

Title of article Silurian Conodonts from Wills Mountain Anticline,
Virginia, West Virginia, and Maryland

see Special Paper v. 161, p. -

Appendix 1 through 86

This image shows a single sheet of white paper with horizontal blue or grey ruling lines. The lines are evenly spaced and run across the width of the page. There are approximately 20 lines visible. The paper appears to be a standard notebook or a sheet of stationery designed for writing. The edges of the paper are slightly irregular, suggesting it might be a scan of a physical document. There is no handwriting or other markings on the page.

SYSTEMATIC PALEONTOLOGY

Introduction

Only form species are described in the following section. The interpretation of form, however, has been modified by the realization that discrete form species of conodonts are parts of a multielement apparatus. The writer has assumed wide morphologic variation in the interpretation of the form species found in a given sample, and has also accepted wide variation for some form species through time. Such variation is recorded in the remarks following the description of these forms.

Where a form lineage has been definitely spelled out by previous workers through the use of form subspecies, the writer has followed the original worker's interpretation unless there was compelling evidence to the contrary. Thus the writer has followed Walliser's interpretations of the forms Ozarkodina typica and Spathognathodus primus and has named new subspecies of these forms. However, the writer has also given species rank to two of Walliser's subspecies of the form Ozarkodina ziegleri. This later change was made when it was concluded that the two subspecies did not fit into a multielement group similar to that including Ozarkodina ziegleri ziegleri (Walliser, 1964, p. 14).

In the case of the Spathognathodus sagitta bohemicus lineage described by the writer, species designations have been given to the various forms included.

This was done to distinguish them clearly from the geographic form subspecies described by Walliser for Spathognathodus sagitta.

Repository. All figured specimens in the writer's collection have been assigned individual museum numbers. These are listed under the heading, Repository, following the taxonomy of each individual form species.

The bulk of the specimens in the collection have been catalogued in the following manner:

Each productive bulk sample has been assigned a museum number. These numbers are listed on Figures 11-15.

Each species described has been assigned an index letter as listed on Figures 11-15.

Specimens in the bulk collection are catalogued by the bulk sample museum number and the index letter assigned to the particular species. For example, all unfigured specimens of Spathognathodus primus primus from sample CB-McK6C (Figure 11) are deposited on the slide bearing the designation VPIL-1314⁴EE.

All specimens are deposited in the paleontological collection of the Department of Geological Sciences of the Virginia Polytechnic Institute and State University.

Genus HINDEODELLA Bassler, 1925

Remarks. Specimens of the form genus Hindeodella from the upper Devonian are typified by denticles of alternating size on the posterior blade. This characteristic, however, is lacking in some Silurian forms, for example, Hindeodella equidentata. Silurian conodonts assigned to the form genus Hindeodella are not always clearly distinguishable from specimens assigned to the form genus Ligonodina. Furthermore the transition of plectospathodid elements such as Plectospathodus alternatus into Hindeodella-like forms has been observed in upper Silurian faunas. This feature of late Silurian plectospathodid elements has been referred to by Jeppsson (1971) as hindeodellization.

HINDEODELLA CONFLUENS Branson & Mehl

Pl. 5, figs. 5, 9-11, 21, 23, 25, 26; Pl. 15, fig. 7

Hindeodella confluens Branson & Mehl, 1933, p. 45, Pl. 3, figs. 21-23;

Rexroad & Craig, 1971, p. 690, Pl. 79, figs. 21-23.

Oral view. Entire unit strongly compressed. Posterior blade straight, twisted along axis with oral margin deflected outward distally. Antero-lateral blade straight and bent abruptly inward, or continuously curved inward as much as 45 degrees. Flexure of blade occurs at anterior edge of cusp or as far back as mid-point of cusp in which case the anterior edge of the cusp is sharply flexed inward along its whole length.

Aboral view. Basal excavation a deep, elongate groove under cusp, constricted anteriorly and posteriorly to narrow, shallow groove continuing toward both ends of blade.

Inner lateral view. Posterior blade deep, straight or gently arched. Antero-lateral blade straight or slightly curved, bent downward as much as 45 degrees from horizontal.

Cusp weakly biconvex in cross-section, with sharp anterior and posterior edges; cusp as broad in plane of blade as blade is deep, slightly inclined to posterior. Anterior edge of cusp twisted or folded inward in position of flexure of the antero-lateral blade.

Posterior blade denticles, 7 to 12 in number, weakly biconvex in cross-section, with sharp anterior and posterior edges, partially fused. Blade denticles increasingly inclined posteriorly to as much as 45 degrees at end of blade. Base of denticles lengthened in posterior direction with increasing posterior inclination.

Denticles of antero-lateral blade, 3 to 9 in number, erect, unequal in size, broadest in medial part of blade, partially fused, with sharp edges in plane of blade, height as great as two-thirds height of cusp.

Occurrence. Cosner Gap Member of Mifflintown-middle Tonoloway Formations.

Material studied. Approximately 150 specimens.

Repository. Figured specimens, VPIL 900-908.

HINDEODELLA EQUIDENTATA Rhodes

Pl. 10, figs. 16, 22; Pl. 15, fig. 2; Pl. 16, fig. 27

Hindeodella equidentata Rhodes, 1953, p. 303, Pl. 23, figs. 248, 252-254; Walliser, 1957, p. 34, Pl. 2, fig. 23; Ziegler, 1960, p. 182, Pl. 15, fig. 10; Ethington & Furnish, 1962, p. 1267, Pl. 173, fig. 2; Spasov & Veselinović, 1963, p. 244, Pl. 2, figs. 10, 11; Serpagli & Greco, 1964, p. 200, Pl. 37, fig. 7; Walliser, 1964, p. 36, Pl. 8, fig. 3; Pl. 32, fig. 11; Philip, 1965, p. 102, Pl. 8, fig. 11; Philip, 1966, p. 445, Pl. 3, fig. 1; Mashkova, 1970, p. 212, Pl. 5, fig. 7.

Hindeodella cf H. equidentata Rhodes. Walliser, 1960, p. 30, Pl. 8, fig. 15.

Remarks. Material from the Appalachians is comparable in every respect to the material described by Rhodes (1953) from the Aymestry Limestone in Great Britain. Complete specimens bear 12 to 14 denticles on the posterior blade. The material studied suggests a close relationship to Ligonodina? silurica. The writer has specimens of L.? silurica which show denticle development intergradational with H. equidentata.

Occurrence. Cosner Gap Member of Mifflintown-Wills Creek Formations.

Material studied. Approximately 120 specimens.

Repository. Figured specimens, VPIL 909-912.

HINDEODELLA PRISCILLA Stauffer

Pl. 14, figs. 8, 13, 16.

Hindeodella priscilla Stauffer, 1938, p. 429, Pl. 50, fig. 6; Walliser, 1964, p. 36, Pl. 9, fig. 12; Pl. 32, figs. 12, 13; Philip, 1965, p. 102, Pl. 8, figs. 13, 14, 24, 25; Philip, 1966, p. 445, Pl. 3, figs. 2, 6-9, 11, 18.

Hindeodella n. sp. Walliser, 1960, p. 30, Pl. 8, fig. 16; Ziegler, 1960, p. 183, Pl. 15, figs. 3, 4.

Remarks. No complete specimens were recovered, but numerous fragments show good agreement with Hindeodella priscilla as interpreted by Walliser (1964). Fragments of mature specimens indicate that the element undergoes considerable ontogenetic change with the blade becoming bar-like and the denticles becoming discrete with increasing size.

Occurrence. Upper Tonoloway Formation.

Material studied. Approximately 50 specimens.

Repository. Figured specimens, VPIL 913-915.

Genus LIGONODINA Bassler, 1925

Remarks. Like Hindeodella, this form genus ranges from middle Ordovician to middle Triassic and is a common element in many apparatuses with highly evolved auxilliary elements. Like Hindeodella, variation of this form genus is poorly understood because of the fragmental nature of most specimens obtained from acid residues. The form

genus is characterized by a large cusp, a denticulated posterior bar, and a denticulated downward extension from the main cusp or an anticusp as redefined by Huddle (1968).

An anticusp is defined as a "downward projection of main cusp" (Hass in Moore, 1962, p. W6).

In the strict terms of this definition, it is questionable whether some Silurian specimens assigned to the form genus Ligonodina are properly assigned. It seems that the strict use of anticusp in identifying the form genus Ligonodina has been tacitly overlooked. Ethington and Furnish (1962, p. 1268) distinguished forms as Ligonodina or Hindeodella on the basis of the development of the antero-lateral process. If the antero-lateral process branches laterally and aborally from the cusp, the form is assigned to Ligonodina; and, if the antero-lateral process is produced by bending and twisting of the anterior bar, the form is assigned to Hindeodella.

Some authors, however, have assigned the form name Ligonodina to specimens which have the antero-lateral process turned inward and downward sharply, regardless of whether it branches laterally and aborally from the cusp or anterior to the cusp. An example of this is Ligonodina salopia Rhodes (1953, Pl. 23, figs. 245, 257, 260). These figured specimens clearly show the bending of the antero-lateral process well in advance of the cusp, and they have been placed by various authors, including Ethington and Furnish (1962, p. 1272), in synonymy with Ligonodina silurica. The writer has followed Rhodes (1953), Walliser (1964),

and Rexroad and Craig (1971) in assigning such specimens to the form genus Ligonodina, however, he has questioned this generic assignment.

