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Conodont Zonation of the Kinderhookian Series, Washington County, Iowa

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Abstract

Conodonts recovered from Kinderhookian strata in northern Washington County, Iowa, are correlated with exposures previously studied in north-central Iowa, at Burlington, Iowa, and in western Illinois. Paucity of conodonts in the English River Siltstone and lower McCraney Limestone precludes accurate age assignment of these beds. Conodonts diagnostic of the *Siphonodella quadruplicata-S. crenulata* Assemblage Zone (probably upper *cu*I and lower *cu*IIα) occur in the upper part of the McCraney Limestone and lower and middle parts of the Prospect Hill Siltstone. An erosional unconformity is present at the top of the McCraney Limestone in Washington County, Iowa.

The upper part of the Prospect Hill Siltstone and entire Wassonville Dolomite carry a conodont fauna indicative of the *Siphonodella isosticha-S. cooperi* Assemblage Zone suggesting a correlation with the middle and upper *cu*IIα strata in Germany. A disconformity exists between the Wassonville Dolomite and the Burlington Limestone in Washington County, and is marked by a thin glauconitic layer at the base of the Burlington. Elements of the *Gnathodus semiglaber-Pseudopolygnathus multistriata* and the *Bactrognathus-Polygnathus communis* Assemblage Zones are present in the glauconitic bed; however, the two zones are not delimited in Washington County.

Conodonts secured from the Burlington Limestone are forms characteristic of the *Bactrognathus-Taphrognathus* Assemblage Zone (probably upper *cu*IIβ/γ) of the Midcontinent Region.

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Explanation of Plate 3. Magnifications should read . . . Figs. 1,3 are X26; 10,11 are X28; all others are X22.

Explanation of Plate 4. Magnifications should read . . . Figs. 1,4,9 and 11 are X32; all others are X24.

Explanation of Plate 5. Magnifications should read . . . Figs. 1,2 and 6 are X28; 4,5,7 and 8 are X31, 3 is X35.

Explanation of Plate 6. Magnifications should read . . . Figs. 7,8,11 are X21; 14,15 are X29; 2,6,9 are X37; all others are X32.

Explanation of Plate 7. Magnifications should read . . . Figs. 1-4, 6-8,10 and 12 are X29; all others are X42.

Conodont Zonation of the Kinderhookian Series, Washington County, Iowa

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INTRODUCTION AND PREVIOUS INVESTIGATIONS

This investigation is an attempt to collate the previous work on the Kinderhookian Series in Iowa, including the standard section near Burlington, Iowa, the type sections along the English River, Washington County, Iowa, and the North-Central Iowa section in Pocahontas and Humboldt counties. Previous workers have attempted to define and trace the individual units of the Kinderhookian throughout Iowa and correlate them with the standard Mississippi Valley section of Iowa, Illinois, and Missouri.

Initially, the Kinderhookian was defined as the strata lying below the Burlington Limestone and above the "Devonian slates" (Meek & Worthen, 1861). Subsequent redefinitions of the Kinderhookian units resulted in numerous disagreements and contradictory statements. The resultant literature is voluminous. The controversies arose primarily due to discontinuities in the lateral and variable facies relationships of the involved units, which are essentially shales and siltstones. Additional difficulties concern the much debated placement of the Devonian-Mississippian boundary in the Midcontinent Region. Lower units of the originally defined Kinderhookian have subsequently been placed in the Devonian (Collinson & Scott, 1961) using conodonts as time indicators.

Little attempt will be made to discuss the Devon-Carboniferous boundary problem. However, the writer defines the lower Kiñderhookian boundary in Washington County purely on the basis of conodonts. The author feels that the boundary problem has been discussed adequately by previous authors (Collinson, 1961; Klapper, 1962; Collinson *et al.* 1962; Anderson, 1964), and frequent references to their works will be sufficient to support the placement of the lower Kinderhookian boundary at the base of the English River Formation, as defined in this report.

The conodont zones established in Germany, by Bischoff, Voges, and Ziegler for the most part, serve as an international standard reference section for the Devonian and Mississippian Systems. Collinson, *et al.*, 1962, were thus able to recognize the boundary in the Mississippi Valley standard section on the basis of correlation of the Mississippi Valley conodont zones with those in Germany. This correlation resulted in a complete revision of the long accepted boundary definition. These authors found the lower three formations of the original Kinderhookian (Saverton, Sylamore, and Louisiana) to be Devonian in age, and revised the Devon-Carboniferous boundary, and consequently the base of the Kinderhookian, upward to the top of the Louisiana Formation, with a subsequent endorsement of the name Champ Clark Series, which was originally proposed for the same group of strata by Workman & Gillette (1956, p. 14). Collinson *et al.*, (1962) defined the Champ Clark Series as the uppermost Devonian Series in the Mississippi Valley standard section, including, by definition, the Saverton, Sylamore, and the Louisiana Formations.

Hence, the Kinderhookian Series now includes those units underlying the Burlington Limestone and with the base of the Hannibal or "Glen Park" Formations as the lower boundary.

Scott & Collinson (1961), Collinson (1961), and Collinson *et al.* (1964) have worked on the standard section in the Mississippi Valley region of southeastern Iowa, west and southwestern Illinois, and northwest Missouri, whereas, Anderson (1964) investigated the Devonian-Mississippian section of north-central Iowa. The Washington County Devonian-Mississippian sequence was studied by Thomas (1949), Youngquist & Patterson (1949), and Youngquist & Downs (1951). Collinson more recently studied this section and made brief references to it (Collinson, 1961). The Washington County section represents the "link" between the north-central and southeast Iowa provinces in that the stratigraphic relationships of the two provinces may be interpreted by investigation of the respective conodont faunas and pinchouts and intertonguing of the individual units.

PROCEDURES

A representative conodont fauna was recovered from Kinderhookian strata in south-central Iowa. The collecting involved channel sampling of two and one-half-foot intervals and bulk samples (1 kg.) at two-foot intervals of the units involved. The samples were taken from measured sections of the Maple Mill, English River, McCraney, Prospect Hill, Wassonville, and Burlington Formations exposed at four localities in northern Washington County, Iowa. The procedures outlined by Collinson, 1963, were followed for recovery of the conodont faunas from limestones and shales. The residues were placed in a Franz Isodynamic Separator and then hand picked to recover the conodonts.

Preliminary field work was begun in the fall of 1964 and continued through the field seasons of spring and fall of 1965.

ACKNOWLEDGMENTS

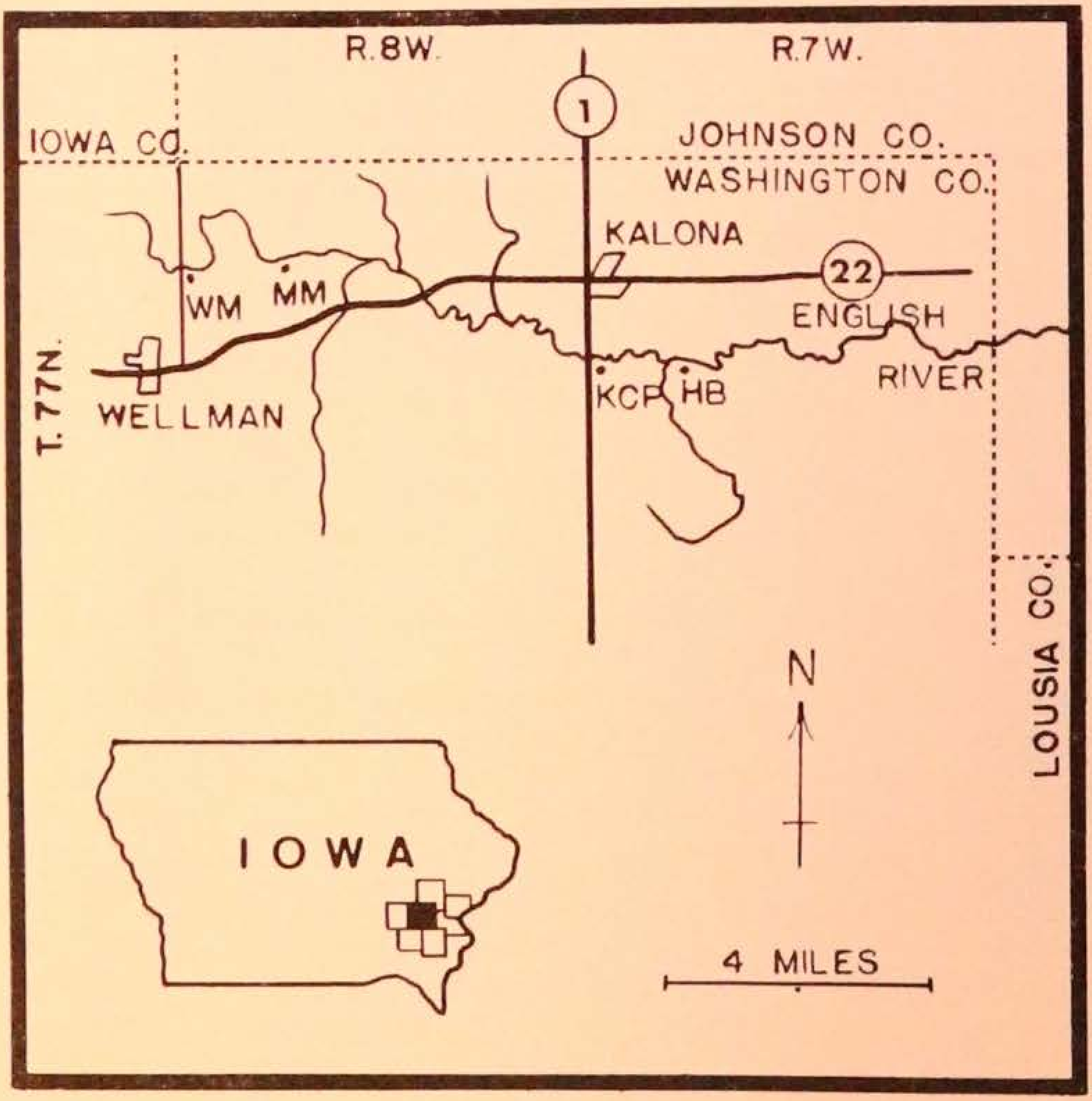
Dr. Brian F. Glenister suggested the problem, directed the project, aided in the preparation of the report, and accompanied the author into the field on several occasions. Mr. Fred Dorheim, of the Iowa Geological Survey, and Dr. W. M. Furnish, of the Department of

Geology, discussed the stratigraphy with the author. Dr. Holmes Semken studied and identified the fish faunas recovered from the material, and Mr. H. L. Strimple pointed out key crinoid horizons in the section. Dr. Charles Collinson gave freely of his time and conclusions, especially concerning the Devonian-Mississippian Boundary problem in Iowa and Illinois. Dr. Gilbert Klapper, Pan American Petroleum Company, discussed distinguishing morphologic characteristics of the faunal elements, particularly his revision of the siphonodellids. Mr. Joseph Kulik discussed environments of deposition and subsurface stratigraphy of the Kinderhookian units in the surrounding region. Mr. Richard Beinert discussed some of the Maple Mill faunal and stratigraphic implications. My wife, Margaret, served as field assistant and typed the manuscript.

COLLECTING LOCALITIES

Wassonville Mill Locality (designated WM on index map). Seven-

Figure 1
Index and Locality Map



teen feet of Wassonville dolomite and eleven feet of Burlington dolomite are exposed in a quarry on the south bank of the English River about one mile north of Daytonville, Iowa, at SW¼, SW¼, sec. 7, R.8W., T.77N., Washington County, Iowa. The Burlington Formation is extremely cherty throughout the exposure, with thin discontinuous chert bands spaced two to three inches apart. A thin glauconitic bed marks the base of the Burlington, and separates the buff dolomite of the Burlington from the lithologically similar Wassonville Formation below. The Wassonville dolomite contains nodular chert, which may be up to five inches thick in places. The Wassonville, at this locality, is more thickly bedded than the Burlington, and this feature, along with the chert variations and glauconite bed, serve to make the two formations visually distinguishable. Conodonts were recovered from the middle portion of the exposed Burlington, the basal glauconitic zone, and from throughout the Wassonville strata exposed.

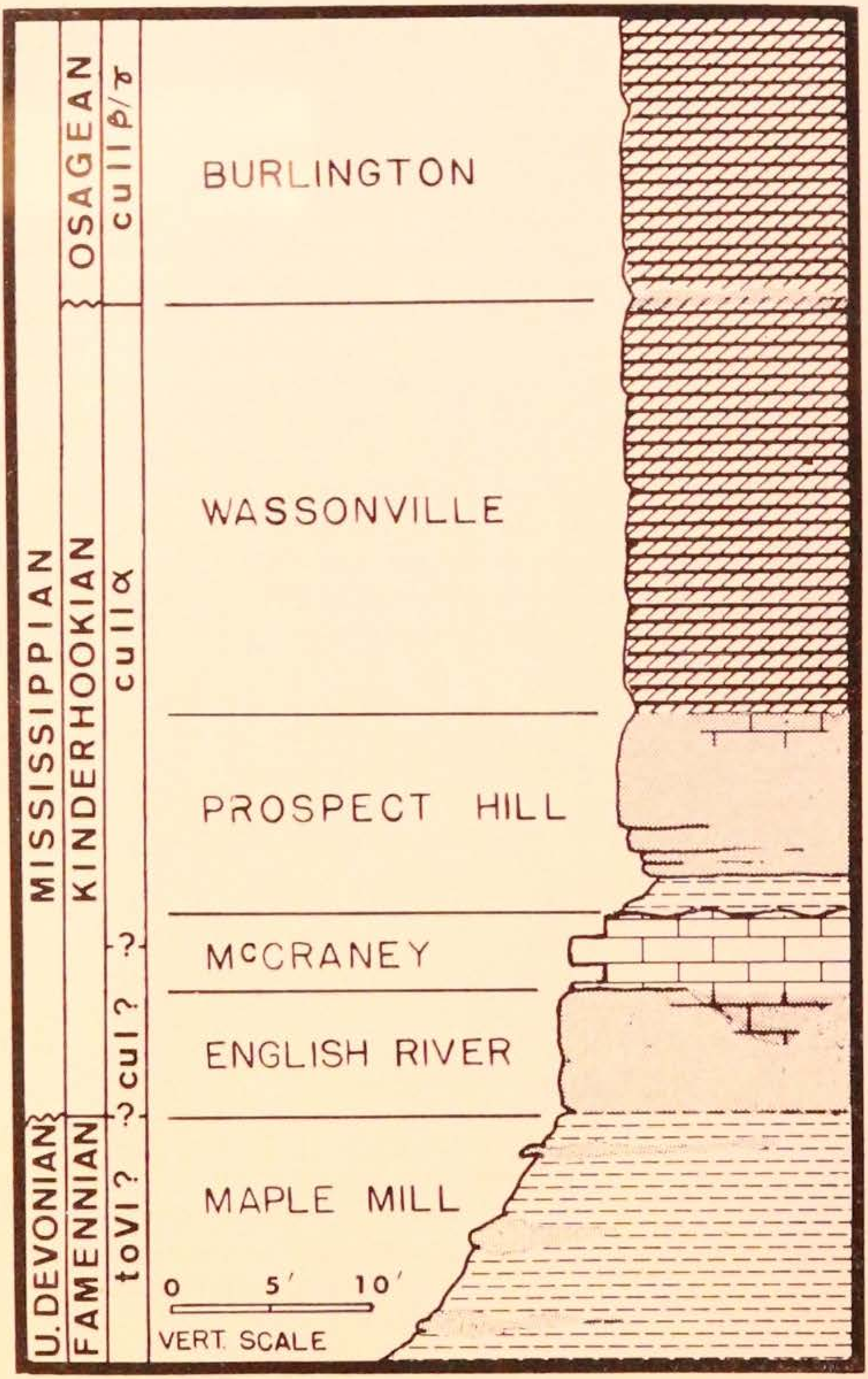
Maple Mill Locality (designated MM on index map). Eight feet of white, English River Siltstone are exposed at the base of this section, and grade upward into two feet of deep red, semi-lithographic limestone of the McCraney Formation. The McCraney appears to have an undulating "erosion" surface at the top, which can best be examined by carefully scraping away the overlying shale-mudstone unit. The shale-mudstone layer is the basal unit of the Prospect Hill Formation in the area, and contains a bone fragment zone near its base. The bone residue appears to be concentrated in the low areas of the erosion surface. A one and one-half to two-foot reddish siltstone unit represents the upper portion of the Prospect Hill in this region. The Prospect Hill Siltstone grades upward into the Wassonville Formation, which is approximately seventeen feet thick at this locality.

This section is exposed about 200 yards downstream of the bridge in a cut bank of the English River, at NW¼, SE¼, sec. 8, R.8W., T.77N., Washington County, Iowa, one mile east of the town of Daytonville, Iowa.

Few conodonts were recovered from the English River Siltstone, but the rest of the formations yielded abundant, well-preserved faunas. The bone residue at the base of the Prospect Hill Formation is exceptionally productive, and yielded over one-half the total number of conodonts of this investigation.

Kalona Clay Pit Locality (designated KCP on index map). An exposure containing eleven feet of Maple Mill Shale, seven feet of English River Siltstone, and ten feet of Prospect Hill Siltstone (including a three-foot basal shale unit) is situated one mile south of the intersection of Highways 1 and 22, on the south bank of the English River, at NW¼, NW¼, sec. 19, R.7W., T.77N., immediately south of the town

Figure 2
Generalized Columnar Section



of Kalona, in Washington County, Iowa. The succession at this locality is similar to that at the Maple Mill locality, however, the units are somewhat thicker here. No McCraney Limestone was observed at this location. The Wassonville-Prospect Hill contact is exposed along the bluff about 330 yards downstream from the highway bridge. A thin "fish-tooth" layer marks the base of the Wassonville at this locality.

Random samples were collected from the shale units at this locality. The conodont fauna recovered from the basal Prospect Hill shale unit is the same as that of the shale unit at the Maple Mill locality.

High Bridge Locality (designated HB on index map). This locality is a road cut approximately two miles southeast of Kalona, Iowa, at NE¼, NW¼, sec. 20, R.7W., T.77N., on the south bank of the English River, Washington County, Iowa. Fifteen feet of Maple Mill Shale are exposed at the base of the section. Four feet of English River Siltstone overlie the shale, which, in turn, is overlain by ten feet of Prospect Hill Siltstone (including a two-foot basal shale unit). A two-inch thick continuous chert layer caps the exposure, and may represent the base of the Wassonville. A similar chert band is common at, or near, the Wassonville base wherever the unit is exposed in Washington County. The English River Formation was barren of conodonts at this locality, whereas the Prospect Hill Formation yielded a well-preserved and abundant conodont fauna.

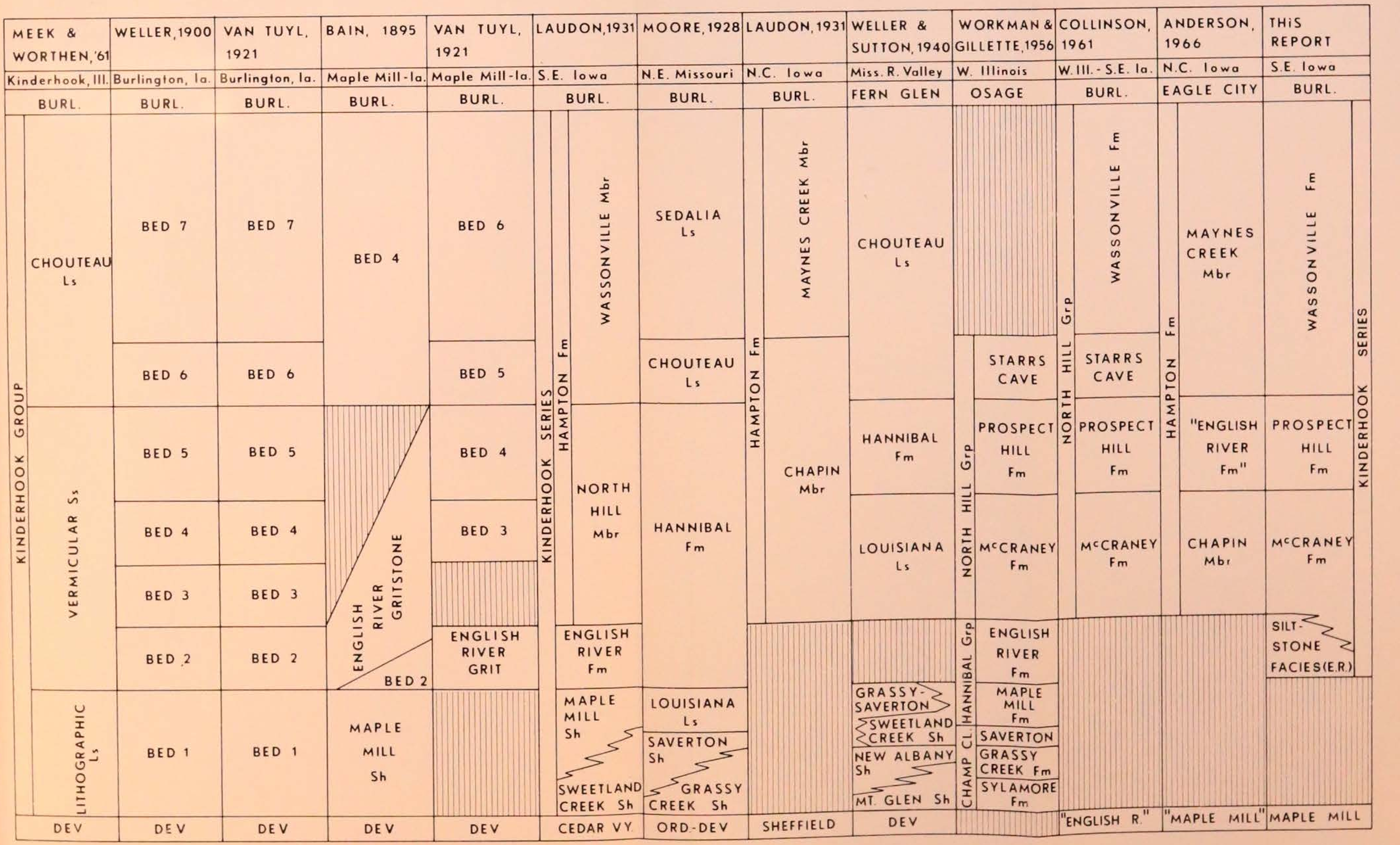
Figure 3 has been constructed in an effort to illustrate evolution of the thinking concerning terminology and vertical and horizontal relationships of all the nomenclature. Examination of the chart should help to point out previous errors in correlation and age determinations, and may be a useful guide summarizing the following section.

