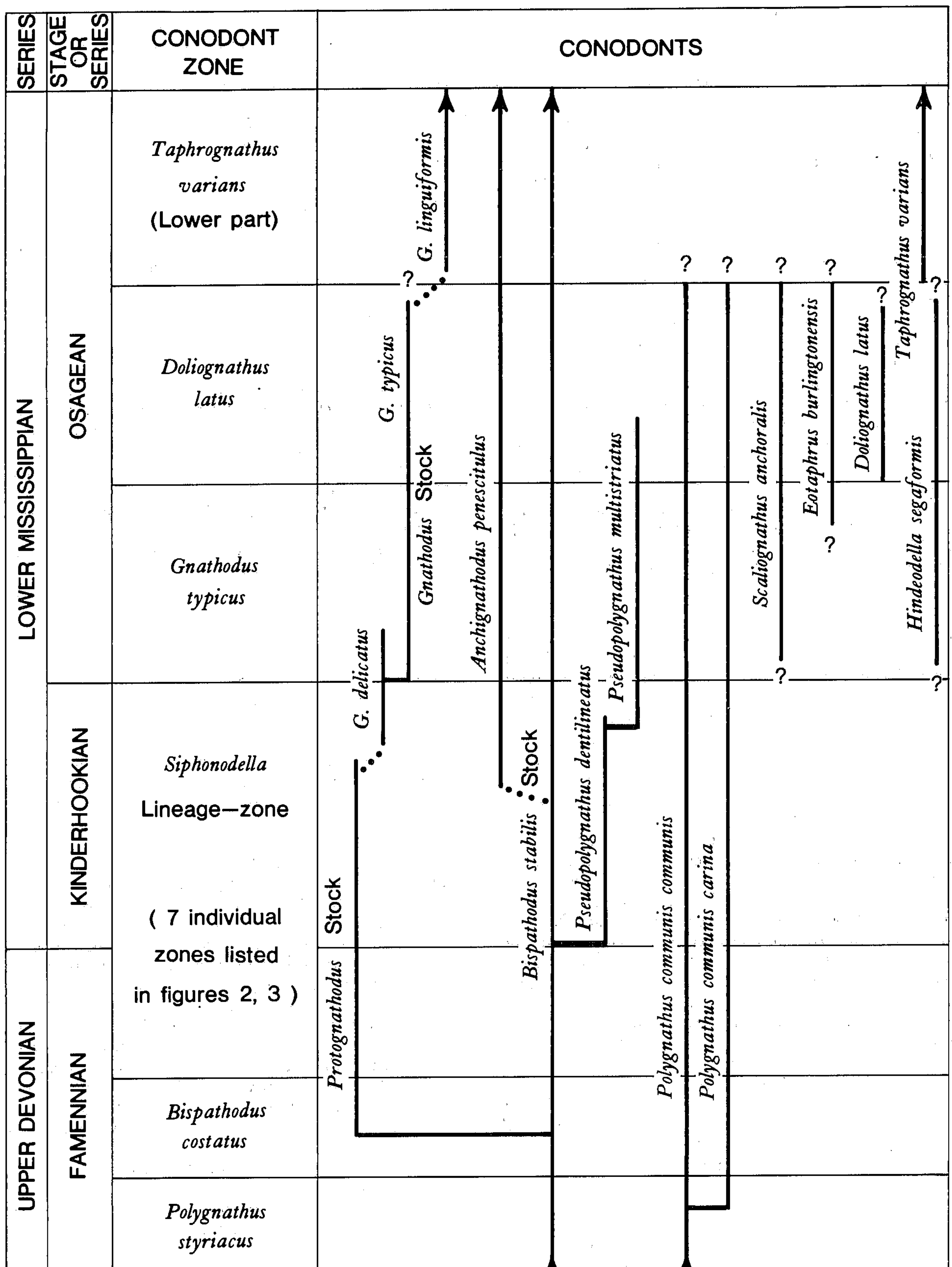

FIGURE 5.—Range and phylogeny of important Osagean conodonts.