Reexamination of the form genera Ligonodina and Hindeodella is warranted in view of the observations made by Jeppsson (1971) on the spatial arrangement of elements in the conodont apparatus. It is generally accepted that at least two pairs of ligonodinid elements are part of the conodont apparatus on the basis of assemblages found in shales and of the ratios of elements found in acid residues. These elements (hi elements in Figure 20) occur in right- and left-handed symmetry pairs and are visualized by Jeppsson as being arranged in nested lateral pairs, bounding a single medial trichonodellid and a pair of plectospathodid elements. On the basis of measurements of specimens of Ligonodina elegans, Jeppsson reports that the outer and inner elements of the right- and left-handed groups are distinguishable. The distinction is based on the slight posteriorward shift of the denticles on the outer element so that the denticles of the posterior bars of the nested pair of elements of the apparatus are positioned opposite one another. This is taken to mean that Jeppsson is reporting that ligonodinid elements of the same apparatus can occur in two morphologically distinct varieties. Alignment of the denticles of the posterior bars of a nested pair of elements could also be produced if the flexure of the anterior bar of the outer pair moved anteriorly. Variations similar to this seem to occur in Ligonodina? silurica of the writer's collection.

Jeppsson's observation does alert us to the possibility that the position and mode of development of the flexure of the antero-lateral process may not be adequate criteria for distinguishing the two form genera Hindeodella and Ligonodina, but simply the means of distinguishing the inner and outer members of the right and left handed pairs of the form elements in a single apparatus. Jeppsson also states that the hindeodelliform and ligonodiniform elements fill homologous functions in the conodont apparatus.

LIGONODINA BREVIS n. sp.

Pl. 10, figs. 1, 4, 6-9, 12, 15; Pl. 15, figs. 6, 10, 11.

Holotype. Pl. 10, fig. 12.

Diagnosis. A species of Ligonodina with both posterior bar and antero-lateral process short and of nearly equal length.

Oral view. Posterior bar straight, short, only slightly longer than cusp. Antero-lateral process bowed inward from anterior of cusp at angle of 45 to 90 degrees with line of development of bar. Bar widest at cusp, gradually tapering distally.

Aboral view. Basal excavation deepest under cusp, continuing to ends of posterior bar and antero-lateral process as tapering V-shaped trough.

Inner lateral view. Posterior bar gently arched. Antero-lateral process with nearly straight or continuously curved aboral margin, curved downward 45 to 90 degrees from horizontal. Lateral faces of bar and antero-lateral process flattened to convex.

Cusp subcircular to subquadrate near base, compressed distally with sharp edges on outer posterior and inner anterior margins, gently curved posteriorly between 10 and 30 degrees.

Denticles of posterior bar, 5 to 6 in number, circular to ovate in cross-section, separated from one another about width of smallest denticle, increasing in size posteriorly. Bar denticles increasingly inclined posteriorly toward end of bar with base elongated in direction of inclination.

Antero-lateral process denticles, 5 to 7 in number, circular to ovate in cross-section, separated from one another as much as width of 2 denticles, smallest adjacent to cusp and distally, all denticles gently curved posteriorly.

Remarks. Small specimens from the Wills Creek and lowest Tonoloway formations have widely separated denticles and generally 1 or 2 fewer denticles on the posterior bar and the antero-lateral process than specimens from the McKenzie Member of the Mifflintown Formation. The cusp in these forms is inclined posteriorly 30 degrees or more. These forms may represent a distinct phyletic subspecies or juvenile specimens of Ligonodina brevis n. sp.

Occurrence. McKenzie Member of Mifflintown-lowest Tonoloway Formations.

Material studied. Approximately 200 specimens.

Repository. Holotype, VPIL 922, paratypes, VPIL 916-921, 923-926.

LIGONODINA? SILURICA Branson & Mehl

Pl. 10, figs. 2, 3, 4, 10, 13, 19, 21, 23;

Pl. 15, figs. 15, 17, 19-22.

Ligonodina silurica Branson & Mehl, 1933, p. 48, Pl. 3, figs. 18-20;

Walliser, 1957, p. 38, Pl. 2, fig. 10; Reichstein, 1962, p. 538,

Pl. 1, fig. 2; Spasov & Veselinović, 1963, p. 244, Pl. 1, fig. 5;

Walliser, 1964, p. 42, Pl. 8, fig. 13, Pl. 32, fig. 15; Philip,

1969, p. 291, Pl. 18, figs. 4, 7, 8; Mashkova, 1970, p. 214, Pl. 4,

fig. 16, Pl. 6, figs. 2, 6, Pl. 8, figs. 2, 4, 8; Text-fig. 1,

fig. 5.

Ligonodina kentuckyensis Branson & Branson, 1947, p. 555, Pl. 82,

figs. 28, 35; Rexroad, 1967, p. 35, Pl. 2, fig. 5; Pollock,

Rexroad, & Nicoll, 1970, p. 755, Pl. 114, figs. 9, 10.

Ligonodina ingens Walliser, 1957, p. 37, Pl. 2, fig. 20.

Ligonodina n. sp. A, Rexroad and Craig, 1971, p. 691, Pl. 79,

figs. 18-20.

Oral view. Posterior bar long, straight or gently bowed outward, commonly twisted along its axis with oral surface turned outward. Bar tapers gradually toward posterior end. Antero-lateral process turned inward sharply at anterior edge of cusp or slightly in front of cusp making an angle of 45 to 90 degrees with the longitudinal axis of the posterior bar.

Aboral view. Basal excavation deepest under cusp, as wide as bar, and continuous under posterior bar and antero-lateral process as broad shallow V-shaped trough.

Postero-lateral view. Posterior bar straight to gently arched, with flat or gently convex lateral faces. Antero-lateral process curved downward 45 to 90 degrees, slightly twisted distally.

Cusp, stout, inclined or curved posteriorly 20 to 45 degrees, subquadrate to ovate in cross-section at base becoming sub-circular distally, compressed laterally, with anterior edge commonly twisted distally in direction of antero-lateral process. Posterior edge of cusp rarely flattened at base or with shallow depression extending vertically about one-fifth length of cusp.

Posterior bar denticles, 8 to 12 in number, circular to ovate. One to two needle-like denticles posterior to cusp, then denticles gradually increase in size and become increasingly inclined posteriorly to a maximum of 45 degrees toward end of blade. Denticles uniformly to irregularly separated about width of 1 or 2 of the smallest denticles. Base of distal 4 or 5 denticles increasingly lengthened in the direction of inclination of the denticles.

Denticles of antero-lateral process, 4 to 7 in number, ovate to circular in cross-section, discrete, slightly curved posteriorly.

Comparisons. This species agrees with the forms which have previously been assigned to the form species Ligonodina silurica.

In the redescription of the fauna of the Bainbridge Formation, Rexroad & Craig (1971) point out that two distinct forms are present in the topotype material. One form is consistent with the fragmented lectotype and one form is consistent with Ligonodina silurica of previous authors. This latter form has been listed as Ligonodina n. sp. A by Rexroad and Craig. The writer is in agreement with the redefinition of the form species, L. silurica, but has listed his material tentatively as L? silurica because of questions about the placement of this species in the genus, Ligonodina. This action is discussed below under "Remarks". Ligonodina? silurica in the writer's collection also shows a tendency to grade into Hindeodella equidentata which has a straight posterior blade and posterior blade denticles of nearly equal size, in contrast to the arched posterior bar of L? silurica with denticles which increase in size from anterior to posterior.

Remarks. The writer is dissatisfied with the generic assignment of the material here described and to emphasize this doubt, has listed the form as L? silurica. The writer's doubts concerning this form center around the variability of the point of flexure of the antero-lateral process in relation to the cusp. Ethington and Furnish (1962) place forms in Ligonodina if the antero-lateral process branches laterally and aborally from the cusp. They place forms which have the flexure of the antero-lateral process anterior to the cusp, in the form genus Hindeodella.

According to these criteria some of the Appalachian forms would be assigned to the form genus Hindeodella and others to the form genus Ligonodina. Large numbers of forms which the writer has assigned to L? silurica vary in just this detail so that they could be divided between these two form genera. No compelling reason was obvious to the writer which should dictate dividing the two groups. Biological considerations based on multielement species seem to indicate the two forms occurred in the same multielement apparatus indicating that the form genera might eventually have to be revised. This problem is also discussed in the remarks under the generic section on Ligonodina.

Occurrence. Cosner Gap Member of Mifflintown-Wills Creek Formations.

Material studied. Approximately 1300 specimens.

Repository. VPIL 927-940.

LIGONODINA n. sp.

Pl. 9, figs. 7, 8, 10; Pl. 10, fig. 18.

Description. A species of Ligonodina Bassler with high, gently arched, laterally bowed posterior blade. Antero-lateral process half as long as posterior blade, bent downward approximately 90 degrees, nearly in plane of posterior blade or with cusp and antero-lateral process broadly curved inward as much as 45 degrees. Posterior blade and antero-lateral process strongly compressed laterally. Posterior blade denticles, as many as 14 in number, biconvex in cross-section, compressed laterally, partially fused, with sharp edges in plane of blade.