PREVIOUS WORK ON THE KINDERHOOKIAN SERIES

In 1856, Swallow correlated the Chouteau Limestone, Vermicular Sandstone, and the Lithographic Limestone of Missouri with the Chemung Formation of New York. James Hall (1858, p. 46) also regarded the strata between the Burlington Limestone and the "Chattanooga Shale" as Chemung in age. In 1860, C. A. White questioned the Chemung age assignment of these beds, and demonstrated that their faunas were more closely related to those of the overlying Sub-Carboniferous than to the Chemung. In 1861, Meek & Worthen recognized that the faunas of these beds were distinctly younger than the Chemung Formation of New York, and proposed that they be called the Kinderhook Group, after the town of Kinderhook, Illinois, where the beds were well exposed. The Kinderhook Group of Meek & Worthen included, by definition, the Lithographic Limestone (Louisiana), Vermicular Sandstone (Hannibal), and Chouteau Limestone. This same

MEEK & WORTHEN,'61		WELLER,1900	W & 956	COLLINSON, 1961		ANDERSON, 1966		THIS REPORT	
Kinderhook, Ill.		Burlington, Ia.	B	W. Ill. - S.E. Ia.		N.C. Iowa		S.E. Iowa	
BURL.		BURL.		BURL.		EAGLE CITY		BURL.	
KINDERHOOK GROUP	CHOUTEAU Ls	BED 7		NORTH HILL Grp	WASSONVILLE Fm	HAMPTON Fm	MAYNES CREEK Mbr	WASSONVILLE Fm	KINDERHOOK SERIES
		BED 6	S		STARRS CAVE				
	VERMICULAR Ss	BED 5	CT		PROSPECT HILL Fm		"ENGLISH RIVER Fm"	PROSPECT HILL Fm	
		BED 4	EY		McCRANEY Fm		CHAPIN Mbr	McCRANEY Fm	
		BED 3							
		BED 2	SH					SILT-STONE FACIES(E.R.)	
	LITHOGRAPHIC Ls	BED 1	E ON m RE						
DEV		DEV		"ENGLISH R."		"MAPLE MILL"		MAPLE MILL	

Figure 3
Previous Nomenclatorial and Correlation Summary Chart



classification was later applied to equivalent strata in Iowa (Van Tuyl, 1921). Moore (1928) moved the lower boundary of the Kinderhook Group down to include the Grassy Creek and Saverton Formations, on the basis of his recognition of an "unconformity of importance" at the base of the Grassy Creek, and the coincidence of distribution of these units with that of the rest of the overlying Kinderhookian strata.

Laudon (1931) investigated the strata of southeastern and north-central Iowa, and placed the lower boundary of the Kinderhookian below the "Chattanooga" Shale and suggested that the erosional unconformity, which beveled the Cedar Valley, Sheffield, and Lime Creek Formations, which the base of the "Chattanooga" represents, marked the beginning of Kinderhookian time.

In 1940, Weller & Sutton proposed the term Iowa Series for those beds previously called Lower Mississippian in the Mississippi Valley region. These authors included within the Iowa Series the Kinderhook, Osage, and Meramec Groups, apparently overlooking Moore's suggestion that the Kinderhookian be elevated to Series rank. Moreover, Weller & Sutton included within the Kinderhook Group the New Albany Shale, Mountain Glen Shale, Grassy-Saverton Shale, Sweetland Creek Beds, Louisiana Limestone, Hannibal Shale, Springville Shale, Chouteau Limestone, and the Rockford Limestone.

Weller *et al.* (1948) divided the Kinderhookian Series into the upper Easley Group and lower Fabius Group. The Easley Group included all the formations above the top of the Louisiana Limestone and below the Burlington Limestone, and the Fabius Group included all the formations below the top of the Louisiana Limestone and above the base of the Sylamore Formation.

Workman & Gillette (1956, p. 14) suggested that the term Fabius Group be suppressed on the grounds that the formations included within the definition of the group are not exposed in the type area along the Fabius River in northeastern Missouri. These authors suggested, instead, the name Champ Clark Group for these formations, for an exposure at Champ Clark Bridge, near Louisiana, Missouri. In addition, they proposed that the Kinderhookian Series be divided into three groups; the Champ Clark Group at the bottom, Hannibal Group (including the "Glen Park," Maple Mill, and English River Formations) in the middle, and the North Hill Group (including the McCraney, Prospect Hill, and Starrs Cave Formations) at the top. The Hannibal and North Hill Groups replaced the Easley Group of Weller *et al.* (1948).

Mehl (1960) discussed the age and stratigraphic relationships of the beds at the Kinderhookian type section and pointed out that the Maple Mill Shale was considered to be Devonian in age by Thomas

(1949), and that the McCraney was also believed to be Devonian by some authors. He concluded that there are no Lower Mississippian strata at the type Kinderhookian section.

Collinson (1961) cited the conodont work of Scott & Collinson (1961) which indicated an Upper Devonian age for the Sylamore, Grassy Creek, Saverton, and Louisiana Formations in the standard Mississippian section. This conodont evidence also supported a lowermost Mississippian age assignment for the overlying "Glen Park" Formation. Collinson (1961, p. 102) concluded that the formations previously referred to the Fabius Group (Weller *et al.*, 1948) and the Champ Clark Group (Workman & Gillette, 1956) and considered as Devonian or Mississippian, be assigned to the Upper Devonian Series. Consequently, the Kinderhookian Series in the standard section is now defined as bounded at the top by the base of the Burlington and at the bottom by the base of the "Glen Park," or where it is absent, by the base of the Hannibal (Collinson, 1961, p. 102).

The units included within the Hannibal Group (Workman & Gillette, 1956) were studied by Scott & Collinson (1961) and the stratigraphic implications of the included conodont faunas was reviewed by Collinson (1961, p. 106-107). The conodont fauna of the Maple Mill Shale (at the standard section and in Washington County, Iowa) proved to be Late Devonian in age.

House (1962) recovered a clymeniid ammonoid fauna, and Collinson (1961) reported a conodont fauna, from the English River Formation at Burlington, both of which indicated Devonian age. Collinson (1961, p. 106) implied that the "English River" Formation at Burlington must be equivalent to the upper Saverton, and the "Maple Mill" Formation equivalent to the lower Saverton, Grassy Creek, and Sylamore Formations. The English River Formation in Washington County, Iowa, however, yielded a Hannibal (Mississippian) conodont fauna (Collinson, 1961) and was considered to be equivalent to some part of the Hannibal Formation in the standard section.

Collinson (1961) continued usage of the term North Hill Group (Workman & Gillette, 1956), and noted that the Wassonville Formation of Iowa is lithologically similar to the other formations in the group, and nearly coincident with the geographic extent of the other formations in the group; Collinson included the Wassonville Formation within the North Hill Group.

In Washington County, the English River Formation appears to be Lower Mississippian in age, and its base marks the base of the Kinderhookian Series in the area. The Prospect Hill and Wassonville Formations in Washington County, Iowa, yielded conodont faunas equivalent to the German *cu*IIα strata.

The range of the genus *Siphonodella* corresponds to the interval of the Hannibal and Chouteau Formations of the Mississippian standard section, which are *cu*I through *cu*II$^{\alpha}$ equivalents (Collinson *et al.*, 1962, chart 5). The uppermost occurrence of *Siphonodella* marks the Kinderhookian-Valmeyeran boundary (Collinson *et al.* , 1962, p. 14). *Siphonodella* ranges through the Prospect Hill and Wassonville Formations in Washington County, but is absent in basal Burlington strata.

The Kinderhookian Series of Washington County, Iowa, is herein defined as the strata underlying the Burlington Formation and overlying the Maple Mill Shale. This designation includes strata ranging in age from lower *cu*I through *cu*II$^{\alpha}$. The Series may be correlated with the Tournasian in Germany.

FAUNA AND CORRELATION

Maple Mill Formation. Peterson (1947) described a conodont fauna from a unit which he considered to be the Maple Mill Shale, and which contained conodont genera diagnostic of both Devonian and Mississippian. In addition, he noted the greater abundance of Mississippian forms in the fauna, and concluded that the Maple Mill was basal Kinderhookian in age. Peterson (1947, p. 6) correlated the shale with the Bushberg and Hannibal of Missouri and the "Bushberg-Hannibal" (pre-Weldon Shale) Formation of Oklahoma.

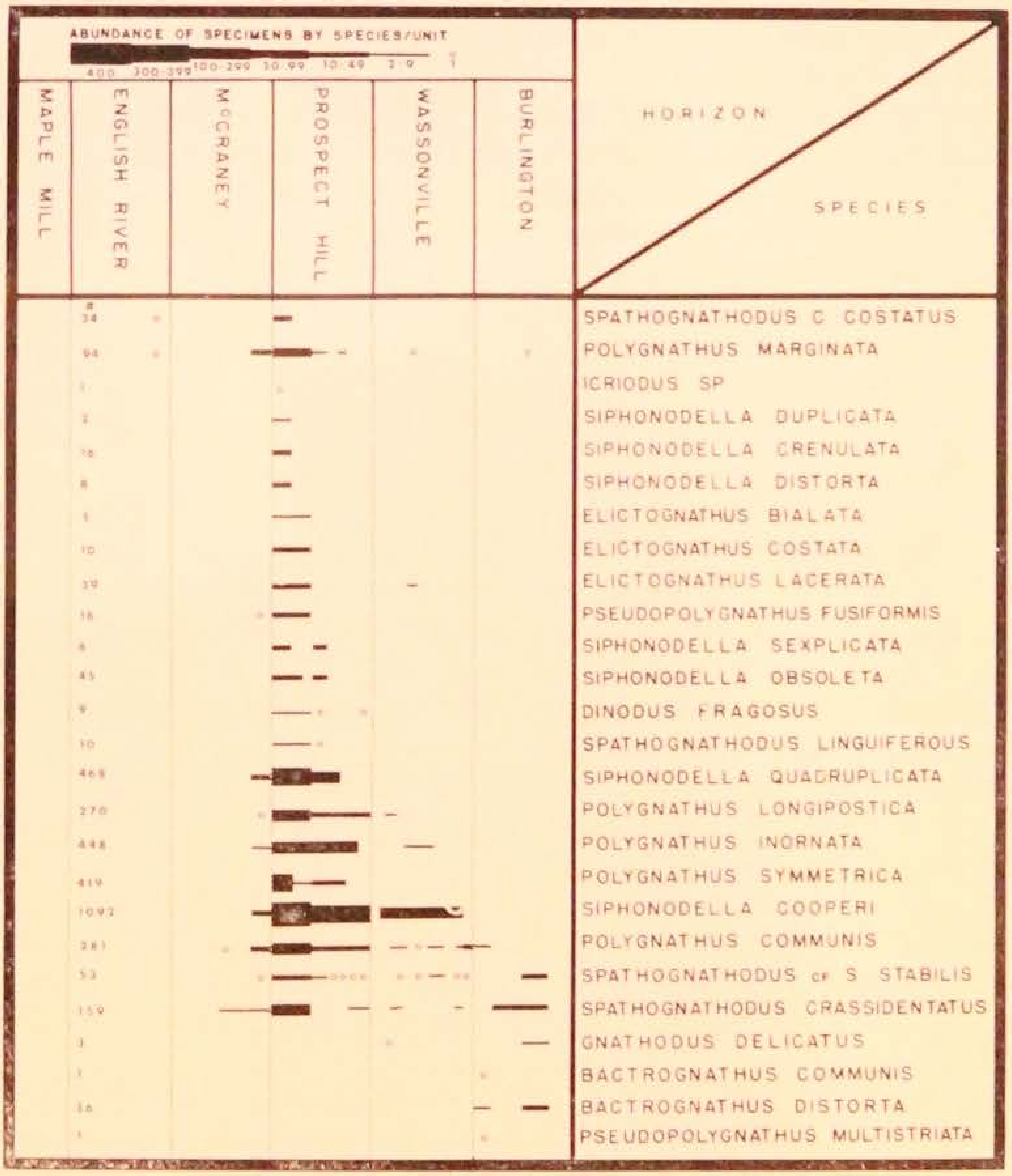
In 1949, Thomas reported a conodont fauna from the Maple Mill Shale in the type area, and correlated it with the Saverton Shale of Missouri (Grassy Creek of his usage).

Scott & Collinson (1961, p. 104) recovered a fauna from the type Maple Mill Shale, and stated that it was contemporaneous with the *to*IV portion of the Saverton Shale. They suggested that the Maple Mill of Iowa represents a northern, silty extension of the Saverton of Missouri.

Anderson (1966) sampled a shale unit overlying the Aplington Formation in north-central Iowa, which he called the "Maple Mill" Shale. He suggested that (p. 401) "the entire sequence of 'Maple Mill,' Aplington and Sheffield Formations of north-central Iowa may actually correspond to the Maple Mill Shale of south-central Iowa." In addition, Anderson (1966, figure 3) correlated the "Maple Mill" with the upper part of the Saverton Shale, but did not designate an upper boundary, implying that the "Maple Mill" may range as high as *to*V or *to*VI in age.

Collinson (1967, personal communication) stated that the Maple Mill is currently considered to be restricted by differentiation of the Lime Creek, Sheffield, and Aplington Formations. He further states that the Maple Mill conodonts are late Famennian in age. However,

Figure 4
Faunal Abundance and Range Chart



Mr. Richard Beinert (1968, personal communication) who is currently studying exposures of the uppermost Maple Mill strata in Washington County, Iowa, reports recovery of a few Lower Mississippian conodonts from these strata, which he considers to be "leaked" from overlying beds.

The writer recovered a sparse conodont fauna from random samples in the upper portion of the Maple Mill Shale exposed at the High Bridge and Clay Pit localities, Washington County, Iowa.

English River Formation. Bain (1895, p. 322) proposed the name English River Gritstone for exposures along the English River, Washington County, Iowa, and correlated the unit with the "yellow sand layer" at Burlington, Iowa. Moore (1928, p. 50) noted the abundant sandstones and siltstones in the upper parts of the Hannibal Formation, and stated (p. 56) that the sandy beds at Kinderhook, Illinois are the equivalents of the English River Siltstone at Burlington and the English River Formation in Washington County, Iowa. Weller (1900), Van Tuyl (1921), and Laudon (1929) correlated the English River with the Hannibal Shale of Missouri on the basis of the macrofauna. Thomas (1949) reported a Mississippian conodont fauna from the type English River.

Collinson (1961) investigated the conodont faunas of the English River Formation at the type section, and at Burlington. He recovered a Devonian conodont fauna from the siltstone at Burlington, and assigned an Upper Devonian age to the unit. This age assignment was established by House (1962) who reported clymeniid ammonoids from the same strata. The conodonts recovered from the type English River, however, proved to be Mississippian in age (Collinson, 1961, p. 106). Collinson concluded that the English River at Burlington is contemporaneous with part of the Saverton Shale, and that the English River type section (Washington County, Iowa) is equivalent to the Hannibal Shale, in part.

More recently, Collinson (1967, personal communication) commented on the age difference of the type English River, and the so-called "English River" at Burlington, and stated that in view of this age difference "it seems desirable to recognize the beds at Burlington as belonging to the Maple Mill inasmuch as the Maple Mill contains identical, though thinner, siltstones both at Burlington and other places."

Anderson (1964; 1966) reported a conodont fauna from the "English River" Formation of north-central Iowa, which he considered to be *cu*I-*cu*IIα in age. According to Anderson (1964, p. 33), well records establish the presence of two siltstones, "English River" and "Prospect Hill" (Anderson's usage) in north-central Iowa. These units are separated by a limestone unit ("McCraney" of Anderson's usage). This sequence may represent, in north-central Iowa, the English River-McCraney-Prospect Hill succession of southeastern Iowa. Anderson sampled the "only siltstone exposed at the surface" which he considered to be the "English River" Formation. Only two conodonts were recovered from the English River type section, neither of which was recorded in Anderson's "English River" fauna. Anderson's entire conodont fauna is represented in the Prospect Hill fauna of Washington County. This resemblance of the "English River" fauna to that of the Prospect Hill of this report, and the absence of the two English River species from the north-central Iowa "English River" Formation, seems to justify correlation with Anderson's "English River" Formation with the Prospect Hill Formation of Washington County, rather than with the type English River.

Polygnathus marginata and *Spathognathodus costatus costatus* represent the entire type English River fauna recovered during this study. *P. marginata* has been reported from the Bushberg (Branson & Mehl, 1934) and from the German *cu*II strata (Bischoff, 1957), and *S. costatus costatus* was reported from the Hannibal (Branson, 1934) and from *to*VI strata, with isolated occurrences in Lower and Middle *cu*I strata in the Sauerland. No specimens of *Siphonodella* were recovered from the siltstone.

Collinson (1967, personal communication) stated that the type English River contains an unequivocal Kinderhookian conodont fauna, and on this basis, and in conjunction with the fauna recovered in this study, the English River Formation in Washington County, Iowa, can be assigned a Lower Mississippian (probable *cu*I) age, and the Devonian-Mississippian Boundary placed at its base.

Mr. Fred Dorheim (1967, personal communication) of the Iowa Geological Survey, stated that the survey recognizes that the English River Siltstone is Mississippian in age, however, for convenience in logging and correlation, the systemic boundary is placed at the base of the McCraney Formation, which is easily recognized in the subsurface. Collinson (1967, personal communication) is in agreement with this arrangement as a matter of convenience.

It seems appropriate here to discuss a possible alternative to the long-standing nomenclatorial problems associated with the English River Siltstones and other similar units in the upper Maple Mill Formation.

The term English River, as originally proposed, was applied to the siltstone exposed along the English River in Washington County, Iowa. Subsequent designation of the siltstone at Burlington, Iowa, as "English River" was based on its similarity of position in sequence as the type English River. It appears probable, from several lines of evidence that these two siltstones (at Burlington and in Washington County) are not equivalent, but actually discontinuous and distinct. As previously mentioned, Collinson has shown that the two units are faunally dissimilar. Moreover, he recognized that the so-called "English River" is lithologically indistinguishable from thinner siltstone beds scattered throughout the upper Maple Mill Shale at Burlington. An unconformity occurs at the top of the siltstone at Burlington which may progressively bevel the unit in a northward and westward direction, effecting removal of the unit in Washington County, Iowa. An apparent faunal unconformity at the base of the type English River supports the idea that uppermost Maple Mill sediments were removed in this area.

There are minor lithologic differences between the siltstones in the two areas. The siltstone at Burlington is somewhat more calcareous than that in Washington County, and is more massively bedded than the type English River.

A further line of evidence supports the possibility that the two siltstones are not equivalents. The basal McCraney Formation, in Louisa County, Iowa, is quite sandy (especially in well samples), suggesting that the type English River Formation may be an equivalent of the lower and middle McCraney Formation at Burlington.

In deference to these remarks, the writer proposes suppression of the term English River, or "English River," as previously used in reference to the siltstone at Burlington, restricting the term to use to that siltstone in the type area, along the English River, in Washington County, Iowa.