fig. 9, collections LNG-7, 8), based on an association of *A. penescitulus* n. subsp., *Bi. aculeatus aculeatus, B. hamatus, P. communis communis,* and *"S." elongatus,* without *D. latus.*

Taphrognathus varians *Zone*

The base of the *Taphrognathus varians* Zone is defined by the first occurrence of *Taphrognathus varians,* and the top is defined by the first occurrence of the genus *Cavusgnathus.* The *T. varians* Zone, which spans the Osagean-Meramecian boundary, is correlative with faunal unit 7 of Lane (1974, p. 278). The boundary between the lower, Osagean part of this zone, which is discussed herein, and the upper, Meramecian part is not as yet clearly defined. However, differences between early and late forms in the *T. varians* and *Gnathodus linguiformis–G. texanus* lineages, which are becoming apparent with increased study of the faunas, should eventually provide a solution. For example, *G. linguiformis,* which occurs in the lower part of the zone, can be differentiated by the gradual descent of its posterior tip from *G. texanus,* as was pointed out to me by H. R. Lane (oral comm. December 1975). The lower part of the *T. varians* Zone in the Great Basin and Rocky Mountain regions contains a sparse fauna consisting only of these conodonts: *T. varians, G. linguiformis, Anchignathodus penescitulus, Bactrognathus? deflexus, Bispathodus stabilis* (probably a homeomorph of the older species), *B. stabilis* with a posterior twist of the blade as in *Bactrognathus, Metalonchodina* sp., and possibly a *Taphrognathus-Cavusgnathus* transitional species. This lower part of the zone has been found in Utah in collections containing the nominal species and occurring directly above the *Doliognathus latus* Zone in the phosphatic member of the Deseret Limestone in the type section at Ophir Canyon in the Oquirrh Mountains and in the phosphatic member of the Woodman Formation at Buckhorn Canyon in the Dugway Range. The zone has also been recognized in collections containing the nominal species in the phosphatic member of the Deseret at Ogden Canyon in the Wasatch Mountains and at Dog Valley Peak in the Pavant Range, Utah. Other collections lacking the nominal species but assigned to this zone have been found at Buckhorn, Ophir, and Ogden canyons. Another important collection that probably represents the lower part of this zone is my collection CH-11A, which contains *G. linguiformis* in association with zone 9–10 foraminiferans, from the Little Flat Formation in the Chesterfield Range, Idaho (Sando and others 1976, p. 468–70).

ADDENDUM

While this paper was in press, I had an opportunity to examine with Willi Ziegler and H. R. Lane the conodont holotypes, including that of *Gnathodus typicus,* that were published by C. L. Cooper in 1939. Unfortunately, the holotype of *G. typicus* does not appear to match well the concept of this species as employed by conodont workers during the past two decades. Consequently, the species, *G. typicus,* as well as the conodont zone bearing that name, which is proposed herein and is used in the companion paper by Sandberg and Gutschick (1979), may be renamed in the near future.

SELECTED REFERENCES

Achauer, C. W., 1959, Stratigraphy and microfossils of the Sappington Formation in southwestern Montana: Billings Geological Society Guidebook, 10th Annual Field Conference: p. 41–49.

Beach, G. A., 1961, Late Devonian and Early Mississippian biostratigraphy of central Utah: Brigham Young University Geology Studies, v. 8, p. 37–54, 2 pls.

Beinert, R. J., Klapper, G., Sandberg, C. A., and Ziegler, W., 1971, Revision of *Scaphignathus* and description of *Clydagnathus? ormistoni* n. sp. (Conodonta, Upper Devonian): Geologica et Palaeontologica, v. 5, p. 81–91, 2 pls.

Branson, E. B., and Branson, C. C., 1941, Geology of Wind River Mountains, Wyoming: American Association of Petroleum Geologists Bulletin. v. 25, no. 1, p. 120–51.