Denticles of antero-lateral blade inclined toward cusp, otherwise as posterior blade denticles. Cusp biconvex in cross-section, with sharp edges in plane of blade, inclined slightly inward and toward posterior.

Occurrence. Upper McKenzie Member of Mifflintown Formation.

Material studied. 5 specimens.

Repository. Figured specimens, VPIL 941-944.

Genus LONCHODINA Bassler, 1925

Remarks. This form genus is typified by a marked off-set of the denticle rows of the anterior and posterior bar and a wide attachment area. The form genus can be confused with Plectospathodus on the basis of overall appearances and the descriptions of the two form genera are not mutually exclusive. The importance of distinguishing the two form genera becomes obvious when biological considerations are observed. Jeppsson (1969) placed Lonchodina in the multielement genus Ligonodina. According to Jeppsson this latter genus does not include any element which is homologous with the form genus Spathognathodus. The form genus Plectospathodus, however, is associated by Jeppsson with Spathognathodus in the multielement genus Hindeodella.

LONCHODINA DETORTA Walliser

Pl. 15, fig. 14

Lonchodina n. sp. (a) Walliser, 1957, p. 39, Pl. 3, figs. 29, 30.

Lonchodina detorta Walliser, 1964, p. 43, Pl. 9, fig. 20; Pl. 30, figs. 34-37; Legault, 1968, p. 11, Pl. 2, figs. 1-4.

Stratigraphic horizon. Upper Tonoloway Formation.

Material studied. 1 specimen.

Repository. Figured specimen, VPIL 945.

LONCHODINA WALLISERI Ziegler

Pl. 5, figs. 1, 2, 6; Pl. 6, figs. 1-3, 5, 6, 17,
27; Pl. 15, figs. 18, 24, 25; Pl. 16, fig. 29.

Lonchodina n. sp. (b) Walliser, 1957, p. 40, Pl. 3, figs. 27, 28.

Lonchodina walliseri Ziegler, 1960, p. 188, Pl. 14, figs. 2, 6, 7;

Spasov & Veselinović, 1963, p. 245, Pl. 2, figs. 13, 15; Walliser, 1964, p. 44, Pl. 8, fig. 17; Pl. 30, figs. 26-33; Rexroad, 1967, p. 37, Pl. 3, fig. 6; Nicoll & Rexroad, 1968, p. 40, Pl. 4, figs. 8, 9; Philip, 1969, p. 292, Pl. 17, fig. 19; Mashkova, 1970, p. 217, Pl. 4, fig. 13; Pl. 8, fig. 1.

Oral view. Anterior and posterior blade straight or gently bowed, concave inward. Anterior blade laterally compressed. Blade widened inwardly under cusp, tapered gradually to posterior end. Submedial cusp rotated on blade with posterior edge inward. Denticle rows of posterior and anterior blade offset with reference to one another, but continuous with anterior and posterior edges of cusp. Posterior blade of large specimens twisted axially so that oral margin is turned outward.

Aboral view. Basal excavation deepest and expanded inward under cusp, continuing posteriorly as shallow V-shaped trough. Excavation constricted anteriorly, continuing to anterior end of blade as shallow groove.

Inner lateral view. Blade nearly straight or gently arched, inner margin of basal excavation strongly curved upward under cusp, continuing in gentle arch to posterior end of blade.

Cusp biconvex, with or without sharp edges in plane of blade, slightly inclined inward and posteriorward.

Posterior blade denticles 5 to 8 in number, largest over medial part of blade, often slightly separated, erect, or rarely curved inward.

Anterior blade denticles 4 to 7 in number, discrete or partially fused at base, erect or rarely curved inward.

Remarks. Some small and medium-sized specimens of L. walliseri resemble Ozarkodina tenuiramea and cannot always be definitely distinguished from it.

Occurrence. Cosner Gap Member of Mifflintown-Wills Creek Formations.

Material studied. Approximately 475 specimens.

Repository. Figured specimens, VPIL 959-972.

LONCHODINA? GREILINGI Walliser

Pl. 7, figs. 5, 13, 17, 21, 24; Pl. 9, figs. 12, 13;

Pl. 12, fig. 2; Pl. 15, figs. 23, 26, Pl. 16, figs. 9,

15, 16, 21.

Lonchodina greilingi Walliser, 1957, p. 38, Pl. 3, figs. 20-26;
1960, p. 31, Pl. 8, figs. 17, 18; Ethington & Furnish, 1962,
p. 1274, Pl. 173, fig. 10; Spasov & Veselinović, 1963, p. 245,
Pl. 1, figs. 11; Walliser, 1964, p. 44, Pl. 8, fig. 7; Pl. 30,
figs. 7-9; Barnett, Kohut, Rust & Sweet, 1966, Pl. 58, fig. 8;
Legault, 1968, p. 12, Pl. 2, figs. 10-12; Philip, 1969, p. 292,
Pl. 17, figs. 17, 18, 21; Text-fig. 1e.

Lonchodina greilingi greilingi Walliser. Mashkova, 1970, p. 215,
Pl. 4, fig. 15; Pl. 9, fig. 3; Text-fig. 1, fig. 20.

Lonchodina? greilingi Walliser. Rexroad & Craig, 1971, p. 692,
Pl. 79, figs. 33-38.

Oral view. Posterior and anterior blades extended straight or
bowed inward with interior angle between blades as small as 120 degrees.
Cusp nearly erect or curved inward as much as 45 degrees.

Aboral view. Basal excavation deepest under cusp, expanded inward
with inner rounded margin deflected posteriorly. Basal excavation
continuing to ends of blades. Blade widest at base with flattened
faces or with strongly rounded cross-section.

Inner lateral view. Posterior blade one-half to twice as long as
anterior blade. Aboral margin of posterior blade gently curved, aboral
margin of anterior blade usually straight. Angle between posterior and
anterior blade varies from 90 to 120 degrees. Basal excavation expressed
on inner face of blade beneath cusp as rounded conical ridge rising
nearly to height of blade.

Cusp subtriangular, with inner edge rounded to nearly circular in cross-section at base, becoming circular or biconvex distally. Inner face of cusp commonly deflected in direction of longer blade. Cusp with sharp edges in plane of blade or with ridges originating at oral surfaces of blades, extending along length of cusp.

Posterior blade denticles 5 to 8 in number, circular to ovate in cross-section, occasionally with sharp edges, unequal in size. Denticles irregularly spaced, nearly erect, generally smaller adjacent to cusp and at end of blade. Denticles over middle of blade gently to strongly curved inward.

Remarks. Rexroad and Craig (1971) have questioned the generic assignment of this species because of its symmetry transition with Trichonodella inconstans. Walliser (1957, p. 51) also noted the similarity in development of L.? greilingi to Trichonodella inconstans and assigned the two forms to the same biological apparatus. The difference between the two forms is a matter of symmetry. L.? greilingi is asymmetrical while T. inconstans is bilaterally symmetrical. This same developmental similarity and symmetry pattern is noted also for the biologically related pairs, Plectospathodus extensus-Trichonodella excavata and Plectospathodus flexuosus-Trichonodella symmetrica. Since Walliser's types have not been studied by the writer, the questioned generic assignment raised by Rexroad and Craig is continued.

Occurrence. McKenzie Member of Mifflintown-Wills Creek Formations.

Material studied. Approximately 110 specimens.

Repository. Figured specimens, VPIL 946-958A.

Genus NEOPRIONIODUS Rhodes and Müller, 1956

Remarks. This form genus is distinguished by its undenticulated antiscusp from the very similar genus Synprioniodina. In terms of multielement species, the distinction between these form genera has little significance. Species of both form genera occur within the complex of multielement species associated with Spathognathodus primus (sensu lato). In the writer's collection, the form Neoprioniodus excavatus is associated with Spathognathodus primus primus. Jeppsson (1969) reports that the form Synprioniodina bicurvata is associated with Spathognathodus primus. Indeed, a form ascribed to Synprioniodina bicurvata (sensu lato) is associated with Spathognathodus steinhornensis eosteinhornensis of the Spathognathodus primus lineage.

In terms of form taxonomy, the dichotomy between Neoprioniodus and Synprioniodina is also quite questionable since the two forms are intergradational. Specimens of N. excavatus with a denticulated, antiscusp as well as specimens of S. bicurvata with a non-denticulated antiscusp are quite common.

In describing N. excavatus, the cusp and antiscusp are considered to be anterior with reference to the denticulated bar. This is consistent with the orientation established by Jeppsson (1971). It must be understood, however, that in specimens with curvature like N. Excavatus the denticulated blade originates on the outer side of the cusp and then curves posteriorly.

NEOPRIONIODUS EXCAVATUS (Branson & Mehl)

Pl. 9, figs. 16, 21, 22, 25, 27; Pl. 15, fig. 8.

Prioniodus excavatus Branson & Mehl, 1933, p. 45, Pl. 3, figs. 7, 8.

Prioniodina bicurvata (Branson & Mehl). Walliser, 1957, p. 46, Pl. 2,

figs. 18, 19; Ethington & Furnish, 1962, p. 1283, Pl. 173, fig. 17;

Spasov & Veselinović, 1963, p. 247-8, Pl. 2, fig. 14; Serpagli &

Greco, 1964, p. 207, Pl. 37, fig. 11.