The writer recognizes the alternative that the two siltstones may be lateral equivalents and, thereby, time-transgressive, however, the current available evidence more strongly suggests discontinuity of the silt bodies.

McCraney Formation. Moore (1928, p. 21) first proposed the term McCraney (originally spelled McKerney) Formation for a "Lithographic" limestone exposed in McCraney Creek, near Kinderhook, Illinois. The formation was designated as the upper unit of Moore's Hannibal Formation in Missouri.

In 1929, Laudon (p. 267-268) defined the lithology of the North Hill Member of the Hampton Formation, exposed at Burlington, as a basal, semi-lithographic limestone unit, a sandstone unit and a thin oolitic unit. The semi-lithographic unit was correlated, by Laudon, with Moore's McCraney Limestone.

Workman & Gillette (1956, p. 28) continued usage of the term North Hill, but raised it to group status, and included within it, by definition, the Starrs Cave, Prospect Hill, and McCraney Formations, in descending order.

Collinson (1961, p. 107) reported a conodont fauna from the McCraney Formation, at Cascade Station, in Burlington, which ". . . clearly shows the McCraney to be of Mississippian age and correlative with part of the Chouteau."

Scott & Collinson (1961, p. 119) recovered a sparse conodont fauna from the McCraney Formation at Burlington, which is dominated by *Siphonodella* and consists entirely of Mississippian species. The Mc-

Craney fauna was correlated with the upper half of the *Gattendorfia*-Stufe (*cu*I), and the lowermost part of the *Pericyclus*-Stufe (*cu*IIα) in Europe.

The conodonts recovered from the McCraney Formation (see figure 4) in Washington County, were secured from the upper half of the exposed unit, the lower half being barren. The fauna resembles that described by Scott & Collinson (1961). Siphonodellids dominate the fauna, and *Polygnathus communis* is the next most abundant element. *P. communis* is especially abundant in Lower Mississippian rocks (Scott & Collinson, 1961, p. 119). The two McCraney faunas differ in other significant aspects, however. The Washington County material does not contain *Dinodus fragosus* and *Elictognathus lacerata*, which were reported from the McCraney at Burlington.

Siphonodella quadruplicata, *Polygnathus marginata*, and *Pseudopolygnathus fusiformis* are present in the Washington County McCraney, but were not reported from the McCraney at Burlington (Scott & Collinson, 1961). These three species first appear at the base of *cu*IIα strata in Germany. The presence of these somewhat younger elements throughout the upper portion of the McCraney Formation in Washington County suggests correlating it with the middle and upper McCraney Formation at Burlington, and with most of the Upper *cu*I and Lower *cu*IIα subzones of the *Gattendorfia*- and *Pericyclus*-Stufen respectively. Part of the McCraney in Washington County has been removed by post-McCraney erosion as evidenced by the undulating upper surface of the unit, and a lag concentrate (fish plate) residue in the trough areas on the surface.

Conodont elements contemporaneous with this period of erosion were recovered, with an admixed fauna, from the overlying Prospect Hill shale unit. It appears probable that there is some portion of *cu*IIα strata missing at the top of the McCraney Formation, at least in Washington County (see figure 5).

Time equivalency of the McCraney Formation with the north-central Iowa section remains in doubt; however, it seems probable that the "McCraney" (Anderson, 1964) may be the subsurface equivalent, and the hiatus indicated on the regional correlation chart (see figure 5) represents a knowledge gap in north-central Iowa, rather than a physical break, or missing section.

Prospect Hill Formation. Moore (1928, p. 23) defined the Prospect Hill Formation as Van Tuyl's (1921) bed 5 at Prospect Hill, Burlington, Iowa. He remarked on the lithologic similarity to the English River Siltstone and the faunal dissimilarity with that unit. He further stated that although a large Chouteau faunal element was recovered from the Prospect Hill, the Formation most probably is best correlated with the uppermost Hannibal Formation.

Laudon (1929) recognized the siltstone unit at Burlington, and included it as a unit within the North Hill Member of the Hampton Formation.

Thomas (1949) recovered a conodont fauna from the Prospect Hill Siltstone, at the Maple Mill Locality, which he correlated with the Hannibal fauna. He suggested that the Hannibal grades laterally into the English River and Prospect Hill Formations of Washington County.

Youngquist & Patterson (1949) reported a conodont fauna from the Prospect Hill Formation exposed at Burlington, in Louisa County, and in Washington County. Their fauna closely compares with that of the Prospect Hill Formation of this report.

Workman & Gillette (1956, p. 30) correlated the Prospect Hill Formation (of Illinois) with the Chouteau Formation in Missouri, but cautioned that ". . . it may be a lens of siltstone in the midst of a limestone succession."

Collinson (1961) recovered a conodont fauna from the Prospect Hill Formation at Burlington, which resembles that of the upper Chouteau Formation.

The conodont fauna of the "English River" Formation of north-central Iowa (Anderson, 1964; 1966) is entirely represented in the Prospect Hill fauna, as herein described. The so-called "English River" (Anderson, 1966) of north-central Iowa is a misnomer.

Workman & Gillette (1956) and Collinson (1961) cited evidence of an erosional unconformity at the top of the McCraney Formation in Illinois. A similar erosion surface is present at the top of the McCraney in Washington County. Overlying this undulating surface is a two-inch claystone layer, and above it is a four-inch blue-green shale. The claystone contains abundant glauconite "pellets" and a "fish-plate" concentrate. The shale unit is considered the basal portion of the Prospect Hill Siltstone. The contained conodont fauna of the shale is somewhat older in aspect as compared to that of the overlying siltstone and underlying McCraney Limestone. *Siphonodella duplicata*, *S. crenulata*, *Dinodus fragosus*, *Elictognathus bialata*, *E. lacerata*, and *Spathognathodus costatus costatus* were recovered from the shale member (including the claystone unit) at the Maple Mill and High Bridge localities. S. *costatus costatus* has not been recovered from rocks younger than *cu*I in age. The remaining above mentioned species are characteristic forms of the McCraney Formation at Burlington (Scott & Collinson, 1961), and are indicative of the *Siphonodella duplicata* Assemblage Zone (Collinson, *et al.*, 1962) and of Upper *cu*I through Lower *cu*II∝ strata in Germany.

The shale unit also contains diagnostic species of the *Siphonodella quadruplicata-S. crenulata* Assemblage Zone, however, the upper boundary of this Assemblage Zone can be placed at the base of the upper third of the siltstone portion of the formation—the uppermost occurrence of *S. quadruplicata.*

Wassonville Formation. Bain (1895, p. 322) proposed the name Wassonville Formation for a thirty-five-foot earthy, magnesian limestone exposed at Wassonville Mill, on the English River, Washington County, Iowa.

Youngquist & Downs (1951) sampled what they thought to be the Wassonville strata exposed at the Kalona Clay Pit locality, and listed (p. 785) the stratigraphic section as follows:

Wassonville	*Feet*
4. Dolomite, brown, fractured containing one chert band, fossiliferous, basal part containing much reworked English River grit	5
3. Shale, blue to gray, soft, unctuous, carrying chunks of English River grit. Numerous fish in base.	6
English River	
2. Gritstone, blue to gray, massive, very fossiliferous	5
1. Shale, deep blue to gray, very soft, unctuous, carbonaceous and stained at top, filled with pyrite in lower part, unfossiliferous	14

These authors stated (p. 785) that their conodont fauna ". . . came from the middle and upper portions of the six-foot shale unit (no. 3) at the base of the Wassonville," and that no conodonts were recovered from the overlying "dolomite."

The writer proposes that units 3 and 4 of Youngquist & Downs' "Wassonville" Formation are actually the basal shale and siltstone units, respectively, of the Prospect Hill Formation. Youngquist & Downs' conodont fauna is identical to the Prospect Hill faunas from the Maple Mill and High Bridge localities, and furthermore contains specimens of *Siphonodella quadruplicata*, *S. duplicata*, and *Elictognathus lacerata* which are not represented in the Wassonville faunas of this report. The "Wassonville" Formation of Youngquist & Downs is therefore considered to be the same unit as the Prospect Hill as herein defined.

Collinson (1961) reported that the oolitic Starrs Cave Formation, at Burlington, is barren of conodonts. An "oolitic" zone near the base of the Wassonville, in Washington County, proved to be barren of conodonts also, and on this basis, and on lithology, is correlated with the Starrs Cave Formation (see figure 5).

Anderson (1964) recovered a conodont fauna from the lower five feet of the Maynes Creek Member of the Hampton Formation at several localities in north-central Iowa. The Maynes Creek fauna (Anderson, 1964, table 5) contains *Siphonodella quadruplicata* and *S. obsoleta* which are not represented in the Wassonville fauna of this report, but are present in the Prospect Hill of Washington County. This seems to indicate that the lower five feet of Maynes Creek is slightly older than the base of the Wassonville and may be equivalent to the uppermost Prospect Hill. By position in sequence, this would place the Chapin Member, of north-central Iowa equivalent to some portion of the Prospect Hill.

The conodont fauna of the upper Prospect Hill and the entire Wassonville Formations closely resembles that of the *Siphonodella isosticha-S. cooperi* Assemblage Zone (Collinson, *et al.*, 1962), and correlative with the uppermost *cu*IIα zone in Germany. In Washington County the upper limit of this zone is marked by the disconformable relationship of the Wassonville and Burlington Formations. This disconformity is contemporaneous with the "major unconformity in the Mississippi Valley" of Collinson, *et al.* (1962, p. 22).

Burlington Formation. A sparse conodont fauna was secured from the Burlington Limestone exposed at the top of the Wassonville Mill section. A basal glauconitic layer of the Burlington contains an admixed, as well as an indigenous fauna. Some conodont elements, diagnostic of the *Gnathodus semiglaber-Pseudopolygnathus multistriata* and *Bactrognathus-Polygnathus communis* Assemblage Zones (Collinson, *et al.*, 1962), are present in the glauconite unit. These zones are not otherwise delimited in Washington County.

Bactrognathus distorta, a form common throughout the remaining portion of the exposed Burlington strata, is diagnostic of the *Bactrognathus-Taphrognathus* Assemblage Zone of the upper part of the Burlington. Collinson, *et al.* (1962, p. 23) stated that the "lower part of the *Bactrognathus-Taphrognathus* Assemblage Zone is readily distinguished by undescribed z-shaped bactrognathids" (herein referred to *B. distorta*), and correlated the zone with the upper part of the German *cu*IIβ/γ zone. The conodont fauna secured from the Burlington is dominated by *B. distorta*, and seems to justify correlating the exposed portion of the Burlington Formation, in Washington County, Iowa, with the *Bactrognathus-Taphrognathus* Assemblage Zone of the Midcontinent Region, and with the upper *cu*IIβ/γ strata in Germany. It is evident that a hiatus of considerable magnitude (lower and middle *cu*IIβ/γ) exists at the base of the Burlington Formation in Washington County.

SUMMARY AND CONCLUSIONS

Placement of the Devonian-Mississippian Boundary in the Washington County section cannot be determined accurately from the data

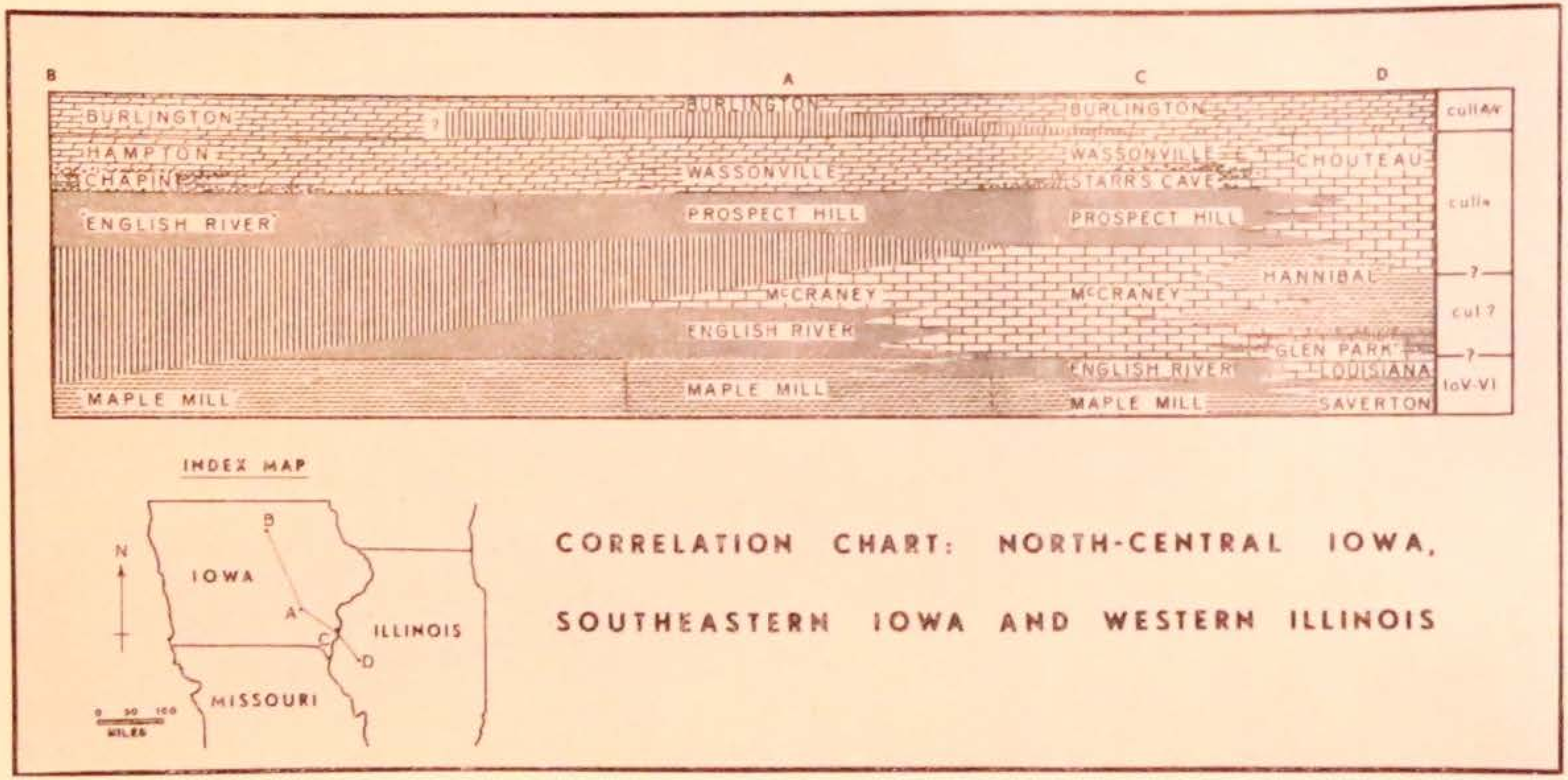


Figure 5
Correlation Chart

secured during this study. However, the sparse fauna recovered suggests a Lower Carboniferous Age, rather than a Devonian Age. No evidence of Collinson, Scott & Rexroad's (1962) *Gnathodus* n. sp. *B-G. kockeli*, or *Siphonodella sulcata* Assemblage Zones is present in Washington County.

Other than the elements of the *Siphonodella duplicata* Assemblage Zone recovered from the basal Prospect Hill Shale Member, no evidence of this zone was secured from below the middle of the McCraney—where it should fall stratigraphically.

The *Siphonodella isosticha-S. cooperi* and *S. quadruplicata-S. crenulata* Assemblage Zones are well documented in Washington County, and are coincident with the entire Wassonville, Prospect Hill and upper half of the McCraney Formations. These units are, therefore, believed to be *cu*II$^{\alpha}$ in age.

Collinson, Scott & Rexroad's (1962) *Bactrognathus-Polygnathus communis* and *Gnathodus semiglaber-Pseudopolygnathus multistriata* Assemblage Zones are not represented in Washington County, except for the occurrence of some of the diagnostic species in the basal Burlington glauconitic layer.

The correlations proposed in figure 5 are based on recognition of Collinson, Scott & Rexroad's (1962) Assemblage Zones in Washington County. It should be understood, however, that in no case were the faunas from the Washington County section fully representative of those designated as "characteristic" of each Assemblage Zone. Correlation with the north-central Iowa section is based on the time equivalencies of that section with the Assemblage Zones of Collinson, *et al.*, (1962) as determined by Anderson (1964; 1966).

SYSTEMATIC PALEONTOLOGY

Genus *BACTROGNATHUS* Branson & Mehl, 1941

Bactrognathus BRANSON & MEHL, 1941, p. 98.

Type species. Bactrognathus hamata Branson & Mehl, 1941, p. 98, pl. 19, figs. 5-8; (OD).

Diagnosis. The specimens assigned to this genus compare favorably to the generic description of Branson & Mehl (1941, p. 98).

Remarks. Branson & Mehl (1941, p. 98) stated that "there is such a variety among the species of this genus that it is difficult to include all the characters in the generic analysis." Additional work should be done on the bactrognathids in order to more precisely differentiate the species of *Bactrognathus* as the genus has a relatively short range.

Occurrence. Bactrognathus is restricted to rocks of the Valmeyeran Series, which includes the "Sedalia," Fern Glen, and Burlington Formations and is equivalent to a part of $cu II\beta/\gamma$ strata in Europe (Collinson, *et al.*, 1962, chart 5). *Bactrognathus* has also been reported from the Middle Osahean, Lake Valley Formation of New Mexico (Burton, 1964, range chart).

BACTROGNATHUS COMMUNIS Hass, 1959

Bactrognathus communis HASS, 1959, p. 380-381, pl. 46, figs. 20,25-27, 30,31; BURTON, 1964, range chart.

Remarks. See Hass (1959) for discussion of the characteristics of the species.

Occurrence. The species is restricted to rocks of the Osagean Series. *Bactrognathus communis* has been reported from the Chappel Limestone of Texas (Hass, 1959) and the Tierra Blanca and Alamogordo Members of the Lake Valley Formation of New Mexico (Burton, 1964).

This species occurs in the Burlington Formation at the Wassonville Mill locality, Washington County, Iowa.

Material studied. 1 specimen.

BACTROGNATHUS DISTORTA Branson & Mehl, 1941

Pl. 4, Figs. 5,8

Bactrognathus distorta BRANSON & MEHL, 1941, p. 99, pl. 19, figs. 10,11; BURTON, 1964, range chart; REXROAD & SCOTT, 1964, p. 22-23, pl. 3, figs. 9,10.

Diagnosis. This species is characterized by a thick anterior limb which has a horn-like denticle at the posterior end, and by a strongly recurved lateral process.

Remarks. The holotype of *Bactrognathus distorta* is severely worn and abraded. The lateral margins are not transversely rounded on a well-preserved specimen, but are sharp and broadly flared with a pronounced expansion on the inner lateral margin in the area of the lateral process offset (see pl. 4, fig. 8).

The unit has a deep, sub-triangular basal cavity under the main blade and lateral process junction, which extends as a deep trough to the anterior tip and under the lateral process to the posterior extremity of the unit.

The degree of recurvature of the lateral process is variable, but in oral view, the unit is z-shaped in most specimens.

Occurrence. Bactrognathus distorta has been reported from the Sycamore Formation of Oklahoma (Branson & Mehl, 1941), the Lake Valley Formation of New Mexico (Burton, 1964), and the upper portion of the New Providence Formation of Indiana (Rexroad & Scott, 1964).

The species was recovered from the Burlington Formation at the Wassonville Mill locality, Washington County, Iowa.

Material studied. 34 specimens.

Repository. Figured hypotype, S.U.I. 12537.

Genus *DINODUS* Cooper, 1939

Dinodus COOPER, 1939, p. 386.

Type species. Dinodus leptis Cooper, 1939, p. 386, pl. 47, figs. 63, 75,76; (OD).

Remarks. See Klapper (1966, p. 24) for a discussion of the generic characteristics.

Occurrence. Dinodus has been reported from the Lower Mississippian of North America and ranges from *cu*I through *cu*II$^{\alpha}$ (Tournasian) in Europe (Voges, 1959).

DINODUS FRAGOSUS (Branson, 1934)

Palmatodella fragosa BRANSON, 1934, p. 333, pl. 27, fig. 5; KNECHTEL & HASS, 1938, p. 518-520.

Dinodus fragosus (Branson). SCOTT & COLLINSON, 1961, p. 122, pl. 2, fig. 22; HASS, 1943, p. 307-309.

Diagnosis. See Branson (1934) for a discussion of the specific characteristics.

Remarks. The specimens in the Washington County material are broken, but compare closely with those illustrated by Branson (1934, pl. 27, fig. 5) from the Hannibal Formation and Hass (1959, pl. 49, figs. 16,23) from the Chappel Formation.

Occurrence. Dinodus fragosus is known from the Hannibal (Branson, 1934), McCraney (Scott & Collinson, 1961), and Chouteau (Branson & Mehl, 1938) Formations of Missouri and the Chappel Formation (Hass, 1959) of Texas. Voges (1959) reported isolated occurrences of *D. fragosus* in middle *cu*I and lower *cu*II$^{\alpha}$ strata in Europe.