Branson, E. B., and Mehl, M. G., 1938, The conodont genus *Icriodus* and its stratigraphic distribution: Journal of Paleontology, v. 12, no. 2, p. 156–66, pl. 26.

Burton, R. C., 1964, A preliminary range chart of Lake Valley Formation (Osage) conodonts in the southern Sacramento Mountains, New Mexico: New Mexico Geological Society Guidebook, 15th Field Conference, Ruidosa County: p. 73–75, 1 chart.

————, 1965, Conodonts of the Mississippian System in the Sacramento Mountains, New Mexico: Ph.D. dissertation, University of New Mexico, Albuquerque, 214 p., 9 pls.

Chapman, J. S., 1958, Conodonts from the *Manticoceras* zone (Devonian), Confusion Range, Millard County, Utah: Master's thesis, University of Kansas, Lawrence, 53 p.

Clark, D. L., 1967, Conodonts as indicators of diachronism in Devonian rocks of the Great Basin, United States: In Oswald, D. H. (ed.), International symposium on the Devonian System, Calgary, Alberta, Sept. 1967: Calgary, Alberta Society of Petroleum Geologists, v. 2, p. 673–77.

Clark, D. L., and Becker, J. H., 1960, Upper Devonian correlations in western Utah and eastern Nevada: Geological Society of America Bulletin, v. 71, no. 11, p. 1661–74, 2 pls.

Clark, D. L., and Ethington, R. L., 1966, Conodonts and biostratigraphy of the Lower and Middle Devonian of Nevada and Utah: Journal of Paleontology, v. 40, no. 3, p. 659–89, pls. 82–84.

————, 1967, Conodonts and zonation of the Upper Devonian in the Great Basin: Geological Society of America Memoir 103, 94p., 9 pls.

Collinson, C., Rexroad, C. B., and Thompson, T. L., 1971, Conodont zonation of the Northern American Mississippian: In Sweet, W. C., and Bergström, S. M. (eds.), Symposium on conodont biostratigraphy: Geological Society of America Memoir 127, p. 353–94, 8 figs., 1 table.

Collinson, C., Scott, A. J., and Rexroad, C. B., 1962, Six charts showing biostratigraphic zones and correlations based on conodonts from the Devonian and Mississippian rocks of the Upper Mississippi Valley: Illinois Geological Survey Circular 328, 32p., 6 charts.

Cooper, C. L., 1945, Devonian conodonts from northwestern Montana: Journal of Paleontology, v. 19, no. 6, p. 612–15, 1 pl.

Cooper, C. L., and Sloss, L. L., 1943, Conodont fauna and distribution of a Lower Mississippian black shale in Montana and Alberta: Journal of Paleontology, v. 17, no. 2, p. 168–76.

Dreesen, R., and Dusar, M., 1974, Refinement of conodont biozonation in the Famennian type area: Belgium Geological Survey, International Symposium on Belgian Micropaleontological Limits from Emsian to Viséan, Namur, Sept. 1–10, 1974, pub. 13, 36p., 7 pls.

Ethington, R. L., 1965, Late Devonian and Early Mississippian conodonts from Arizona and New Mexico: Journal of Paleontology, v. 39, no. 4, p. 566–89, pls. 67–68.

Ethington, R. L., Furnish, W. M., and Wingert, J. R., 1961, Upper Devonian conodonts from Bighorn Mountains, Wyoming: Journal of Paleontology, v. 35, no. 4, p. 759–68.

Flower, R. H., 1958, Cambrian-Mississippian beds of southern New Mexico: The Hatchet Mountains and the Cooks Range-Florida Mountain areas, Grant, Hidalgo and Luna counties, southwestern New Mexico: Roswell Geological Society Guidebook, 11th Field Conference, May 14, 15, 16, 1958, p. 61–78.

