be used on a world-wide basis for correlation and should be taken into consideration when designating the basal boundary of the Carboniferous.
(3) The Devonian-Carboniferous boundary-stratotype should be designated in a continuous marine succession, where the working boundary can be recognized. All other considerations being equal, the stratotype should preferably be designated in the region where the original chronostratigraphic units (stages) were defined.
(4) Coincidence of systemic and stage boundaries is recommended, hence any part of the Tournaisian that falls below the base of the Carboniferous should be redesignated and placed in the Famennian.
(5) We also propose to ask the President of the I.U.G.S. Commission on Stratigraphy to constitute a Committee on the Devonian/Carboniferous boundary and to charge this Committee to examine the proposed conodont limit in a sufficient number of sections to allow the subsequent selection of a suitable stratotype.
After some discussion by T. N. George, M. Streel, J. Th. Dutro, M. Gordon, W. H. C. Ramsbottom and W. P. van Leckwijck, the stated proposals were accepted in principle as a desirable basis for consideration by the proposed I.U.G.S. Committee on the Devonian-Carboniferous boundary. The constitution of this Devonian/Carboniferous junction Committee was further discussed on August 24th, and the decision was taken to recommend that Professor T. N. George and Professor M. Streel should be included as members of this Committee on behalf of the I.U.G.S. Subcommission on Carboniferous Stratigraphy.

Comparison between conodont zonation and spore assemblages at the Devonian-Carboniferous boundary in the western and central United States and in Europe[1])

By Charles A. Sandberg, Maurice Streel and Richard A. Scott

With 4 figures and 4 plates

Abstract

A new conodont fauna, the *Siphonodella praesulcata* Fauna, occurs in very high Devonian beds in the Sappington Member of the Three Forks Formation in Montana and in the Leatham Formation in Utah. The fauna is dominated by *Siphonodella praesulcata* n. sp., a primitive narrow siphonodellid that ranges from near the base of the Devonian Middle *Spathognathodus costatus* Zone (in Utah) into the basal Carboniferous *S. sulcata* Zone (in the Upper Mississippi Valley). As its recognition is important to the correct placement of the Devonian-Carboniferous boundary based on conodonts, *S. praesulcata* n. sp. is described, illustrated, and discriminated from its descendant, *S. sulcata*, which is redescribed.
Two spore assemblages containing *Hymenozonotriletes lepidophytus* are illustrated from occurrences in very high Devonian beds of the Sappington Member in Montana and from the middle part of the Saverton Shale in Illinois. These are correlated respectively with the PLs 2—3 and PLi spore assemblages of Streel in Europe. In terms of associated or bracketing conodont faunas, the spore assemblages occur within the *Siphonodella praesulcata* Fauna in Montana and within the *Spathognathodus aculeatus* Zone (equivalent to the Middle to Upper *S. costatus* Zone) in Illinois.
The Devonian-Carboniferous boundary in North America is reevaluated on the basis of the new conodont and spore evidence. The highest part of the Devonian is discerned through conodonts by the presence of either the *Protognathodus* Fauna, generally in calcareous or shaly lithofacies, or the *Siphonodella praesulcata* Fauna, generally in silty lithofacies, and through spores by the presence of *Hymenozonotriletes lepidophytus* spore assemblages. Reportedly younger, possibly basal Carboniferous occurrences of *H. lepidophytus* in the eastern United States do not agree with the North American range nor with the worldwide range of *H. lepidophytus* assemblages and are regarded as reworked or misdated.
The *Siphonodella sulcata* Zone marks the base of the Carboniferous in North America and Europe, and, as defined herein, can probably be used throughout the world. In the western United States, the *S. sulcata* Zone contains the lowest joint occurrence of *S. sulcata, Protognathodus kuehni, Pseudopolygnathus dentilineatus*, and *Patrognathus variabilis*. Only *P. variabilis* has not yet been found within this zone in the Upper Mississippi Valley and in Germany. In the Upper Mississippi Valley, the *Protognathodus kuehni - P. kockeli* Zone was found to contain *S. sulcata*, and hence this zone is abandoned and included in the *S. sulcata* Zone. The *S. sulcata - P. kockeli* Zone in Germany also should be amended to *S. sulcata* Zone. Continued use of *P. kockeli* in the zonal name is misleading as this species is an important constituent of the underlying *Protognathodus* Fauna.

Introduction

Purpose and scope

A new conodont fauna, herein named the *Siphonodella praesulcata* Fauna, is recognized in very high Devonian beds of the Sappington Member of the Three Forks Formation in Montana and of the correlative Leatham Formation in Utah. The fauna is dominated by the oldest known siphonodellid, *Siphonodella praesulcata* n. sp., which is described herein. This primitive new species is described and illustrated from occurrences in the Sappington Member and the Leatham Formation, and in the dually named "Glen Park" Formation of Collinson (1961 b, p. 104—105) or "Hamburg oolite" of Koenig and Martin (1961, p. 30) in Missouri. It is also present in the Bonaparte Gulf Basin of northwestern Australia, where it was cited as *Polygnathus* sp. **B** by Druce (1969), and in the Middle *Spathognathodus costatus* Zone in Germany (Willi Ziegler, written commun., Sept. 30, 1969). As *Siphonodella praesulcata* ranges from near the base of the Devonian Middle *S. costatus* Zone into the basal Carboniferous *S. sulcata* Zone, its discrimination from closely similar but generally younger *S. sulcata* is important to the worldwide placement of the Devonian-Carboniferous boundary based on conodonts.
Spore assemblages containing *Hymenozonotriletes lepidophytus* Kedo are illustrated from an occurrence in the Sappington Member in Montana (Sandberg, 1965, p. N16; Sandberg and Klapper, 1967, p. B8—B10; Macqueen and Sandberg, 1970, p. 49—51) and from the middle part of the Saverton Shale in Illinois (Collinson, 1961a, p. 67). The Montana assemblage is

[1]) Publication authorized by the Director, U.S. Geological Survey

apparently bracketed by the *Siphonodella praesulcata* Fauna; the Illinois assemblage occurs with a conodont fauna that is correlated with the Middle to Upper *Spathognathodus costatus* Zone.

On the basis of the new conodont and spore evidence, the base of the Carboniferous (base of the Mississippian) in North America is reevaluated. In the western United States, the *Siphonodella sulcata* Zone is marked by the lowest joint occurrence of *Siphonodella sulcata, Pseudopolygnathus dentilineatus, Protognathodus kuehni*, and *Patrognathus variabilis*. In the Upper Mississippi Valley, it is recommended that the *Protognathodus kuehni - P. kockeli* Zone (*Gnathodus* n. sp. B - *G. kockeli* Assemblage Zone of Collinson and others, 1962) be abandoned. This zone, which has been alternatively assigned to the basal Mississippian by Collinson, Scott, and Rexroad (1962, p. 19) or to the highest Devonian (Ziegler, 1969, p. 357), was now found to contain both *Siphonodella praesulcata* n. sp. and *S. sulcata*, and hence it should be included in the *S. sulcata* Zone.

Sources of data and acknowledgments

The biostratigraphic discussion, the identification and illustration of conodonts, and the correlation of conodont zones are the responsibility of the senior author. The spore assemblages are identified and illustrated by Streel and Scott. All three authors are jointly responsible for the interpretations and conclusions.

We wish to thank Mrs. Betty L. Arnone for preparing the conodont samples and Mrs. Imogene L. Doher for preparing the spore samples. The help of John W. Huddle and Robert M. Kosanke, U.S. Geological Survey, and of Gilbert Klapper, University of Iowa, in reviewing this paper is gratefully acknowledged. R. C. Gutschick, University of Notre Dame, provided valuable counsel on biostratigraphic problems and helped measure and sample some sections in Montana and Utah.

Age significance of *Hymenozonotriletes lepidophytus* spore assemblages

Spore assemblages containing *Hymenozonotriletes lepidophytus* Kedo are known from many parts of the world, including the eastern United States, eastern and western Canada, North Africa, the British Isles, Western Europe, the Byelorussian S.S.R. (White Russia), and western Australia. (See Owens and Streel, 1967, and Owens, 1971, for summaries of known occurrences.) Some of the more recent papers dealing with these assemblages are those by Dolby (1971), Dolby and Neves (1970), Lanzoni and Magloire (1969), McGregor (1971), Neves and Dolby (1967), Paproth and Streel (1971), Streel (1966, 1967, 1969, 1971), and Utting and Neves (1971).

Most assemblages containing *Hymenozonotriletes lepidophytus* appear to be unquestionably of latest Devonian age. The only valid occurrences of *H. lepidophytus* in rocks that may be of Carboniferous age are those in the Berea Sandstone in Ohio. *H. lepidophytus* was identified, under the synonym *Endosporites lacunosus*, by Winslow (1962) from the Berea Sandstone and the underlying Bedford Shale. The Berea should be regarded as the highest documented occurrence of *H. lepidophytus* in Ohio, as Winslow (1962) did not report *E. lacunosus* from spore assemblages in the overlying Sunbury Shale and she reported only two specimens, which could well be reworked, from the Cuyahoga Formation, directly above the Sunbury. Evidence for the Mississippian (Lower Carboniferous) age of the Sunbury Shale, Berea Sandstone, and most of the Bedford Shale in the Appalachian Basin of Ohio, Pennsylvania, and West Virginia, was summarized by de Witt (1970). On the basis of a conodont fauna reported by Hass (1947, p. 136), we agree with de Witt (1970, p. G6) that the Sunbury, which does not contain *H. lepidophytus*, is unquestionably Mississippian in Ohio. However, the sole conodont species reported by de Witt (1970) from the Bedford Shale, which does contain *H. lepidophytus*, is *Spathognathodus anteposicornis*. This species characterizes the latest Devonian *Protognathodus* Fauna in the Upper Mississippi Valley. Conodonts or other fossils are unreported from the Berea Sandstone, which at present must be considered as virtually undated. Even if the Berea Sandstone in Ohio is later proved to be Carboniferous on the basis of conodonts or ammonoids, it should be emphasized that the only two reported occurrences of *H. lepidophytus* there are in sandstones and hence could be reworked. North of Ohio, in southernmost Ontario, the Sunbury, Berea, and Bedford contain *H. lepidophytus* assemblages that are suggestive of a latest Devonian age (McGregor, 1971). This raises the further possibility that the Berea and the Sunbury may be time-transgressive units that cross the Devonian-Carboniferous boundary regionally.

Conodont zonation across the Devonian-Carboniferous boundary

The history of the placement of the Devonian-Carboniferous boundary has been detailed by Paproth (1964) in the Fifth Congress and summarized by Austin, Druce, Rhodes, and Williams (1970) in the Sixth Congress. These latter authors presented the then current (mainly to 1967) knowledge of conodont zonation across the Devonian-Carboniferous boundary in West Germany, the Upper Mississippi Valley, Wyoming, and western England, based on data from Voges (1959), Ziegler (1962), Collinson Scott, and Rexroad (1962), Sandberg and Klapper (1967), and Rhodes, Austin, and Druce (1969). The

present (May 1971) conodont zonation, which incorporates all recently proposed changes in zonal nomenclature including those advocated herein, is given for the Rocky Mountains and Great Basin of the western United States, the Upper Mississippi Valley of the central United States, and Germany (fig. 1).

Montana conodonts originally identified as *Scaphignathus velifer* were reassigned to *S. subserratus*. Hence, in the absence of the zonal name-bearer, the use of *S. velifer* Zone was abandoned in favor of *Scaphignathus subserratus-Pelekysgnathus inclinatus* Fauna, which probably is equivalent to the Upper *S. velifer* Zone in Germany.

	Rocky Mountains and Great Basin: Conodont zone	Rocky Mountains and Great Basin: Spores	Upper Mississippi Valley: Conodont zone	Upper Mississippi Valley: Spores	Germany: Conodont zone
CARBONIFEROUS	UPPER *Siphonodella crenulata*		*Siphonodella isosticha - Siphonodella cooperi*		UPPER *Siphonodella crenulata*
	LOWER *Siphonodella crenulata* V		*Siphonodella quadruplicata*		LOWER *Siphonodella crenulata*
	Siphonodella sandbergi- Siphonodella duplicata		*Siphonodella duplicata s.s.*		*Siphonodella-Pseudopolygnathus triangulus triangulus*
					Siphonodella-Pseudopolygnathus triangulus inequalis
	Siphonodella sulcata		*Siphonodella sulcata*		*Siphonodella sulcata*
DEVONIAN	IV *Siphonodella praesulcata* FAUNA	◄ PLs 2-3 ASSEMBLAGE	*Protognathodus* FAUNA		*Protognathodus* FAUNA
			?		UPPER *Spathognathodus costatus*
	MIDDLE *Spathognathodus costatus*		*Spathognathodus aculeatus*	◄ PLi ASSEMBLAGE	MIDDLE *Spathognathodus costatus*
	LOWER *Spathognathodus costatus*				LOWER *Spathognathodus costatus*
	UPPER *Polygnathus styriacus* III				UPPER *Polygnathus styriacus*
					MIDDLE *Polygnathus styriacus*
					LOWER *Polygnathus styriacus*
	Scaphignathus subserratus- Pelekysgnathus inclinatus FAUNA II				UPPER *Scaphignathus velifer*
					MIDDLE *Scaphignathus velifer*

Figure 1. Comparison of North American conodont zones and spore assemblages with standard German conodont zonation. Roman numerals designate conodont zones or faunas that are positioned on Figure 2.

Rocky Mountains and Great Basin

The uppermost Devonian and lowermost Mississippian conodont zones recognized in Montana and Wyoming, in the Northern Rocky Mountains, were charted, discussed, and documented by Sandberg and Klapper (1967, fig. 3, p. B44–B61). Figure 1 expands their chart to present the known zones of the entire Rocky Mountains and Great Basin region and incorporates four major changes.

(1) On the basis of a recent reevaluation by Klapper and Sandberg (in Klapper and others, 1971; and in Beinert and others, 1971), the

(2) The Middle *Spathognathodus costatus* Zone has been recognized in Nevada by Sandberg (in Klapper and others, 1971) on the basis of the joint occurrence of *Pseudopolygnathus trigonicus, Polynathus vogesi, Spathognathodus disparilis*, and *S. costatus*. This fauna occurs in the middle unit of the Pilot Shale at Bactrian Mountain (Sandberg and Poole, 1970).

(3) The *Siphonodella praesulcata Fauna* is here named and defined to comprise the known range of *Siphonodella praesulcata* n. sp. below the first occurrence of *S. sulcata* – i. e., from near the base of the Middle *Spathognathodus costatus* Zone to the top of

the Devonian. (The term Fauna, as used here and by several other conodont workers, denotes a newly recognized concurrent-range assemblage, of which the geographic distribution or relation to adjacent zones is insufficiently known to warrant formal zonal designation.) The *Siphonodella praesulcata* Fauna is apparently restricted to a clastic regressive-marine lithofacies that generally lacks many of the normal marine species of the standard conodont zonation. It is present in the Sappington Member of the Three Forks Formation in Montana and in the Leatham Formation in Utah.