This species was recovered from the Prospect Hill Formation at the High Bridge and Maple Mill localities, Washington County, Iowa.

Material studied. 9 specimens.

Genus *ELICTOGNATHUS* Cooper, 1939

Solenognathus BRANSON & MEHL, 1934 (*non* SWAINSON, 1939), p. 270-271. (*non* AGASSIZ, 1846, BLEEKER, 1856-57, PICET & HUMBERT, 1866).

Elictognathus COOPER, 1939, p. 386-387; HASS, 1959, p. 386.

Solenodella BRANSON & MEHL, 1944, *nomen nudum*, p. 244; _____ & _____, 1948, p. 527.

non Solenodella ELIAS, 1956, p. 113 (= *Ozarkodina*).

Type species. Solenognathus lacerata Branson & Mehl, 1934, pl. 22, figs. 5,6; (OD).

Diagnosis. Laterally compressed and slightly arched units with lateral ridges on both sides near the aboral edge. Outer lateral ridge is poorly developed, but the inner lateral ridge may form a shelf which can be denticulated on the upper surface. Apical denticle located directly over the basal cavity, about one third the length of the unit from the posterior tip.

Remarks. Solenognathus Branson and Mehl is invalid due to homonymy. The first name applied to a species of this taxonomic unit is *Elictognathus* Cooper, 1939, and it is considered the valid generic name.

Solenodella Branson & Mehl, 1944, is not described, nor is a type species designated or described, and is thereby regarded a *nomen nudum*.

The species referred to *Solenodella* by Elias (1956) lack the diagnostic inner and outer lateral ridges, or "shelves," and are considered to be more appropriately assigned to *Ozarkodina*.

Rexroad & Scott (1964, p. 25) proposed that specific differentiation within *Elictognathus* be based on the width and ornamentation of the inner lateral ridge, and on the gross differences in denticle patterns of the upper edge of the unit. These bases for differentiation were applied in the present study.

Occurrences. Elictognathus does not occur in the earliest Mississippian rocks, but is a characteristic element in the Middle and Upper Kinderhookian Series. The species is restricted to rocks ranging in age from *cu*I through *cu*IIα in the Sauerland (Voges, 1959, Table 1), and to North American equivalents, *i.e.* Hannibal and Chouteau Formations of the Mississippi Valley (Collinson, *et al.*, 1962, Chart 1).

ELICTOGNATHUS BIALATA (Branson & Mehl, 1934)

Pl. 6, Fig. 1.

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

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

Elictognathus bialata (Branson & Mehl), COOPER, 1939, p. 387, pl. 45, figs. 1,2; HASS, 1959, p. 370, pl. 49, fig. 21; VOGES, 1959, p. 277-278, pl. 33, figs. 18,19; KLAPPER, 1966, p. 25-26, pl. 5, fig. 14; ANDERSON, 1964, p. 52, pl. 8, fig. 15.

Diagnosis. Elictognathus with the inner lateral ridge developed into a shelf-like platform. A row of denticles on the oral side of the shelf forms a thin parapet parallel to the blade.

Remarks. The specimens herein referred to *Elictognathus bialata* compare favorably with those originally described by Branson & Mehl (1934, p. 273).

Occurrence. See Klapper (1966, p. 26) for complete list of occurrences through May, 1966.

The species ranges from upper *cu*I through lower *cu*II∝ in the Sauerland (Voges, 1959).

Elictognathus bialata is restricted to the shale member of the Prospect Hill Formation and was recovered at the High Bridge and Maple Mill localities, Washington County, Iowa.

Material studied. 5 specimens.

Repository. Figured hypotype, S.U.I. 12538.

ELICTOGNATHUS COSTATA (Branson, 1934)
Pl. 7, figs. 19,22

Solenognathus costata BRANSON, 1934, p. 332, pl. 27, fig. 7; COOPER, 1939, p. 410, pl. 44, figs. 33-35; BEACH, 1961, pl. 5, fig. 1.

Bryantodus microdens HUDDLE, 1934, p. 69, pl. 21, figs. 10,11.

Solenognathus amphelicta COOPER, 1939, p. 410, pl. 44, figs. 10,11,12.

Solenognathus araia COOPER, 1939, p. 410, pl. 44, figs. 31,32.

Solenognathus micra COOPER, 1939, p. 412, pl. 44, figs. 48,49.

Solenognathus eurynota COOPER, 1939, p. 411, pl. 44, figs. 55-57.

Solenognathus fulcra Branson & Mehl. COOPER, 1939, p. 411, pl. 44, figs. 61-63.

Pinacognathus? deflecta YOUNGQUIST & PATTERSON, 1949, p. 60, pl. 15, fig. 5.

Solenodella costata (Branson). BISCHOFF & ZIEGLER, 1956, p. 166, pl. 12, figs. 18,19; BISCHOFF, 1957, p. 55, pl. 6, fig. 15; BEACH, 1961, p. 51.

Elictognathus lacerata (Branson & Mehl). HASS, 1956, p. 386-387, pl. 2, fig. 21, *non* fig. 22 (=*E. lacerata*); FREYER, 1961, pl. 2, figs. 4,5.

Pinacognathus profunda (Branson & Mehl). VOGES, 1959, p. 288, pl. 35, fig. 45.

Elictognathus costata (Branson). REXROAD & SCOTT, 1964, p. 25, pl. 3, fig. 24.

Diagnosis. The oral outline of the blade is straight across the middle to the apical denticle, and then curves downward abruptly to the posterior end. The apical denticle is located directly over the small basal cavity, and the lateral ridges are narrow.

Remarks. Elictognathus costata is differentiated from *E. lacerata* in that it lacks the prominent denticles which form a high area in the oral outline anterior to the apical denticle, which is characteristic of *E. lacerata*. Hass (1959, p. 386) judged *E. costata* to be a junior subjective synonym of *E. lacerata* because he did not consider differences in oral outline and denticle size sufficient to warrant specific designation. Rexroad & Scott (1964, p. 25) agreed in part with Hass, but pointed out that *E. costata* forms are the most abundant of the elictognathids present in the lower part of the Kinderhookian, and *E. lacerata* forms predominate in the upper part of the Kinderhookian sequence.

The author believes that *Elictognathus costata* and *E. lacerata* should be differentiated on differences in oral outline and relative lateral ridge sizes (*E. lacerata* has much wider lateral ridges). This conclusion is supported by the apparent stratigraphic separation of each form's numerical optimum.

Occurrence. Elictognathus costata has been reported from the Hannibal Formation of Missouri (Branson, 1934), the New Albany Shale and Rockford Limestone of Indiana (Rexroad & Scott, 1964), the Gardner Formation of Utah (Beach, 1961), the pre-Weldon Shale of Oklahoma (Cooper, 1939), the Maury Formation of Tennessee (Hass, 1956) and the Prospect Hill Formation of Iowa (Youngquist & Patterson, 1949).

Bischoff (1957, Table 2) recorded *Elictognathus costata* from *cu*IIα-*β* strata in the Rhenish Schiefergebirge, whereas, Voges (1959, Table 1) recorded isolated occurrences of the species in the middle and upper *cu*I strata in the Sauerland.

In Washington County, Iowa, *Elictognathus costata* was recovered from the Prospect Hill Formation at the High Bridge and Maple Mill localities.

Material studied. 10 specimens.

Repository. Figured hypotype, S.U.I. 12541.

ELICTOGNATHUS LACERATA (Branson & Mehl, 1934)

Pl. 6, Figs. 4,5

Solenognathus lacerata BRANSON & MEHL, 1934, p. 271, pl. 22, figs. 5,6; COOPER, 1939, p. 411, pl. 44, fig. 30.

Solenognathus tabulata BRANSON & MEHL, 1934, p. 271-272, pl. 22, fig. 7; COOPER, 1939, p. 412, pl. 44, figs. 64-66.

Solenognathus costata BRANSON, 1934, p. 332, pl. 27, fig. 7; COOPER, 1939, p. 410-411, pl. 44, figs. 33-35.

Solenognathus tenera BRANSON, 1934, p. 332-333, pl. 27, fig. 8; BRANSON & MEHL, 1938, p. 140, pl. 34, fig. 14; COOPER, 1939, p. 412, pl. 44, figs. 36,37.

Bryantodus camurus HUDDLE, 1934, p. 68-69, pl. 2, figs. 6-9.

Polygnathellus similis HUDDLE, 1934, p. 93, pl. 7, fig. 20 (*non* fig. 21).

Solenognathus anida COOPER, 1939, p. 410, pl. 44, figs. 46-48.

Solenognathus anomala COOPER, 1939, p. 410, pl. 44, figs. 15-17.

Solenognathus anomalodus COOPER, 1939, p. 410, pl. 44, figs. 27-29.

Solenognathus camura (Huddle). COOPER, 1939, p. 410, pl. 44, figs. 58-60.

Solenognathus carinata (Cooper). COOPER, 1939, p. 410, pl. 43, figs. 55-57.

Solenognathus dicha COOPER, 1939, p. 411, pl. 44, figs. 70-72.

Solenognathus cura COOPER, 1939, p. 411, pl. 44, figs. 7-9.

Solenognathus isomeces COOPER, 1939, p. 411, pl. 44, figs. 4-6.

Solenognathus macra COOPER, 1939, p. 411-412, pl. 44, figs. 13,14.

Solenognathus oliga COOPER, 1939, p. 412, pl. 44, figs. 21-23,52-54.

Solenognathus pecta COOPER, 1939, p. 412, pl. 44, figs. 1-3.

Solenognathus plecta COOPER, 1939, p. 412, pl. 43, figs. 47-52,58-60.

Solenognathus syntyla COOPER, 1939, p. 412, pl. 44, figs. 38,39.

Solenognathus trinodus COOPER, 1939, p. 412, pl. 44, figs. 67-69.

Solenognathus tyla COOPER, 1939, p. 412, pl. 44, figs. 24-26,42,43.

Solenognathus typica COOPER, 1939, p. 412, pl. 44, figs. 18-20,44,45, 49-51; 1943, ______, *in* Cooper & Sloss, p. 171, pl. 28, fig. 13.

Solenodella lacerata (Branson & Mehl). BRANSON & MEHL, 1944, *in* Shimer & Shrock, Index fossils of North America, p. 244, pl. 94, fig. 4.

Solenodella lateranodosa THOMAS, 1949, p. 428-429, pl. 3, fig. 19.

Solenodella tenera (Branson). THOMAS, 1949, p. 436, pl. 3, figs. 18,20.

Solenodella tenera (Branson)? YOUNGQUIST & DOWNS, 1951, p. 790-791, pl. 111, fig. 3.

Elictognathus lacerata (Branson & Mehl). HASS, 1951, p. 2539, pl. 1, fig. 3; ______, 1956b, pl. 1, fig. 5; CLOUD, BARNES & HASS, 1957, p. 813, pl. 5, fig. 4; HASS, 1959, p. 386-387, pl. 49, figs. 1-8,12; VOGES, 1959, p. 278-279, pl. 33, fig. 20; SCOTT & COLLINSON, 1961, p. 123; KLAPPER, 1966, p. 26, pl. 5, figs. 18-21; REXROAD & SCOTT, 1964, p. 26-27, pl. 3, figs. 18-20.

Solenodella costata (Branson). BISCHOFF & ZIEGLER, 1956, p. 166, pl. 21, figs. 18,19; BISCHOFF, 1957, p. 55, pl. 6, fig. 15; BEACH, 1961, p. 51, pl. 5, fig. 1.

Diagnosis. Oral outline characterized by two prominent high peaks; one at the apical denticle and the other near the anterior end of the unit. The lateral ridges, especially the inner side, are wide and shelf-like.

Remarks. E. lacerata is maintained as a species separate from *E. costata* on the basis of the double peaked oral outline. When this distinction is made a stratigraphic separation of the peak occurrence of the two species may be recognized.

Occurrence. See KLAPPER (1962, p. 47-48) for complete list of occurrences through August, 1962.

Rexroad & Scott (1964) have reported *Elictognathus lacerata* from the upper New Albany Shale and Rockford Limestone of Indiana.

Bischoff (1957) reported *Elictognathus lacerata* as ranging from middle *cu*I through lower *cu*II$^{\propto}$ strata in Europe. Voges (1959) recorded the species from upper *cu*I through lower *cu*II$^{\propto}$ strata, with an isolated occurrence in middle *cu*I, and a reworked specimen in *cu*IIβ/γ strata in the Sauerland.

Elictognathus lacerata was recovered from the Wassonville Formation at the Maple Mill locality and the Prospect Hill Formation at the Maple Mill and High Bridge localities, Washington County, Iowa.

Material studied. 39 specimens.

Repository. Figured hypotypes, S.U.I. 12539, 12540.

Genus *GNATHODUS* Pander, 1856

Gnathodus PANDER, 1856, p. 33 (*non* FIEBER, 1866).

Dryphenotus COOPER, 1939, p. 386.

Type species. Gnathodus mosquensis Pander, 1856, p. 34, pl. 2, figs. 10,10a-c; (OD).

Diagnosis. The genus is characterized by the deep, widely flaring basal cavity situated near the posterior end of the blade. The upper surface of the flared cavity forms a platform which may be smooth, weakly ornamented by nodes or strongly ornamented by nodes and transverse ridges.

Remarks. Gnathodus evolved from *Spathognathodus* by a shift of the basal cavity to the posterior end of the bar, and an increase in flaring of the cavity lips (Rexroad & Scott, 1964, p. 28). Gnathodids are distinguishable from spathognathodids on the basis of the enlarged basal cavity, and ornamentation of the oral surface of the platform. However, a few spathognathodids (*i.e.* S. *linguiferous* and S. *aculeatus*) developed denticles above the basal cavity region. These denticles are derived from the sides of the blade, and are thereby independent of the basal cavity. The platform ornamenation in *Gnathodus* is nodose in nature, and never attains the true denticle development stages of *Spathognathodus*.

Gnathodids are useful in zoning the middle and late Kinderhookian and early Osagean rocks of the Mississippi Valley (Collinson, *et al.*, 1962, Chart 3). They are rare or absent in the early Kinderhookian.

Occurrence. Gnathodus has been reported from the Champ Clark, Kinderhookian and Osagean Series in the standard Mississippi Valley section. (Collinson, *et al.*, 1962.)

Voges (1959) and Bischoff (1957) both have recorded occurrences of *Gnathodus* in strata ranging in age from *cu*I through and above *cu*III$^{\propto}$ in Germany. Scott & Collinson (1961) recovered gnathodids from the upper Saverton and Louisiana Formations in Illinois, which they consider to be *to*VI in age. Apparently, *Gnathodus* ranges across the Devonian-Carboniferous Boundary.

GNATHODUS DELICATUS Branson & Mehl, 1938
Pl. 7, Figs. 11,13

Gnathodus delicatus BRANSON & MEHL, 1938, p. 145, pl. 34, figs. 25,26,27; HASS, 1951, pl. 1, fig. 4; ——, 1956b, pl. 1, fig. 8; ——, 1959, p. 394, pl. 46, figs. 3-7; pl. 48, figs. 1-5,8; VOGES, 1959, p. 283, pl. 33, figs. 31-33; ZIEGLER, *et al.*, 1960, p. 42-43, pl. 4, figs. 7-14; REXROAD & SCOTT, 1964, p. 29-30, pl. 2, figs. 4-6.

Gnathodus perplexus BRANSON & MEHL, 1938, p. 145, pl. 34, fig. 24.

Gnathodus texanus (Roundy), COOPER, 1939, p. 388, pl. 41, figs. 26,27.

Diagnosis. The widely flaring basal cavity situated near the posterior end of the blade is asymmetrical, the outer lateral portion being more flared than the inner lateral, and set closer to the posterior end. In lateral view, the denticulate oral outline of the blade is straight and parallels the aboral keel.

Description. The carina projects slightly beyond the margin of the platform. A single node is present close to the carina on both the inner and outer platforms. The node on the outer platform is situated closer to the posterior end of the unit than that on the inner platform.

Remarks. The "rectangular" lateral outline, and the asymmetrical platform outline are diagnostic of *G. delicatus*, however, the more characteristic linear arrangement of nodes on the platform is entirely lacking in the Washington County specimens. They are considered transitional forms and were assigned to *G. delicatus* on the basis of the two diagnostic features present.

Occurrence. Gnathodus delicatus has been reported from the Chouteau Formation of Missouri (Branson, 1944), the middle division of the Arkansas Novaculite of Arkansas (Hass, 1951), the pre-Weldon Shale of Oklahoma (Cooper, 1939), the Chappel Formation in Texas (Hass, 1959) and the Rockford Limestone and lower part of the New Providence Shale in Indiana (Rexroad & Scott, 1964).

Voges (1959) reported a tentative middle *cu*IIβ/γ to lower *cu*IIδ range for the species in the Sauerland, and questions the upper and lower limits.

Gnathodus delicatus was recovered from the Wassonville Formation at the Maple Mill locality and the Burlington Formation at the Wassonville Mill locality, Washington County, Iowa.

Material studied. 3 specimens.

Repository. Figured hypotype, S.U.I. 12548.

Genus *POLYGNATHUS* Hinde, 1879

Polygnathus HINDE, 1879, p. 361-362; MILLER, 1889, p. 520; BRYANT, 1921, p. 23-24; ROUNDY, 1926, p. 13.

Macropolygnathus, COOPER, 1939, p. 392.

Ctenopolygnathus MULLER & MULLER, 1957, p. 1084.

Type species. Polygnathus robusticostata Bischoff & Ziegler, 1957, p. 95, pl. 3, figs. 4-10; (pending decision on proposal to I.C.Z.N. by Ziegler, Klapper, & Lindström).

Remarks. Müller & Müller (1957, p. 1084-1085) used the attenuation of the posterior portion of the platform to distinguish *Ctenopolygnathus* and *Polygnathus*. They proposed that all forms which have no posterior extension of the carina beyond the platform should be referred to *Polygnathus*, and species which possess both an anterior and posterior free blade referred to *Ctenopolygnathus*. Müller & Müller contended that *Ctenopolygnathus* is morphologically intermediate between *Spathognathodus* and *Polygnathus*, but that it evolved from a different stock.

The generic differentiation cannot be maintained because the carinal termination is highly variable in polygnathids. Anderson (1964, p. 93) noted several Devonian species, *Polygnathus brevillamina* and *P. agustidiscus*, and Klapper (1962, p. 71) suggested the Lower Mississippian species *P. longipostica*, as examples of extreme variation in the carinal termination in *Polygnathus*.

Occurrence. Polygnathus ranges from the Lower Devonian (Emsian) through the Lower Carboniferous *cu*IIβ/γ (Voges, 1959) and *cu*III$^{\propto}$ (Bischoff, 1957). The genus has been found as high as the Burlington in North America, which is considered to be a *cu*IIβ/γ equivalent by Collinson, *et al.* (1962, Charts 1 and 5).

Forms resembling *Polygnathus* are also well represented in the European Triassic faunas and the Triassic (Ladinian) *Protrachyceras* Zone (Mosher & Clark, 1965, p. 555) suggesting homeomorphic development.

POLYGNATHUS COMMUNIS Branson & Mehl, 1934

Pl. 1, Figs. 4,5,7,8,12; Pl. 7, Figs. 20,21

Polygnathus communis BRANSON & MEHL, 1934, p. 293, pl. 24, figs. 1-4; BRANSON, 1934, p. 308, pl. 25, figs. 5,6; BRANSON & MEHL, 1938, p. 145, pl. 34, figs. 39-41; COOPER, 1939, p. 399, pl. 39, figs. 1,2,9,10,23,24; MEHL & THOMAS, 1947, p. 15, pl. 1, fig. 37; YOUNGQUIST & PATTERSON, 1949, p. 62, pl. 15, figs. 7,8; YOUNGQUIST & DOWNS, 1951, p. 787, pl. 111, figs. 4,5,19,20; HASS, 1951, p. 2538-2539, pl. 1, fig. 10; ——, 1956a, p. 25, pl. 2, figs.

2-5; ———, 1956b, pl. 1, fig. 10; BISCHOFF & ZIEGLER, 1956, p. 156-157, pl. 12, figs. 1-3; BISCHOFF, 1957, p. 42, pl. 2, figs. 24,26,27, (*non* figs. 23,25 *P. pura*); ZIEGLER, 1957, p. 46, pl. 2, fig. 15; HASS, 1959, p. 390, pl. 49, figs. 9-11,13; VOGES, 1959, p. 288-290, pl. 34, figs. 1-7; ZIEGLER, 1960, p. 2, pl. 1, fig. 9; FREYER, 1961, pl. 1, figs. 15,16; SCOTT & COLLINSON, 1961, p. 130, pl. 1, figs. 7-10; pl. 2, fig. 30; BEACH, 1961, p. 49, pl. 6, figs. 1-4; KLAPPER, 1966, p. 21, pl. 6, figs. 6,11; REICHSTEIN & SCHWAB, 1962, p. 24, pl. 1, figs. 2,4,11; ZIEGLER, 1963, pl. 1, figs. 5-8; ANDERSON, 1964, p. 100-103, pl. 5; figs. 17,18; pl. 8, figs. 23,25; BURTON, 1964, range chart; ETHINGTON, 1965, p. 581, pl. 67, fig. 7; ANDERSON, 1966, p. 411.