Groessens, E., and Noël, B., 1974, Étude litho- et biostratigraphique du Rocher du Bastion et du Rocher Bayard à Dinant: Belgium Geological Survey, International Symposium on Belgian Micropaleontological Limits from Emsian to Viséan, Namur, Sept. 1–10, 1974, pub. 15, 17p., 1 pl.

Hass, W. H., 1943, Corrections to the Kinderhook conodont faunas, Little Rocky Mountains, Montana: Journal of Paleontology, v. 17, p. 307–8.

Helms, Jochen, 1959, Conodonten aus dem Saalfelder Oberdevon (Thüringen): Geologie, v. 8, no. 6, p. 634–77, 6 pls.

Hoggan, R. D., 1975, Paleoecology of the Guilmette Formation in eastern Nevada and western Utah: Brigham Young University Geology Studies, v. 22, pt. 1, p. 141–97.

Johnson, D. B., 1972, Devonian stratigraphy of southern Cortez Mountains, Nevada: Master's thesis, University of Iowa, Iowa City, 55p.

Johnson, J. G., and Sandberg, C. A., 1977, Lower and Middle Devonian continental-shelf rocks of the western United States: In Murphy, M. A., Berry, W. B. N., and Sandberg, C. A. (eds.), Western North America: Devonian: University of California–Riverside, Campus Museum Contribution 4, p. 121–43.

Klapper, G., 1958, An Upper Devonian conodont fauna from the Darby Formation of the Wind River Mountains, Wyoming: Journal of Paleontology, v. 32, no. 6, p. 1082–93, pls. 141–42.

————, 1966, Upper Devonian and Lower Mississippian conodont zones in Montana, Wyoming, and South Dakota: University of Kansas Paleontological Contributions, Paper 3, 43p., 6 pls.

———, 1969, Lower Devonian conodont sequence, Royal Creek, Yukon Territory, and Devon Island, Canada: Journal of Paleontology, v. 43, no. 1, p. 1–27, pls. 1–6.

———, 1977, Lower and Middle Devonian conodont sequence in central Nevada, with contributions by D. B. Johnson: In Murphy, M. A., Berry, W. B. N., and Sandberg, C. A. (eds.), Western North America: Devonian: University of California–Riverside, Campus Mus. Contribution 4, p. 33–54.

Klapper, G., and Furnish, W. M., 1962, Devonian-Mississippian Englewood Formation in Black Hills, South Dakota: American Association of Petroleum Geologists Bulletin, v. 46, no. 11, p. 2071–78.

Klapper, G., and Johnson, D. B., 1975, Sequence in conodont genus *Polygnathus* in Lower Devonian at Lone Mountain, Nevada: Geologica et Palaeontologica, v. 9, p. 65–83, 3 pls.

Klapper, G., and Murphy, M. A., 1975, Silurian–Lower Devonian conodont sequence in the Roberts Mountains Formation of central Nevada: University of California Publications Geological Science, v. 111, 62p., 12 pls.

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 Devonian conodont biostratigraphy: In Sweet, W. C., and Bergström, S. M. (eds.), Symposium on conodont biostratigraphy: Geological Society of America Memoir 127, p. 285–316, 6 figs.

Knechtel, M. M., and Hass, W. H., 1938, Kinderhook conodonts from Little Rocky Mountains, northern Montana: Journal of Paleontology, v. 12, no. 5, p. 518–20.

Koucky, F. L., Cygan, N. E., and Rhodes, F. H. T., 1961, Conodonts from the eastern flank of the central part of the Big Horn Mountains, Wyoming: Journal of Paleontology, v. 35, no. 4, p. 877–79.

Lane, H. R., 1974, Mississippian of southeastern New Mexico and west Texas: A wedge-on-wedge relation: American Association of Petroleum Geologists Bulletin, v. 58, no. 2, p. 269–82.

Miller, R. H., 1976, Revision of Upper Ordovician, Silurian, and Lower Devonian stratigraphy, southwestern Great Basin: Geological Society of America Bulletin, v. 87, no. 7, p. 961–68, 1 pl.