A spore assemblage containing abundant *Hymenozonotriletes lepidophytus* is present in the Sappington Member and is apparently bracketed by condont collections assigned to the *Siphonodella praesulcata* Fauna. The spore assemblage is correlatable with the PLs 2—3 spore assemblage of Streel (in Paproth and Streel, 1971), which occurs within the range of the *Protognathodus* Fauna in Germany.

(4) The Upper *Siphonodella crenulata* Zone has been recognized in the lower part of the Milligen Formation in Idaho, west of the area shown on Figure 2. The fauna includes the zonal name-bearer in addition to the species previously reported by Sandberg (in Macqueen and Sandberg, 1970, p. 51).

Upper Mississippi Valley

The conodont zonation for the Upper Mississippi Valley is basically that of Collinson, Scott, and Rexroad (1962) with five modifications that result from more recent studies.

(1) The *Spathognathodus aculeatus* Zone, which occurs in the middle part of the Saverton Shale, contains a fauna that includes as its important unreworked constituents: *S. aculeatus, S. fissilis* (a species very close to *S. supremus*), and *S. disparilis*. On the basis of comparisons with faunas of the *S. costatus* Zone in the western United States, the fauna of the middle Saverton can be no older than Middle *S. costatus* Zone. In the absence of more diagnostic species, we date this fauna as equivalent to Middle to Upper *S. costatus* Zone.

The dating based on spores is in close agreement with that provided by the conodonts. The *Hymenozonotriletes lepidophytus* spore assemblage that occurs with our best conodont collection is correlatable with the PLi spore assemblage of Streel (in Paproth and Streel, 1971). *Spathognathodus costatus ultimus* has been found within the range of the PLi spore assemblage at the Chanxhe section (loc. 26) in Belgium (Bouckaert, Streel, and Thorez, 1971).

(2) The conodont fauna of the uppermost part of the Saverton Shale and of the Louisiana Limestone was renamed the *Protognathodus* Fauna by Ziegler (1969), who compared it to an identical fauna between the Upper *Spathognathodus costatus* and *Siphonodella sulcata-Protognathodus kockeli* Zones in Germany. The conodonts that have their lowest occurrence in the *Protognathodus* Fauna are *P. kockeli, Spathognathodus anteposicornis,* and *S. culminidirectus* (including *S. collinsoni*). *Protognathodus meischneri* and *P. collinsoni*, which also occur in this fauna, have their lowest occurrence at the Lower/Middle *S. costatus* Zone boundary in Utah.

(3) The *Protognathodus kuehni - P. kockeli* Zone (*Gnathodus* n. sp. B - *G. kockeli* Zone of Collinson and others, 1962) is herein included in the basal part of the *Siphonodella sulcata* Zone. The fauna, which occurs in the "Glen Park" Formation of Collinson ("Hamburg oolite" of Koenig and Martin) and in the lowest beds of the Hannibal Shale contains the lowest joint occurrence of *Pseudopolygnathus dentilineatus, Protognathodus kuehni,* and *Siphonodella sulcata*. Other important species are *S. praesulcata* n. sp., *Protognathodus kockeli, P. meischneri, P. collinsoni,* and *Spathognathodus anteposicornis*. Our recommended change makes the base of the *S. sulcata* Zone in the Upper Mississippi Valley coincident with that in Wyoming; only *Patrognathus variabilis* is as yet unreported from the Upper Mississippi Valley.

(4) The name of the *Siphonodella quadruplicata-S. crenulata* Zone (Collinson and others, 1962) was changed to *S. quadruplicata* Zone by Rexroad (1969, p. 9). *S. crenulata* is rare in the Upper Mississippi Valley, and forms previously assigned to that species were misidentified.

(5) The name of the *Siphonodella* n. sp. A - *S. cooperi* Zone (Collinson and others, 1962) was changed to *S. isosticha-S. cooperi* Zone by Rexroad and Scott (1964).

Germany

The zonation given in the chart (fig. 1) is based on the work of Voges (1959) and Ziegler (1962, 1969). The *Ghathodus kockeli-Pseudopolygnathus dentilineatus* Zone of Voges was changed to *Siphonodella sulcata-Protognathodus kockeli* Zone by Ziegler (1969), who reported *S. sulcata* in the basal part of this zone at Hönnetal. The presence of *S. sulcata* in the upper part of Voges' zone previously had been reported by Sandberg and Klapper (1967, p. B46).

We recommend that the *Siphonodella sulcata-Protognathodus kockeli* Zone of Ziegler (1969) be amended to *S. sulcata* Zone. Continued use of *P. kockeli* in the zonal name is misleading as *P. kockeli* is also a key species of the underlying *Protognathodus* Fauna in Germany and in the Upper Mississippi Valley. Standardization of the name, *S. sulcata* Zone, permits its worldwide usage with identical faunal connotation as the basal conodont zone of the Carboniferous.

Biostratigraphy

Montana

In Montana, the Devonian-Carboniferous boundary lies within the upper part of the Sappington Member of the Three Forks Formation. The biostratigraphy of the Sappington and its relations to adjacent units will be summarized here, so that the relative positions of conodont and spore collections may be discussed and evaluated. (For more detailed biostratigraphic discussions, see Gutschick and others, 1962; Sandberg, 1965; Sandberg and Klapper, 1967; and Macqueen and Sandberg, 1970.)

The Sappington Member is a thin lensatic body of clastic rocks that is bounded by unconformities, as shown in the diagrammatic cross section (fig. 2). It is underlain by Upper Devonian (Famennian) rocks and overlain by Lower Carboniferous (Kinderhook) rocks.

On the east, the Sappington unconformably overlies the Trident Member of the Three Forks Formation. Conodont collections from the highest limestone of the Trident at localities 5, 7, and 12 (Sandberg and Klapper, 1967, p. B44, B49) are now assigned to the *Scaphignathus subserratus-Pelekysgnathus inclinatus* Fauna (Upper Famennian) by Sandberg and Klapper (in Klapper and others, 1971). To the west (and in areas of local uplift not shown on Figure 2), the Sappington truncates the Trident and rests on the underlying nonfossiliferous, evaporitic Logan Gulch Member of the Three Forks. Farther west, in east-central Idaho (fig. 2), the Sappington rests on the Birdbear Member of the Jefferson Formation, which contains a conodont fauna of the Lower *Palmatolepis quadrantinodosa* Zone (Lower Famennian).

Throughout Montana, the Sappington Member is unconformably overlain by the Lodgepole Limestone, which contains an ubiquitous conodont fauna of the Lower *Siphonodella crenulata* Zone (Sandberg and Klapper, 1967). At about the Montana-Idaho State line (fig. 2), the Lodgepole grades by intertonguing of limestone with argillite into the Milligen Formation, which contains the same conodont fauna at its base (Sandberg and others, 1967).

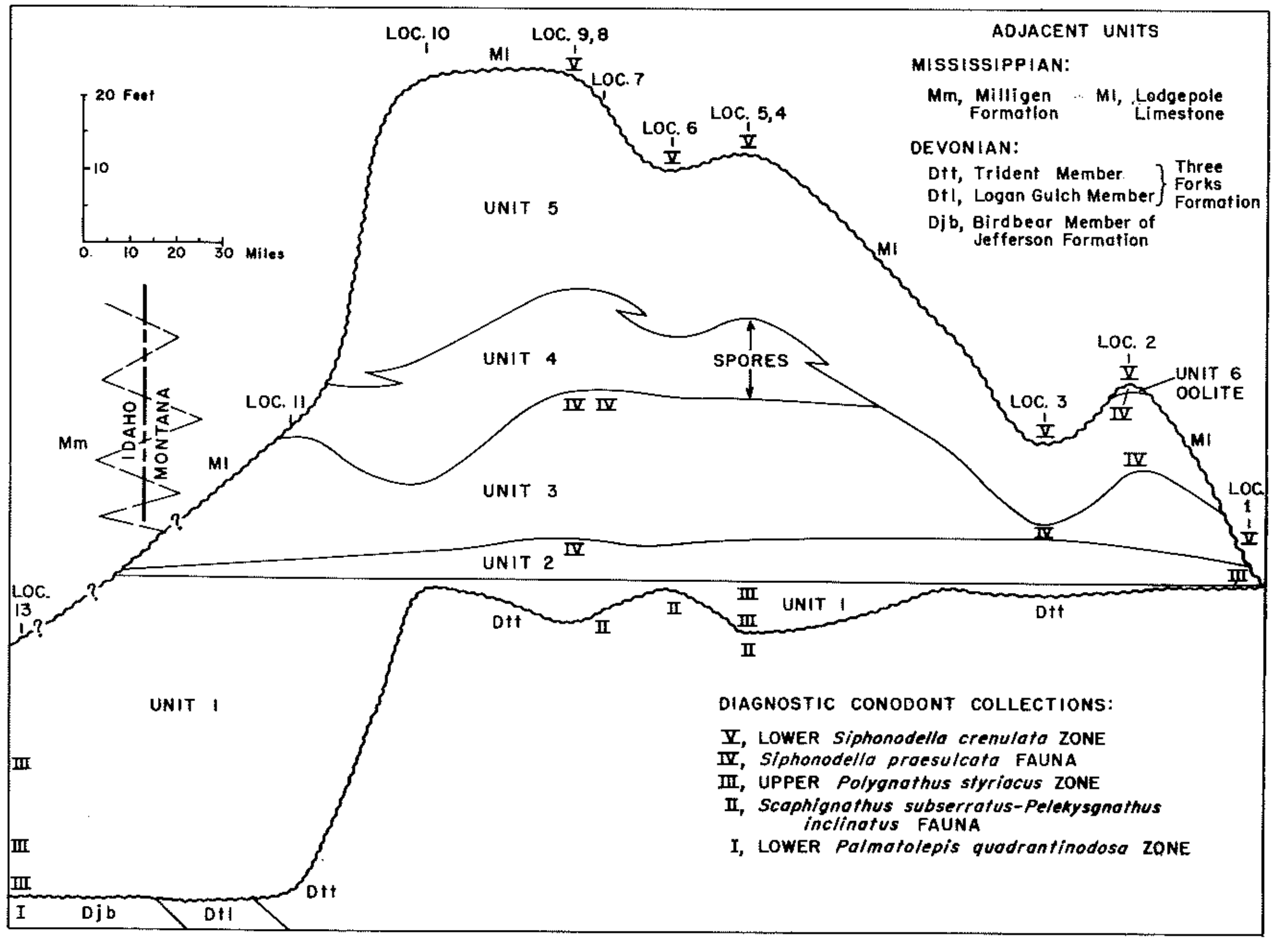

Figure 2. Cross section of Sappington Member from Beaverhead Mountains, Idaho (loc. 13), to Little Belt Mountains, Montana (loc. 1), showing position of conodont and spore collections. Localities are named and described in Locality Register.

The Sappington Member is divided into six units, numbered from the base upward. The lower five units. recognized by Sandberg (1962, 1965) are widespread lithogenetic units. Unit 6, which is herein designated, is at present recognized only at one section (loc. 2; see Locality Register for name and detailed location of this and other sections; also see location on index map, fig. 3), where it was preserved from pre-Lodgepole erosion.

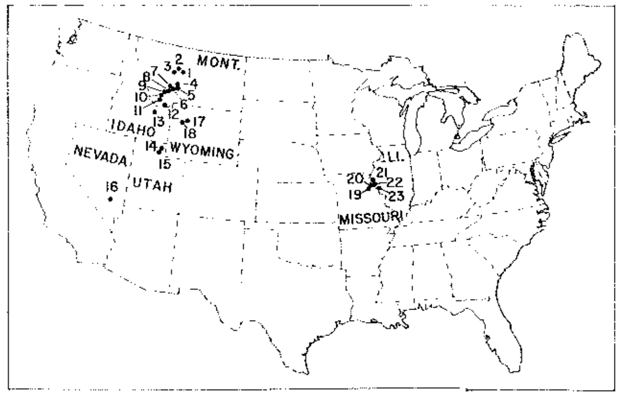

Figure 3. Index map of United States showing localities 1–23. See Locality Register for names and detailed locations.

In ascending order, the six lithogenetic units of the Sappington are: (1) An eastward-transgressive marine black carbonaceous shale that filled irregularities in the underlying erosion surface; (2) an alga-sponge-brachiopod biostromal nodular silty limestone or nodular calcareous siltstone that was deposited on a mud flat or shallow bank; (3) a lower siltstone that contains interbeds of argillaceous siltstone, shale, and some brachiopod-rich silty limestone and represents shallow-water deposition under conditions of fluctuating sea level; (4) a medial slightly calcareous shale that generally is devoid of brachiopods and other normal-marine fossils because of brackish-water deposition but contains abundant silt-filled animal burrows and some marine siltstone channel fills; (5) a westward-regressive marine calcareous siltstone containing scattered brachiopods and some channels filled by clam-echinoderm calcarenite; and (6) a thin brachiopod-bearing silty oolite. Gutschick, Suttner, and Switek (1962) recognized four widespread subdivisions of the basal black shale (unit 1), which they designated by the letters A to D in ascending order; their higher units E, F, G, and H correspond exactly to units 2. 3, 4, and 5, respectively.

The basal black shale (unit 1) is a complex of interesting and unusual lithofacies. It was unquestionably deposited in a shallow marginal-marine environment, which received occasional influxes of brackish or fresh water, as evidenced by the presence of logs of silicified wood. The unit contains transgressive lag deposits generally at its base, commonly near its top (beneath subunit C of Gutschick and others, 1962), and less commonly as lenses within the black shale. These lag deposits are generally 1/2- to 4-inch-thick beds of limonitic phosphatic sandstone, siltstone, or shale that contain abundant coprolites, phosphatic pellets and nodules, conodonts, and fish remains. Most of the conodonts are indigenous to the lag deposits and their concentration is explainable by current winnowing; a small percentage of the conodonts is obviously reworked from older faunas. Within the black shale occur thin interbeds of chertified siltstone and spicular or radiolarian chert and less common calcareous siltstone and limestone concretions. Subunit C, only a few inches thick, is a widespread zone of conchostracan-rich shale, currently being studied by Gutschick and Sandberg (1970), which locally contains abundant impressions of soft-bodied organisms such as starfish.