Polygnathus adola COOPER, 1939, p. 399, pl. 39, figs. 33-36.

Polygnathus marginata Branson & Mehl. COOPER, 1939, p. 401, pl. 41, figs. 15,16.

Polygnathus communis bifurcata HASS, 1959, p. 390, pl. 48, figs. 11,12; SCOTT & COLLINSON, 1961, p. 130-131, pl. 1, fig. 11.

Polygnathus communis carina HASS, 1959, p. 391, pl. 47, figs. 8,9.

Polygnathus cf. *P. styriaca* Ziegler. ZIEGLER, 1960, p. 22, pl. 1, fig. 8.

Polygnathus communis communis Branson & Mehl. REXROAD & SCOTT, 1964, p. 33-34, pl. 2, figs. 17,18.

Description. See Klapper, 1966, p. 21.

Remarks. The oral outline of the platform varies considerably in the Washington County specimens, ranging from a near circular shape to a long semi-elliptical shaped platform, with a pointed posterior end. The carina leads directly into the platform and may be straight to slightly curved throughout. Aborally, the basal cavity is located immediately posterior to the blade-platform junction. In some forms the basal cavity is small, and projects shallowly into the platform, while in others, the cavity is somewhat larger, and is so deeply set into the surface that the area immediately surrounding the basal cavity is broadly depressed.

Hass' (1959) subspecies, *Polygnathus communis bifurcata*, possesses a secondary carina and keel. It is herein considered synonymous with *P. communis* on the basis that Hass' forms represent a specific variation within *P. communis*. Hass (1959, Table 1) recovered over 3,000 individuals of *P. communis* from the Chappel Formation, only four of which displayed the subspecific characteristics. The numerical insignificance of the forms possessing the diagnostic features of *P. communis bifurcata* tends to confirm the interpretation that it is a growth abnormality. Scott & Collinson (1961, p. 130) discussed the variation within *P. communis* and noted three lines of intraspecific variation: 1) specimens with low broad, ovate platforms ranging to high ellipsoidal platforms, 2) specimens with nodes or ridges located on the anterior lateral margins of the platform as opposed to the common absence of oral surface ornamentation, and 3) transverse ridges on the oral surface as opposed to the normal smooth oral surface.

Hass distinguished *Polygnathus communis carina* on the characteristic presence of nodes located on the anterior lateral margins. Degrees of variation of this feature are extreme (Scott & Collinson, 1961, p. 130). The writer believes that the nodose development on the surface of *P. communis carina* is within the range of variation of *P. communis*, and should not be distinguished from it.

Polygnathus communis communis, Rexroad & Scott lacks an aboral keel extending from the basal cavity to the posterior end of the platform. A wide variation in keel development was noted in the Washington County material. The range of variation extends from forms lacking a keel to forms with a high, sharp keel traversing the entire length of the platform. The evidence of such extremes of variability in keel development in the Washington County forms assigned to this species suggests that *P. communis communis* should not be distinguished from *P. communis*.

Occurrence. Rexroad & Scott (1964) reported *Polygnathus communis* from the Rockford Limestone and lower part of the New Providence Shale in Indiana and the species has been recovered from the Lake Valley Formation of New Mexico (Burton, 1964) and from the Martin Formation of Arizona (Ethington, 1965).

Voges (1957) recorded the species from *to*V through *cu*IIβ/γ strata in the Sauerland, and Bischoff (1957) recorded a *to*V through *cu*II$^{\alpha}$ range for the species. *Polygnathus communis* ranges across the Devonian-Mississippian Boundary.

Polygnathus communis was recovered from the Prospect Hill Formation at the High Bridge and Maple Mill localities, the Wassonville and Burlington (in part) Formations at the Wassonville Mill and the Wassonville Formation at the Maple Mill locality. The species was recovered also from the McCraney Formation at the Maple Mill locality, Washington County, Iowa.

Material studied. 281 specimens.

Repository. Figured hypotypes, S.U.I. 12499, 12500, 12501.

POLYGNATHUS INORNATA Branson, 1934

Pl. 1, Figs. 16,17; Pl. 2, Figs. 4,5,8; Pl. 5, Figs. 1-8

Polygnathus inornata BRANSON, 1934, p. 309, pl. 25, figs. 8,26; BRANSON & MEHL, 1938, p. 146, pl. 34, fig. 37; COOPER, 1939, p. 400, pl. 39, figs. 11,12; YOUNGQUIST & PATTERSON, 1949, p. 64, pl. 17, figs. 4,5,9,13; THOMAS, 1949, p. 436, pl. 3, fig. 36; YOUNG-

QUIST & DOWNS, 1951, p. 787-788, pl. 111, figs. 11,17,18; HASS, 1956, p. 25, pl. 2, figs. 14,15; BISCHOFF & ZIEGLER, 1956, p. 157, pl. 12, fig. 4 (*non* fig. 5=*P. symmetrica*); BISCHOFF, 1957, p. 42, pl. 2, figs. 17,18,20,21; CLOUD, BARNES & HASS, 1957, p. 813, pl. 5, fig. 6; KLAPPER, 1958, p. 1089, pl. 142, figs. 2,3; HASS, 1959, p. 370, pl. 49, fig. 22 (same specimen as CLOUD, BARNES & HASS, 1957); VOGES, 1959, p. 291, pl. 34, figs. 12-20; BEACH, 1961, p. 47-48, pl. 5, figs. 8,13; REXROAD & SCOTT, 1964, p. 35, pl. 2, figs. 19,20; ANDERSON, 1964, p. 107-109, pl. 9, figs. 6,7,13,16; KLAPPER, 1966, p. 19-20, pl. 1, figs. 7-14; pl. 4, figs. 2-4.

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

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

Polygnathus lobata BRANSON & MEHL, 1938, p. 146-147, pl. 34, figs. 44-47; COOPER, 1939, p. 401, pl. 39, figs. 29,30; THOMAS, 1949, p. 436, pl. 3, fig. 11; BISCHOFF, 1957, p. 42, pl. 2, fig. 19; REXROAD & SCOTT, 1964, p. 35-36, pl. 2, figs. 15,16.

Polygnathus curta COOPER, 1939, p. 400, pl. 39, figs. 37,38,49,50.

Polygnathus irregularis COOPER, 1939, p. 400, pl. 39, figs. 57, 58.

Polygnathus longipostica Branson & Mehl, COOPER, 1939, p. 401, pl. 39, figs. 43,44 (*non* figs. 31,32=*P. symmetrica*).

Polygnathus subserrata Branson & Mehl, COOPER, 1939, p. 404, pl. 40, figs. 1,2.

Polygnathus inaequilateralis YOUNGQUIST & PATTERSON, 1949, p. 63, pl. 16, figs. 14,15.

Siphonodella duplicata (Branson & Mehl), THOMAS, 1949, p. 436, pl. 3, fig. 8 (*non* fig. 9=*Siphonodella cooperi*).

Pseudopolygnathus? cf. *P. triangula* Voges, MULLER, 1962, p. 1388, text figs. 9a-c.

Remarks. Klapper (1966, p. 19-29, pl. 1, figs. 7-14; pl. 4, figs. 2-4) discussed and illustrated the extreme variation in three specimens of *Polygnathus inornata* recovered from the Lodgepole Formation in Montana. Almost one hundred specimens similar to Klapper's and to one illustrated and designated as *Polygnathus abnormis* by Branson (1934, pl. 25, fig. 22) were recovered from the fish "tooth" bed near the base of the Prospect Hill Formation in Washington County.

The variation of the form in the Washington County material is fairly continuous and appears to be separated into two distinct phases, best illustrated aborally: 1) gradual increasing degree of aboral surface convolution or crenulation, and 2) lateral development of a secondary platform, or "ridge," on the inner margin of the platform. The variation may reflect an ontogenetic adjustment to the changing environment of deposition (limestone to shale environment). This intraspecific variation is restricted to the fish "tooth" bed of the Prospect

Hill, and does not represent an evolutionary trend in the temporal sense. Plate 5, figs. 1-8 illustrate the transitional stages from the "normal" smooth surface (fig. 3) to the crenulated surface (figs. 4,5 and 8) and then to the secondary platform development (figs. 6,2,1,7).

Occurrence. See Anderson (1964, p. 109) for complete list of occurrences through February, 1964.

The oldest reported occurrence of *Polygnathus inornata* in Europe is in *to*V strata (Bischoff & Ziegler, 1956, pl. 12, fig. 4) and the youngest occurrence is given as *cu*III$^{\alpha}$ (Bischoff, 1957). *P. inornata* occurs in the Wassonville Formation at the Wassonville Mill and the Maple Mill localities, the Prospect Hill Formation at the Maple Mill and High Bridge localities, and in the McCraney Formation at the Maple Mill locality, Washington County, Iowa.

Material studied. 448 specimens.

Repository. Figured hypotypes, S.U.I. 12504, 12505, 12506, 12507, 12508, 12509, 12510, 12511, 12512.

POLYGNATHUS LONGIPOSTICA Branson & Mehl, 1934
Pl. 1, Figs. 1-3,10,14,15,18; Pl. 2, Figs. 1-3,6,7

Polygnathus longipostica BRANSON & MEHL, 1934, p. 294, pl. 24, figs. 8-11,13; BRANSON, 1934, p. 311, pl. 25, fig. 18; YOUNGQUIST & PATTERSON, 1949, p. 65, pl. 15, figs. 16-20; REXROAD & SCOTT, 1964, p. 36-37, pl. 2, fig. 26; ANDERSON, 1964, p. 110-111, pl. 9, figs. 1,5,8,12; KLAPPER, 1966, p. 20-21, pl. 4, figs. 1,5.

Polygnathus lanceolata BRANSON, 1934, p. 313, pl. 25, fig. 21; YOUNGQUIST & PATTERSON, 1949, p. 64-65, pl. 16, fig. 16.

Polygnathus scapha HUDDLE, 1934, p. 102, pl. 8, figs. 33-35, text fig. 3, fig. 2; COOPER, 1939, p. 403, pl. 40, figs. 17,18,28,29 (*non* figs. 19,20=*P. symmetrica*).

non Polygnathus lanceolata Branson, BRANSON & MEHL, 1938, p. 148, pl. 34, fig. 42 (=*P. flabella* BRANSON & MEHL).

non Polygnathus longipostica Branson & Mehl, COOPER, 1939, p. 401, pl. 39, figs. 31,32,43,44 (figs. 31,32=*P. symmetrica*; figs. 43,44=*P. inornata*).

Polygnathus ortha COOPER, 1939, p. 401, pl. 39, figs. 3,4.

Polygnathus permarginata Branson, COOPER, 1939, p. 402, pl. 40, figs. 61,62.

Polygnathus subserrata Branson & Mehl, COOPER, 1939, p. 404, pl. 39, figs. 51,52,65,66,75,76; pl. 40, figs. 9,10,42,43 (*non* figs. 1,2=*P. inornata*).

Polygnathus toxophora COOPER, 1939, p. 404, pl. 39, figs. 67,70.

Polygnathus adunca YOUNGQUIST & PATTERSON, 1949, p. 60-61, pl. 16, figs. 18,19.

Polygnathus cunulae YOUNGQUIST & PATTERSON, 1949, p. 62, pl. 15, figs. 11-13.

Polygnathus cymbiformis YOUNGQUIST & PATTERSON, 1949, p. 62-63, pl. 17, figs. 14,15.

Polygnathus inopinata YOUNGQUIST & PATTERSON, 1949, p. 64, pl. 16, figs. 20,21.

Polygnathus cf. *P. subserrata* Branson & Mehl, YOUNGQUIST & PATTERSON, 1949, p. 67, pl. 17, fig. 10.

Polygnathus subtortilis YOUNGQUIST & PATTERSON, 1949, p. 67, pl. 17, fig. 3.

Polygnathus anida Cooper, THOMAS, 1949, p. 436, pl. 3, figs. 10,12.

Polygnathus aff. *symmetrica* Branson, YOUNGQUIST & DOWNS, 1951, p. 789, pl. 111, fig. 6.

Diagnosis. *Polygnathus* with an attenuate posterior end and a prominent anterior free blade. The carina is sigmoidal, and commonly displays a large denticle at the posterior tip, although this characteristic may be absent in some specimens. Troughs of moderate depth flank the carina on both sides extending the entire length of the platform. The anterior lateral margins are upturned to, or below the level of the carina.

Remarks. Branson & Mehl (1934, p. 293) discussed the differences between *Polygnathus longipostica* and *P. inornata*. *P. inornata* is distinguished by the extremely sharp flexure or upfolding of the anterior lateral margins, the inner lateral margin being considerably higher than the outer lateral margin.

Occurrence. See Anderson (1964, p. 112) for complete list of occurrences through February, 1964.

Polygnathus longipostica has been recovered from the Martin Formation of Arizona (Ethington, 1965).

The species was recovered from the McCraney Formation, Prospect Hill Formation and Wassonville Formation at the Maple Mill locality and from the Prospect Hill Formation at the High Bridge locality, Washington County, Iowa.

Material studied. 270 specimens.

Repository. Figured hypotypes, S.U.I. 12494, 12495, 12496, 12497, 12498.

POLYGNATHUS MARGINATA Branson & Mehl, 1934

Pl. 6, Figs. 7,8,11; Pl. 7, figs. 15-18

Polygnathus marginata BRANSON & MEHL, 1934, p. 294-295, pl. 23, figs. 25-27; BISCHOFF, 1957, p. 51; REXROAD & SCOTT, 1964, p. 36, pl. 2, fig. 29.

Pseudopolygnathus fusiformis BRANSON & MEHL, 1934, p. 298-299, pl. 23, figs. 1-3; COOPER, 1939, p. 408, pl. 162, pl. 11, figs. 18,19; BISCHOFF, 1957, p. 51; REXROAD & SCOTT, 1964, p. 38-39, pl. 2, figs. 21-23.

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

Polygnathus lacinata COOPER, 1939, p. 401, pl. 39, figs. 25,26; pl. 40, figs. 3,4.

Polygnathus ortha COOPER, 1939, p. 401, pl. 39, figs. 3,4.

Polygnathus radina COOPER, 1939, p. 403, pl. 39, figs. 5,6.

Polygnathus scobiniformis Branson. COOPER, p. 403, pl. 39, figs. 45-48.

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

non Polygnathus marginata Branson & Mehl. COOPER, 1939, p. 401, pl. 41, figs. 15,16 (=*P. pura* Voges).

Pseudopolygnathus marginata Branson & Mehl. KLAPPER, 1966, p. 13, pl. 1, figs. 1-6.

Diagnosis. *Polygnathus* with a symmetrical platform and slightly upturned anterial lateral margins. The carina commonly projects beyond the pointed posterior end. The basal cavity is broadly rounded anteriorly, and gradually tapers to the posterior tip as a slit in the high keel. The basal cavity is unusually large and flared for *Polygnathus*.

Remarks. Klapper (1966, p. 13) assigned *Polygnathus marginata* to *Pseudopolygnathus* on the basis of the similarity of the basal cavity of the species to that characterizing *Pseudopolygnathus*. The degree of flaring of the basal cavity is highly variable in the Washington County material ranging from a small, thick-lipped ovoid depression, to a high, thin-lipped "tear-drop" shape.

The writer concurs with Rexroad & Scott's (1964, p. 37) opinion that *Polygnathus marginata* be maintained as a polygnathid, until sufficient data can be secured concerning the phylogeny of the species.

Occurrence. See Klapper (1962, p. 97-98) for a complete list of occurrences reported as of August, 1962. Rexroad & Scott (1964) have recovered *Polygnathus marginata* from the lower part of the Rockford Limestone in Indiana.

The species has been recovered from *cu*II strata in Germany (Bischoff & Ziegler, 1956).

Polygnathus marginata was recovered from the Prospect Hill Formation at the Maple Mill and High Bridge localities, with single specimens from the English River Formation at the High Bridge locality, the Wassonville Formation at the Maple Mill locality and the Burlington Formation at the Wassonville Mill locality, Washington County, Iowa.

Material studied. 94 specimens.

Repository. Figured hypotypes, S.U.I. 12513, 12514, 12515.

POLYGNATHUS SYMMETRICA Branson, 1934
Pl. 1, Figs. 6,9,11,13

Polygnathus symmetrica BRANSON, 1934, p. 310, pl. 25, fig. 11; BRANSON & MEHL, 1938b, p. 146, pl. 34, fig. 33; COOPER, 1939, p. 404, pl. 41, figs. 50,51; YOUNGQUIST & PATTERSON, 1949, p. 67, pl. 15, figs. 14,15; BISCHOFF, 1957, p. 44, pl. 2, fig. 22; KLAPPER, 1966, p. 21, pl. 6, figs. 1,5; pl. 4, figs. 7,9; ANDERSON, 1964, p. 121-124, pl. 9, figs. 2,4,9,14,15.

Polygnathus spicata BRANSON, 1934, p. 312-313, pl. 25, fig. 20; COOPER, 1939, p. 404, pl. 39, figs. 67,68.

Polygnathus longipostica Branson & Mehl. COOPER, 1939, p. 401, pl. 39, figs. 31,32; THOMAS, 1949, p. 436, pl. 3, fig. 38.

Polygnathus scapha Huddle. COOPER, 1939, p. 403, pl. 40, figs. 19,20.

Polygnathus biclavula YOUNGQUIST & PATTERSON, 1949, p. 61-62, pl. 15, figs. 23,24.

Polygnathus sagittaria YOUNGQUIST & PATTERSON, 1949, p. 66, pl. 15, figs. 9,10; pl. 16, fig. 13.

Polygnathus undulosa YOUNGQUIST & PATTERSON, 1949, p. 67, pl. 17, figs. 1,2.

Polygnathus hannibalensis YOUNGQUIST & PATTERSON, 1949, p. 63, pl. 17, figs. 16,17.

Polygnathus aff. *P. symmetrica* Branson. ETHINGTON, 1965, p. 584, pl. 67, fig. 5.

Diagnosis. *Polygnathus symmetrica* has a symmetrical platform around a straight or slightly curved carina. The platform is commonly ornamented with transverse ridges. Very little upturning of the anterior lateral margins is evident and only shallow troughs flank the carina.

Remarks. Forms assigned to *Polygnathus symmetrica* have a straight carina which seldom projects beyond the posterior end of the platform, and a symmetrical platform. It is distinguished from *P. longipostica* by these characteristics alone. *P. longipostica* commonly possesses a sigmoidal carina, asymmetrical platform and more pronounced anterior lateral margin upturning.

Occurrence. See Anderson (1964, p. 123) for complete list of occurrences through February, 1964.

Polygnathus symmetrica occurs in the Prospect Hill Formation at the High Bridge and Maple Mill localities and in the Burlington Formation at the Wassonville Mill locality, Washington County, Iowa.

Material studied. 419 specimens.

Repository. Figured hypotypes, S.U.I. 12502, 12503.

Genus *PSEUDOPOLYGNATHUS* Branson & Mehl, 1934

Pseudopolygnathus BRANSON & MEHL, 1934, p. 297-298.

Type species. *Pseudopolygnathus prima* Branson & Mehl, 1934, p. 298, pl. 24, figs. 24,25; (OD).

Diagnosis. Platform is elongate, lanceolate and ornamented by nodes or transverse ridges.

Remarks. *Pseudopolygnathus* is differentiated from *Polygnathus* on the basis of the shallow but broadly flared basal cavity lips. *Pseudopolygnathus* probably evolved from *Spathognathodus*. Several Devonian and Mississippian spathognathodids (*i.e*. *S*. *aculeatus*, *S*. *antiposicornis* and *S*. *linguiferous*) have accessory lateral denticles which are developed from the side of the blade and are not associated with the oral surface of the flared basal cavity. *Spathognathodus costatus* and *S*. *spinulicostatus* have developed accessory inner and outer lateral denticles along the entire length of the blade. Voges (1959, p. 297, text-fig. 5) illustrated a transitional sequence from *Spathognathodus costatus* to *Pseudopolygnathus triangula* which depicts a gradual increase in denticulation and platform size.

Occurrence. *Pseudopolygnathus* occurs in strata ranging in age from *to*III through *cu*IIβ/γ in Germany. It ranges as high as the Burlington (*cu*IIβ/γ equivalent) in the upper Mississippi Valley.

PSEUDOPOLYGNATHUS FUSIFORMIS Branson & Mehl, 1934
Pl. 7, Figs. 1,5,6,9,10,14.