Neoprioniodus excavatus (Branson & Mehl). Walliser, 1964, p. 49, Pl. 8,

fig. 4; Pl. 29, fig. 26; Text-fig. 5c; Mashkova, 1970, p. 218,

Pl. 4, fig. 8; Pl. 7, fig. 7; Rexroad & Craig, 1971, p. 692; Pl.

80, figs. 6-9.

Neoprioniodus cf N. excavatus (Branson & Mehl). Pollock, Rexroad, &

Nicoll, 1970, p. 756, Pl. 114, figs. 18?, 19, (non fig. 20, ?=N.

latidentatus).

Oral view. Posterior blade curved inward as much as 45 degrees from plane of development of cusp. Cusp curved inward as much as 45 degrees. Short compressed anterior process extends from outer anterior margin of cusp, bent outward as much as 30 degrees from plane of development of cusp. Blade widest at base of cusp, tapers gradually to posterior end. Faces of posterior blade plane to gently convex.

Aboral view. Basal excavation deepest and broadest under cusp, continuing to end of, and completely excavating, posterior blade.

Basal excavation broadly rounded under inner anterior edge of cusp, strongly constricted to outer anterior margin and continuing under anterior process as fine groove.

Inner lateral view. Posterior blade curved downward 60 to 80 degrees along its length. Inner aboral margin curved upward sharply from anterior corner of cusp, gently curved to end of posterior blade exposing the basal excavation along its entire length. Anterior process produced outward with anterior aboral corner broadly rounded.

Cusp subterminal, sub-triangular, unequally biconvex, or subquadrate in cross-section at base, becoming biconvex or lacrymalform distally, with posterior edge twisted inward. Cusp strongly curved inward as much as 45 degrees, often with sharp edges in plane of blade.

Denticles of posterior blade, 6 to 22 in number, sub-equal in size, discrete, nearly circular in cross-section, slightly curved inward, occasionally with sharp edges in plane of blade.

Anterior process with no denticles or bearing as many as three fused or discrete denticles.

Remarks. Specimens from the Cosner Gap Member of the Mifflintown Formation have the greatest number of posterior blade denticles. Specimens from the McKenzie Member of the Mifflintown and Wills Creek Formations generally have 10 to 12 posterior blade denticles.

Occurrence. Cosner Gap Member of Mifflintown-Wills Creek Formations.

Material studied. Approximately 625 specimens.

Repository. Figured specimens, VPIL 973-978.

NEOPRIONIODUS MULTIFORMIS Walliser

Pl. 9, figs. 2-5

Neoprioniodus multiformis Walliser, 1964, p. 50, Pl. 8, fig. 10;

Pl. 29, figs. 14, 16-25; Text-fig. 5a; Rexroad & Craig, 1971,
p. 693, Pl. 80, figs. 1-5.

Remarks. The few specimens in the writer's collection agree fairly closely with Walliser's figured specimens (Pl. 29, figs. 17-25). The holotype (Pl. 29, fig. 16) designated by Walliser does not appear consistent with the other figures that he shows of this species; it appears to agree more closely with N. excavatus than with the rest of the figured specimens.

Occurrence. Cosner Gap Member of Mifflintown Formation.

Material studied. 4 specimens.

Repository. Figured specimens, VPIL 979-982.

Genus OZARKODINA Branson & Mehl, 1933

Remarks. The type species of Ozarkodina, as originally defined by Branson and Mehl is characterized by an arcuate, denticulate blade with a large medial to submedial cusp. Many bar-like forms, e.g., O. media and O. ziegleri, have since been included in this form genus.

Differences in development between bar- and blade-like ozarkodinids along with increasing certainty of the association of this element in multielement species will eventually necessitate a complete revision of this form genus. Developmental differences are superficially evident between bar- and blade-like forms. In addition, however, blade forms in the writer's collection show a distinct lack of bilateral symmetry. All specimens of O. typica, for example, when placed with the posterior end of the blade toward the observer are seen to be flattened on the left hand side of the blade.

The blade-like forms of Ozarkodina consistently occur with spathognathodid elements. Some bar-like ozarkodinids in the writer's collection could not be associated with any spathognathodid elements on the basis of common stratigraphic range and similar abundances. Moreover, Jeppsson (1969) has established a multielement genus Ligonodina in which the equivalent of a spathognathodid element is apparently lacking. In the spatial reconstruction of this genus, the ozarkodinid elements are placed erect and well within the posterior extremity of the ligonodid elements. These differences should prove useful in development of lineages of form species and multielement species as well as allow for the useful distinction of kinds of ozarkodinids in multielement genera.

In the following form descriptions, all specimens are conventionally oriented with the cusp erect.

The terms inner and outer are dropped with reference to side views in favor of right and left in describing asymmetric forms. The right and left sides of the elements are determined by viewing them with their cusp erect and the posterior ends toward the observer.

OZARKODINA AEQUALIS Walliser

Pl. 6, figs. 22, 25; Pl. 7, figs. 28, 29.

Ozarkodina ziegleri aequalis Walliser, 1964, p. 62, Pl. 7, fig. 1;

Pl. 24, figs. 19-21, text-fig. 3f.

Oral view. Blade straight or gently bowed. Some specimens with oral margin of posterior blade slightly twisted outward.

Aboral view. Basal excavation developed as deep conical pit under apical cusp, slightly off-set to inner side of blade, strongly constricted anteriorly and posteriorly, and continuing to both ends of blade as shallow groove.

Lateral view. Aboral margin continuously arched in a gentle curve, or with posterior aboral margin deflected downward as much as 45 degrees, from line of development of anterior margin. Basal excavation on some specimens expressed on inner side of blade as conical ridge rising nearly to base of denticles. Lateral faces of blade convex in vertical section. Blade strongly constricted parallel to aboral margin often with development of lip along aboral margin. Posterior blade generally lower in height than anterior blade.

Cusp apical, stout, circular to strongly biconvex in cross-section, inclined or gently curved posteriorly.

Blade denticles 10 to more than 20 in number, anterior blade denticles as numerous as, or 2 to 3 more or less in number than posterior blade denticles. All denticles closely set, ovate to biconvex in cross-section, with rounded or sharp anterior and posterior edges. Height of denticles increases toward cusp.

Comparisons. Many specimens of O. aequalis show considerable similarity to and even grade into O. tenuiramea. O. aequalis has a medially restricted basal excavation and similarly developed denticles on both the anterior and posterior blade. It is distinguished from O. tenuiramea which has the posterior half of the blade excavated as well as relatively widely spaced denticles on the posterior blade. O. aequalis shows considerable similarity to O. ziegleri ziegleri and O. ziegleri crassatoides n. ssp. O. aequalis has a straight or gently bowed blade and is thus distinguished from the various subspecies of O. ziegleri which generally have the anterior blade bent inward.

Remarks. Walliser found this form restricted to his patula Zone of middle Wenlock age, underlying the sagitta Zone. The Appalachian material contains specimens assignable to this form species well up into the local Spathognathodus snajdri Zone of middle to late Ludlow age. This species grades into the form species, Ozarkodina tenuiramea, and many specimens in the writer's collection are difficult to assign to either species. Ozarkodina aequalis is the dominate form, however, in the Spathognathodus sagitta bohemicus Zone.

The writer has interpreted the forms, O. aequalis, O. tenuiramea, and O. sinuosa n. sp. as part of an evolutionary complex associated with Lonchodina walliseri in a single biological apparatus. Because of the intergradational nature of the forms O. aequalis and O. tenuiramea the counts of these two species have been handled arbitrarily. Specimens from the S. sagitta bohemicus Zone have been counted as O. aequalis, while all specimens from the S. bicornutus through the S. snajdri zones have been counted as O. tenuiramea.

Walliser originally described O. aequalis as a subspecies of O. ziegleri. O. ziegleri ziegleri Walliser as well as the specimens assigned to this species by the writer, generally have the anterior blade bent inward. This feature of O. ziegleri is not developed in the form O. aequalis. Specimens assigned to O. ziegleri by the writer are consistently associated with spathognathodid elements of the sagitta lineage. O. aequalis, in the Appalachian material, is consistently associated with Lonchodina walliseri. Because of the differences in development and association, the writer has raised Walliser's subspecies O. ziegleri aequalis to species rank.

Occurrence. Cosner Gap Member of Mifflintown Formation.

Material studied. Approximately 120 specimens.

Repository. Figured specimens, VPIL 983-986.

OZARKODINA EDITHAE MARIAE n. ssp.

Pl. 4, figs. 1-5, 8, 9, 12, 16

Holotype. Pl. 4, fig. 8.

Derivation of name. After my wife, Mary, who helped support this research.

Diagnosis. A subspecies of Ozarkodina edithae Walliser with arched aboral margin. Basal excavation generally restricted to area under cusp but may extend along entire aboral surface.

Oral view. Blade straight or gently bowed laterally. Cusp and denticles curved laterally on some bowed specimens. Basal excavation often expanded asymmetrically.

Aboral view. Basal excavation formed under medial cusp, commonly small, asymmetrically expanded laterally, constricted anteriorly and posteriorly to form shallow groove continuing toward both ends of blade. A few specimens with excavation continuing posteriorly, or to both ends of blade, as tapering, shallow trough.