The age of the base of the Sappington Member is fixed by the lag deposits in unit 1, which at many sections, including localities 1 and 4 (fig. 2), yield conodont faunas that have been assigned to the Upper *Polygnathus styriacus* Zone by Sandberg and Klapper (1967, p. B45). These faunas contain four significant taxa: *Palmatolepis rugosa postera, P. gracilis sigmoidalis, Spathognathodus jugosus,* and *Pseudopolygnathus marburgensis.* Recent studies in the Rocky Mountain region indicate that the same taxa also occur in the lower part of the overlying *Spathognathodus costatus* Zone but that these higher occurrences are with *S. aculeatus.* Faunas from concretions in unit 1 at locality 13 (fig. 2) are dominated by *Palmatolepis gracilis sigmoidalis,* but also contain *P. rugosa postera, Pseudopolygnathus brevipennatus,* and *Spathognathodus jugosus.* The assignment of unit 1 faunas to the Upper *Polygnathus styriacus* Zone is at present accepted with reservations in the absence of *P. styriacus;* future investigation may disclose that these faunas are very slightly younger and assignable to the lowermost part of the Lower *S. costatus* Zone.

Unit 2 of the Sappington Member contains oncolites formed by spongiostromatid algae, sponges (Gutschick and Perry, 1959), arenaceous Foraminifera (Gutschick, 1962), and an extensive brachiopod fauna including *Syringothyris hannibalensis, Spirifer* sp., *Rhipidomella missouriensis, Rhytiophora? arcuatus, Tylothyris clarksvillensis,* and *Beecheria paraplicata* (Rodriguez and Gutschick, 1967). Many elements of this fauna occur also in unit 3, and fewer elements are found in a blastoid-bearing channel fill within unit 4 (Sprinkle and Gutschick, 1967). The scattered brachiopods in unit 5 are chiefly (*Syringothyris, Schellwienella, Spirifer,* and "*Camarotoechia*".

Unit 4 is not as widespread as units 2, 3, and 5 of the Sappington Member. It forms a lensatic body that grades into the overlying unit 5 by the intertonguing of shale with siltstone. The abundant ichnofossils found in both units 4 and 5 were described by Rodriguez and Gutschick (1971).

Sample number Feet above base of unit 4	SP–19A 0–3	SP–18B 3–6	SP–18A 6–9	SP–17D 9–9½	SP–17C 9½–10	SP–17B 10–10½	SP–17A 10½–11
SPORES							
Acanthotriletes famenensis Naumova	–	–	–	x	–	x	–
Baculatisporites fusticulus Sullivan	–	–	–	x	–	–	–
Cristatisporites echinatus Playford	–	–	–	x	x	–	x
Dictyotriletes trivialis (Naumova, in litt.) Kedo	–	–	–	x	–	x	–
Emphanisporites rotatus McGregor	–	–	–	–	–	–	x
Geminospora cf. *svalbardiae* (Vigran) Allen	–	–	x	–	–	–	–
Grandispora echinata Hacquebard	x	x	x	x	x	x	x
Hymenozonotriletes famenensis Kedo	–	–	x	–	–	x	–
Hymenozonotriletes lepidophytus Kedo	x	x	x	x	x	–	–
Knoxisporites cf. *pristinus* Sullivan	x	x	x	x	–	–	–
Lophozonotriletes cf. *malevkensis* Kedo	–	–	x	–	–	–	–
Lophozonotriletes cristifer (Luber) Kedo	–	–	–	x	x	–	–
Lophozonotriletes rarituberculatus Kedo	x	x	–	x	–	–	–
Perotrilites cf. *perinatus* Hughes and Playford	x	x	x	x	–	–	–
Pustulatisporites gibberosus (Hacquebard) Playford	–	–	–	x	–	–	–
Retusotriletes incohatus Sullivan	x	x	x	x	x	x	x
Retusotriletes punctatus Chibrikova	x	x	x	x	x	x	x
Spinozonotriletes conspicuus Playford	–	x	–	–	x	–	–
Spinozonotriletes cf. *tenuispinus* Hacquebard	x	x	x	–	–	–	–
Spinozonotriletes cf. *uncatus* Hacquebard	–	–	–	x	–	x	–
Tumulispora ordinaria Staplin and Jansonius	–	–	–	x	–	–	–
Vallatisporites pusillites Dolby and Neves	x	x	x	x	x	x	x
Vallatisporites vallatus Hacquebard	–	–	–	x	x	–	–
Vallatisporites verrucosus Hacquebard	x	x	x	x	x	–	–
Ancyrospora	–	–	–	x	–	–	–
Archaeoperisaccus	–	–	–	x	–	x	–
Cymbosporites	–	–	x	–	–	x	–
Convolutispora	x	x	–	x	–	x	–
Corbulispora	–	–	–	–	–	x	x
Dibolisporites	x	–	x	–	–	–	–
Hystricosporites	–	–	–	x	–	–	–
cf. *Leiozonotriletes*	x	–	–	x	–	–	–
ACRITARCHS							
Gorgonisphaeridium	x	x	x	x	x	x	x
Baltisphaeridium	x	x	x	–	–	x	x
Veryhachium	x	x	x	–	–	x	x

Figure 4. Distribution of palynomorphs in unit 4 of Sappington Member of Three Forks Formation at Peak 9559, Bridger Range, Montana.

A spore assemblage with *Hymenozonotriletes lepidophytus* occurs throughout the 11-foot-thick unit 4 at Peak 9559, Bridger Range, Montana (fig. 2, loc. 5). Figure 4 lists the spores and acritarchs recorded in 7 samples from unit 4 there. A comprehensive search of unit 4 at other localities has failed to produce any similarly well-preserved spore assemblage.

The *Hymenozonotriletes lepidophytus* spore assemblage at Peak 9559 is correlated with the PLs 2–3 spore assemblage of Streel (in Paproth and Streel, 1971). More precisely it is comparable to the spore assemblage in the part of the Hangenberg Shale that contains conodonts assigned to the *Protognathodus* Fauna by Ziegler (1969)) at Oberrödinghausen (loc. 24) and Stockum (loc. 25), West Germany. It is important to note, however, that the *H. lepidophytus* assemblage at Stockum also occurs a few meters above and below the *Protognathodus* Fauna in shaly facies devoid of any faunal age control. The Peak 9559 assemblage contains *Baculatisporites fusticulus, Cristatisporites echinatus, Grandispora echinata,* and *Lophozonotriletes rarituberculatus,* which characterize the PLs assemblage zone in the Ardenno-Rhine region, and *Dictyotriletes trivialis,* which occurs only in the upper part of this zone (PLs 3 at Stockum (loc. 25). At Peak 9559, as at Stockum, *H. lepidophytus* is represented by a large majority of small specimens (pl. 3, figs. 1–8) in the 25–55 micron size range, where atypical forms (var. *tener* Kedo?) are dominant. The Peak 9559 assemblage also contains a new species of *Archaeoperisaccus,* a genus regarded by McGregor (1969) as not ranging above the Frasnian. This species (pl. 4, fig. 12) has a sac-like outer wall, which does not extend far from the central body and bears an apiculate ornamentation, as yet undescribed in this genus. In a later systematic study, we will try to determine whether the range of *Archaeoperisaccus* should be expanded upward, as our current stratigraphic evidence suggests, or whether the new species might have been reworked from Frasnian rocks.

The conodont collections from units 2, 3, and 5, which are impoverished faunas dominated by *Siphonodella praesulcata* n. sp., are herein assigned to the *Siphonodella praesulcata* Fauna. This fauna has been found near the top of unit 2 at localities 8, 9, and 12, near the top of unit 3 at localities 3, 7, and 8, and at the base of unit 5 at locality 2. Conodonts have not as yet been found anywhere in unit 4. The apparently highest occurrence of the *Siphonodella praesulcata* Fauna is in a 2-foot-thick silty oolite, designated unit 6, at Lick Creek Road (loc. 2). Dominated by *S. praesulcata*, the fauna at locality 2 includes *Spathognathodus aculeatus, S. costatus costatus, S. anteposicornis, S. culminidirectus, S. stabilis, S. inornatus, Polygnathus communis, Palmatolepis gracilis sigmoidalis*, and *P. rugosa postera*. This association appears to indicate a position high in the *Spathognathodus costatus* Zone or low in the *Protognathodus* Fauna of Ziegler (1969).

The occurrences of the *Siphonodella praesulcata* Fauna in units 5 and 6 at locality 2 would appear to be stratigraphically higher than the spore assemblage in unit 4 at locality 5. (See fig. 2.) However, because of the absence of unit 4 at locality 2 and the known facies relation between the basal part of unit 5 and the upper part of unit 4, the occurrence of the *Siphonodella praesulcata* Fauna at the base of unit 5 at locality 2 might be the same age as the spore assemblage. Moreover, it is not certain whether unit 6 would lie above or within unit 5 at other localities, because of the thinness of unit 5 and the unconformity above unit 6 at locality 2. Consequently, even this highest occurrence of the *Siphonodella praesulcata* Fauna might not be significantly younger than the spore assemblage. Despite the inexactness of equal time planes in the upper part of the Sappington Member, it seems reasonable to assume that the *Hymenozonotriletes lepidophytus* spore assemblage at Peak 9559 lies well within the upper part of the range of occurrences of the *Siphonodella praesulcata* Fauna.

Utah

The Leatham Formation of northern Utah is lithologically, faunally, and sequentially almost identical to the Sappington Member of the Three Forks Formation. At its type locality in Leatham Hollow (loc. 14), the 94-foot-thick Leatham was divided by Sandberg and Gutschick (1969) into seven units; these are in ascending order: (1) Lag sandstone and siltstone, ½ foot; (2) silty limestone, 2½ feet; (3) cherty carbonaceous shale, mudstone, and siltstone, 32 feet; (4) bioclastic limestone, 2 feet; (5) alga-sponge-brachiopod biostromal nodular argillaceous limestone, 11 feet; (6) siltstone, 21 feet; and (7) carbonaceous shale, 25 feet. Units 1, 2, and 3 of the Leatham correspond to unit 1 of the Sappington; units 4 and 5 of the Leatham correspond to unit 2 of the Sappington; and unit 6 of the Leatham corresponds to unit 3 of the Sappington. Unit 7 of the Leatham differs lithologically, however, from either unit 4 or 5 of the Sappington. The Leatham unconformably overlies the "contact ledge limestone" of the Beirdneau Formation, which is the same age as the Trident Member of the Three Forks, and is unconformably overlain by the Lodgepole Limestone, the base of which is the same age – Lower *Siphonodella crenulata* Zone – as the base of the Lodgepole in Montana. Units 1 and 2 of the Leatham contain a conodont fauna assignable to the Upper *Polygnathus styriacus* Zone.

Clydagnathus? *ormistoni*, which may have a limited range, was found in unit 2 of the Leatham at locality 14 by Sandberg (in Beinert and others, 1971). Units 5 and 6 of the Leatham contain brachiopod faunas nearly identical to those in units 2 and 3 of the Sappington.

At and near the type section, unit 4 of the Leatham contains an unusually diversified, well-preserved conodont fauna that represents a position at or just above the boundary of the Middle and Lower *Spathognathodus costatus* Zones. Included in this fauna are the following important taxa: *Palmatolepis rugosa postera, P. rugosa rugosa, P. gracilis sigmoidalis, P. gracilis gracilis, P. gonioclymeniae, Spathognathodus costatus costatus, S. costatus spinulicostatus, S. aculeatus, S. disparilis, S. fissilis, S. inornatus, S. stabilis* transitional to *Protognathodus meischneri, P. meischneri, P. collinsoni, Polygnathus perplexus*, and *P. delicatulus* (for which *P. stadleri* Ziegler & Leuteritz, named in Koch and others, 1970, is a junior synonym).

The age of the base of the *Siphonodella praesulcata* Fauna is firmly established by its occurrence in unit 5 of the Leatham Formation at Porcupine Dam (loc. 15). There units 4 and 5 of the Leatham form a single ledge of continuously deposited alga-brachiopod biostromal nodular limestone, only 2 feet thick. The bottom 3 inches of this ledge contains the conodont fauna of the Middle/Lower *Spathognathodus costatus* Zone boundary, and the top 21 inches contains the *Siphonodella praesulcata* Fauna, which is there dominated by *S. praesulcata* n. sp. but also contains many specimens of *Palmatolepis gracilis sigmoidalis* and *Spathognathodus culminidirectus*, and some *Protognathodus meischneri* and *Polygnathus delicatulus*. Thus the oldest known occurrence of the *Siphonodella praesulcata* Fauna is low in the Middle *Spathognathodus costatus* Zone.

Nevada

In eastern Nevada and western Utah, the lithologic and faunal equivalent of the Leatham Formation and of the Sappington Member of the Three Forks Formation is the middle unit of the Pilot Shale (Sandberg and Poole, 1970). The middle unit commonly comprises, in ascending order: (1) A basal black carbonaceous cherty shale containing lag sandstone and, near the top, a conchostracan-bearing shale; (2) an alga-sponge-brachiopod biostromal nodular limestone, which thins and disappears westward; and (3) an upper siltstone containing a brachiopod fauna dominated by *Syringothyris*. At Bactrian Mountain (loc. 16), the lag sandstone just below the conchostracan-bearing shale contains a conodont fauna assigned to the Middle *Spathognathodus costatus* Zone. This fauna, which is younger than that in unit 4 of the Leatham, includes *Pseudopolygnathus trigonicus* and *Polygnathus vogesi*, in addition to taxa such as *Spathognathodus costatus costatus, S. aculeatus, S. disparilis, S. fissilis, Protognathodus meischneri*, and *Palmatolepis gracilis sigmoidalis*, which also occur in the Leatham.

Wyoming

Eastward and cratonward from the Sappington-Leatham-middle Pilot complex, which occurs both on the craton and in the miogeosyncline, the Devonian-Carboniferous boundary lies within the Cottonwood Canyon Member of the Madison Limestone in Wyoming. The complicated biostratigraphy of this member, which comprises two tongues and several lithofacies within each tongue, was discussed in detail by Sandberg and Klapper (1967).

The lower tongue of the Cottonwood Canyon Member contains conodont faunas of the Lower *Spathognathodus costatus* Zone, which were illustrated by Klapper (1966) and listed by Sandberg and Klapper (1967, p. B51). Some of the important zonal constituents are: *Spathognathodus costatus costatus, S. aculeatus, S. jugosus, Palmatolepis gracilis gracilis, P. gracilis sigmoidalis, P. rugosa postera, Icriodus costatus, Polygnathus delicatulus, P. symmetricus, P. obliquicostatus*, and *Pseudopolygnathus marburgensis*.

The upper tongue of the Cottonwood Canyon Member contains, in ascending order, the *Siphonodella sulcata, S. sandbergi-S. duplicata*, and Lower *S. crenulata* Zones. The faunas of these zones are listed by Sandberg and Klapper (1967, p. B51–B57). Conodont collections that have an important bearing on the placement of the Devonian-Carboniferous boundary and on the conodont zonation of the Lower Carboniferous are those from the *S. sulcata* Zone at Windy Gap (loc. 17) and from the lower part of the *S. sandbergi-S. duplicata* Zone at Warm Spring Canyon (loc. 18) and Horse Creek (Sandberg and Klapper, 1967, p. B52).