———, 1978, Early Silurian to Early Devonian conodont biostratigraphy and depositional environments of the Hidden Valley Dolomite, southeastern California: Journal of Paleontology, v. 52, no. 2, p. 323–44, 4 pls.

Neder, I. R., 1973, Conodont biostratigraphy and depositional history of the Mississippian Battleship Wash Formation, southern Nevada: Ph.D. dissertation, University of California–Los Angeles, 226p., 7 pls.

Newman, G. J., 1972a, Conodonts and biostratigraphy of the Lower Mississippian in western Utah and eastern Nevada: Master's thesis, Brigham Young University, Provo, Utah.

———, 1972b, Conodonts and biostratigraphy of the Lower Mississippian in western Utah and eastern Nevada: Geological Society of America Abstracts with Programs, v. 4, no. 5, p. 340.

Norby, R. D., 1971, Conodont biostratigraphy of the Mississippian rocks of southeastern Arizona: Master's thesis, Arizona State University, Tempe, 195 p., 9 figs. 8 tables, 10 pls.

Oversby, B., 1973, New Mississippian formation in northeastern Nevada and its possible significance: American Association of Petroleum Geologists Bulletin, v. 57, no. 9, p. 1779–83.

Paull, R. A., Wolbrink, M. A., Volkmann, R. G., and Grover, R. L., 1972, Stratigraphy of Copper Basin Group, Pioneer Mountains, south-central Idaho: American Association of Petroleum Geologists Bulletin, v. 56, no. 8, p. 1370–1401.

Pierce, R. W., and Langenheim, R. L., Jr., 1972, Mississippian (Tournaisian-Viséan) conodont zones in the Great Basin, southwestern USA: Newsletters on Stratigraphy, v. 2, no. 1, p. 31–44.

———, 1974, Platform conodonts of the Monte Cristo Group, Mississippian, Arrow Canyon Range, Clark County, Nevada: Journal of Paleontology, v. 48, no. 1, p. 149–69, 4 pls.

Pinney, R. I., 1965, A preliminary survey of Mississippian biostratigraphy (conodonts) in the Oquirrh Basin of central Utah: Ph.D. dissertation, University of Wisconsin, Madison, 189p., 4 pls.

Poole, F. G., Baars, D. L., Drewes, H., Hayes, P. T., Ketner, K. B., McKee, E. D., Teichert, C., and Williams, J. S., 1967, Devonian of the southwestern United States: In Oswald, D. H. (ed.), International symposium on the Devonian Symposium, Calgary, Alberta, Sept. 1967: Calgary, Alberta Society of Petroleum Geologists, v. 1, p. 879–912.

Racey, J. S., 1974, Conodont biostratigraphy of the Redwall Limestone of east-central Arizona: Master's thesis, Arizona State University, Tempe, 199p., 7 figs., 6 tables, 6 pls.

Reinbold, M. L., and Langenheim, R. L., Jr., 1977, Late Devonian (Frasnian-Famennian) conodont biostratigraphy, Las Vegas Range, Clark County, Nevada, USA: Newsletters on Stratigraphy, v. 6, no. 3, p. 183–93.

———, 1978, Conodonts of the upper member, Arrow Canyon Formation, and the Crystal Pass Limestone, Late Devonian, Las Vegas Range, Clark County, Nevada: Wyoming Geological Association Earth Science Bulletin, v. 10, no. 2, p. 3–28, 5 pls.

Sandberg, C. A., 1963, Dark shale unit of Devonian and Mississippian age in northern Wyoming and southern Montana: In Short papers in geology and hydrology: U.S. Geol. Survey Prof. Paper 475-C, art. 64, p. C17–C20.

———, 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: Abstracts for 1968: Geological Society of America Special Paper 121, p. 633.

———, 1975, McGowan Creek Formation: New name for Lower Mississippian flysch sequence in east-central Idaho: U.S. Geological Survey Bulletin 1405-E, 11p.