Pseudopolygnathus fusiformis BRANSON & MEHL, 1934, p. 298, pl. 23, figs. 1-3; COOPER, 1939, p. 408, pl. 39, figs. 63,64; pl. 43, figs. 53,54; BISCHOFF & ZIEGLER, 1956, p. 162, pl. 11, figs. 18,19; BISCHOFF, 1957, p. 51; REXROAD & SCOTT, 1964, p. 38-39, pl. 2, figs. 21-23.

Pseudopolygnathus cf. *fusiformis* (Branson & Mehl), VOGES, 1959, p. 295, pl. 34, figs. 42-46.

Macropolygnathus bela COOPER, 1939, p. 393, pl. 42, figs. 20-22.

Macropolygnathus diamesa COOPER, 1939, p. 393, pl. 42, figs. 69,70; pl. 43, figs. 1,2.

Macropolygnathus stena COOPER, 1939, p. 396, pl. 42, figs. 51,52; pl. 43, figs. 3,4.

Polygnathus allocata (Cooper) HASS, 1959, p. 389, pl. 48, figs. 30-32.

Polygnathus brevimarginata BRANSON, 1934, p. 308, pl. 25, fig. 3.

Polygnathus exodus COOPER, 1939, p. 400, pl. 42, figs. 42-44.

Polygnathus lacinata HUDDLE, 1934, p. 95, pl. 8, figs. 1-3.

?*Polygnathus scobiniformis* Branson. COOPER, 1939, p. 403, pl. 39, figs. 47,48.

Pseudopolygnathus stina COOPER, 1939, p. 408, pl. 39, figs. 59,60.

Spathodus delicatulus Branson. COOPER, 1939, p. 413, pl. 41, figs. 17,18.

Diagnosis. This species has a long, narrow, symmetrical platform which tapers at both ends. The oral surface of the platform is ornamented with low nodes positioned at the outermost margins. The nodose margins are separated from the medial carina by shallow, smooth troughs. In lateral view the oral outline rises continually toward the anteriormost portion of the free blade. The carina, in both inner- and outer-lateral views is prominently higher than either of the margins. The elliptical basal cavity is located near the center of the unit, is broader anteriorly, and tapering gradually to the posterior tip of the element.

Remarks. The sharply tapering platform, both anteriorly and posteriorly, as well as the shallow, smooth troughs, serve as diagnostic features of the species, and in the latter feature especially separate the form from similar pseudopolygnathids which are generally more strongly ridged orally (see *P. multistriata*).

Occurrence. This species has been reported from the Bushberg Formation and the Hannibal Formation of Missouri (Branson & Mehl, 1934; Branson, 1934), the New Albany Shale of Indiana (Huddle, 1934), the pre-Weldon Shale of Oklahoma (Cooper, 1939), the Chappel Formation of Texas (Hass, 1959) and the Lower Rockford Formation of Indiana (Rexroad & Scott, 1964).

Bischoff & Ziegler (1956) reported the species from strata of *cu*II age, and in 1957, Bischoff again reported the form from *cu*II$^{\alpha}$-middle *cu*IIβ/γ strata in Germany. Voges (1959) recovered this species from middle and upper *cu*I strata in the Sauerland.

Pseudopolygnathus fusiformis occurs in the Prospect Hill strata in Washington County, Iowa, at the Maple Mill and High Bridge localities.

Material studied. 15 specimens.

Repository. Figured hypotypes, S.U.I. 12516, 12517.

PSEUDOPOLYGNATHUS MULTISTRIATA Mehl & Thomas, 1947

Pseudopolygnathus attenuata MEHL & THOMAS, 1947, p. 17, pl. 1, figs. 9,36; BISCHOFF, 1957, p. 51, pl. 4, figs. 33,35; BURTON, 1964, range chart; REXROAD & SCOTT, 1964, p. 41, pl. 2, fig. 30.

Pseudopolygnathus brevimarginata BRANSON, 1933, p. 322, pl. 26, fig. 3; THOMAS, 1949, pl. 3, fig. 25.

Pseudopolygnathus pachus COOPER, 1939, p. 402, pl. 40, figs. 39,40, 41.

Pseudopolygnathus rustica MEHL & THOMAS, 1947, p. 17, pl. 1, fig. 8.

Pseudopolygnathus striata MEHL & THOMAS, 1947, p. 17, pl. 1, fig. 10; BISCHOFF & ZIEGLER, 1956, p. 164, pl. 11, fig. 20.

Pseudopolygnathus lanceolata HASS, 1959, p. 391, pl. 47, figs. 19-26.

Diagnosis. The platform is commonly tapered at both ends, and is bilaterally symmetrical with a straight to slightly sinuous axis. The outer platform extends farther toward the anterior than does the inner platform in some specimens. Oral surface is ornamented with coarse nodes and transverse ridges. The carina is commonly higher than the margins of the platform in lateral view. The basal cavity is sub-elliptical and tapers anteriorly and posteriorly.

Remarks. Pseudopolygnathus attenuata, P. rustica and *P. striata* Mehl & Thomas represent a growth series of *Pseudopolygnathus* which is evident in the ontogenetic series illustrated by Hass (1959, pl. 47, figs. 20-26) for *P. multistriata*. *P. multistriata* is differentiated from *P. itha* by the blunt, or rounded, posterior end and no anterior free blade. The anterior portion of the platform of *P. prima* Branson & Mehl is wider and more asymmetrical than *P. multistriata* and possesses an alated inner lateral margin.

Occurrence. Pseudopolygnathus multistriata has been reported from the Hannibal (Branson, 1934) and Fern Glen Formations (Mehl & Thomas, 1947) of Missouri, the Alamogordo and Nunn Members of the Lake Valley Formation in New Mexico (Burton, 1964), the pre-Weldon Shale of Oklahoma (Cooper, 1939), the Chappel Formation of Texas (Hass, 1959), and the upper Rockford and lower New Providence Formations of Indiana (Rexroad & Scott, 1964).

Bischoff (1957) reported this species from strata ranging in age from *cu*I through *cu*II$_{\gamma}$ in Germany.

Pseudopolygnathus multistriata occurs in the glauconite bed at the base of the Burlington Formation at the Wassonville Mill locality, Washington County, Iowa.

Material studied. 1 specimen.

Genus *SIPHONODELLA* Branson & Mehl, 1944

Siphonognathus BRANSON & MEHL (*non* RICHARDSON, 1958), 1934, p. 296.

Siphonodella BRANSON & MEHL, 1944, p. 245.

Type species. Siphonognathus duplicata Branson & Mehl, 1934, p. 296, pl. 24, figs. 16,17; (OD).

Diagnosis. See Klapper, 1966, p. 15-16, for discussion of generic characteristics.

Remarks. Previously, the rostral ridges on the oral surface of the platform were used to distinguish *Siphonodella* from *Polygnathus*, but as this is primarily a growth stage phenomena and since some polygnathids also demonstrate rostral ridge development (*e.g. Polygnathus inornata, P. perplexa* and *P. nodocostata*), this morphologic feature is considered superfluous in differentiating *Siphonodella* and *Polygnathus.*

The arrangement and number of rostral ridges and secondary platform ornamentation are highly variable within the genus, but serves to differentiate the species within the genus, although the specific characters may overlap due to the extreme variability.

Aboral morphology serves best to separate siphonodellids from polygnathids. *Siphonodella* has a minute, slit-like basal cavity, whereas *Polygnathus* commonly has a larger ovoid or elliptical one. *Polygnathus* also possesses a low medial keel extending from the basal cavity to the posterior tip, but the keel is absent immediately posterior to the basal cavity in *Siphonodella,* and may be present only near the posterior end of the platform. It is recognized, however, as noted by Collinson, *et al.* (1962) that the two genera intergrade, the primitive siphonodellid, *Siphonodella sulcata,* closely resembling *Polygnathus.*

Occurrence. Collinson, *et al.* (1962) reported *Siphonodella* from the Hannibal and Chouteau Formations of Missouri. Voges (1959) recorded the genus from *cu*I through *cu*IIβ/γ strata in the Sauerland and Bischoff (1957) reported occurrences of three species of *Siphonodella* in *cu*II∝-β strata, with isolated occurrences in *cu*IIγ and *cu*III∝ strata. Species of the genus serve as excellent index or zone fossils for the Kinderhookian Series in the standard Mississippi Valley section. (Collinson, *et al.*, 1962.)

SIPHONODELLA COOPERI Hass, 1959

Pl. 3, Figs. 10,11; Pl. 6, Figs. 2,6,9,10,12,13,16

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

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

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

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

Siphonodella cooperi HASS, 1959, p. 392, pl. 48, figs. 35,36; SCOTT

& COLLINSON, 1961, p. 131, pl. 2, figs. 31,33-35; REXROAD & SCOTT, 1964, p. 43-44, pl. 3, figs. 27-29; ANDERSON, 1964, p. 128-130, pl. 10, figs. 1,2,10,11; KLAPPER, 1966, p. 16, pl. 2, figs. 10,11; pl. 3, figs. 1-4.

Diagnosis. *Siphonodella* with two or three rostral ridges. The longest ridge, on the outer platform, commonly terminates posteriorly at the outer margin of the platform. The inner platform is ornamented with nodes, and the outer platform with transverse ridges.

Remarks. Klapper (1966; 1965, personal communication) regarded the position of the termination of the outer rostral ridge a basis for distinguishing *Siphonodella cooperi* from *S. duplicata*. The outer lateral ridge of *S. cooperi* is terminated at the margin of the platform, whereas, that of *S. duplicata* terminates on the platform at, or near, the basal cavity region. The platform of *S. cooperi* is more elongate and narrower than that of *S. crenulata*, but the two species are transitional. *S. cooperi* is differentiated from *S. obsoleta* Hass by the presence of transverse ridges on the outer platform.

Several immature forms of *Siphonodella*, in the Washington County material, were assigned to this species entirely on the apparant termination of the outer rostral ridge at the margin of the platform.

Occurrence. See Anderson, 1964, p. 130 for complete list of occurrences through February, 1964.

Rexroad & Scott (1964) recovered *Siphonodella cooperi* from the lower portion of the Rockford Limestone in Indiana.

Collinson, *et al.*, (1962, Chart 2) recorded the species from middle Hannibal through upper Chouteau strata. Voges (1959, Table 1) reported *S. cooperi* ranging from lowermost *cu*I through lower *cu*II$^{\alpha}$ in the Sauerland.

Siphonodella cooperi was recovered from the Wassonville Formation at the type Wassonville section and the Maple Mill locality, and the Prospect Hill Formation at the Maple Mill and High Bridge localities, Washington County, Iowa.

Material studied. 1092 specimens.

Repository. Figured hypotypes, S.U.I. 12527, 12528, 12529.

SIPHONODELLA cf. *S. CRENULATA* (Cooper, 1939)

Pl. 2, Figs. 9,12

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

Siphonodella crenulata (Cooper). BISCHOFF & ZIEGLER, 1956, p. 156, pl. 12, figs. 15,16,17; BISCHOFF, 1957, p. 54, pl. 6, figs. 3-5; VOGES, 1959, p. 307-308, pl. 35, figs. 23-30; ZIEGLER, 1960, pl. 3, fig. 11.

Diagnosis. Asymmetrical *Siphonodella* with the outer platform strongly convex, the margin of which is crenulated. The inner platform is ornamented with nodes and the outer with ridges. Two or three rostral ridges are commonly present, but several forms were noted with four or five.

Remarks. The characteristic strongly convex outline and crenulated outer lateral margin distinguishes *Siphonodella crenulata* from all other species in the genus.

Occurrence. Siphonodella crenulata has been reported from the pre-Weldon Shale in Oklahoma (Cooper, 1939), and the basal Lodgepole Formation of Wyoming and Montana (Klapper, 1962). Collinson, *et al.* (1962, Chart 2) recorded the species from the Hannibal and Chouteau Formations of Missouri. Bischoff (1957) recovered *S. crenulata* from *cu*IIα-β strata, with an isolated occurrence in *cu*IIγ strata. Voges (1959) reported this species from *cu*IIα through *cu*IIβ/γ strata in the Sauerland.

The species was recovered from the shale member of the Prospect Hill Formation at the Maple Mill locality, Washington County, Iowa.

Material studied. 16 specimens.

Repository. Figured hypotype, S.U.I. 12518.

SIPHONODELLA DISTORTA (Branson & Mehl, 1934)

Pl. 4, Fig. 10

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

Siphonodella distorta (Branson & Mehl). KLAPPER, 1962, p. 110-111, pl. 3, figs. 6,10-12,14,15.

Diagnosis. Siphonodella with the innermost rostral ridge, on the outer platform, extending to near the posterior end. Three to six rostral ridges may be present. The platform is ornamented with nodes on the inner surface, while the outer surface is commonly unornamented except near the posterior end, which may be nodose in some specimens.

Remarks. The Washington County specimens assigned to this species compare closely with that illustrated by Branson & Mehl, 1934, p. 294, pl. 24, fig. 12.

Occurrence. Siphonodella distorta has been reported from the Bachelor Formation of Missouri (Branson & Mehl, 1934). It has also been reported from the Mississippian portion of the Clark's Fork Formation of Wyoming and Montana (Klapper, 1962).

Siphonodella distorta was recovered from the shale unit of the Prospect Hill Formation at the Maple Mill locality, Washington County, Iowa.

Material studied. 8 specimens.

Repository. Figured hypotype, S.U.I. 12531.

SIPHONODELLA DUPLICATA (Branson & Mehl, 1934)

Pl. 6, Figs. 14,15

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

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

Siphonodella duplicata (Branson & Mehl). BRANSON & MEHL, 1944, p. 245; HASS, 1951, p. 2538, pl. 1, figs. 12,13; ———, 1956, p. 25, pl. 2, figs. 8-11; CLOUD, BARNES & HASS, 1957, p. 809, pl. 5, fig. 5; BISCHOFF, 1957, p. 55, pl. 6, figs. 1,2; HASS, 1959, p. 370, pl. 49, fig. 25 (same specimen as CLOUD, BARNES & HASS, 1957); VOGES, 1959, p. 308-309, pl. 35, figs. 31-34; KLAPPER, 1966, p. 18, pl. 4, fig. 13.

Diagnosis. See Klapper (1966, p. 18) for discussion of diagnostic characteristics.

Remarks. The Washington County specimens referred to this species compare closely to those described and illustrated by Branson & Mehl, 1934.

Occurrence. See Klapper, 1962, p. 113 for complete list of occurrences through August, 1962.

Bischoff (1957) recovered *Siphonodella duplicata* from *cu*IIα-β strata, with isolated occurrences in *cu*IIγ and *cu*IIIα strata in Germany, whereas, Voges (1959) reported the species occurring in middle *cu*I through lower *cu*IIα strata in the Sauerland.

Siphonodella duplicata was recovered from the shale member, Prospect Hill Formation at the Maple Mill locality, Washington County, Iowa.

Material studied. 2 specimens.

Repository. Figured hypotype, S.U.I. 12532.

SIPHONODELLA OBSOLETA Hass, 1959

Pl. 4, Figs. 2,3

Siphonodella obsoleta HASS, 1959, p. 392-393, pl. 47, figs. 1,2; VOGES, 1959, p. 309-310, pl. 35, figs. 40-50; ZIEGLER, 1960, pl. 3, fig. 8; MULLER, 1962, text-figs. 4,8; ANDERSON, 1964, p. 132-134, pl. 10, figs. 3,5; REXROAD & SCOTT, 1964, p. 45, pl. 3, fig. 25.

Siphoondella duplicata (Branson & Mehl). YOUNGQUIST & PATTERSON, 1949, p. 69, pl. 16, figs. 8,9; BISCHOFF, 1957, p. 55, pl. 6, fig. 2.

Siphonodella sp. A HASS, 1959, p. 25, pl. 2, fig. 12.

Siphonodella isosticha (Cooper), KLAPPER, 1962, p. 113-115, pl. 3, figs. 17,19; pl. 5, figs. 9,12; ETHINGTON, 1965, p. 587, pl. 67, figs. 15,17.

Diagnosis. *Siphonodella* with outer rostral ridge continuing to the posterior end as a strongly upturned margin. Two or three rostral ridges are commonly present. The inner platform is nodose, and the outer platform is unornamented between the upturned margin and the carina.

Remarks. *Siphonodella obsoleta* is distinguished from the other species of *Siphonodella* in having the outer rostral ridge extending the entire length of the platform as an upturned margin anteriorly.

Occurrence. See Anderson (1964, p. 133-134) for complete list of occurrences through February, 1964.

Ethington (1965) recovered *Siphonodella obsoleta* from the Escabrosa Formation in Arizona.

Voges (1959) reported this species from middle *cu*I through *cu*II-β/γ strata in the Sauerland.

Siphonodella obsoleta was recovered from the shale unit of the Prospect Hill Formation at the Maple Mill and High Bridge localities, Washington County, Iowa.

Material studied. 45 specimens.

Repository. Figured hypotype, S.U.I. 12530.

SIPHONODELLA QUADRUPLICATA (Branson & Mehl, 1934)

Pl. 2, Figs. 10,11; Pl. 3, Figs. 1-3,6-8;
Pl. 4, Figs. 9,11

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

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

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

Siphonognathus sexplicata Branson & Mehl, COOPER, 1939, p. 410, pl. 41, figs. 38,39.

Siphonodella quadruplicata (Branson & Mehl), BRANSON & MEHL, 1944, *in* Shimer and Shrock, p. 245, pl. 94, figs. 44,45; YOUNGQUIST & PATTERSON, 1949, p. 70, pl. 16, fig. 11; THOMAS, 1949, p. 436, pl. 3, figs. 2,3,6; YOUNGQUIST & DOWNS, 1951, p. 790, pl. 111, fig. 22 (*non* figs. 23-25=*S. obsoleta*); HASS, 1951, p. 2539, pl. 1, fig. 9; ——, 1956, p. 25, pl. 2, fig. 29; CLOUD, BARNES & HASS, 1957, p. 809, pl. 5, fig. 11; HASS, 1959, p. 370, pl. 49, fig. 28 (same specimen as CLOUD, BARNES & HASS, 1957); BEACH, 1961, p. 45, pl. 6, figs. 9,15 (*non* fig. 13=*S. obsoleta*); MULLER, 1962, p. 1388, text fig. 5; ANDERSON, 1964, p. 134-136, pl. 10, figs. 6,8,9,12; KLAPPER, 1966, p. 17-18, pl. 2, figs. 5-8; pl. 3, figs. 9-12; pl. 4, figs. 16,20.

Siphonodella sexplicata (Branson & Mehl), THOMAS, 1949, p. 436, pl. 3, fig. 1.

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

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

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

Diagnosis. Anderson (1964, p. 119) characterized *Siphonodella quadruplicata* by the rostral ridge termination, and stated that "rostral ridges generally do not extend much distance posteriorly beyond the basal cavity." The platform is nodose on the inner margin and has transverse ridges on the outer portion. Four rostral ridges are commonly present on the anterior end on the platform, but some forms may have three or five.

Remarks. Specific differentiation in the Washington County material was based on platform shape and the number of rostral ridges. Units with three or two rostral ridges were assigned to *Siphonodella cooperi*, those with four and five to *Siphonodella quadruplicata*, and those with six rostral ridges to S. *sexplicata*. Generally, the forms with two or three ridges had elongate, narrow platforms, as well, a feature herein considered characteristic of S. *cooperi*. Those forms with six rostral ridges commonly had a broad, almost elliptical platform, and were referred to S. *sexplicata*. Intermediate width platforms commonly had four or five rostral ridges.

Siphonodella cooperi, S. *quadruplicata* and S. *sexplicata* evolved from the same stock (S. *crenulata*) (Rexroad & Scott, 1964, p. 47-50) along lines tending toward multiplicity of rostral ridges, but it is recognized that the three species are transitional into one another. The specific assignments herein are based, finally, on comparison between the specimens on hand.

See Klapper, 1966, for additional comments on the synonyms of *Siphonodella quadruplicata*.

Occurrence. See Anderson (1964, p. 136) for complete list of occurrences through February, 1964.

Rexroad & Scott (1964) recovered *Siphonodella quadruplicata* from the lower part of the Rockford Limestone in Indiana.

Bischoff (1957) reported the species from *cu*IIα-β strata, with an isolated occurrence in *cu*IIγ strata in Germany.

Siphonodella quadruplicata was recovered from the McCraney Formation at the Maple Mill locality, and from the Prospect Hill Formation at the Maple Mill and High Bridge localities, Washington County, Iowa.

Material studied. 468 specimens.

Repository. Figured hypotypes, S.U.I. 12519, 12520, 12521, 12522, 12523.

SIPHONODELLA SEXPLICATA (Branson & Mehl, 1934)

Pl. 3, Figs. 4,5,9,12; Pl. 4, Figs. 6,7

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

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

Siphonodella sexplicata (Branson & Mehl). KLAPPER, 1966, p. 18-19, pl. 4, fig. 18.