The fauna of the basal Carboniferous *Siphonodella sulcata* Zone at Windy Gap (loc. 17) includes these four species, which do not occur in any Devonian faunas from the *Spathognathodus costatus* Zone nor in the *Siphonodella praesulcata* Fauna in the Rocky Mountains and Great Basin: *Siphonodella sulcata, Patrognathus variabilis, Pseudopolygnathus dentilineatus*, and *Protognathodus kuehni*. Also present in the fauna are new, undescribed species of *Pseudopolygnathus* and *Protognathodus* and a variety of forms transitional between *Spathognathodus aculeatus* and *Pseudopolygnathus dentilineatus*.

Siphonodella sulcata ranges upward only into the lower part of the overlying *S. sandbergi-S. duplicata* Zone (fig. 1) at Horse Creek and at Warm Spring Canyon (loc. 18). Its occurrence in that zone is with *S. duplicata* and forms transitional between *S. duplicata* and *S. cooperi. S. sulcata* has not been found with true *S. cooperi* and *S. sandbergi* in the upper part of the zone. Hence the range of *S. sulcata* in the western United States appears to be limited to the lowest part of the Lower Carboniferous (Mississippian).

Upper Mississippi Valley

The formations that straddle the Devonian-Carboniferous boundary in the Upper Mississippi Valley of Missouri and Illinois are, in ascending order, the Saverton Shale, Louisiana Limestone, "Glen Park" Formation of Collinson (in Missouri, also called "Hamburg oolite" by Koenig and Martin, 1961), and Hannibal Shale. The biostratigraphy, correlation, and stratigraphic and nomenclatoral problems of these units were summarized by Collinson (1961b). Columnar measured sections were illustrated by Collinson (1961a) and by Koenig and Martin (1961). The conodont zonation of the sequence was discussed and charted by Collinson, Scott, and Rexroad (1962), and the conodont fauna of the Louisiana Limestone was illustrated by Scott and Collinson (1961) and Scott (1961). The brachiopod fauna of the Louisiana, including key species such as *Syringothyris hannibalensis* and *Rhipidomella missouriensis*, which also occur in the western United States, was described by Williams (1943).

The Saverton Shale contains mostly reworked conodonts ranging in age from Middle Devonian (*Icriodus latericrescens* group) to very late Devonian (*Scaphignathus subserratus* and *Spathognathodus jugosus*). The age of the lower part of the Saverton in terms of the standard German conodont zonation is not known. The lower part may represent the Lower *Spathognathodus costatus* Zone or the Upper *Polygnathus styriacus* Zone, if *S. jugosus* is indigenous there and not reworked as in higher beds of the Saverton.

A large collection of both conodonts and spores was recovered from the same sample in the middle part of the Saverton Shale, 15 feet below the top, at Atlas South (loc. 22). The indigenous conodont fauna most probably includes these taxa: *Spathognathodus aculeatus, S. fissilis, S. disparilis, S. inornatus, S. strigosus, S. stabilis, Palmatolepis gracilis sigmoidalis, Icriodus costatus*, and *Polygnathus delicatulus*. Comparison with *S. costatus* Zone faunas in the western United States indicates that the fauna of the middle part of the Saverton, which was placed in the *S. acu-*

the *Siphonodella praesulcata* Fauna. This fauna has been found near the top of unit 2 at localities 8, 9, and 12, near the top of unit 3 at localities 3, 7, and 8, and at the base of unit 5 at locality 2. Conodonts have not as yet been found anywhere in unit 4. The apparently highest occurrence of the *Siphonodella praesulcata* Fauna is in a 2-foot-thick silty oolite, designated unit 6, at Lick Creek Road (loc. 2). Dominated by *S. praesulcata*, the fauna at locality 2 includes *Spathognathodus aculeatus, S. costatus costatus, S. anteposicornis, S. culminidirectus, S. stabilis, S. inornatus, Polygnathus communis, Palmatolepis gracilis sigmoidalis,* and *P. rugosa postera*. This association appears to indicate a position high in the *Spathognathodus costatus* Zone or low in the *Protognathodus* Fauna of Ziegler (1969).

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A large collection of both conodonts and spores was recovered from the same sample in the middle part of the Saverton Shale, 15 feet below the top, at Atlas South (loc. 22). The indigenous conodont fauna most probably includes these taxa: *Spathognathodus aculeatus, S. fissilis, S. disparilis, S. inornatus, S. strigosus, S. stabilis, Palmatolepis gracilis sigmoidalis, Icriodus costatus,* and *Polygnathus delicatulus*. Comparison with *S. costatus* Zone faunas in the western United States indicates that the fauna of the middle part of the Saverton, which was placed in the *S. acu-*

leatus Zone by COLLINSON, SCOTT, and REXROAD (1962), can be no older than Middle *S. costatus* Zone. It is given a position equivalent to the Middle or Upper *S. costatus* Zone (fig. 1) in the absence of diagnostic species that would permit correlation with one or the other of these zones.

The Atlas South spore assemblage is assigned to the PLi assemblage zone of STREEL (in PAPROTH and STREEL, 1971), which indicates a closely similar very late Devonian age to that provided by the conodonts. The spore assemblage includes: *Hymenozonotriletes lepidophytus, H. famenensis, Acanthotriletes famenensis, Ancyrospora langii, Apiculiretusispora plicata, Archaeozonotriletes famenensis, Emphanisporites* cf. *robustus, Endosporites crassaspinosus, Hystricosporites multifurcatus, Perotriletes,* cf. *perinatus, Raistrickia ampullacea, R. macrura, Retusotriletes incohatus, R. punctatus, R. verrucosus, Spinozonotriletes conspicuus, S.* cf. *uncatus, S.* cf. *tenuispinus,* and the *Vallatisporites pusillites-verrucosus* complex. The five species of spores that characterize the latest Devonian PLs 2–3 assemblage zone in the Sappington Member are not present in the Saverton Shale assemblage.

The size range of *Hymenozonotriletes lepidophytus* at Atlas South corresponds to the large forms that occur near the base of the *H. lepidophytus* biozone in Belgium. These large forms are present at Chanxhe (loc. 26) in the part of the section that contains the conodont *Spathognathodus costatus ultimus* (BOUCKAERT, STREEL, and THOREZ, 1971). This conodont occurs in the Middle and Upper *S. costatus* Zones in Germany.

Acritarchs are also abundant in the Saverton Shale at Atlas South. They include *Gorgonisphaeridium winslowii,* which has a range similar to that of *H. lepidophytus* in many parts of the world.

The conodont fauna of the uppermost part of the Saverton Shale at some localities is more similar to that of the overlying Louisiana Limestone than to that of the middle part of the Saverton (COLLINSON and others, 1962). A facies relationship between the Saverton and Louisiana was suggested by COLLINSON (1961b, fig. 3, p. 104), who noted that they have a reciprocal thickness — i. e., the Louisiana thickens as the Saverton thins, but their total thickness remains relatively constant. Our work supports this observation, but we further suggest that the highest beds of the Saverton are in fact sedimentologically related to the Louisiana. A possible gap is shown between the *Spathognathodus aculeatus* Zone and the *Protognathodus* Fauna on Figure 1, implying that all or part of the Upper *S. costatus* Zone may be missing. We have noted a phosphatic lag sandstone that suggests a physical break in the Saverton, 4 inches below the base of the Louisiana at Hamburg South (loc. 23). This lag bed contains abundant fish remains, many reworked Middle and Late Devonian conodonts, most of the conodont species that are normally present in the middle part of the Saverton, and *Spathognathodus anteposicornis* and *S. culminidirectus,* which generally occur in the Louisiana.

The conodont fauna of the uppermost part of the Saverton Shale and of the Louisiana Limestone was named the *Protognathodus* Fauna by ZIEGLER (1969), who compared it to an identical fauna that occurs between the Upper *Spathognathodus costatus* and *Siphonodella sulcata-Protognathodus kockeli* Zones in Germany. The indigenous fauna of the Louisiana includes the following species: *Protognathodus kockeli, P. collinsoni, P. meischneri, Spathognathodus culminidirectus* (including *S. collinsoni* as juveniles), *S. anteposicornis, S. fissilis, S.* cf. *inornatus, Polygnathus communis,* and *P. delicatulus.*

Protognathodus kockeli is more abundant throughout the Louisiana Limestone than was suggested by COLLINSON, SCOTT, and REXROAD (1962, p. 10). In fact, in the basal 4 inches of the formation at Hamburg South (loc. 23) *P. kockeli* is the most abundant *Protognathodus.* ZIEGLER (1969, p. 349) documented the scarcity of *P. kockeli* relative to *P. meischneri* within the *Protognathodus* Fauna in Germany, but a similar scarcity is not apparent in the *Protognathodus* Fauna of the Upper Mississippi Valley.

A locally sharp disconformity between the Louisiana Limestone or Saverton Shale and the "Glen Park" Formation of COLLINSON marks the Devonian-Carboniferous boundary in parts of the Upper Mississippi Valley. Elsewhere the physical disconformity is between the Hannibal Shale and the Louisiana, suggesting that the "Glen Park" may be a facies of the basal Hannibal. At Jimtown Branch (loc. 21), the "Glen Park" rests with apparent angular unconformity on the Saverton and contains conglomerate, the pebbles of which were apparently derived from the Louisiana Limestone. At that locality, a regolithic sandstone is developed on top of the Saverton and is in turn truncated by the "Glen Park". This sandstone contains the lowest noted occurrence of *Siphonodella praesulcata* in the Upper Mississippi Valley as well as a variety of *Spathognathodus disparilis* that is more advanced than any in the Saverton and actually closer to *Pseudopolygnathus* than to *Spathognathodus.* Both the *S. praesulcata* and the advanced *disparilis* must have been derived from beds in Louisiana or uppermost Saverton that have been removed by erosion. Thus, there may be a slight faunal hiatus at the Devonian-Carboniferous boundary in the Upper Mississippi Valley with part of the *Protognathodus* Fauna missing. ZIEGLER (1969) noted but did not illustrate several juvenile examples of *Pseudopolygnathus dentilineatus* from the *Protognathodus* Fauna in Germany. The absence of *P. dentilineatus* in the *Protognathodus* Fauna of the Upper Mississippi Valley would tend to support a faunal hiatus.

The lowest occurrence of the basal Lower Carboniferous (basal Mississippian) *Siphonodella sulcata* Zone was noted in the "Glen Park" Formation of COLLINSON (1961b) at Stark's Roadcut (loc. 19) and in the basal beds of the Hannibal Shale at Champ Clark Highway Bridge (loc. 20) in Missouri. Both of these units previously were included in the *Protognathodus kuehni-P. kockeli* Zone (*Gnathodus* n. sp. B.-*G. kockeli* Zone of COLLINSON and others, 1962, p. 19). The presence of *S. sulcata* within that zone makes its continued use inadvisable, and so it is here included in the *S. sulcata* Zone. The conodont fauna of the "Glen Park" at locality 19 includes abundant *Siphonodella praesulcata* and scarce *S. sulcata,* both of which are illustrated on Plates 1 and 2, in association with *Polygnathus communis,* and obviously reworked, rounded specimens of Devonian *Palmatolepis, Spathognathodus,* and *Polygnathus.*

Conodont faunas in the basal 3 feet of the Hannibal Shale at locality 20 contain scarce *S. sulcata* and *S. praesulcata* in association with *Spathognathodus aculeatus, Pseudopolygnathus dentilineatus, Protognathodus kuehni, P. kockeli,* and *Polygnathus communis.* The *P. communis* in this fauna includes a variety bearing marginal nodes or weak transverse ridges similar to the variety that occurs in the *S. sulcata* Zone at Windy Gap (loc. 17) in Wyoming. The only important constituent of the Windy Gap fauna that has not yet been found, possibly because of insufficient sampling, in the basal Hannibal fauna is *Patrognathus variabilis.*

Europe

(Ardenno-Rhine region, British Isles, and Russian platform)

The base of the *Hymenozonotriletes lepidophytus* spore assemblage has to date (May 1971) been accurately located in terms of conodonts only in Belgium. The first occurrence of *H. lepidophytus,* at the base of Fa2d, should be within the Lower *Spathognathodus costatus* Zone.

An upward decrease in the size range of *Hymenozonotriletes lepidophytus* in the stratigraphic succession has been noted in Great Britain, Belgium, Germany, and White Russia. The significant change from populations with abundant large forms to populations with small and atypical forms corresponds more or less to the first occurrence of *Quasiendothyra kobeitusana,* a foram that approximately marks the base of Tn1a (uppermost Devonian) in the shelf facies. The lowest occurrence of the conodont *Pseudopolygnathus dentilineatus* is at the same stratigraphic level (base of Tn1a) at Royseux (loc. 27), Belgium, according to BOUCKAERT and ZIEGLER (1965). This first occurrence is somewhat lower than that in the United States, where *P. dentilineatus* appears at the base of the Mississippian (base of the Carboniferous, approximate base of Tn1b).

The base of the Carboniferous System in Belgium may be within or just above a 2- to 10-meters-thick limestone bed, which constitutes the lower part of the Hastière Limestone (Tn1b). An unquestionably Lower Carboniferous conodont fauna occurs slightly above this limestone bed in banc 111 of AUSTIN, CONIL, RHODES, and STREEL (1970, fig. 2, Huy 15) at Royseux (loc. 27). This fauna includes *Siphonodella cooperi* and *Patrognathus variabilis.* The photographed specimen of *P. variabilis* from Royseux (AUSTIN, CONIL, RHODES, and STREEL, 1970, pl. 1, fig. 7) was synonomized with *P. andersoni* by KLAPPER (1971, p. 8). Examination of the original specimen by SANDBERG, however, confirms that it is definitely *P. variabilis,* and not *P. andersoni.* Although the association of *P. andersoni* with *S. cooperi* is as yet unreported from Germany, it occurs with *S. sandbergi* in the upper part of the *S. sandbergi-S. duplicata* Zone (fig. 1) at Windy Gap (loc. 17), Wyoming.

The limestone bed in the lower part of the Hastière Limestone is not spore bearing, but its lower part has been correlated by PAPROTH and STREEL (1971) with the Hangenberg Shale in Germany. The Hangenberg Shale contains an abundant, but partly reworked, *Hymenozonotriletes lepidophytus* assemblage (PLs 2–3), which is equivalent to that in the Sappington Member at Peak 9559 (loc. 5) in Montana. The Hangenberg Shale also contains the *Protognathodus* Fauna, which marks the top of the Devonian on the basis of conodonts (fig. 1). Thus, if the correlation with Germany is correct, the Devonian-Carboniferous boundary should be in the upper part of or slightly above the limestone bed at Royseux, Belgium.

In the Tournai region (loc. 28), Belgium, a more littoral facies of the limestone bed in the lower part of the Hastière Limestone contains the same spore assemblage that has been recorded in Ireland and in Great Britain in the continental Old Red Sandstone (DOLBY, 1971; UTTING and NEVES, 1971). Thus this *Hymenozonotriletes lepidophytus* spore assemblage may be traced from bathyal facies in Germany, through littoral facies in Belgium, to continental facies in Ireland.