Lateral view. Aboral margin curved gently. A few specimens with anterior aboral margin curved downward sharply. Anterior oral margin increasing in height toward medial cusp with tips of denticles rising in nearly straight line to tip of cusp. Posterior blade lower than anterior blade with oral margin increasing in height toward cusp to one-half or two-thirds height of cusp. Thickening of unit occurs from oral margin to a distinct line just below and parallel to base of denticles.

Blade asymmetrically flattened on left side independently of lateral curvature of blade (Cf. definition under Genus Ozarkodina and discussion under O. typica typica).

Cusp 2 to 4 times as wide in plane of blade as blade denticles, slightly inclined to posterior, with sharp anterior and posterior edges. Anterior edge of cusp sharply curved to posterior; posterior edge of cusp straight. Anterior blade denticles occasionally fused into edge of cusp causing width of cusp to vary greatly. Cusp thickened medially along its length on one side making cusp sub-triangular in cross-section.

Denticles, 10 to 20 in number, fine, closely set along nearly whole length but not coalesced, nearly equal in number on anterior and posterior blades. Occasional stout specimens bear discrete denticles. A few specimens with 2 or 3 fewer denticles on anterior blade than posterior blade; decrease in number of anterior blade denticles apparently related to fusion of denticles into cusp. Anterior denticles increasingly inclined posteriorly approaching cusp.

Comparisons. Some specimens of O. edithae mariae n. ssp. show strong similarities to O. edithae edithae, O. typica typica, O. typica intermedia n. ssp., and O. typica denckmanni. O. edithae mariae n. ssp. has arched aboral margin and nearly equally long anterior and posterior blades and is distinguished from O. edithae edithae which has a straight aboral margin with anterior blade longer than posterior blade.

O. edithae mariae n. ssp. has fine denticles, no noticeable constriction of blade parallel to aboral margin and is thus distinguished from O. typica typica which has coarse denticles, with noticeable concave constriction on both sides of blade paralleling aboral margin. O. edithae mariae n. ssp. has 10 or fewer denticles on each half of the blade and is thus distinguished from O. typica intermedia n. ssp. which has a longer blade, from 10 to 15 denticles on each half of the blade, and a constriction paralleling aboral margin of blade. O. edithae mariae n. ssp. is distinguished from O. typica denckmanni by the longer lower blade and noticeable constriction of blade paralleling aboral margin in O. typica denckmanni.

Occurrence. Upper Cosner Gap Member of Mifflintown Formation.

Material studied. Approximately 70 specimens.

Repository. Holotype, VPIL 992; paratypes, VPIL 987-991, 993-995.

OZARKODINA ORTUFORMIS Walliser

Pl. 12, figs. 5, 9, 21, 25, 28

Ozarkodina ortuformis Walliser, 1964, p. 59, Pl. 9, fig. 18; Pl. 24, figs. 7-8, 10-13; Text-fig. 3, figs. 1, m.

Oral view. Anterior blade bent inward as much as 30 degrees from axis of posterior blade, posterior blade twisted slightly along its axis with oral surface outward. Cusp slightly curved inward.

Aboral view. Basal excavation deepest and widest under cusp with slight lateral expansion of margins. Inner lateral expansion of basal excavation displaced posteriorly in relation to smaller outer expansion. Basal excavation constricted anteriorly, continuing toward end of blade as narrow groove; basal excavation constricted posteriorly to narrow groove or shallow tapering trough continuing toward end of blade.

Lateral view. Anterior blade bent downward as much as 60 degrees from axis of posterior blade and slightly higher than posterior blade. Cusp high, curved posteriorly, with sharp anterior and posterior edges. Denticles, 5 to 9 in number, unequal in size, with sharp anterior and posterior edges, separated from one another as much as the width of single denticle. Anterior blade generally with one less denticle than posterior blade. Middle denticle or denticles of anterior blade largest. Denticles of posterior blade increasingly inclined posteriorly to as much as 45 degrees.

Comparisons. O. ortuformis has the denticles of the anterior and posterior blade evenly spaced and the anterior blade bent inward and downward. It is distinguished from O. ortus in which the anterior denticles are more closely spaced than the posterior denticles and which has a relatively straighter blade. O. ortuformis has strong similarities to the various subspecies of O. ziegleri, with single specimens sometimes being indistinguishable.

However, O. ortuformis has a cusp which is high in relation to blade length and widely separated denticles and is thus distinguished from O. ziegleri ssp. which have relatively longer blades and more closely spaced denticles.

Remarks. Walliser described this species from the eostein-hornensis Zone in the Celson section. The Appalachian occurrence extends the range of this species downward to the base of Walliser's (1964) crispus Zone.

Occurrence. Upper Wills Creek-lowest Tonoloway Formations.

Material studied. Approximately 35 specimens.

Repository. Figured specimens, VPIL 996-1000.

OZARKODINA SERRATA n. sp.

Pl. 4, figs. 11, 15, 19-25

Holotype. Pl. 4, fig. 22a-b.

Derivation of name. Serratus, Lat., toothed like a saw; after the serrate appearance of the oral margin.

Diagnosis. A species of Ozarkodina with stout strongly arched blade, with numerous very short, fused blade denticles, and with base completely excavated.

Oral view. Blade straight or gently bowed laterally, oral margin and edges of cusp offset to flattened side of blade. Posterior blade occasionally twisted slightly along its axis.

Aboral view. Basal excavation deepest under cusp and expanded laterally to produce small flaring lips. Basal excavation continues distally toward both ends of blade as shallow, gradually tapering trough.

Lateral view. Aboral margin curved with anterior blade bent downward as much as 80 degrees from line of development of posterior blade. Oral margin of anterior blade rises in a nearly straight line to tip of cusp. Oral margin of posterior blade straight from posterior end, rising sharply 2 or 3 denticles before cusp. Posterior blade lower and generally greatly reduced in development in contrast to anterior blade. Blade, cusp, and denticles flat on inner side, thickened on outer side from oral edge to concave constriction, subparallel to aboral margin and marking depth of basal excavation. This constriction generally developed on both sides of blade.

Cusp, medial, slightly inclined posteriorly, subtriangular in cross-section. Cusp with sharp anterior and posterior edges.

Denticles, small, 28 to 32 in number, generally equally numerous on anterior and posterior blades, subequal to unequal in size, very short, with or without tips fused to finely serrate edge.

Comparisons. Ozarkodina serrata n. sp. is morphologically distinct from all other species studied. The development of the basal excavation and of the anterior oral margin indicate a possible evolutionary relationship to O. edithae mariae n. ssp. and O. ziegleri crassatoides n. ssp.

Occurrence. Upper McKenzie Member of Mifflintown Formation.

Material studied. Approximately 60 specimens.

Repository. Holotype, VPIL 1007; paratypes, VPIL 1001-1006,
1008-1009.

OZARKODINA SINUOSA n. sp.

Pl. 16, figs. 13, 14, 18, 22, 24, 25, 28, 30.

Holotype. Pl. 16, fig. 30.

Derivation of name. Sinuosus, Lat.; full of curves.

Diagnosis. A species of Ozarkodina with blade strongly twisted axially, with anterior oral surface twisted outward and posterior oral surface twisted inward. Blade slightly sigmoidal in oral view, with anterior end of blade curved inward and posterior end of blade curved outward. Basal excavation generally limited to area under cusp and posterior aboral surface but in some specimens extends under anterior blade. Posterior blade denticles often widely spaced and separated from each other as much as width of single denticle. Anterior blade denticles closely set or spaced as posterior blade denticles.

Oral view. Blade slightly sigmoidal with anterior end of blade curved inward and posterior end of blade curved outward. Entire blade twisted strongly along axis with anterior oral surface turned outward and posterior oral surface inward.

Aboral view. Basal excavation widest and deepest under medial cusp. Excavation continuing to posterior end of blade as gradually tapering shallow V-shaped trough, constricted anteriorly to shallow tapering groove.

Lateral view. Aboral margin gently arched from anterior end to cusp, or slightly posterior of cusp, and then curved downward. Faces of blade flat or gently convex in vertical section, with line of constriction paralleling aboral margin to produce slight lateral lip. Height of blade relatively low in comparison to O. tenuiramea, with posterior blade lower than anterior blade.

Cusp, medial, stout, circular in cross-section, to reduced and indistinguishable from other blade denticles.

Denticles of posterior blade, 7 to 9 in number, erect, nearly circular in cross-section, separated as much as width of single denticle. Anterior blade denticles 5 to 7 in number, oval to circular in cross-section, closely set and slightly inclined toward cusp, or separated as much as width of single denticle and erect.

Comparisons. O. sinuosa n. sp. grades into forms which are assignable to O. tenuiramea and some specimens can be assigned only arbitrarily to either species. O. sinuosa, n. sp. appears sigmoidal in oral view and has a strongly twisted blade, especially the posterior part which is sharply curved downward. It is distinguished from O. tenuiramea which is nearly straight in oral view and which has a relatively higher blade with relatively moderate twisting of the posterior blade.

Remarks. This form is interpreted as part of a gradational series which also includes O. aequalis and O. tenuiramea. O. sinuosa becomes the dominant form of this series in the Wills Creek Formation. Each of the forms in this series is associated with Lonchodina walliseri in the Appalachian material. This series is interpreted as one of the elements associated with L. walliseri in a single biological apparatus.