Diagnosis. Siphonodella with six rostral ridges on the anterior end of the platform. The platform is broadly ellipsoidal, or ovoid, in outline.

Remarks. See remarks under S. *quadruplicata* in this paper.

Occurrence. Siphonodella sexplicata has been reported from the Bachelor Formation of Missouri (Branson & Mehl), Cooper's (1939) pre-Weldon Shale, the Mississippian portion of the Clark's Fork Formation of Wyoming and Montana (Klapper, 1962), the Lodgepole Formation of Montana (Klapper, 1962) and the upper part of the New Albany Shale of Indiana (Rexroad & Scott, 1964).

The species was recovered from the shale unit of the Prospect Hill Formation at the Maple Mill and High Bridge localities, Washington County, Iowa.

Material studied. 8 specimens.

Repository. Figured hypotypes, S.U.I. 12524, 12525, 12526.

Genus *SPATHOGNATHODUS* (Branson & Mehl, 1934)

Spathodus BRANSON & MEHL (*non* BOULENGER, 1900), 1934, p. 46.

Ctenognathus PANDER (*non* FAIRMAIRE, 1843), 1865, p. 32; FAY, 1959, p. 195.

Pandorina STAUFFER (*non* BORY de ST. VINCENT, 1823; SCACCHI, 1833), 1940, p. 428.

Spathognathodus BRANSON & MEHL, 1941, p. 428.

Mehlina YOUNGQUIST, 1945, p. 363.

Pandorinellina HASS, 1959, p. 378-379.

Branmehla HASS, 1959, p. 381.

Type species. Ctenognathus murchisoni Pander, 1856, p. 32, pl. 4, fig. 17; pl. 6, figs. 18a,18b.

Diagnosis. Blade-like unit which is straight or slightly bowed laterally and which may, or may not be, slightly arched, orally. Basal cavity is commonly small, with or without flared lips.

Remarks. Ziegler (1961, p. 1237) discussed the nomenclatural problems which have arisen between *Spathognathodus* and *Ctenognathus*, and the writer agrees with his proposal that the first name applied to a species of this genus, *Spathognathodus*, is valid. *Ctenognathodus*, Fay is considered a junior subjective synonym of *Spathognathodus*. Hass (1959) regarded *Branmehla* distinct from *Spathognathodus* on the posterior position of the basal cavity in *Branmehla*. The position of the basal cavity is highly variable within *Spathognathodus* and even within growth stages of the same species of spathognathodid. The posterior location of the basal cavity in *Branmehla* falls within the range of variation of *Spathognathodus*, and is considered a junior subjective synonym of *Spathognathodus*.

Occurrence. Spathognathodus ranges from the middle Ordovician through the Triassic, but many significant short-ranged species occur throughout this time span.

SPATHOGNATHODUS COSTATUS COSTATUS (Branson, 1934)

Pl. 7, Figs. 2-4,7,8,12

Spathodus costatus BRANSON, 1934, p. 303-304, pl. 27, fig. 13; BRANSON & MEHL, 1938, p. 136, pl. 33, fig. 1.

Spathognathodus costatus (Branson). THOMAS, 1949, pl. 4, fig. 10; BISCHOFF & ZIEGLER, 1956, p. 166, pl. 13, fig. 3; BISCHOFF, 1957, p. 56, pl. 4, fig. 28; ZIEGLER, 1957, pl. 1, figs. 15,18,22; HELMS, 1959, pl. 3, figs. 2-4.

Spathognathodus spinulicostatus (Branson). SANNEMANN, 1955, pl. 24, fig. 9 (*non* fig. 8=*S. spinulicostatus*).

Spathognathodus cf. *S. costatus* (Branson). VOGES, 1959, p. 297, pl. 34, figs. 47,48.

Spathognathodus tridentatus (Branson). FREYER, 1961, pl. 2, figs. 9,10.

Diagnosis. Spathognathodus with a thick blade and a sub-central basal cavity with broadly flaring thick lips. A parapet row of denticles rises from the inner side of the blade and extends the entire length of the unit. The denticles near the anterior and posterior ends of the blade are set close to the carina, whereas, those near the center are set apart from it. Each denticle is joined to the carina by a narrow transverse ridge. The denticles are commonly higher than the carina and a shallow trough lies between them and the carina.

Remarks. The Washington County specimens referred to this species compare closely to those described and illustrated by Branson (1934).

Occurrence. Spathognathodus costatus costatus has been reported from the Hannibal Formation of Missouri (Branson, 1934) and the English River Formation (Washington County) (Thomas, 1949) of Iowa.

Ziegler (1957) reported this species from *to*VI strata near Steinberg, Germany, and Bischoff (1957) recorded the species from the Rheno-Herzynischen Highlands in strata ranging in age from below *to*IV through *to*VI. Ziegler reported *Spathognathodus costatus costatus* in upper *to*V through *to*VI strata and Voges (1959) recovered this species from *to*VI strata with isolated occurrences in lower and middle *cu*I strata in the Sauerland.

This species was recovered from the shale unit of the Prospect Hill Formation and from the English River Formation at the Maple Mill locality, Washington County, Iowa.

Material studied. 24 specimens.

Repository. Figured hypotypes, S.U.I. 12535, 12536.

SPATHOGNATHODUS CRASSIDENTATUS (Branson & Mehl, 1934)

Pl. 4, Figs. 1,4

Spathodus crassidentatus BRANSON & MEHL, 1934, p. 276, pl. 22, figs. 17,18; BRANSON, 1934, p. 303, pl. 27, fig. 12; ———, 1938, p. 182; BRANSON & MEHL, 1938, p. 132, pl. 33, fig. 5; COOPER, 1939, p. 413, pl. 45, fig. 19; COOPER & SLOSS, 1943, p. 171-175, pl. 28, fig. 1.

Spathognathodus crassidentatus (Branson & Mehl). YOUNGQUIST & PATTERSON, 1949, p. 71, pl. 15, fig. 2; THOMAS, 1949, pl. 2, figs. 16,24; pl. 4, fig. 6; BISCHOFF & ZIEGLER, 1956, p. 166, pl. 13, fig. 3; BISCHOFF, 1957, p. 56; ANDERSON, 1964, p. 138-140, pl. 8, figs. 1-4; KLAPPER, 1966, p. 23-24, pl. 5, figs. 15-17.

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

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

Diagnosis. The blade is long, thin and bowed laterally, with a subcentrally located basal cavity. The oral outline is highest at the anterior end, decreasing in height to the region above the anterior tip of the basal cavity, where it rises again, gradually, to a secondary high above the posterior end of the basal cavity. The outline then descends rather abruptly, to the posterior end of the blade. The two anteriormost denticles are almost twice as wide and somewhat higher than the rest. These denticles form the apex, or highest area, in the oral outline. The basal cavity is symmetrical, broadly rounded anteriorly and tapering to a point posteriorly. The lips are thick and moderately flared.

Remarks. Many species of spathognathodids with a sub-central basal cavity have been proposed on slight variations in the oral outline. Differences in the oral outline of the Washington County material is extreme, and those species herein placed into synonymy with *Spathognathodus crassidentatus* fit within this range of variation. The writer considers the shape of the basal cavity and major, or generalized, differences in the oral outline as criteria for differentiating the species of *Spathognathodus*.

Occurrence. Spathognathodus crassidentatus has been reported from the Bachelor (Branson & Mehl, 1934) and Hannibal (Branson, 1934) Formations of Missouri, the black shale at the base of the Madison Formation in Montana (Cooper & Sloss, 1943), the Maple Mill, English River, Prospect Hill (Thomas, 1949) and Maynes Creek (Anderson, 1964) Formations of Iowa, the Mississippian portion of the Englewood Formation of Wyoming and Montana (Klapper, 1962) and the lower part of the Rockford Formation (Rexroad & Scott, 1964).

Bischoff (1957) reported this species from below *to*VI through *cu*II$_{\gamma}$ strata in Germany.

This species was recovered from the Prospect Hill Formation at the Maple Mill and High Bridge localities, the Wassonville Formation at the Wassonville Mill and Maple Mill localities and the Burlington Formation at the Wassonville Mill locality, Washington County, Iowa.

Material studied. 159 specimens.

Repository. Figured hypotype, S.U.I. 12533.

SPATHOGNATHODUS LINGUIFEROUS (Branson, 1934)

Spathodus linguiferous BRANSON, 1934, p. 306-307, pl. 27, fig. 24; BRANSON & MEHL, 1938, p. 132, pl. 33, fig. 4; BRANSON, 1944, p. 181; 223, pl. 32, fig. 4.

Nodognathus linguiferous (Branson). COOPER, 1939, p. 398, pl. 40, figs. 56-58.

Spathognathodus linguiferous (Branson). HASS, 1959, pl. 49, fig. 24; ANDERSON, 1964, p. 140-141, pl. 8, figs. 4,5.

Diagnosis. Spathognathodus with a single lateral denticle developed from the inner lateral side directly over the basal cavity.

Remarks. Spathognathodus linguiferous differs from *Spathognathodus aculeatus* in that the latter has three or more lateral denticles which develop anteriorly or posteriorly of the basal cavity. *S. costatus costatus* has a row of denticles on the inner lateral side extending the entire length of the platform. *S. antiposicornis* Scott has one inner lateral denticle, but it is invariably located immediately anterior to the basal cavity.

See Anderson (1964, p. 141-142) for discussion of the synonymies of *Spathognathodus linguiferous*.

Occurrence. *Spathognathodus linguiferous* has been reported from the Hannibal (Branson, 1934) and Bachelor (Branson & Mehl, 1934) Formations of Missouri, the pre-Weldon Shale of Oklahoma (Cooper, 1939) and the Maynes Creek Formation of Iowa (Anderson, 1964).

This species was recovered from the shale member of the Prospect Hill Formation at the Maple Mill and High Bridge localities, Washington County, Iowa.

Material studied. 10 specimens.

SPATHOGNATHODUS cf. *S. STABILIS* (Branson & Mehl, 1934)
Pl. 6, Fig. 3

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

Spathognathodus stabilis (Branson & Mehl). KLAPPER, 1966, p. 23, pl. 5, figs. 6,7.

Diagnosis. Straight to slightly incurved *Spathognathodus* which is arched from the anterior end of the basal cavity to the posterior tip of the blade.

Remarks. Washington County forms assigned to this species do not display the degree of variation in oral outline as reported in the literature. A single characteristic feature, common to all Washington County specimens, serves to make their assignment to *Spathognathodus stabilis* questionable. There is an abrupt break in the oral outline immediately above the anterior end of the basal cavity. This morphologic feature has not been previously reported or illustrated in other specimens of *S. stabilis*. The anterior portion of the blade has 4-5 subequal denticles with a much larger denticle immediately posterior to them. The larger denticle forms the oral outline break. In lateral view, smaller sub-equal denticles extend to the posterior, parallel to the arched aboral outline. This oral outline break is common to all specimens assigned to this species, and the specimens range throughout the sampled sections.

Occurrence. *Spathognathodus stabilis* has been reported from the Saverton (Grassy Creek of Branson & Mehl, 1934), Bachelor (Branson & Mehl, 1934), Hannibal (Branson, 1934) and the Chouteau (Branson, 1944) Formations of Missouri, the pre-Weldon Shale of Oklahoma (Cooper, 1939), the Maple Mill, English River, and Prospect Hill Formations of Iowa (Youngquist & Patterson, 1949), the Clark's Fork (Darby of Klapper, 1958), Bull Lake Creek, Wyoming, the "Exshaw"

Formation of Alberta (Cooper & Sloss, 1943), the black shale at the base of the Madison Formation (Cooper & Sloss, 1943) of Montana, the Lodgepole Formation of Wyoming and Montana (Klapper, 1962), the Englewood and Pahasapa Formations of South Dakota (Klapper, 1962) and the New Albany Shale of Indiana (Rexroad & Scott, 1964).

Bischoff & Zeigler (1956) reported this species ranging from *to*III through *cu*IIδ strata in Germany. Bischoff (1957) recovered the species from below *to*VI through *cu*III∝ strata in the Sauerland. Ziegler (1962) recorded the range of the species from middle *to*III∝ through *to*VI, but his investigation was restricted to the Devonian and the range may actually be higher.

Spathognathodus stabilis was recovered from the Prospect Hill Formation at the High Bridge and Maple Mill localities and from the Wassonville and Burlington Formations at the Wassonville Mill locality, Washington County, Iowa.

Material studied. 51 specimens.

Repository. Figured hypotype, S.U.I. 12534.

EXPLANATION OF PLATE 1

All figures are from the shale member, Prospect Hill Formation. Figures 1,2,3 are X24; 15,18 are X29; all others are X36.

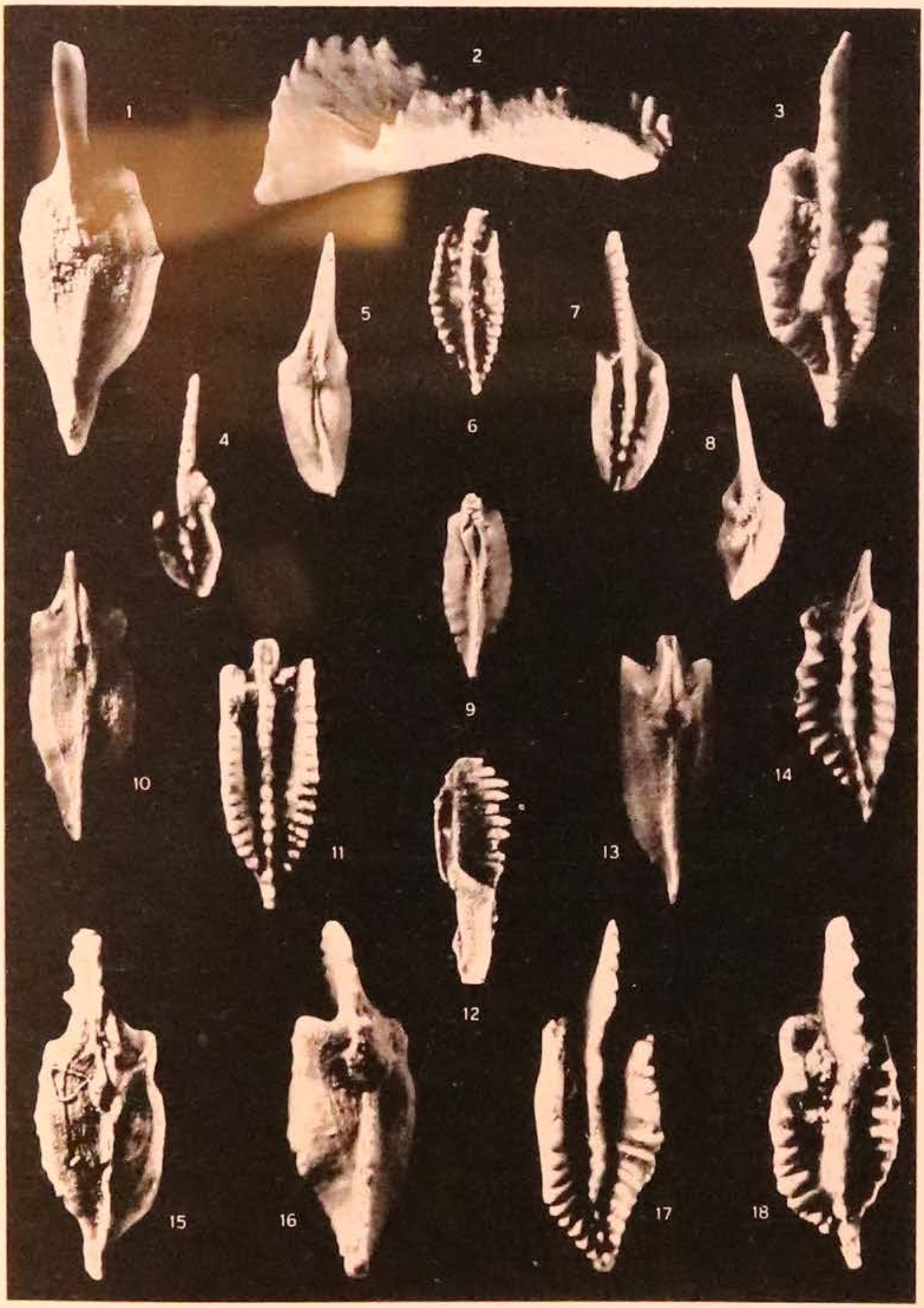
FIGS. 1-3,10,14,15,18—*Polygnathus longipostica* Branson & Mehl. 1,2,3, Aboral, left lateral and oral views of S.U.I. hypotype 12494; 10,14, aboral and oral views of S.U.I. hypotype 12495; 15,18, aboral and oral views of S.U.I. hypotype 12496.

4,5,7,8,12—*Polygnathus communis* Branson & Mehl. 4,8,12, Oral and aboral and right lateral views of S.U.I. hypotype 12499; 5,7, aboral and oral views of S.U.I. hypotype 12500.

6,9,11,13—*Polygnathus symmetrica* Branson. 6,9, Oral and aboral views of S.U.I. hypotype 12502; 11,13, oral and aboral views of S.U.I. hypotype 12503.

16,17—*Polygnathus inornata* Branson. Aboral and oral views of S.U.I. hypotype 12504.

Plate 1



EXPLANATION OF PLATE 2

All figures are from the shale member, Prospect Hill Formation. All figures are X33.

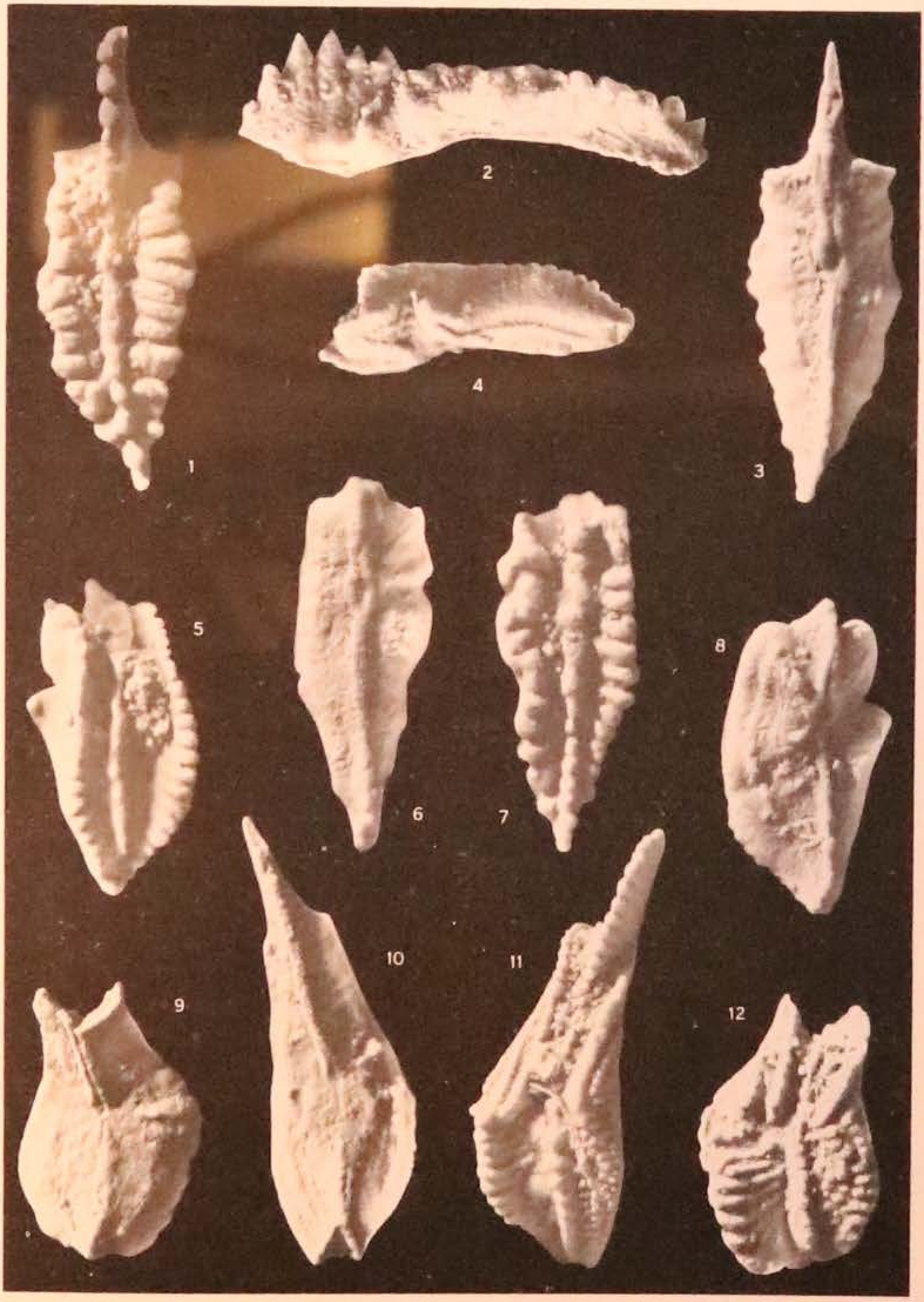
FIGS. 1-3,6,7—*Polygnathus longipostica* Branson & Mehl. 1,2,3, Oral, left lateral and aboral views of S.U.I. hypotype 12497; 6,7, aboral, and oral views of S.U.I. hypotype 12498.