Post-*lepidophytus* assemblages occur both in Great Britain at Avon George (RHODES, AUSTIN, and DRUCE, 1969) and in Belgium at Feluy (loc. 29) and Ecaussines d'Enghien (loc. 30) in rocks containing *Patrognathus variabilis.* If *P. variabilis* marks the base of the Carboniferous in Europe as it does in the western United States, then the top of the *Hymenozonotriletes lepidophytus* assemblage zone must be very close to the Devonian-Carboniferous boundary.

Conclusions

1) A new conodont fauna, the *Siphonodella praesulcata* Fauna, is recognized in very high Devonian rocks in Montana and Utah. It is characterized by the presence of *S. praesulcata* n. sp., below the lowest occurrence of *S. sulcata.*

2) On the basis of conodonts, the highest part of the Devonian may be discerned by the presence of either the *Siphonodella praesulcata* Fauna, generally in silty lithofacies, or of the *Protognathodus* Fauna,

generally in calcareous or shaly lithofacies. The *Protognathodus* Fauna is characterized by the joint occurrence of *Protognathodus kockeli, Spathognathodus anteposicornis,* and *S. culminidirectus,* below the lowest occurrence of *Protognathodus kuehni. Protognathodus meischneri* and *P. collinsoni* are long-ranging forms that indicate only a proximity to the Devonian-Carboniferous boundary. They range from the Middle *Spathognathodus costatus* Zone into the *Siphonodella sulcata* Zone.

3) The two new *Hymenozonotriletes lepidophytus* spore assemblages illustrated herein are from very high Devonian beds. They can be correlated with Streel's PLi and PLs 2–3 spore assemblages in Europe. Their very late Devonian age, which is supported by conodont evidence, matches the age of similar *H. lepidophytus* assemblages throughout the world. We know of no North American assemblage of *H. lepidophytus* that has been positively dated as Lower Carboniferous (Mississippian) by means of other index fossils, such as conodonts or ammonoids.

4) On the basis of conodonts, the base of the Carboniferous is indicated on a worldwide basis by the presence of the *Siphonodella sulcata* Zone. This zone is characterized by the lowest joint occurrence of *S. sulcata, Patrognathus variabilis,* and *Protognathodus kuehni.* The criteria for distinguishing *S. sulcata* from *S. praesulcata n.* sp., which may occur with it, are given under Selected Systematics. *Pseudopolygnathus dentilineatus* first appears at the base of the Carboniferous in the United States. The same or a similar species first occurs in uppermost Devonian beds in Germany and Belgium.

Selected systematics

Only those species that are new or require redescription and are critical to the placement of the Devonian-Carboniferous boundary are discussed herein.

Conodonts

Genus *Siphonodella* Branson & Mehl 1944
Type species: *Siphonognathus duplicata* Branson & Mehl 1934 (p. 296–297, pl. 24, figs. 16–17)

Siphonodella praesulcata n. sp. Sandberg
Pl. 1, Figs. 1–17; Pl. 2, Figs. 10–19
1969 *Polygnathus* sp. B. Druce. – Druce, p. 108, pl. 26, figs. 5a–7c.

Holotype. – The specimen illustrated on Plate 1, Figures 1–4, is designated the holotype.

Derivatio nominis. – To indicate that this species precedes and is ancestral to *Siphonodella sulcata*.

Type locality. – Lick Creek Road, Little Belt Mountains, Montana (loc. 2).

Type stratum. – Top two feet (unit 6) of Sappington Member of Three Forks Formation.

Diagnosis. – A species of *Siphonodella* with a symmetrical, narrow, slightly arched platform ornamented on both sides by weak to obsolescent transverse ridges that are separated from the straight to slightly curved carina by wide adcarinal troughs. The straight to slightly curved basal cavity is in juvenile specimens completely open, but in mature specimens it is partly inverted to form a raised, flat area (herein called a pseudokeel) that contains a deep pit near its anterior end. The free blade is short, low, and fairly even topped.

Remarks. – In oral view, the platform of *Siphonodella praesulcata* n. sp. is narrow, and the two sides are nearly equal in area. There is a wide variation in platform outline, however, among all the specimens studied and even within single collections. The three most common platform outlines are these: (1) Platform sides fairly straight and nearly parallel for most of their length (e. g., pl. 1, fig. 5); (2) platform sides arcuate with pronounced convergence both anteriorly and posteriorly from widest point that most commonly is at mid-length (e. g., pl. 1, figs. 1, 16; pl. 2, figs. 15, 18); and (3) platform sides convergent anteriorly and posteriorly but with a pronounced constriction, which presages the formation of an incipient rostrum in some specimens of *S. sulcata,* near the anterior end (e. g., pl. 1, figs. 8, 12). Moreover, there are variations in the length:width ratio of the platform and in its posterior termination within each of these types. The posterior tip may be sharply pointed (pl. 1, figs. 1, 2, 5; pl. 2, fig. 15) or rounded (pl. 1, fig. 16; pl. 2, fig. 18). Within a single colection (MO–6, loc. 19), the platform ranges from long and slender (pl. 2, figs. 15, 18) to short and stubby (pl. 1, fig. 14; pl. 2, fig. 12).

The transverse ridges are generally weak and short. In some specimens they are very weak overall (pl. 1, fig. 14; pl. 2, fig. 15), but in others they are weakest at the anterior end of the platform (pl. 1, fig. 10; pl. 2, figs. 10, 12). Some specimens have wide adcarinal troughs and transverse ridges that are very short and are hardly more than elongated marginal nodes (e. g., pl. 1, fig. 12).

The carina contains 2 to 6 discrete nodes near its midlength, but commonly it is fused anteriorly and (or) posteriorly. The carina may be straight or slightly curved, but its curvature is generally less than that of the pseudokeel on the same specimen (e. g., pl. 1, figs. 8–9, 10–11; pl. 2, figs 18–19).

The open basal cavity in juvenile specimens of *Siphonodella praesulcata* n. sp. is as long and nearly as wide as the platform and is deepest near its anterior end. A distinct medial groove extends the entire length of the basal cavity and about half the length of the free blade. The pseudokeel of mature specimens is as long as but generally half as wide as the platform. Uncommonly, it is much narrower (e. g., pl. 1, fig. 15). The pseudokeel has a deep pit near its anterior end and retains the long medial groove of the basal cavity. The pseudokeel generally is raised from the rest of the aboral surface of the platform and commonly it is flanked by deep furrows (e. g., pl. 1, fig. 13).

The great differences in the shape, length, and ornamentation of the platform of *Siphonodella praesulcata* n. sp. appear to be intraspecific, because they occur within single collections, no two individuals of which bear entirely the same characteristics. As now conceived, *S. praesulcata* is a single species, whose high variation suggest its rapid evolution at a time of great tectonic change, which occurred throughout the world near the close of the Devonian and beginning of the Carboniferous.

Siphonodella praesulcata n. sp. closely resembles *S. sulcata,* and transitional forms, which are difficult to assign, have been observed. Although the platforms of both species may be curved, the degree of curvature is much greater in *S. sulcata* than in *S. praesulcata.* This curvature is better reflected by the curvature of the basal cavity or pseudokeel than by the curvature of the carina. Specimens that have a strongly curved basal cavity or pseudokeel are assigned to *S. sulcata.* Moreover, the platform of *S. sulcata* is slightly asymmetrical with a tendency toward greater width on the outer side, whereas the platform of *S. praesulcata* is symmetrical with both sides nearly equal in area. The transverse ridges are stronger and longer in *S. sulcata,* and they are separated from the carina by adcarinal grooves rather than by adcarinal troughs as in *S. praesulcata.*

Material. – From 14 collections at ten measured sections (locs. 2, 3, 7, 8, 9, 12 in Montana; loc. 15 in Utah; locs. 19, 20 in Missouri; and loc. 21 in Illinois), 175 specimens.

Range. – *Siphonodella praesulcata* n. sp. occurs within the latest Devonian *Siphonodella praesulcata* Fauna (Middle *Spathognathodus costatus* Zone to top of Devonian) and in the basal Carboniferous *S. sulcata* Zone. It is found in the Sappington Member of the Three Forks Formation in Montana, in the Leatham Formation in Utah, and in the "Glen Park" Formation of Collinson, the pre-"Glen Park" regolith, and the basal beds of the Hannibal Shale in Missouri and Illinois. It is also reported, as *Polygnathus* sp. B Druce, from the basal 50 feet of the Burnt Range Formation in northwestern Australia (Druce, 1969, fig. 6). Forms simliar to *S. praesulcata* also occur in the Middle *Spathognathodus costatus* Zone in Germany (Willi Ziegler, written commun., Sept. 30, 1969).

Siphonodella sulcata (Huddle)
Pl. 2, Figs. 1–9
1934 *Polygnathus sulcata* Huddle. – Huddle, p. 101, pl. 8, figs. 22–23.
1962 *Siphonodella sulcata* (Huddle). – Collinson, Scott, and Rexroad, chart 2.
non 1967 *Siphonodella sulcata* (Huddle)?. – Boogaert, p. 186, pl. 3, fig. 16.
1967 *Siphonodella*? n. sp. a Boogaert. – Boogaert, p. 186, pl. 3, figs. 17–18.
? 1968 *Siphonodella sulcata* (Huddle). – Canis, p. 550–551, pl. 72, figs. 5 (= gerontic *S. sulcata*), 22, 23 (= *Siphonodella duplicata* transitional to *S. sulcata*).
non 1969 *Siphonodella sulcata* (Huddle). – Druce, p. 122–123, pl. 39, figs. 1a, 1b.

Diagnosis. – Slightly asymmetrical, arched platform is ornamented on both sides by transverse ridges, which are separated from the strongly curved, nodose carina by narrow adcarinal grooves. The strongly curved basal cavity is in juvenile specimens completely open, but in mature specimens it is partly inverted to form a raised, flat area (herein termed a pseudokeel) that contains a deep pit near its anterior end. The free blade is short and low.

Remarks. – *Siphonodella sulcata* is closely similar to *S. duplicata* Branson and Mehl, but *S. duplicata,* as illustrated by Klapper (1966, pl. 4, fig. 13) has marginal ridges along the sides of the rostrum at the anterior end of the platform. In *S. sulcata,* the rostrum is shorter and the marginal ridges are absent, or incipient and only faintly suggested by deepening of the adcarinal grooves and slight upturning of the platform margins (pl. 2, fig. 3). Moreover, most specimens of *S. duplicata* do not have adcarinal grooves, and many specimens of *S. duplicata* show incipient breakdown of transverse ridges into nodes particularly at the posterior end of the platform. The transverse ridges of *S. sulcata* are not incipiently nodose. Aborally, some of the oldest specimens of *S. duplicata* that are transitional to *S. sulcata* may have a flat area that resembles the pseudokeel of *S. sulcata,* but in these the flat area is flush with the adjoining platform and is not raised as in *S. sulcata.* The specimen illustrated as *S. sulcata* by Canis (1968, pl. 72, figs. 22–23) is typical of specimens of *S. duplicata* that are transitional to *S. sulcata.*

Siphonodella sulcata is also very close to *S. praesulcata* n. sp. and many transitional specimens have been observed (e. g., pl. 2, figs. 5–6, 10–11). The criteria for distingguishing these species are given under *S. praesulcata.*

Range. – *Siphonodella sulcata* occurs throughout the *S. sulcata* Zone and only in the lower part of the overlying *S. sandbergi-S. duplicata Zone.* It is found in the Cottonwood Canyon Member of the Madison Limestone in Wyoming, in the "Glen Park" Formation of Collinson and Hannibal Shale in the Upper Mississippi Valley, in the New Albany Shale in Indiana (Huddle, 1934), and in the Hangenberg Limestone in Germany (Sandberg and Klapper, 1967; Ziegler, 1969). Hass (1947, table 4) reported but did not illustrate *S. sulcata* from the basal part of the Sunbury Shale in Ohio.

References cited

Austin, R., Conil R., Rhodes, F., and Streel, M., 1970: Conodontes, spores et foraminifères du Tournaisian inférieur dans la vallée du Hoyoux: Belgique Soc. Géol. Ann., v. 93, pt. 2, p. 305–315, 1 pl.

Austin, R. L., Druce, E. C., Rhodes, F. H. T., and Williams, J. A., 1970: The value of conodonts in the recognition of the Devonian-Carboniferous boundary, with particular reference to Great Britain: 6th Internat. Cong., Stratigraphy and Geology of Carboniferous, Sheffield, 1967, Compte rendu, v. 2, p. 431–444, 1 pl.

Austin, R. L., and Rhodes, F. H. T., 1971: New Dinantian conodont faunas of France and Belgium; a preliminary note, in Colloque sur la Stratigraphie du Carbonifère, Liège, April 1969: Cong. et Colloques, Univ. Liège, v. 55, p. 193–196 (date of imprint, 1970).

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

Boogaert, H. A. van A., 1967: Devonian and Lower Carboniferous conodonts of the Cantabrian Mountains (Spain) and their stratigraphic application: Leidse Geol. Mededel., v. 39, p. 129–192, 3 pls.

Bouckaert, J., Streel, M., and Thorez, J., 1968: Schéma biostratigraphique et coupes de référence du Famennien belge; note preliminaire: Soc. Géol. Belgique Ann., v. 91, no. 3, p. 317–336.

—.— 1971: Le Famennien supérieur et les couches de transition dévono-carbonifère dans la vallée de l'Ourthe, in Colloque sur la Stratigraphie du Carbonifère, Liège, April 1969: Cong. et Colloques, Univ. Liège, v. 55, p. 25–46 (date of imprint, 1970).

Bouckaert, J., and Ziegler, W., 1965: Conodont stratigraphy of the Famennian Stage (Upper Devonian) in Belgium: Belgium Service Géol., Expl. Cartes Géol. Minières Belgique Mem., no. 5, 30 p., 5 pls.

Branson, E. B., and Mehl, M. G., 1934: Conodont studies no. 4; Conodonts from the Bushberg sandstone and equivalent formations of Missouri: Missouri Univ. Studies, v. 8, no. 4, p. 265–300, pls. 22–24 (date of imprint, 1933).

Canis, W. F., 1968: Conodonts and biostratigraphy of the Lower Mississippian of Missouri: Jour. Paleontology, v. 42, no. 2, p. 525–555, pls. 72–74.

Caro-Moniez, M., 1962: Sur un niveau à spores du Dévonien supérieur du sondage de Tournai (Belgique): Soc. Géol. Nord Ann., v. 82, p. 111–115, pls. 1–2.

Chizhova, V. A., 1970: Correlation of Devonian and Carboniferous boundary beds in Eastern and Western Europe according to data resulting from the study of Ostracoda: 6th Internat. Cong. Stratigraphy and Geology of Carboniferous, Sheffield, 1967, Compte rendu, v. 2, p. 547–555.