———, 1976, Conodont biofacies of Late Devonian *Polygnathus styriacus* Zone in western United States: In Barnes, C. R. (ed.), Conodont paleoecology: Geological Association of Canada Special Paper 15, p. 171–86.

———, 1978, Upper Devonian and Lower Mississippian conodont zonation of the Great Basin and Rocky Mountains: Geological Society of America Abstracts with Programs, v. 10, no. 5, p. 237.

Sandberg, C. A., and Gutschick, R. C., 1969, Stratigraphy and conodont zonation of type Leatham Formation (Devonian and Mississippian), Bear River Range, Utah: Geological Society of America Abstracts with Programs, v. 1, pt. 5, p. 70–71.

———, 1977, Deep-water Osagean conodont faunas from a starved basin in Utah: Geological Society of America Abstracts with Programs, v. 9, no. 5, p. 649.

———, 1978, Biostratigraphic guide to Upper Devonian and Mississippian rocks along the Wasatch Front and Cordilleran Hingeline, Utah: U.S. Geological Survey Open-File Report 78-351, 52p., 16 figs.

———, 1979, Guide to conodont biostratigraphy of Upper Devonian and Mississippian rocks along the Wasatch Front and Cordilleran Hingeline, Utah: In Sandberg, C. A., and Clark, D. L. (eds.), Conodont biostratigraphy of the Great Basin and Rocky Mountains: Brigham Young University Geology Studies, v. 26, pt. 3, p. 107–134.

Sandberg, C. A., Hall, W. E., Batchelder, J. N., and Axelsen, C., 1975, Stratigraphy, conodont dating, and paleotectonic interpretation of type Milligen Formation (Devonian), Wood River area, Idaho: U.S. Geol. Survey Journal of Research, v. 3, no. 6, p. 707–20.

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. Geological Survey Bulletin 1251-B, 70p.

Sandberg, C. A., and Mapel, W. J., 1967, Devonian of the Northern Rocky Mountains and Plains: In Oswald, D. H. (ed.), International symposium on the Devonian System, Calgary, Alberta, Sept. 1967: Calgary, Alberta Society of Petroleum Geologists, v. 1, p. 843–77.

Sandberg, C. A., Mapel, W. J., and Huddle, J. W., 1967, Age and regional significance of basal part of Milligen Formation, Lost River Range, Idaho: In Geological Survey research 1967: U.S. Geological Survey Professional Paper 575-C, p. C127–31.

Sandberg, C. A., and Poole, F. G., 1977, Conodont biostratigraphy and depositional complexes of Upper Devonian cratonic-platform and continental-shelf rocks in the Western United States: In Murphy, M. A., Berry, W. B. N., and Sandberg, C. A. (eds.), Western North America: Devonian: University of California–Riverside, Campus Museum Contribution 4, p. 144–82.

Sandberg, C. A., Streel, M., and Scott, R. A., 1972, Comparison between conodont zonation and spore assemblages at the Devonian-Carboniferous boundary in the western and central United States and in Europe: Congrés International de Stratigraphie et Géologie du Carbonifère, 7th, Krefeld, 1971, Compte rendu, v. 1, p. 179–203, 4 pls.

Sandberg, C. A., and Ziegler, W., 1973, Refinement of standard Upper Devonian conodont zonation based on sections in Nevada and West Germany: Geologica et Palaeontologica, v. 7, p. 97–122, 5 pls.

———, 1976, Working zonation and refined speciation of *Siphonodella* (Conodonta, Upper Devonian and Lower Carboniferous): Geological Society of America Abstracts with Programs, v. 8, no. 4, p. 506–7.

———, 1979, Taxonomy and biofacies of important conodonts of Late Devonian *styriacus*-Zone, United States and Germany: Geologica et Palaeontologica, v. 13, p. 173–212, 7 pls.