4,5,8—*Polygnathus inornata* Branson. Left lateral, oral and aboral views of S.U.I. hypotype 12505.

9,12—*Siphonodella* cf. *S. crenulata* (Cooper). Aboral and oral views of S.U.I. hypotype 12518.

10,11—*Siphonodella quadruplicata* (Branson & Mehl). Aboral and oral views of S.U.I. hypotype 12519.

Plate 2



EXPLANATION OF PLATE 3

All figures are from the shale member, Prospect Hill Formation. Figures 1,3 are X33; 10,11 are X35; all others are X28.

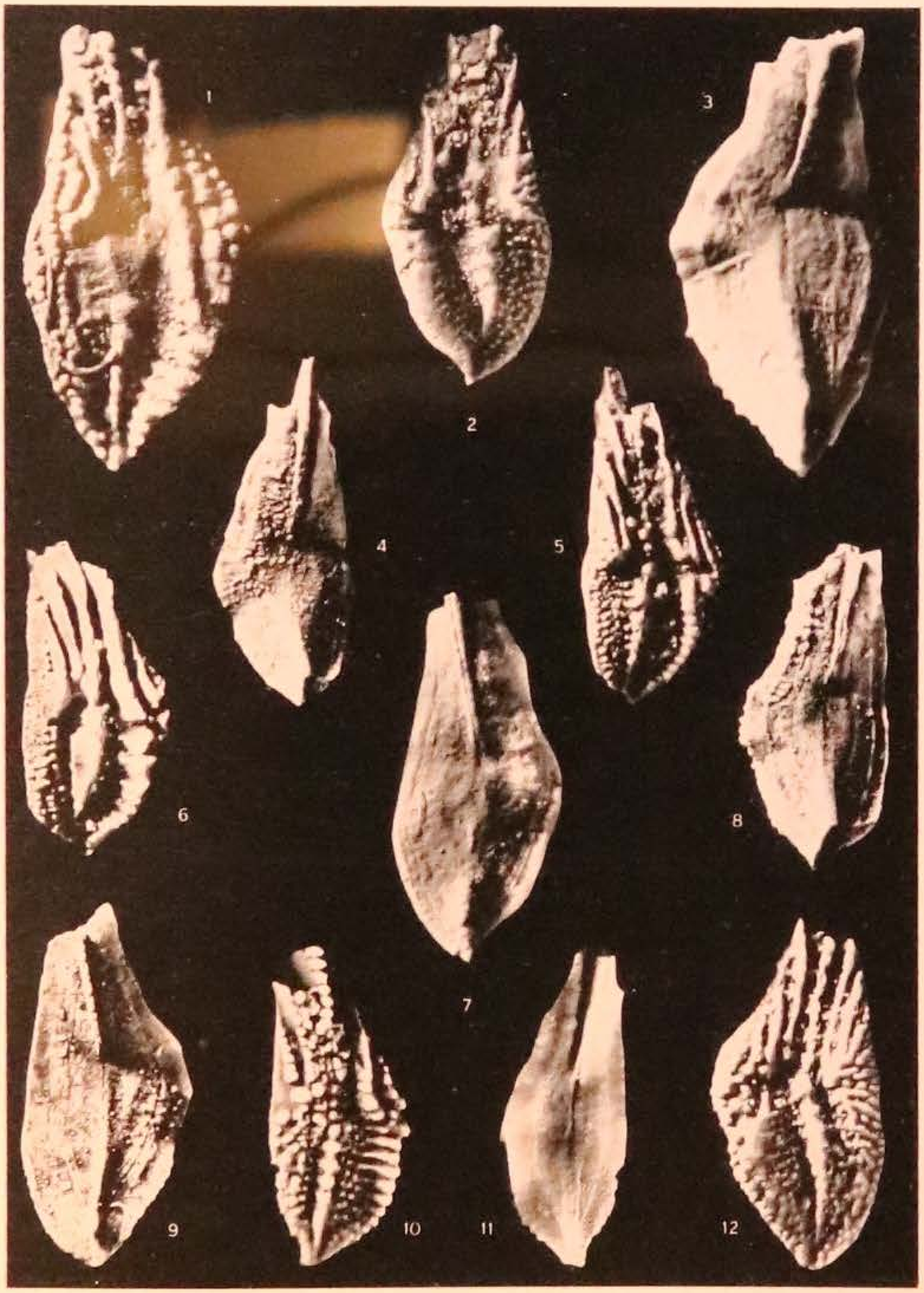
FIGS. 1,3—*Siphonodella* cf. *S. quadruplicata* (Branson & Mehl). Oral and aboral views of S.U.I. hypotype 12520.

2,6-8—*Siphonodella quadruplicata* (Branson & Mehl). 2,7, Oral and aboral views of S.U.I. hypotype 12521; 6,8, oral and aboral views of S.U.I. hypotype 12522.

4,5,9,12—*Siphonodella sexplicata* (Branson & Mehl). 4,5, Aboral and oral views of S.U.I. hypotype 12524; 9,12, aboral and oral views of S.U.I. hypotype 12525.

10,11—*Siphonodella cooperi* Hass. Oral and aboral views of S.U.I. hypotype 12527.

Plate 3



EXPLANATION OF PLATE 4

Figures 5 and 8 are from the Burlington Formation; all others are from the shale member, Prospect Hill Formation. Figures 1,4,9 and 11 are X50; all others are X38.

FIGS. 1,4–*Spathognathodus crassidentatus* (Branson & Mehl). Left and right lateral views of S.U.I. hypotype 12533.

2,3–*Siphonodella obsoleta* Hass. Aboral and oral views of S.U.I. hypotype 12530.

5,8–*Bactrognathus distorta* Branson & Mehl. Oral and aboral views of S.U.I. hypotype 12537.

6,7–*Siphonodella sexplicata* (Branson & Mehl). Oral and aboral views of S.U.I. hypotype 12526.

9,11–*Siphonodella quadruplicata* (Branson & Mehl). Aboral and oral views of S.U.I. hypotype 12523.

10–*Siphonodella distorta* (Branson & Mehl). Oral views of S.U.I. hypotype 12531.

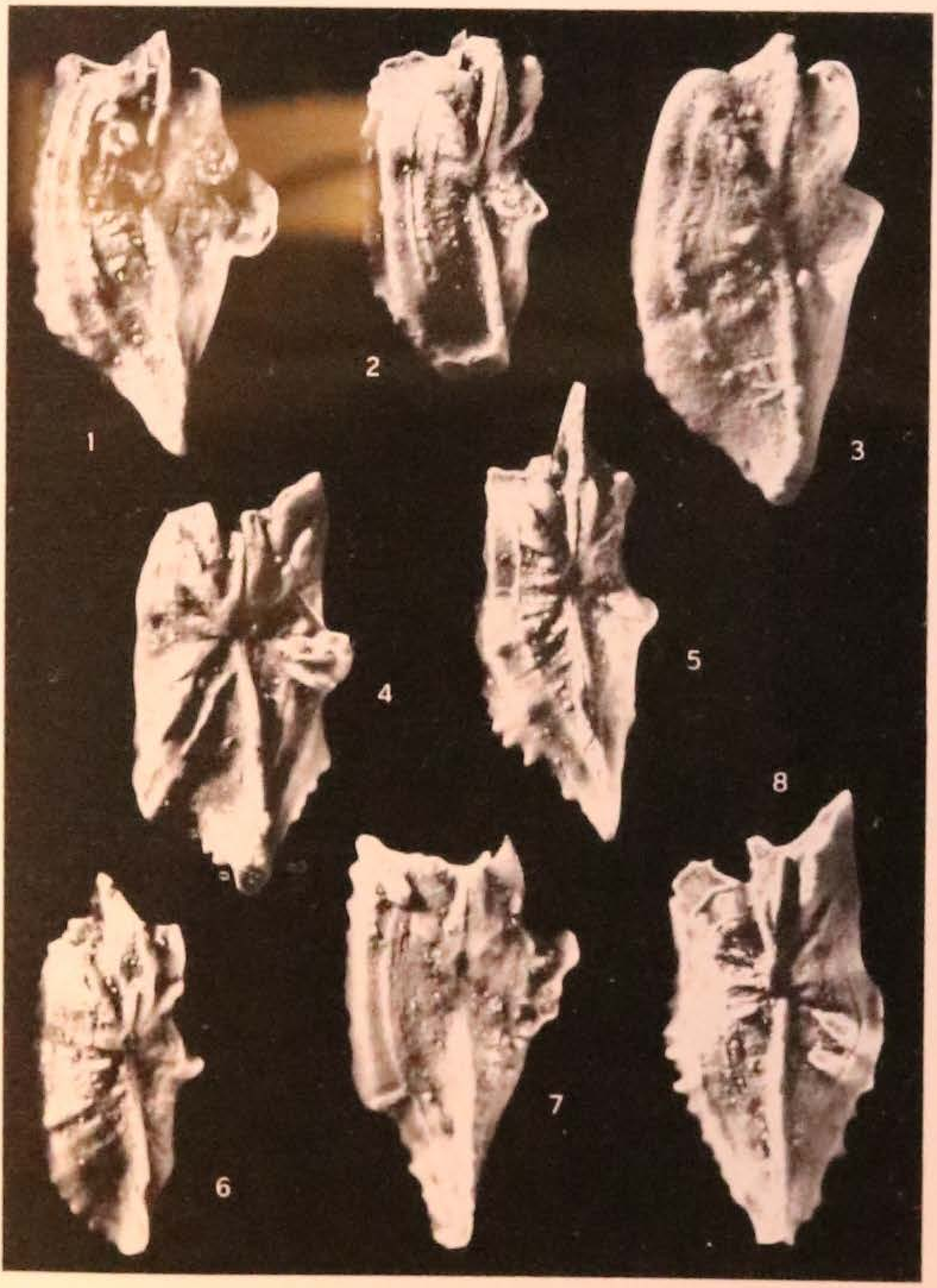
Plate 4

EXPLANATION OF PLATE 5

All figures are from the shale member, Prospect Hill Formation. Figures 1,2, and 6 are X40; 4,5,7, and 8 are X44; 3 is X50.

FIGS. 1-8—*Polygnathus inornata* Branson. All aboral views of S.U.I. hypotypes 12506, 12507, 12505, 12508, 12509, 12510, 12511, 12512 respectively.

Plate 5



EXPLANATION OF PLATE 6

All figures are from the shale member, Prospect Hill Formation. Figures 4,8 are X38; 4,18 are X54; 6,9,12 are X69; all others are X60.

FIGS. 1–*Elictognathus bialata* (Branson & Mehl). Right lateral view of S.U.I. hypotype 125328. Shelf side.

2,6,9,10,12,13,16–*Siphonodella cooperi* Hass. 2,6,9, Left lateral, oral and aboral views of S.U.I. hypotype 12542; 10,12, aboral and oral views of hypotype 12528; 13,16, aboral and oral views of hypotype 12529.

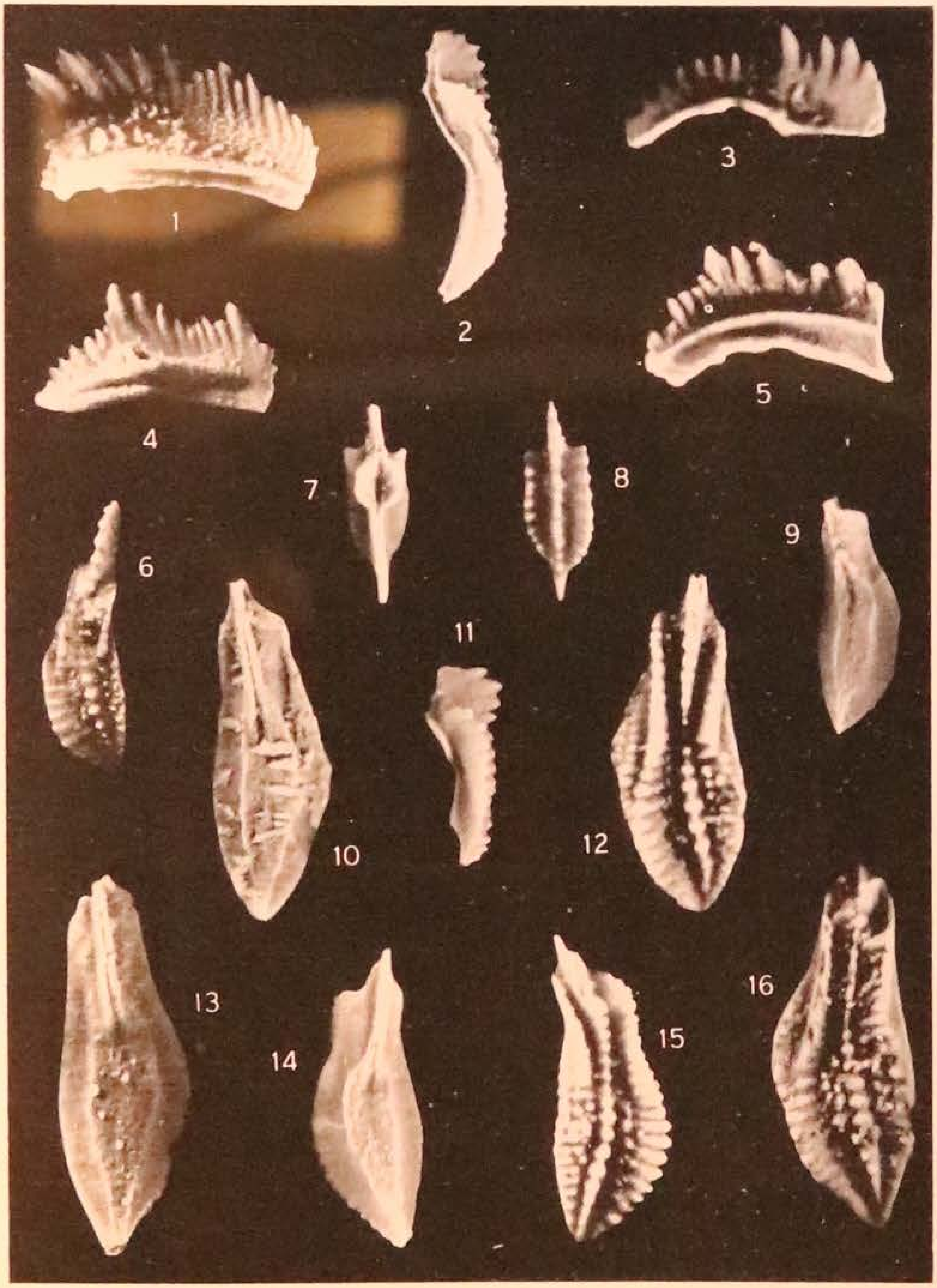
3–*Spathognathodus* cf. *S. stabilis* (Branson & Mehl). Right lateral view of S.U.I. hypotype 12534.

4,5–*Elictognathus lacerata* (Branson & Mehl). 4, Right lateral view of S.U.I. hypotype 12539; 5, right lateral view of S.U.I. hypotype 12540.

7,8,11–*Polygnathus marginata* Branson & Mehl. Aboral, oral and left lateral views of S.U.I. hypotype 12513.

14,15–*Siphonodella duplicata* (Branson & Mehl). Aboral and oral views of S.U.I. hypotype 12532.

Plate 6



EXPLANATION OF PLATE 7

Figures 11 and 13 are from the Wassonville Formation; all others are from the shale member, Prospect Hill Formation. Figures 1-4, 6-8, 10 and 12 are X39; all others are X58.

FIGS. 1,5,6,9,10,14—*Pseudopolygnathus fusiformis* Branson & Mehl. 1,6,10, Oral, left lateral and aboral views of S.U.I. hypotype 12516; 5,9,14, oral, right lateral and aboral views of S.U.I. hypotype 12517.

2-4,7,8,12—*Spathognathodus costatus costatus* (Branson). 2,3,4, Left lateral, oral and right lateral views of S.U.I. hypotype 12535; 7,8,12, left lateral, right lateral and oral views of S.U.I. hypotype 12536.

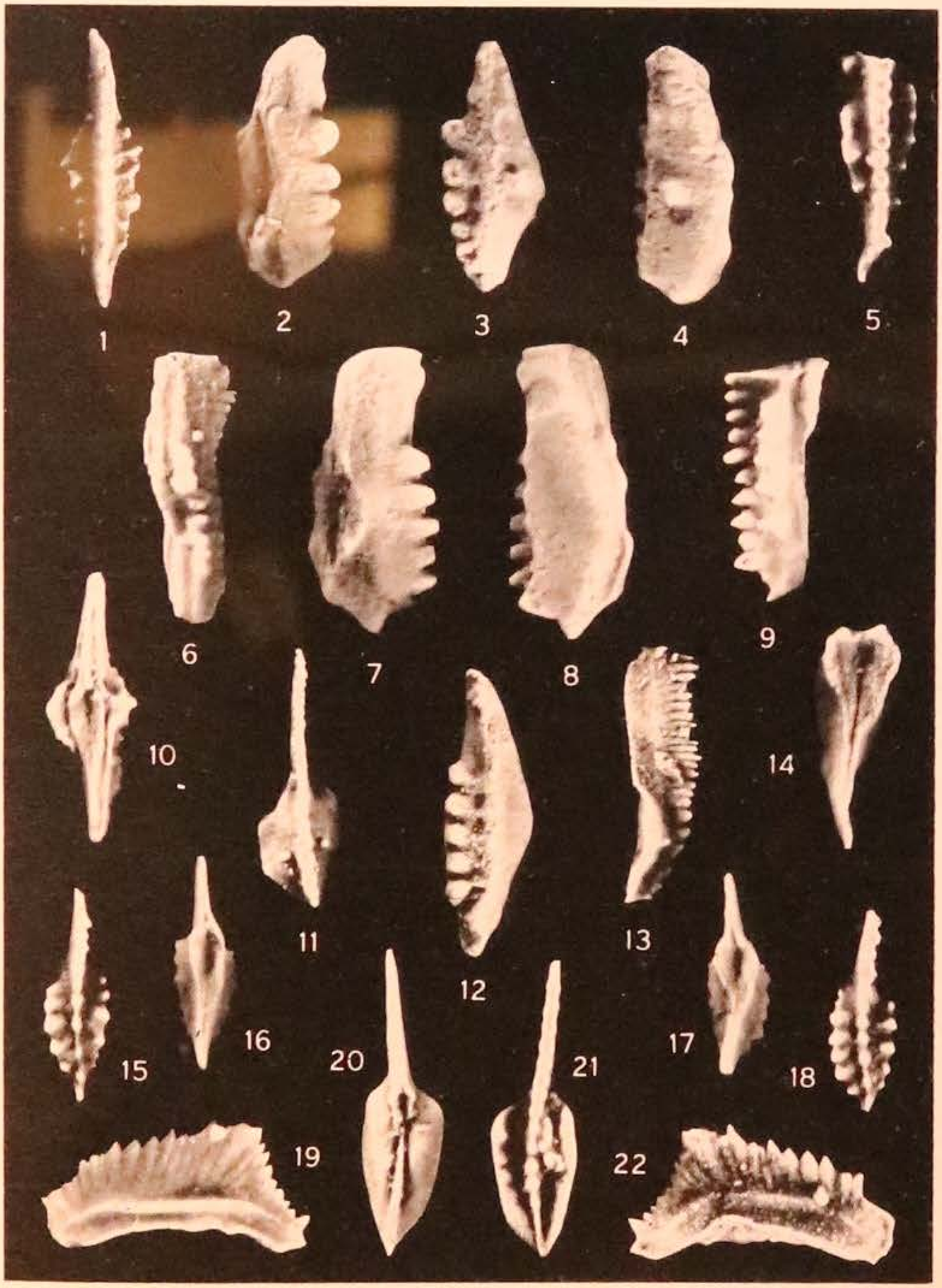
11,13—*Gnathodus delicatus* Branson & Mehl. Oral and left lateral view of S.U.I. hypotype 12548.

15-18—*Polygnathus marginata* Branson & Mehl. 15,16, Oral and aboral views of S.U.I. hypotype 12514; 17,18, aboral and oral views of S.U.I. hypotype 12515.

19,22—*Elictognathus costata* (Branson). Left lateral and right lateral views of S.U.I. hypotype 12541.

20,21—*Polygnathus communis* Branson & Mehl. Aboral and oral views of S.U.I. hypotype 12501.

Plate 7



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