Collinson, Charles, 1961a: Road log; Second day of field conference, in Kansas Geol. Soc. Guidebook, 26th Ann. Field Conf., Northeastern Missouri and west-central Illinois: p. 49–74.

—.— 1961b: The Kinderhookian Series in the Mississippi Valley, in Kansas Geol. Soc. Guidebook, 26th Ann. Field Conf., Northeastern Missouri and west-central Illinois: p. 100–109.

Collinson, Charles, 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 Geol. Survey Circ. 328, 32 p., 6 charts.

Conil, R., 1959: Recherches stratigraphiques sur les terrains dinantiens dans le bord nord du bassin de Namur: Acad. Royale Belgique Mém., Cl. Sci., ser. 2, v. 14, no. 5, 176 p., 18 pls.

—.— 1964: Localités et coupes types pour l'étude du Tournaisien inférieur: Acad. Royale Belgique Mém., Cl. Sci., ser. 2, v. 15, no. 4, 87 p., 14 pls.

deWitt, Wallace, Jr., 1970: Age of the Bedford Shale, Berea Sandstone, and Sunbury Shale in the Appalachian and Michigan Basins, Pennsylvania, Ohio, and Michigan: U.S. Geol. Survey Bull. 1294–G, 11 p.

Dolby, G., 1971: Spore assemblages from the Devonian-Carboniferous transition measures in south-west Britain and southern Eire, in Colloque sur la Stratigraphie du Carbonifère, Liège, April 1969: Cong. et Colloques, Univ. Liège, v. 55, p. 267–274, pl. 14 (date of imprint, 1970).

Dolby, G., and Neves, R., 1970: Palynological evidence concerning the Devonian-Carboniferous boundary in the Mendips, England: 6th Internat. Cong., Stratigraphy and Geology of Carboniferous, Sheffield, 1967, Compte rendu, v. 2, p. 631–646, 2 pls.

Druce, E. C., 1969: Devonian and Carboniferous conodonts from the Bonaparte Gulf Basin, Northern Australia, and their use in international correlation: Australia Bur. Mineral Resources, Geology and Geophysics Bull. 98, 242 p., 43 pls.

Gutschick, R. C., 1962: Arenaceous Foraminifera from oncolites in the Mississippian Sappington Formation of Montana: Jour. Paleontology, v. 36, no. 6, p. 1291–1304, pls. 174–175.

Gutschick, R. C. and Perry, T. G., 1959: Sappington (Kinderhookian) sponges and their environment: Jour. Paleontology, v. 33, no. 6, p. 977–985.

Gutschick, R. C., and Sandberg, C. A., 1970: Latest Devonian conchostracans along Cordilleran miogeosyncline, Alberta, Montana, Utah, and Nevada (abs.): Am. Assoc. Petroleum Geologists Bull., v. 54, no. 5, p. 849–850.

Gutschick, R. C., Suttner, L. J., and Switek, M. J., 1962: Biostratigraphy of transitional Devonian-Mississippian Sappington Formation of southwest Montana, in Billings Geol. Soc. Guidebook, 13th Ann. Field Conf.: p. 79–89.

Haas, W. H., 1947: Conodont zones in Upper Devonian and Lower Mississippian formations of Ohio: Jour. Paleontology, v. 21, no. 2, p. 131–141.

Huddle, J. W., 1934: Conodonts from the New Albany shale of Indiana: Bulls. Am. Paleontology, v. 21, no. 72, 136 p. 12 pls.

Klapper, Gilbert, 1966: Upper Devonian and Lower Mississippian conodont zones in Montana, Wyoming, and South Dakota: Kansas Univ. Paleont. Contr., Paper 3, 43 p., 6 pls.

—.— 1971: *Patrognathus* and *Siphonodella* (Conodonta) from the Kinderhookian (Lower Mississippian) of western Kansas and southwestern Nebraska: Kansas Geol. Survey Bull. 202, pt. 3, 14 p., 2 pls.

Klapper, Gilbert, Sandberg, C. A., Collinson, Charles, Huddle, J. W., Orr, R. W., Rickard, L. V., Schumacher, Dietmar, Seddon, George, and Uyeno, T. T., 1971: North American Devonian conodont biostratigraphy, in Sweet, W. C., and Bergström, S. M., eds., Symposium on Conodont Biostratigraphy: Geol. Soc. America Mem. 127, p. 285–316, 6 figs.

Koch, Michael, Leuteritz, Klaus, and Ziegler, Willi, 1970: Alter, Fazies und Paläogeographie der Oberdevon/Unterkarbon-Schichtenfolge an der Seiler bei Iserlohn: Fortschr. Geologie Rheinland u. Westfalen, v. 17, p. 679–732, 10 pls.

Koenig, J. W., and Martin, J. A., 1961: Road log; First day of field conference, in Kansas Geol. Soc. Guidebook, 26th Ann. Field Conf., Northeastern Missouri and west-central Illinois: p. 9–48.

Legrand, R., Mamet, B., and Mortelmans, G., 1966: Sur la stratigraphie du Tournaisien de Tournai et de Leuze;

Problèmes de l'étage Tournaisien dans sa localité-type: Soc. Géol. Belgique Bull., v. 74, no. 2–3, p. 140–188.

Lanzoni, E., and Magloire, L., 1969: Associations palynologiques et leurs applications stratigraphiques dans le Dévonien supérieur et Carbonifère inférieur du grand erg occidental (Sahara algérien): Inst. français du pétrole Rev. et Annales combustibles liquides, v. 24, no. 4, p. 441–453, 8 pls.

Macqueen, R. W., and Sandberg, C. A., 1970: Stratigraphy, age, and interregional correlation of the Exshaw Formation, Alberta Rocky Mountains: Canadian Petroleum Geology Bull., v. 18, no. 1, p. 32–66.

Mapel, W. J., and Sandberg, C. A., 1968: Devonian paleotectonics in east-central Idaho and southwestern Montana, in Geological Survey Research 1968: U.S. Geol. Survey Prof. Paper 600–D, p. D115–D125.

McGregor, D. C., 1969: Devonian plant fossils of the genera *Kryshtofovichia*, *Nikitinsporites*, and *Archaeoperisaccus*, in Contributions to Canadian Paleontology: Canada Geol. Survey Bull. 182, p. 91–106, pls. 11–12.

—.— 1971: *Hymenozonotriletes lepidophytus* Kedo and associated spores from the Devonian of Canada, in Colloque sur la Stratigraphie du Carbonifère, Liège, April 1969: Cong. et Colloques, Univ. Liège, v. 55, p. 315–326, pls. 21–23 (date of imprint, 1970).

Neves, R., and Dolby, G., 1967: An assemblage of miospores from the Portishead Beds (Upper Old Red Sandstone) of the Mendip Hills, England: Pollen et Spores, v. 9, no. 3, p. 607–614, 2 pls.

Owens, B., 1971: Recognition of the Devonian-Carboniferous boundary by palynological methods, in Colloque sur la Stratigraphie du Carbonifère, Liège, April 1969: Cong. et Colloques, Univ. Liège, v. 55, p. 349–364 (date of imprint, 1970).

Owens, B., and Streel, M., 1967: *Hymenozonotriletes lepidophytus* Kedo, its distribution and significance in relation to the Devonian-Carboniferous boundary: Rev. Palaeobotany and Palynology, v. 1, no. 1–4, p. 141–150.

Paproth, Eva, 1964: Die Untergrenze des Karbons: 5th Cong. Internat., Stratigraphie et Géologie du Carbonifère, Paris, 1963, Compte rendu, v. 2, p. 611–618.

Paproth, Eva, and Streel, Maurice, 1971: Corrélations biostratigraphiques près de la limite Dévonien/Carbonifère entre les faciès littoraux ardennais et les faciès bathyaux rhénans, in Colloque sur la Stratigraphie du Carbonifère, Liège, April 1969: Cong. et Colloques, Univ. Liège, v. 55, p. 365–398, pls. 24–26 (date of imprint, 1970).

Rexroad, C. B., 1969: Conodonts from the Jacobs Chapel Bed (Mississippian) of the New Albany Shale in southern Indiana: Indiana Geol. Survey Bull. 41, 55 p., 9 pls.

Rexroad, C. B., and Scott, A. J., 1964: Conodont zones in the Rockford Limestone and the lower part of the New Providence Shale (Mississippian) in Indiana: Indiana Geol. Survey Bull. 30, 54 p., 3 pls.

Rhodes, F. H. T., Austin, R. L., and Druce, E. C., 1969: British Avonian (Carboniferous) conodont faunas, and their value in local and intercontinental correlation: British Mus. (Nat. History) Bull., Geology, suppl. no. 5, 313 p., 31 pls.

Rodriguez, Joaquin, and Gutschick, R. C., 1967: Brachiopods from the Sappington Formation (Devonian-Mississippian) of western Montana: Jour. Paleontology, v. 41, no. 2, p. 364–384, pls. 41–44.

—.— 1971: Late Devonian-early Mississippian ichnofossils from western Montana and northern Utah, in Crimes, T. P., and Harper, J. C., eds., Trace fossils: Liverpool, p. 407–438, 10 pls.

Sandberg, C. A., 1962: Stratigraphic section of type Three Forks and Jefferson Formations at Logan, Montana, in Symposium, The Devonian System of Montana and adjacent areas, Billings Geol. Soc. Guidebook, 13th Ann. Field Conf., Sept. 1962: p. 47–50.

—.— 1965: Nomenclature and correlation of lithologic subdivisions of the Jefferson and Three Forks Formations of southern Montana and northern Wyoming: U.S. Geol. Survey Bull. 1194–N, 18 p.

Sandberg, C. A., and Gutschick, R. C., 1969: Stratigraphy and conodont zonation of type Leatham Formation (Devonian and Mississippian), Bear River Range, Utah (abs.): Geol. Soc. America Abs. with Programs, 1969, pt. 5, Rocky Mtn. Sec., p. 70–71.

Sandberg, C. A., and Klapper, Gilbert, 1967: Stratigraphy, age, and paleotectonic significance of the Cottonwood Canyon Member of the Madison Limestone in Wyoming and Montana: U.S. Geol. Survey Bull. 1251–B, 70 p.

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. Geol. Survey Prof. Paper 575–C, p. C127–C131.

Sandberg, C. A., and Poole, F. G., 1970: Conodont biostratigraphy and age of West Range Limestone and Pilot Shale at Bactrian Mountain, Pahranagat Range, Nevada (abs.): Geol. Soc. America, Abs. with Programs, v. 2., no. 2, Cordilleran Sec., p. 139.

Schindewolf, O. H., 1937: Zur Stratigraphie und Paläontologie der Wocklumer Schichten (Oberdevon): Prussia Geol. Landesanstalt Abh., new ser., no. 178, 132 p., 4 pls.

Scott, A. J., 1961: Three new conodonts from the Louisiana Limestone (Upper Devonian) of western Illinois, in Paleontological notes: Jour. Paleontology, v. 35, p. 1223–1227.

Scott, A. J., and Collinson, Charles, 1961: Conodont faunas from the Louisiana and McCraney Formations of Illinois, Iowa, and Missouri, in Kansas Geol. Soc. Guidebook, 26th Ann. Field Conf., Northeastern Missouri and west-central Illinois: p. 110–141, pls. 1–2.

Sprinkle, James, and Gutschick, R. C., 1967: *Costatoblastus*, a channel fill blastoid from the Sappington Formation of Montana: Jour. Paleontology, v. 41, no. 2, p. 385–402, pl. 45.

Streel, M., 1966: Critères palynologiques pour une stratigraphie détaillée du Tn1a dans les bassins Ardenno-Rhénans: Soc. Géol. Belgique Ann., v. 89, Bull. 3, p. 65–96, 2 pls.

—.— 1967: Associations de spores des stratotypes du Famennien, du Strunien et du Tournaisien dans les bassins Ardenno-Rhénans (note préliminaire): Rev. Palaeobotany and Palynology, v. 5, no. 1–4, p. 63–74, 1 pl.

—.— 1969: Corrélations palynologiques entre les sédiments de transition Dévonien/Dinantien dans les bassins Ardenno-Rhénans: 6th Internat. Cong., Stratigraphy and Geology of Carboniferous, Sheffield, 1967, Compte rendu, v. 1, p. 3–18, 1 pl.

—.— 1971: Distribution stratigraphique et géographique d'*Hymenozonotriletes lepidophytus* Kedo, d'*Hymenozonotriletes pusillites* Kedo et des assemblages tournaisiens, in Colloque sur la Stratigraphie du Carbonifère, Liège, April 1969: Cong. et Colloques, Univ. Liège, v. 55, p. 121–147 (date of imprint, 1970).

Utting, J., and Neves, R., 1971: Palynology of the Lower Limestone Shale Group (Basal Carboniferous Limestone series) and Portishead Beds (Upper Old Red Sandstone) of the Avon Gorge, Bristol, England, in Colloque sur la Stratigraphie du Carbonifère, Liège, April 1969: Cong. et Colloques, Univ. Liège, v. 55, p. 411–422, pls. 27–28 (date of imprint, 1970).

Voges, Adolph, 1959: Conodonten aus dem Unterkarbon I und II (*Gattendorfia*- und *Pericyclus*-Stufe) des Sauerlandes: Paläont. Zeitschr., v. 33, no. 4, p. 266–314, pls. 33–35.

—.— 1960: Die Bedeutung der Conodonten für die Stratigraphie des Unterkarbons I und II (*Gattendorfia*- und *Pericyclus*-Stufe) im Sauerland: Fortschr. Geol. Rheinland u. Westfalen, v. 3, pt. 1, p. 197–228, 5 pls.
Vöhringer, Eugen, 1960: Die Goniatiten der unterkarbonischen *Gattendorfia*-Stufe im Hönnetal (Sauerland): Fortschr. Geologie Rheinland u. Westfalen, v. 3, pt. 1, p. 107–196, 7 pls.
Weyer, D., 1965: Etroeungt im Morvan (Zentralfrankreich): Zentrales Geol. Inst. Berlin Abh., v. 1, p. 290–302, pl. 24A.
Williams, J. S., 1943: Stratigraphy and fauna of the Louisiana limestone of Missouri: U.S. Geol. Survey Prof. Paper 203, 133 p.
Winslow, M. R., 1962: Plant spores and other microfossils from Upper Devonian and Lower Mississippian rocks of Ohio: U.S. Geol. Survey Prof. Paper 364, 93 p., 27 pls.
Ziegler, Willi, 1962: Taxionomie und Phylogenie Oberdevonischer Conodonten und ihre stratigraphische Bedeutung: Hessisches Landesamt Bodenforschung Abh., no. 38, 166 p., 14 pls.
—.— 1969: Eine neue Conodontenfauna aus dem höchsten Oberdevon: Fortschr. Geologie Rheinland u. Westfalen, v. 17, p. 343–360, 2 pls.