Occurrence. Wills Creek Formation.

Material studied. Approximately 70 specimens.

Repository. Holotype, VPIL 1017, paratypes, VPIL 1010-1016.

OZARKODINA TENUIRAMEA Walliser

Pl. 6, figs. 4, 7-16, 18-21, 23, 24, 26, 28, 29;

Pl. 7, figs. 1, 6, 8, 11, 15, 19, 23.

Ozarkodina ziegleri tenuiramea Walliser, 1964, p. 62, Pl. 7, fig. 15;

Pl. 24, figs. 22-28; Text-fig. 3g, h; Philip, 1969, p. 294, Pl. 18, figs. 5, 10, 16, 20, 26-28.

Oral view. Blade straight, gently bowed, or occasionally sigmoidal with posterior end of blade curved outward and anterior end of blade curved inward. Blade commonly twisted axially with oral surface of posterior blade turned inward, or with posterior oral surface turned inward and anterior oral surface turned outward. Cusp and denticles occasionally gently curved inward. Inner aboral margin of basal excavation commonly expanded inward to produce lateral lip.

Aboral view. Basal excavation deepest under medial cusp, expanded laterally on inner side and continuing to posterior end of blade as gradually tapering shallow trough. Excavation constricted anteriorly and continuing to anterior end of blade as narrow groove.

Lateral view. Anterior aboral margin straight or very gently curved. Aboral margin slightly arched under medial cusp, variably curved downward to posterior end of blade. Blade relatively low in height compared to O. aequalis, with posterior blade slightly lower than anterior blade. Lateral faces of blade convex in vertical section with line of constriction paralleling aboral margin, often producing slight lateral lip. Cusp stout, medial, nearly circular in cross-section, inclined toward posterior.

Anterior blade denticles, 5 to 8 in number, closely set, nearly circular to biconvex in cross-section, increasingly inclined toward posterior from anterior end of blade to cusp. Posterior blade denticles, 5 to 8 in number, closely set or each separated as much as width of single denticle, generally circular in cross-section, erect or slightly inclined toward posterior.

Comparison. O. tenuiramea shows considerable similarity to O. aequalis and O. sinuosa n. sp. O. tenuiramea has the posterior aboral surface completely excavated and has widely separated posterior blade denticles. In contrast O. aequalis has a relatively higher blade with the basal excavation restricted to a medial position, and equally large anterior and posterior blade denticles.

O. tenuiramea is distinguished from O. sinuosa n. sp. which is sigmoidal in oral view and has the blade strongly twisted axially, especially the posterior part of the blade which is also strongly curved downward. O. tenuiramea also shows considerable similarity to O. ziegleri ziegleri and O. ziegleri crassatoides. O. tenuiramea has a straight or sigmoidally curved blade as seen in oral view in contrast to the subspecies of O. ziegleri, which have the anterior blade bent inward.

Remarks. O. tenuiramea was originally named by Walliser (1964) as a subspecies of O. ziegleri. O. tenuiramea, in the Appalachian material is associated with Lonchodina walliseri, while forms assigned to O. ziegleri are associated with elements of the sagitta lineage. Because of the differences cited, the writer has raised Walliser's subspecies O. ziegleri tenuiramea to species rank.

Occurrence. McKenzie Member of Mifflintown Formation.

Material studied. Approximately 800 specimens.

Repository. Figured specimens, VPIL 1018-1044.

OZARKODINA TYPICA Branson & Mehl

OZARKODINA TYPICA DENCKMANNI Ziegler

Pl. 12, figs. 14, 16, 24, 27.

Ozarkodina denckmanni Ziegler, 1956, p. 103, Pl. 6, figs. 30, 31; Pl. 7, figs. 1, 2; Ziegler, 1960, p. 190, Pl. 15, figs. 13-15; Walliser, 1960, p. 31, Pl. 8, figs. 13, 14; Spasov & Veselinović, 1963, p. 246, Pl. 1, fig. 10; Philip, 1965, p. 106, Pl. 9, figs. 2, 4, 6-8; Barnett, Kohut, Rust & Sweet, 1966, Pl. 58, fig. 7; Moskalenko, 1967, p. 201, Pl. 1, fig. 11.

Ozarkodina typica denckmanni Ziegler. Walliser, 1964, p. 61, Pl. 9, fig. 14; Pl. 26, figs. 3-11; Legault, 1968, p. 15, Pl. 1, figs. 5, 6.

Occurrence. Upper Tonoloway Formation.

Material studied. Approximately 130 specimens.

Repository. Figured specimens, VPIL 1045-1048.

OZARKODINA TYPICA INTERMEDIA n. ssp.

Pl. 12, figs. 1, 3, 6, 15, 17, 19, 20, 23.

Holotype. Pl. 12, fig. 20a, b.

Derivation of name. Intermedius Lat., intermediate, after its transitional development between O. typica typica and O. typica denckmanni.

Diagnosis. A subspecies of Ozarkodina typica with 20 to 35 closely set blade denticles on a relatively long blade which is constricted along both sides parallel to aboral margin. Basal excavation under medial cusp and expanded laterally to produce a conical pit.

Comparisons. In contrast to Ozarkodina typica intermedia n. ssp., O. typica typica has approximately 10 to 20 coarse, unequal blade denticles with basal excavation only slightly produced laterally. O. typica denckmanni has denticles which are slightly more discrete and a longer lower blade than O. typica intermedia n. ssp. O. edithae mariae n. ssp. generally has fewer than 16 denticles on a relatively short blade which is not compressed parallel to aboral margin.

Occurrence. Lower Wills Creek-?upper Wills Creek Formation.

Material studied. Approximately 70 specimens.

Repository. Holotype, VPIL 1055; paratypes VPIL 1049-1054, 1056.

. OZARKODINA TYPICA TYPICA Branson & Mehl

Pl. 4, figs. 6, 7, 10, 13, 14, 17, 18; Pl. 7, figs. 30-32.

Ozarkodina typica Branson & Mehl, 1933, p. 51, Pl. 3, figs. 43-45;

Rhodes, 1953, p. 320, Pl. 23, figs. 251, 261, 262; Rexroad,
1967, p. 39, Pl. 2, figs. 7, 8; Pollock, Rexroad & Nicoll, 1970,
p. 757, Pl. 113, figs. 16-18; Rexroad & Craig, 1971, p. 694,
Pl. 80, figs. 32-34.

Ozarkodina typica typica Branson & Mehl. Walliser, 1964, p. 61,

Pl. 9, fig. 21; Pl. 25, figs. 20, 21; Pl. 26, fig. 2.

Oral view. Blade straight or slightly bowed. Occasional specimens have posterior blade gently twisted about long axis of blade. Outer margins of basal excavation not visible.

Aboral view. Basal excavation approximately medial, with slight lateral protrusion of margins under cusp. Anterior and posterior to cusp, basal excavation constricted to shallow groove continuing toward both ends of blade.

Lateral view. Blade arched with anterior end of blade bent downward 30 to 80 degrees from line of development of posterior blade.

Aboral margin arched continuously or with anterior and posterior aboral margins straight and meeting at an angle beneath basal excavation. Anterior blade generally higher than posterior blade. Height of both blades increases slightly toward medial cusp. Oral margin of both anterior and posterior blades straight, with anterior margin rising one-half to two-thirds of height of cusp. Blade increases gradually in thickness from oral margin to line continuous with upper surface of laterally expressed basal excavation, then constricts to form concave groove paralleling aboral margin, developed on both sides of blade. Blade, denticles, and cusp considerably flattened on one side.

Cusp apical, 2 to 3 times as wide in plane of blade, as blade denticles, with sharp anterior and posterior edges, slightly inclined to posterior. Anterior edge of cusp sharply inclined to posterior along line continuous with tips of anterior blade denticles. Cusp subtriangular in cross-section.

Blade denticles, 10 to 20 in number, coarse, subequal to unequal in size, fused to midpoint, generally with broad tips. Denticles equally numerous on anterior and posterior blades or with posterior blade bearing as many as four more denticles than anterior blade. Posterior blade denticles nearly erect or slightly inclined posteriorly. Anterior blade denticles erect at anterior end but increasingly inclined posteriorly toward cusp. Blade and denticles flattened only on left side of blade in oral view with posterior end of blade toward observer. Such flattening is subdued or apparently lacking on some specimens.

Comparisons. See Comparisons under O. edithae mariae n. ssp.,
O. typica intermedia, n. ssp., and O. typica denckmanni.

Discussion. Specimens of O. typica are observed with right- and left-handed bowing of blade; and it is possible to interpret 2 oppositely bowed blades as a bi-laterally symmetrical pair. This mirror image symmetry is only apparent, since the elements are left-handed with respect to lateral flattening. Some species now referred to Ozarkodina do not show the asymmetric development of Ozarkodina typica typica. A new form genus may eventually be needed when more ozarkodinid species are studied with respect to the orientation of the element in a biological apparatus as proposed by Jeppsson.

Occurrence. Cosner Gap-McKenzie members of Mifflintown Formation.

Material studied. More than 300 specimens.

Repository. Figured specimens, VPIL 1057-1066.

ÖZARKODINA ZIEGLERI CRASSATOIDES n. ssp.