Sandberg, C. A., Ziegler, W., Leuteritz, K., and Brill, S. M., 1978, Phylogeny, speciation, and zonation of *Siphonodella* (Conodonta, Upper Devonian and Lower Carboniferous): Newsletters on Stratigraphy, v. 7, no. 2, p. 102–20, 2 figs.

Sando, W. J., Dutro, J. T., Jr., Sandberg, C. A., and Mamet, B. L., 1976, Revision of Mississippian stratigraphy, eastern Idaho and northeastern Utah: U.S. Geological Survey Journal of Research, v. 4, no. 4, p. 467–79.

Sartenaer, P., and Sandberg, C. A., 1974, New North American species of Upper Famennian rhynchonellid genus *Megalopterorhynchus* from Lost River Range, Idaho: Journal of Paleontology, v. 48, no. 4, p. 756–65, 1 pl.

Seddon, G., 1970, Pre-Chappel conodonts of the Llano region, Texas: University of Texas, Bureau of Economic Geology, Report of Investigations 68, 130p., 19 pls.

Skipp, B., and Sandberg, C. A., 1975, Silurian and Devonian miogeosynclinal and transitional rocks of the Fish Creek Reservoir window, central Idaho: U.S. Geological Survey Journal of Research, v. 3, no. 6, p. 691–706.

Smith, J. F., Jr., and Ketner, K. B., 1968, Devonian and Mississippian rocks and the date of the Roberts Mountains thrust in the Carlin-Pinon Range area, Nevada: U.S. Geological Survey Bulletin 1251-I, p. I1–I18.

Thompson, T. L., 1967, Conodont zonation of lower Osagean rocks (Lower Mississippian) of southwestern Missouri: Missouri Geological Survey Report of Investigations 39, 88p., 6 pls.

Thompson, T. L., and Fellows, L. D., 1970, Stratigraphy and conodont biostratigraphy of Kinderhookian and Osagean (Lower Mississippian) rocks of southwestern Missouri and adjacent areas: Missouri Geological Survey Report of Investigations 45, 263p., 10 pls.

Tillman, C. G., and Ketner, K. B., 1970, Devonian conodonts from Lone Mountain, Elko County, Nevada: Geological Society of America Abstracts with Programs, v. 2, no. 7, p. 707.

Verville, G. J., Sanderson, G. A., Brenckle, P. L., and Lane, H. R., 1973, Upper Paleozoic biozonation in the unit no. 19 well, Church Buttes Field, Uinta County, Wyoming: Wyoming Geological Association Guidebook 1973, p. 165–71, 3 pls.

Weddige, K., 1977, Die Conodonten der Eifel-Stufe im Typusgebiet und in benachbarten Faziesgebieten: Senckenbergiana Lethaea, v. 58, no. 4–5, p. 271–419, 6 pls.

Weddige, K., and Ziegler, W., 1977, Correlation of Lower/Middle Devonian boundary beds: Newsletters on Stratigraphy, v. 6, no. 2, p. 67–84.

Ziegler, W., 1962, Taxionomie und Phylogenie Oberdevonischer Condonten und ihre stratigraphische Bedeutung: Hessisches Landesamt Bodenforschung Abhandlungen 38, 166p., 14 pls.

———, 1971, Conodont stratigraphy of the European Devonian: In Sweet, W. C., and Bergström, S. M. (eds.), Symposium on conodont biostratigraphy: Geological Society of America Memoir 127, p. 227–84, 6 charts.

Ziegler, W., Klapper, G., and Johnson, J. G., 1976, Redefinition and subdivision of the *varcus*-Zone (Conodonts, Middle-?Upper Devonian) in Europe and North America: Geologica et Palaeontologica, v. 10, p. 109–32, 4 pls.

Ziegler, W., Sandberg, C. A., and Austin, R. L., 1974, Revision of *Bispathodus* group (Conodonta) in the Upper Devonian and Lower Carboniferous: Geologica et Palaeontologica, v. 8, p. 97–112, 3 pls.