Locality Register

United States

All localities, expect localities 10 and 11, yielded at least one zonally or faunally assignable conodont collection. Spore assemblages were found only at localities 5 and 22. All localities, except localities 4 and 10, were personally sampled by C. A. Sandberg. All sections, except for those that are otherwise credited, were also measured by C. A. Sandberg. References to published lists of conodonts and measured sections are given.

1. Bandbox Mountain, Little Belt Mountains. About 250 feet vertically below the 7,952-foot summit in the NE 1/4 NW 1/4 sec. 20, T. 14 N., R. 10 E., Judith Basin County, Mont., on the White Sulphur Springs 1 : 250,000 Army Map Service sheet NL 12–5. For conodont lists, see Sandberg and Klapper (1967, p. B50, B61).
2. Lick Creek Road, Little Belt Mountains. About 150 feet west of road in the C NW 1/4 sec. 19, T. 16 N., R. 6 E., Judith Basin County, Mont., on the Great Falls 1 : 250,000 Army Map Service sheet NL 12–2. Section measured by C. A. Sandberg and R. C. Gutschick.
3. Rock Creek, Dry Range. On north side of creek, opposite junction of Ellis Creek in the SW corner sec. 19, T. 13 N., R. 4 E., Meagher County, Mont., on the White Sulphur Springs 1 : 250,000 Army Map Service sheet NL 12–5. Section measured by C. A. Sandberg and R. C. Gutschick.
4. North Frazier Lake, Bridger Range. In the NW 1/4 SW 1/4 sec. 9, T. 2 N., R. 6 E., Gallatin County, Mont., in the Sedan 1 : 62,500 quadrangle. Section measured by R. C. Gutschick.
5. Peak 9559, Bridger Range (USGS Paleobot. Loc. D–1765–2). At elevation of about 9,280 feet in the SE 1/4 SE 1/4 SE 1/4 sec. 21, T. 2 N., R. 6 E., Gallatin County, Mont., in the Sedan 1 : 62,500 quadrangle. For conodont list, see Sandberg and Klapper (1967, p. B61).
6. Logan. In Logan Gulch on north side of Gallatin River in the SW 1/4 SE 1/4 sec. 25, T. 2 N., R. 2 E., Gallatin County, Mont., in the Manhattan 1 : 62,500 quadrangle. For columnar section, see Sandberg (1965, fig. 3).
7. Mud Spring Gulch. At elevation of about 4,630 feet in the C NE 1/4 SW 1/4 sec. 1, T. 2 N., R. 1 E., Broadwater County, Mont., in the Three Forks 1 : 62,500 quadrangle.
8. Ingleside Quarry. About 0.6 mile south of quarry, at elevation of about 4,450 feet in the NE 1/4 SE 1/4 NW 1/4 sec. 4, T. 1 S., R 1 W., Gallatin County, Mont., in the Three Forks 1 : 62,500 quadrangle.
9. Antelope Creek. About 0.4 mile east of creek, at elevation of about 4,620 feet in the SW 1/4 NE 1/4 NE 1/4 sec. 2, T. 1 S., R. 2 W., Madison County, Mont., in the Jefferson Island 1 : 62,500 quadrangle.
10. Bouge Canyon, Ruby Range. In the SE 1/4 sec. 28, T. 5 S., R. 5 W., Madison County, Mont., in the Laurin Canyon 1 : 24,000 quadrangle. Section measured by R. C. Gutschick.
11. Ashbough Canyon, Blacktail Mountains. About 0.3 mile south of creek, at elevation of about 7,940 feet in the NE 1/4 NE 1/4 SE 1/4 sec. 33, T. 9 S., R. 8 W., Beaverhead County, Mont., in the Ashbough Canyon 1 : 24,000 quadrangle.
12. Sheep (Arrowhead) Mountain, Centennial Range. At elevation of about 7,800 feet in the NW 1/4 NW 1/4 SW 1/4 sec. 28, T. 14 S., R. 1 W., Beaverhead County, Mont., in the Upper Red Rock Lake 1 : 62,500 quadrangle.
13. Long Canyon, Beaverhead Mountains. At elevation of about 7,800 feet in the C sec. 35, T. 10 N., R. 30 E., Clark County, Idaho, on the Dubois 1 : 250,000 Army Map Service sheet NL 12–10. See Mapel and Sandberg (1968); the bed identified as Milligen Formation in the photograph (Mapel and Sandberg, 1968, fig. 6) is actually unit 1 of the Sappington Member of the Three Forks Formation, and the so-called "pod of dolomite" is a concretion containing a conodont fauna of the Upper *Polygnathus styriacus* Zone.
14. Leatham Hollow, Bear River Range. At elevation of about 6,000 feet on east side of Leatham Hollow in the SE 1/4 NW 1/4 NW 1/4 sec. 34, T. 11 N., R. 2 E., Cache County, Utah, in the Logan 1 : 125,000 quadrangle. For summarized section, see Sandberg and Gutschick (1969).

15. Porcupine Dam, Bear River Range. In roadcut along north side of reservoir in the SE 1/4 NE 1/4 NW 1/4 sec. 17, T. 9 N., R. 2 E., Cache County, Utah, in the Logan 1 : 125,00 quadrangle. Section measured by C. A. Sandberg and F. G. Poole.
16. Bactrian Mountain, Pahranagat Range. At elevation of about 5,100 feet in sec. 11, T. 5 S., R. 59 E., Lincoln County, Nev., on the Caliente 1 : 250,000 Army Map Service sheet NJ 11–9. For summarized section, see Sandberg and Poole (1970).
17. Windy Gap, Washakie Range. At elevation of about 8,200 feet on north end of Black Mountain, 0.9 mile south of Windy Gap, in the E 1/2 SW 1/4 SE 1/4 sec. 36, T. 43 N., R. 106 W., Fremont County, Wyo., in the Indian Point 1 : 24,000 quadrangle. For conodont lists, see Sandberg and Klapper (1967, p. B51, B52, B54).
18. Warm Spring Canyon, Wind River Range. Just above creek level at elevation of about 7,350 feet in the S 1/2 SW 1/4 SW 1/4 sec. 31, T. 42 N., R. 107 W., Fremont County, Wyo., in the Dubois 1 : 24,000 quadrangle.
19. Stark's Roadcut. About 0.5 mile south of Stark Nursery, in the SE 1/4 SW 1/4 sec. 25, T. 54 N., R. 2 W., Pike County, Mo., in the Bowling Green 1 : 62,500 quadrangle. Section measured by Koenig and Martin (1961, figs. 18, 19).
20. Champ Clark Highway Bridge. North of west bridge piers near the C W 1/2 NE 1/4 sec. 18, T. 54 N., R. 1 W., Pike County, Mo., in the Bowling Green 1 : 62,500 quadrangle. Section measured by C. W. Collinson.
21. Jimtown Branch. Along creek in the SW corner sec. 16, T. 6 S., R. 5 W., Pike County, Ill., in the Pittsfield 1 : 62,500 quadrangle. Section measured by Collinson (1961a, fig. 14).
22. Atlas South (USGS Paleobot. Loc. D–4584). In east bluff of Mississippi River Valley near C SE 1/4 sec. 35, T. 6 S., R. 5 W., Pike County, Ill., in the Nebo 1 : 62,500 quadrangle. Section measured by Collinson (1961a, fig. 12).
23. Hamburg South. Along creek in south part of town of Hamburg in the SW 1/4 NE 1/4 sec. 35, T. 9 S., R. 3 W., Calhoun County, Ill., in the Hardin 1 : 62,500 quadrangle. Section measured by Collinson (1961a, fig. 5).

Europe

Spore assemblages from all localities were studied by M. Streel. (See Paproth and Streel, 1971.)

24. Oberrödinghausen (Hönnetal) railroad cut near Balve, Sauerland, North Rhine-Westphalia, Federal Republic of Germany. Standard profile for Devonian-Carboniferous boundary based on goniatites (Schindewolf, 1937; Vöhringer, 1960). Lower Carboniferous conodonts were described by Voges (1960). Ten of 13 spore samples from the highest Devonian Hangenberg Shale yielded spore assemblages; 10 samples from the Devonian Wocklumer Limestone and Carboniferous Hangenberg Limestone were unproductive.
25. Stockum, on southwest side of Spitze Kahlenberg, near Plettenberg, Sauerland, North Rhine-Westphalia, Federal Republic of Germany. Hangenberg Shale with limestone lens containing pre-*Gattendorfia*-Stufe goniatites and conodonts assigned to the *Protognathodus* Fauna (Weyer, 1965; Ziegler, 1969). Four productive spore samples in 4 m of the Hangenberg Shale, directly above the goniatite-bearing limestone lens.
26. Chanxhe, right side of Ourthe Valley, south of Liège, Belgium. For lithologic description and fossil content, see Conil (1964), Streel (1966), and Bouckaert, Streel, and Thorez (1968, 1971).
27. Royseux, left side of Hoyoux Valley, southwest of Liège, Belgium. For fossil content, see Bouckaert and Ziegler (1965, p. 17) and Austin, Conil, Rhodes, and Streel (1970).
28. Borehole at Tournai, Belgium. Samples stored by the Geological Survey of Belgium. For lithologic description and fossil content, see Legrand, Mamet, and Mortelmans (1966). For spores, see Caro-Moniez (1962, sample at 315 m). Samples from 325 m to 314 m redescribed by Streel (in Paproth and Streel, 1971).
29. Feluy, Samme River, south of Brussels, Belgium. Section described by Conil (1959, pl. 6); conodonts, by Austin and Rhodes (1971); ostracods, by Chigova (1970, p. 552).
30. Ecaussines d'Enghien, Sennette River, south of Brussels, Belgium. Section described by Conil (1959, pl. 6).

Discussion

Owens: I was interested to see in the spore assemblages which were recovered from these deposits representatives of the characteristic Frasnian spore genus *Archaeoperisaccus*. Previous records of this distinctive genus have not been made in associations with *Hymenozonotrilites lepidophytus*. Do the authors consider this would be reworked?

Streel: Of course, we are never able to avoid completely the reworking hypothesis. But the very good state of preservation of the sample is not in favour of an entirely reworked material. On another hand, the assemblage contains many characteristic species from the highest part of the *lepidophytus* assemblage-zone which make the reworking hypothesis very improbable in terms of the European zonation of both spores and conodonts.
As far as the *Archaeoperisaccus* species is concerned, we are not yet able to prove whether this species is new or whether we have a very high record or, why not, a few reworked specimens.

Plate 1

All magnifications x40

Siphonodella praesulcata n. sp. Sandberg

(Figs. 1–9, 12–13, 16–17, *Siphonodella praesulcata* Fauna; figs. 10–11, 14–15, *Siphonodella sulcata* Zone)

Fig.

1–4 Holotype (USNM 173591) with narrow platform widest at midlength and cavity partly inverted to form pseudokeel. 1, 2) Left and right oral views forming stereo pair, 3) aboral view, 4) right lateral view. (Loc. 2, sample LKR–15, Sappington Member of Three Forks Formation.)

5–7 Paratype (USNM 173592), juvenile specimen with narrow straight-sided platform and completely open basal cavity. 5) Oral, 6) aboral, 7) right lateral views. (Loc. 2, sample LKR–15, Sappington Member.)

8–9 Paratype (USNM 173593) with stubby platform constricted near anterior end and partly inverted basal cavity with deep pit. 8) Oral, 9) aboral views. (Loc. 3, sample RK–1, Sappington Member.)

10–11 Paratype (USNM 173594) with constriction just anterior to midlength and cavity partly inverted to form pseudokeel. 10) Oral, 11) aboral views. (Loc. 19, sample MO–6, "Glen Park" Formation of Collinson.)

12–13 Paratype (USNM 173595) showing platform with wide adcarinal troughs and pseudokeel flanked by deep furrows. 12) Oral, 13) aboral views. (Loc. 3, sample RK–1, Sappington Member.)

14–15 Paratype (USNM 173596), abnormal specimen showing nearly smooth platform and nearly completely inverted narrow basal cavity with slit-like pit. 14) Oral, 15) aboral views. (Loc. 19, sample MO–6, "Glen Park" Formation of Collinson.)

16–17 Paratype (USNM 173597), large specimen with symmetrical platform and partly inverted basal cavity. 16) Oral, 17) aboral views. (Loc. 15, sample PD–2, Leatham Formation.)

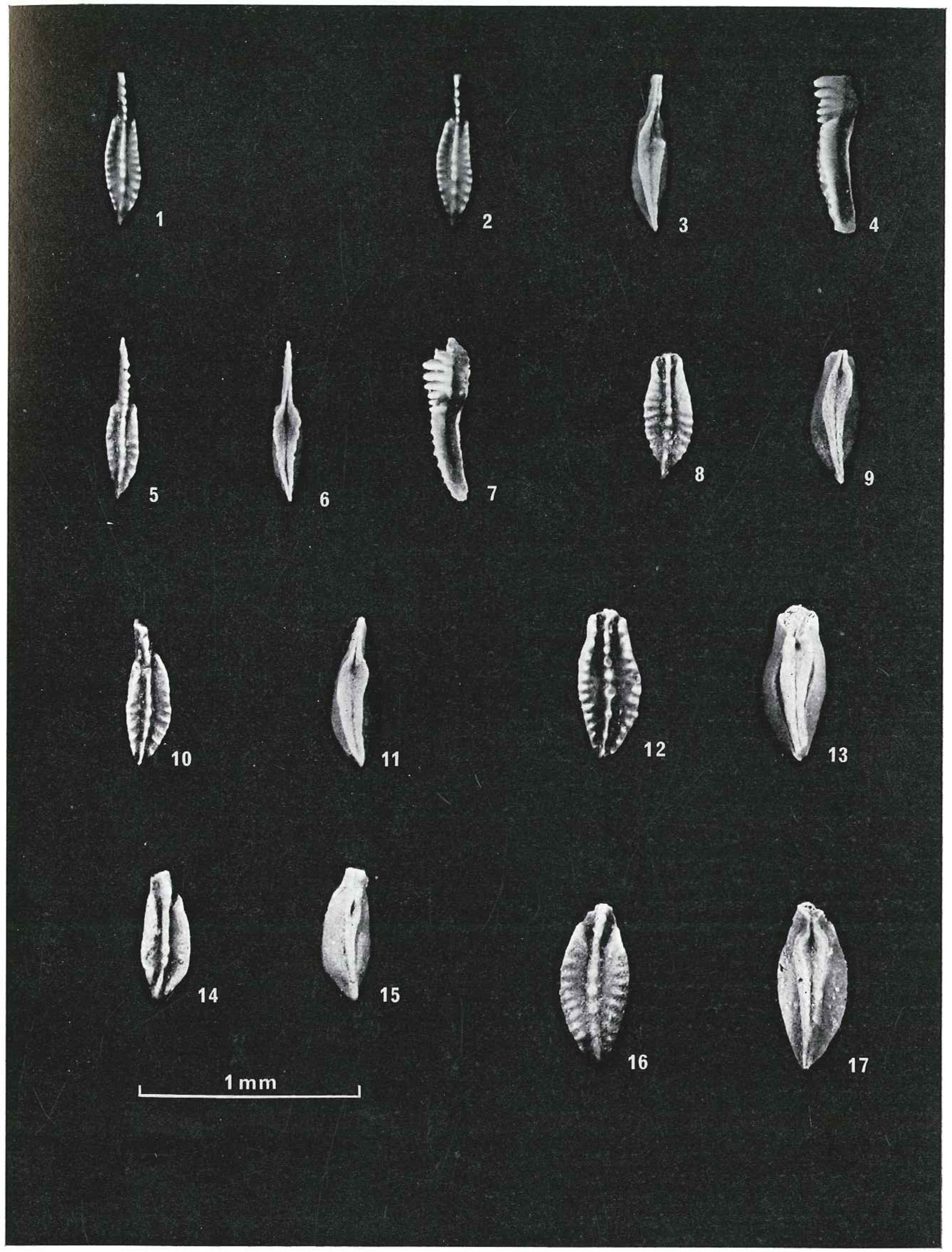

Plate 2

All magnifications x40

Siphonodella sulcata (HUDDLE)

Fig.