Pl. 5, figs. 3, 4, 7, 8, 12-20, 24.

Holotype. Pl. 5, fig. 18.

Derivation of name. Similar to crassa; after the gross similarity of the form to O. crassa Walliser.

Diagnosis. A subspecies of Ozarkodina zieglerei Walliser with stout medial cusp having subtriangular cross-section, and with tips of anterior blade denticles rising along a line continuous with anterior edge of cusp.

Oral view. Anterior blade bent inward as much as 30 degrees from line of development of cusp and posterior blade. Cusp commonly curved inward.

Aboral view. Basal excavation deep, diagonally expanded under apical cusp, continuous under posterior blade as shallow tapering trough and under anterior blade as narrow groove.

Lateral view. Aboral margin arched with anterior blade bent downward 10 to 45 degrees from line of development of posterior blade. Anterior blade higher than posterior blade. Oral margin of anterior blade rises continuously from end of blade in straight line continuous with anterior edge of cusp. Posterior blade about one-third as high as cusp. Basal excavation expressed laterally as rounded conical ridge rising one-half height of posterior blade. Cusp stout, equal to one-half blade length in height, with sharp or rounded anterior and posterior edges, inclined posteriorly. Posterior margin of cusp straight or slightly curved posteriorly, anterior margin broken sharply and inclined posteriorly in line with tips of anterior blade denticles. Cusp with subtriangular cross-section.

Denticles, 10 to 18 in number, subequal to unequal in size, equally divided between anterior and posterior blade or with anterior blade bearing as many as 4 more denticles than posterior blade. Anterior denticles commonly closely set but not coalesced, erect anteriorly, increasingly inclined posteriorly toward cusp. Posterior denticles closely set or discrete and separated as much as width of single denticle, erect adjacent to cusp, increasingly inclined posteriorly toward end of blade up to as much as 45 degrees.

Comparisons. O. ziegleri crassatoides n. ssp. shows a resemblance to O. ziegleri ziegleri, O. crassa, O. edithae, and O. typica. O. ziegleri crassatoides n. ssp. has closely set anterior blade denticles, the tips of which rise continuously in a straight line to tip of cusp and is thus distinguished from O. ziegleri ziegleri which has discrete, separated denticles on anterior blade with highest denticles not adjacent to cusp, and from O. crassa which has coarse, discrete anterior denticles and a straight blade in oral view. O. ziegleri crassatoides n. ssp. has coarse, closely set denticles and is distinguished from O. edithae which has fine partially fused denticles both anterior and posterior to cusp and a straight blade in oral view. O. ziegleri crassatoides n. ssp. has a moderately large, asymmetrically flared, medial basal excavation which is often continuous to posterior end of blade and is thus distinguished from O. typica which has a small basal excavation restricted to region under cusp and a straight or gently bowed blade in oral view.

Occurrence. Lower third of McKenzie Member of Mifflintown-?lower Wills Creek Formations.

Material studied. Approximately 225 specimens.

Repository. Holotype, VPIL 1077; paratypes, VPIL 1067-1076, 1078-1080.

Genus PANDERODUS Ethington, 1959

PANDERODUS SIMPLEX (Branson & Mehl)

Pl. 5, fig. 22; Pl. 10, figs. 14, 17, 20.

Paltodus simplex Branson & Mehl, 1933, p. 42, Pl. 3, fig. 4.

Paltodus acostatus Branson & Branson, 1947, (part), p. 554, Pl. 82,
figs. 1-5 (only); Rhodes 1953, p. 296, Pl. 21, figs. 111, 112;
Pl. 22, figs. 163, 164; Pl. 23, figs. 212, 213.

Paltodus cf. P. acostatus Branson & Branson. Walliser, 1960, p. 31,
Pl. 7, fig. 10.

Panderodus acostatus (Branson & Branson). Serpagli & Greco, 1964,
p. 204, Pl. 36, fig. 4.

Panderodus simplex (Branson & Mehl). Rexroad, 1967, p. 45, Pl. 4,
figs. 7, 8; Nicoll & Rexroad, 1968, p. 54, Pl. 7, fig. 28; Philip,
1969, p. 294, Pl. 17, figs. 2, 3, 5, 12; Pollock, Rexroad, & Nicoll,
1970, p. 758, Pl. 114, figs. 23-25; Rexroad & Craig, 1971, p. 697,
Pl. 81, figs. 35-40.

Occurrence. Cosner Gap Member of Mifflintown-Tonoloway Formations.

Material studied. Approximately 90 specimens.

Repository. Figured specimens, VPIL 1081-1084.

Genus PLECTOSPATHODUS Branson & Mehl, 1933

PLECTOSPATHODUS ALTERNATUS Walliser

Pl. 14, figs. 18, 20.

Plectospathodus cf. P. extensus Rhodes. Ziegler, 1960, p. 191, Pl. 15,
figs. 6, 7.

Sp. indet. a Walliser, 1960, p. 35, Pl. 7, fig. 14.

Plectospathodus alternatus Walliser, 1964, p. 64, Pl. 9, fig. 17;

Pl. 30, figs. 23-25; Philip, 1966, p. 448, Pl. 3, figs. 10, 17,
21, 25; Barnett, Kohut, Rust & Sweet, 1966, Pl. 58, fig. 15.

Occurrence. Upper Tonoloway Formation.

Material studied. Approximately 40 specimens.

Repository. Figured specimens, VPIL 1085-1086.

PLECTOSPATHODUS EXTENSUS Rhodes

Pl. 7, figs. 4, 7, 9, 10, 14, 16, 20, 27; Pl. 12, fig. 18; Pl. 15,
figs. 1, 3-5, 13; Pl. 16, figs. 4, 5.

Plectospathodus extensus Rhodes, 1953, p. 323, Pl. 23, figs. 236-240;

Walliser, 1957, p. 43, Pl. 3, figs. 1, 2; Walliser, 1960, p. 32,
Pl. 8, fig. 20; Ethington & Furnish, 1962, p. 1281, Pl. 173,
fig. 6; Spasov & Veselinović, 1963, p. 247, Pl. 2, fig. 4; Walli-
ser, 1964, p. 64, Pl. 8, fig. 1; Pl. 30, figs. 13, 14; Serpaglio &
Greco, 1964, p. 207, Pl. 37, fig. 10; Barnett, Kohut, Rust & Sweet,
1966, Pl. 58, fig. 13, Mashkova, 1970, p. 221, Pl. 4, fig. 14; Pl. 11,
figs. 6-8; Pl. 12, figs. 1-4; Text-fig. 1, fig. 6; Rexroad & Craig,
1971, p. 698, Pl. 82, figs. 1, 2.

Oral view. Anterior and posterior blades nearly straight or strongly
bowed with aboral edges twisted inward. Shorter anterior blade typically
curved inward more than posterior blade.

Anterior blade occasionally curved around with distal end subparallel to distal end of inwardly curved posterior blade, with aboral margins twisted inward so that ends of posterior and anterior blades are nearly perpendicular to each other. Cusp nearly erect or inclined inward as much as 60 degrees.

Aboral view. Basal excavation deepest under cusp, strongly produced inward under base of cusp. Basal excavation broadly rounded on inner margin or extended under inner side of cusp as elongate trough. Basal excavation slightly constricted anteriorly and posteriorly, continuous toward ends of both blades as shallow tapering trough.

Inner lateral view. Blades gently to strongly arched, with posterior blade curved downward more strongly than anterior blade. Anterior blade approximately one-half length of posterior blade. Inner margin of basal excavation emarginated vertically as rounded notch or as elongate compressed trough rising on inner face of cusp nearly to height of blades.

Cusp subtriangular, ovate, or subcircular in cross-section near base, frequently with sharp edges in plane of blade. Distally cusp becomes biconvex or lacrymalform with posterior edge of cusp twisted inward. Cusp nearly erect on gently arched and bowed specimens or strongly inclined inward as much as 60 degrees on strongly arched and bowed specimens.

Denticles of posterior blade 7 to 12 in number, sub-equal in size, ovate to subcircular in cross-section. Denticles discrete, divergent in plane of blade, slightly curved inward.

Denticles of anterior blade 4 to 7 in number, unequal in size, ovate to subcircular in cross-section. Denticles erect adjacent to cusp; denticles inclined away from cusp as much as 45 degrees near end of blade. Third and fourth or fourth and fifth denticles often nearly as large as cusp.

Remarks. Specimens of P. extensus from the Cosner Gap Member are generally less strongly arched and bowed than specimens from the McKenzie Member of Mifflintown and Wills Creek Formations. Cosner Gap specimens, on the average, have longer anterior and posterior blades with 1 or 2 more denticles per blade than McKenzie and Wills Creek specimens.

The few specimens from the upper Tonoloway Formation which are referable to this species have nearly straight anterior and posterior blades with the anterior blade bent inward at the cusp. These latter specimens do not have the base of the cusp strongly produced to the inner side of the blade, but they do have the inner margin of the basal excavation slightly emarginated vertically under the cusp. The specimens from the upper Tonoloway Formation are not as stout or as well preserved as material from the Mifflintown and Wills Creek Formations, but probably represent a phyletic subspecies of P. extensus.

Occurrence. Cosner Gap Member of Mifflintown-Tonoloway Formations.