1–2 Juvenile specimen (USNM 173598) showing asymmetrical platform, strongly curved carina, and strongly curved open basal cavity. 1) Oral, 2) aboral views. (*S. sulcata* Zone, loc. 17, sample WG–20A, Cottonwood Canyon Member of Madison Limestone.)

3–4 Mature specimen (USNM 173599) showing weak adcarinal grooves, strongly curved carina and pseudokeel, and deep pit. 3) Oral, 4) aboral views. (Lower part of *S. sandbergi-S. duplicata* Zone, loc. 18, sample WS–1F, Cottonwood Canyon Member.)

5–6 Juvenile specimen (USNM 173600) showing typical strongly curved basal cavity of *S. sulcata*, but tendencies toward *S. praesulcata* in platform outline and oral surface. 5) Oral, 6) aboral views. (*S. sulcata* Zone, loc. 17, sample WG–20A, Cottonwood Canyon Member.)

7–9 Characteristic specimen (USNM 173601) showing asymmetrical platform, weak adcarinal grooves, and strongly curved pseudokeel with deep pit. 7) Oral, 8) aboral, 9) right lateral views. (*S. sulcata* Zone, loc. 19, sample MO–6, "Glen Park" Formation of COLLINSON.)

Siphonodella praesulcata n. sp. SANDBERG

(All from *S. sulcata* Zone, loc. 19, sample MO–6, "Glen Park" Formation of COLLINSON.)

10–11 Paratype (USNM 173602) showing characteristic straight carina, strong adcarinal troughs, and slightly curved pseudokeel of *S. praesulcata*, but tendency toward *S. sulcata* in asymmetrical outline of platform. 10) Oral, 11) aboral views.

12–14 Paratype (USNM 173603), characteristic of *S. praesulcata* in oral and lateral views but displaying abnormal (pathological) secondary ridge around pseudokeel. 12) Oral, 13) aboral, 14) right lateral views.

15–17 Paratype (USNM 173604), characteristic specimen showing narrow symmetrical platform, slightly curved carina and pseudokeel, strong adcarinal troughs, weak transverse ridges, and low free blade. 15) Oral, 16) aboral, 17) right lateral views.

18–19 Paratype (USNM 173605), characteristic specimen showing narrow symmetrical platform, straight carina, and slightly curved pseudokeel. 18) Oral, 19) aboral views.

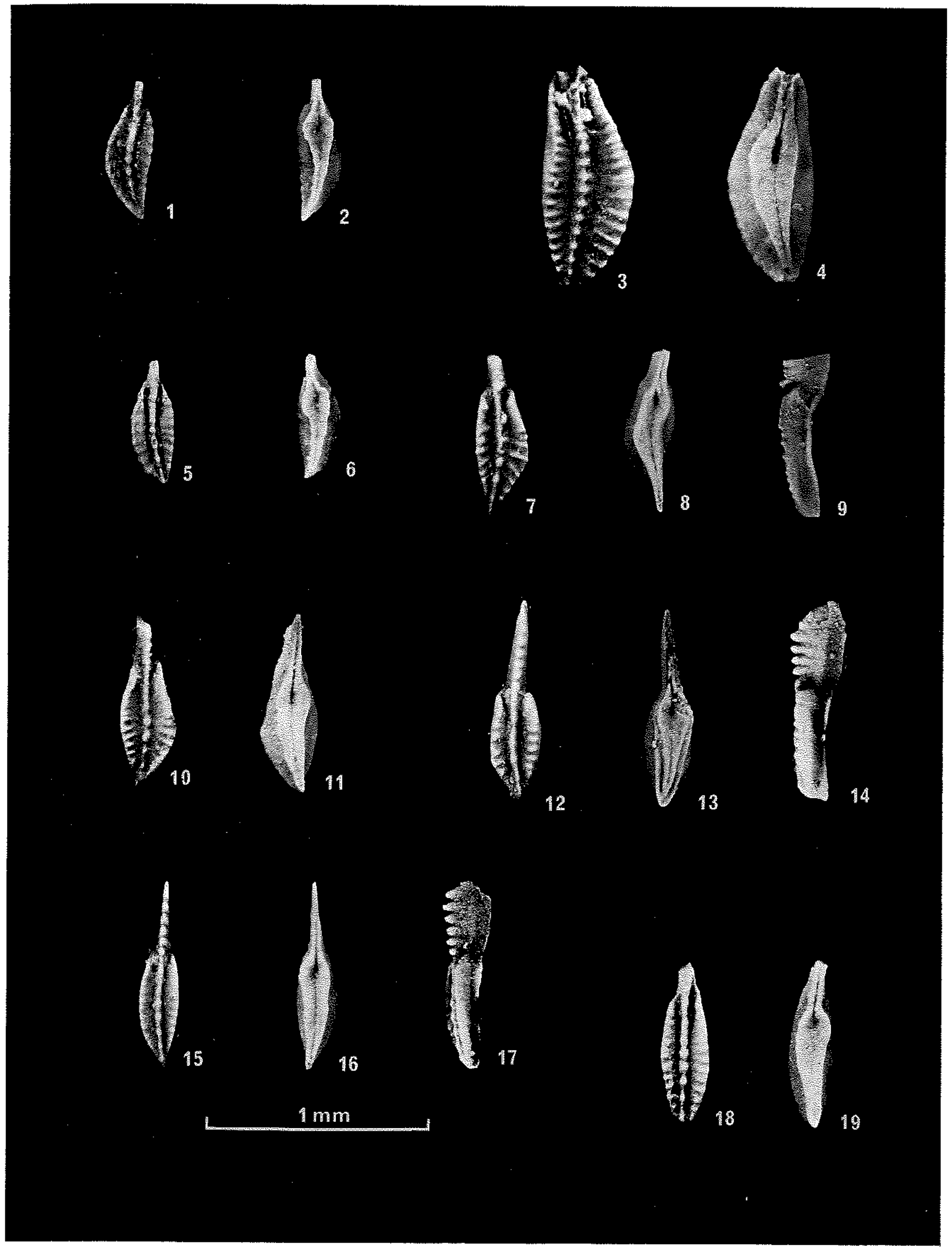

Plate 3

Magnifications x500 to x5000

Palynomorphs from PLs 2–3 assemblage zone in unit 4 of Sappington Member of Three Forks Formation, Peak 9559, Montana (loc. 5; USGS Paleobot. Loc. D–1765–2). Figures 1–2, 6–12, 15–18, and 22–23 from sample SP–18A; Figures 3–5, 13–14, 19–21, and 24–32 from sample SP–17C. ST, stereoscan picture; TR, transmitted-light photomicrograph.

Fig.	
1–5	*Hymenozonotriletes lepidophytus* Kedo. 1, 2) ST, proximal surface, x500; TR, x500. 3, 4, 5) TR, x500; ST, distal surface, x500; ST, part x2000.
6–8	*Vallatisporites pusillites* (Kedo) Dolby and Neves (on left) and *Hymenozonotriletes lepidophytus* Kedo (on right). 6) both, TR, x500; 7) both, ST, about x700, proximal surface of *V. pusillites* and part of distal surface of *H. lepidophytus;* 8) *H. lepidophytus* only, ST, distal surface, x4800.
9–10	*Vallatisporites pusillites* (Kedo) Dolby and Neves. ST, part, distal ornamentation, x4200; TR, distal focus, x500.
11–12	*Lophozonotriletes* cf. *malevkensis* Kedo. TR, distal focus, x1000; ST, proximal surface, x1000.
13–14	cf. *Vallatisporites verrucosus* Hacquebard. ST, proximal surface, about x500; TR, distal focus, x500.
15–21	*Retusotriletes incohatus* Sullivan. 15, 16, 17, 18) ST, part, showing smooth exine, x1800; ST, proximal surface, x500; TR, x500; TR, part, showing internal (?) punctate structure, x1000. 19, 20, 21) ST, part, showing thickness of exine at equator, x2000; ST, distal surface, x500; TR, x500.
22–23	*Knoxisporites* cf. *pristinus* Sullivan. TR, x500; ST, proximal surface, x500.
24–26	*Gorgonisphaeridium* sp. Staplin, Jansonius, and Pocock. ST, part, x5000; TR, x1000; ST, x1000.
27–32	*Grandispora echinata* Hacquebard. 27, 28, 29) ST, part, subequatorial region, x5000; ST, proximal surface, x500; TR, proximal focus, x500. 30, 31, 32) ST, part, subequatorial region, x5000; ST, proximal surface, x500; TR, distal focus, x500.

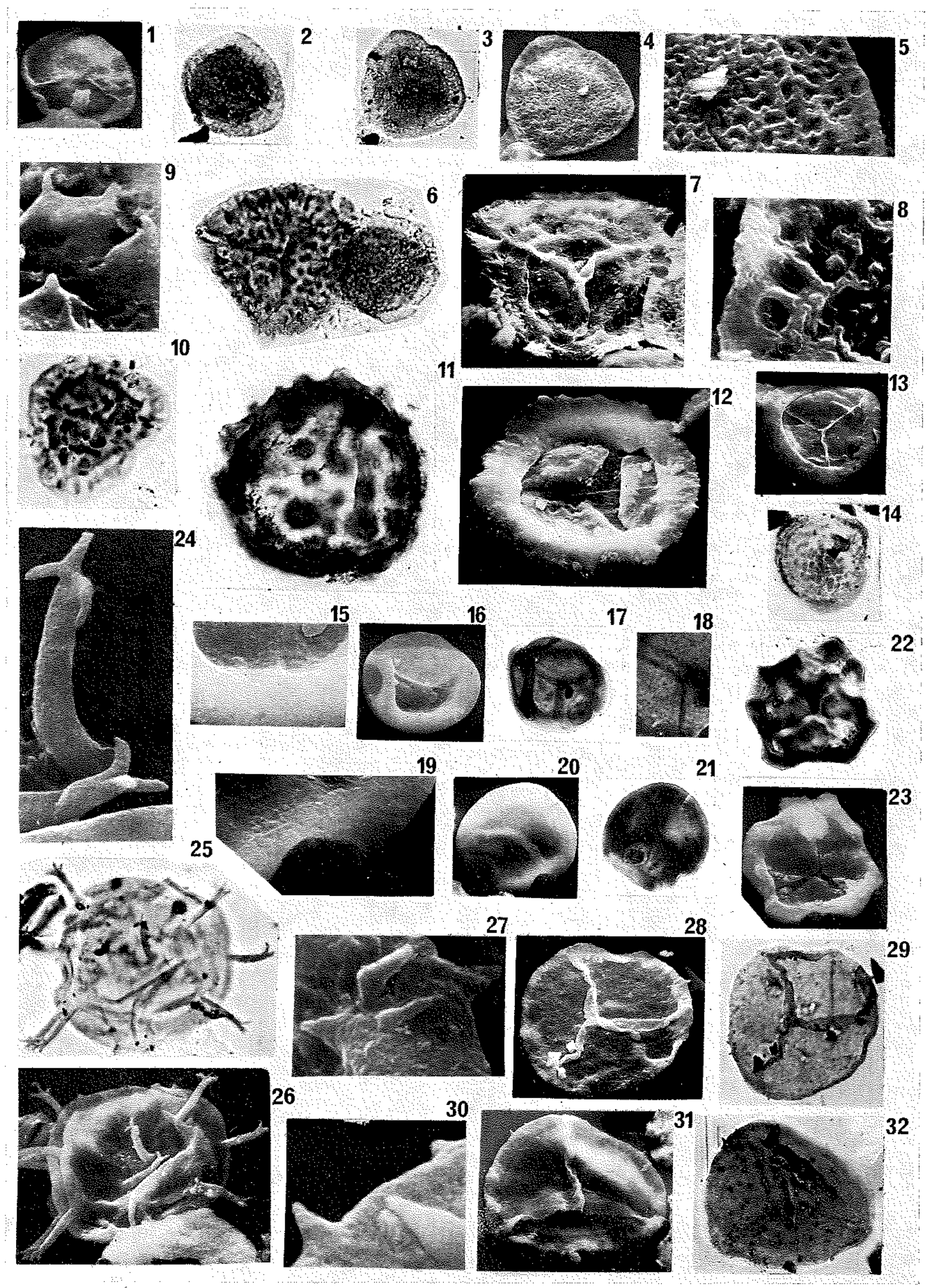

Plate 4

All magnifications x400

Palynomorphs from PLi assemblage zone, 15 feet below top of Saverton Shale, Atlas South, Illinois (loc. 22; USGS Paleobot. Loc. D–4584): Figures 2, 4, 5, 11, 14, and 16–18. Palynomorphs from PLs 2–3 assemblage zone, sample SP–17D from unit 4 of Sappington Member of Three Forks Formation, Peak 9559, Montana (loc. 5; USGS Paleobot. Loc. D–1765–2): Figures 1, 3, 6–10, 12, 13, and 15. All specimens viewed by transmitted light.

Fig.
1–4 *Hymenozonotriletes lepidophytus* Kedo
5 *Hymenozonotriletes famenensis* Kedo
6 *Lophozonotriletes cristifer* (Luber) Kedo
7 *Lophozonotriletes* cf. *malevkensis* Kedo
8 *Vallatisporites vallatus* Hacquebard
9 *Vallatisporites verrucosus* Hacquebard
10 *Vallatisporites pusillites* var. *major* (Kedo) Dolby and Neves
11 *Vallatisporites pusillites* (Kedo) Dolby and Neves
12 *Archaeoperisaccus* sp.
13 *Hystricosporites* sp.
14 *Perotrilites* cf. *perinatus* Hughes and Playford
15 *Pustulatisporites gibberosus* (Hacquebard) Playford
16 *Emphanisporites* cf. *robustus* McGregor
17 *Spinozonotriletes conspicuus* Playford
18 *Raistrickia macrura* (Luber) Dolby and Neves