Material studied. Approximately 700 specimens.

Repository. Figured specimens, VPIL 1087-1102.

PLECTOSPATHODUS FLEXUOSUS Branson & Mehl

Pl. 7, figs. 12, 18, 22, 25, 26; Pl. 16, fig. 7.

Plectospathodus flexuosus Branson & Mehl, 1933, p. 47, Pl. 3, fig. 31, 32; Walliser, 1964, p. 65, Pl. 9, fig. 10; Pl. 30, figs. 15, 16; Pollock, Rexroad & Nicoll, 1970, p. 758, Pl. 113, figs. 19, 20; Mashkova, 1970, p. 222, Pl. 2, fig. 10; Pl. 4, fig. 4; Pl. 11, figs. 9-13; Rexroad & Craig, 1971, p. 698, Pl. 82, figs. 3-7. Plectospathodus elegans Rhodes, 1953, p. 323, Pl. 23, figs. 255, 263, 264.

Oral view. Posterior blade long straight or gently curved. Anterior blade, one-half as long as posterior blade, bent or curved inward 20 to 45 degrees with reference to posterior blade. Cusp nearly erect or inclined inward as much as 45 degrees. Blade, cusp, and denticles strongly compressed laterally.

Aboral view. Basal excavation a small pit under apical cusp, slightly expanded inward. Basal excavation strongly constricted anteriorly and posteriorly and continuous under both blades as shallow, barely visible groove.

Inner lateral view. Posterior blade long, gently curved downward. Anterior blade, one-half length of posterior blade, straight or gently curved downward. Measured in vertical plane, angle between posterior and anterior blade varies from 90 to 135 degrees.

Posterior blade and anterior blade diverge 45 to 55 degrees, and 45 to 80 degrees respectively from line of development of cusp. Lateral faces of blade flat or gently convex. Inner margin of basal excavation slightly emarginated vertically under cusp.

Cusp apical, nearly erect or inclined inward as much as 45 degrees, with outer face weakly concave to convex, inner face convex.

Denticles of posterior blade, 6 to 10 in number, of unequal size, fused nearly to tips or discrete with sharp lateral edges. Denticles erect along most of blade, with several at end of blade slightly inclined posteriorly. Denticles biconvex to plano-convex in cross-section with flattened face outward.

Denticles of anterior blade, 3 to 6 in number, typically with second and/or third denticle as large as cusp, otherwise developed as denticles of posterior blade.

Occurrence. Cosner Gap Member of Mifflintown-Wills Creek Formations.

Material studied. Approximately 120 specimens.

Repository. Figured specimens, VPIL 1103-1108.

PLECTOSPATHODUS? n. sp.

Pl. 9, figs. 6, 9, 11, 14, 15.

Description. Posterior? blade bent strongly downward about third or fourth denticle from cusp. Anterior? blade curved downward, then curved inward strongly about third or fourth denticle from cusp.

Cusp and all blade denticles closely set, partially fused, with sharp edges in plane of blade. Basal excavation deepest, slightly expanded inward under apical cusp, continued under both blades as shallow V-shaped trough.

Remarks. Poorly preserved material permits only uncertain generic assignment of this new species.

Occurrence. Upper third of McKenzie Member of Mifflintown Formation.

Material studied. 8 specimens, all fragmentary.

Repository. Figured specimens, VPIL 1109-1113.

Genus SPATHOGNATHODUS Branson & Mehl, 1941

Remarks. This genus is the most abundant form in the sections studied. It is also the most highly variable form studied and one which shows perhaps the greatest evolution. This may indicate that its functional role in the conodont animal was active and changing in Silurian times.

Several species of this genus were observed to lack bilateral symmetry. These species are all one-handed in that they all are flattened consistently on the same side.

Klapper (1969) has also reported that the lower Devonian forms, S. remscheidensis, S. optimus, and S. exiguus philipi have the anterior third of the blade offset to the right.

In describing specimens of Spathognathodus which are not bilaterally symmetrical, the writer has used the terms right and left rather than inner and outer to describe lateral views. In determining right and left sides, the blade is placed upright with the posterior end of the element toward the observer.

SPATHOGNATHODUS BICORNUTUS n. sp.

Pl. 1, figs. 5-7, 11, 13-16, 18; Pl. 2, figs. 1, 4, 6, 16.

Gen. indet., sp. Walliser, 1964, p. 92, Pl. 32, fig. 2.

Gen. indet., n. sp. d Walliser, 1964, p. 91, Pl. 32, fig. 27.

Holotype. Pl. 1, fig. 11a, b.

Derivation of name. Bicornutus, Lat.; having two horns; refers to prominent anterior and posterior cusps.

Diagnosis. A species of Spathognathodus with large asymmetric subquadrate basal excavation and with prominent anterior and posterior terminal or subterminal cusps.

Oral view. Blade straight or gently bowed laterally. Blade tapers anteriorly and posteriorly to sharp edge. Lateral lobes of basal excavation variously positioned under posterior half of blade, subquadrate to rounded in outline. Lateral lobes of several small specimens begin anterior to midpoint of blade and may extend along axis of blade as much as one-half length of blade.

Lateral lobes extend along axis of blade approximately one-fifth length of blade in large specimens. Inner lobe rectangular to rounded, outer lobe rounded, often with outer posterior corner strongly directed posteriorly. Outer lobe as much as twice width of inner lobe perpendicular to blade.

Aboral view. Basal excavation broadest and deepest under posterior half of blade, continues to anterior end of blade as shallow groove and to posterior end as tapering V-shaped trough.

Lateral view. Blade outline changes from rectangular to trapezoidal with increasing size of specimen. Blade increases in thickness from oral margin to longitudinal line continuous with upper surface of lateral lobes of basal excavation, then constricts sharply to aboral margin. Anterior and posterior edges of blade straight and nearly vertical on small specimens. With development of anterior and posterior cusps, aboral corners become increasingly elongated to longitudinal spur-like processes and anterior and posterior margins of blade become convex, concave, or resupinate. Aboral margin straight in small specimens, with increased elongation of aboral corners, anterior and posterior ends of blade progressively arch downward. Apices of terminal cusps same height as rest of blade in small specimens, as much as twice height of blade in some large specimens. In all growth stages blade length varies greatly relative to blade height; there are many very short adult specimens.

Denticles, including cusps, strongly compressed laterally with sharp anterior and posterior edges. Denticles between cusps, subequal, fused except for discrete tips, vary in number from 5 to 8. Medial denticles fewest in number on large specimens. Medial denticles decrease in number due to fusion of denticles into edges of anterior and posterior cusps. Some small or intermediate specimens have single small denticles at ends of blade on free edges of cusps; these become fused into cusps on large specimens.

Remarks. Variation in this form is extreme. There are few identical specimens within single samples.

Comparisons. Walliser (1964, Pl. 32, figs. 2, 27) figured two specimens which the writer has interpreted as being conspecific with S. bicornutus n. sp. Walliser treated the smaller of these specimens (Pl. 32, fig. 2) as an aberrant form of S. sagitta rhenanus but did not give a species designation for the larger one (Pl. 32, fig. 27). The collection under study, however, contains specimens which show a complete gradation between forms similar to Walliser's specimens.

Small specimens of S. bicornutus n. sp. show considerable resemblance to S. sagitta bohemicus. However, these specimens of S. bicornutus n. sp. lack the fused denticles over the basal excavation which are typical of S. sagitta bohemicus.

Occurrence. Lowest third of McKenzie Member of Mifflintown Formation.

Material studied. More than 800 specimens.

Repository. Holotype, VPIL 1117; paratypes, VPIL 1114-1116, 1118-1126.

SPATHOGNATHODUS CRISPUS

Pl. 14, figs. 1-4, 9, 14, 19, 21, 24, 27.

Spathognathodus crispus. Walliser, 1964, p. 74, Pl. 9, fig. 3; Pl. 21, figs. 7-13.

Oral view. Blade straight with large asymmetric, subquadrate lobes of basal excavation extending under posterior half of blade and slightly beyond end of blade. Transverse width of outer lateral lobe of basal excavation as much as twice that of inner lateral lobe. A few specimens from middle of Wills Creek Formation with basal excavation asymmetrically bilobate, developed diagonally to blade, and extending beyond end of blade.

Aboral view. Basal excavation widest under posterior quarter of blade, tapering gradually to posterior end of blade, or rounded and extending beyond end of blade. Anteriorly, basal excavation constricted sharply and continuing toward anterior end of blade as narrow groove.

Lateral view. Blade rectangular with straight aboral, oral, and anterior margins. Posterior margin straight, erect or inclined slightly to anterior, or concave with posterior oral corner extending beyond posterior aboral corner. A few specimens show gradual decrease in height of blade over posterior third of basal excavation to end of blade.

Denticles over anterior half of blade, 6 to 8 in number, subequal, fused except for tips. Denticles over posterior half of blade completely fused to knife-like ridge, or with 1 to 2 discrete denticles at posterior end of blade. A few specimens with 9 to 17 denticles with no fusion over posterior half of blade and with height of blade decreasing gradually to end of blade over posterior part of basal excavation.

Comparisons. S. crispus has a markedly asymmetric basal excavation which extends beyond the posterior end of the blade and has the denticles of the posterior half of the blade completely fused. In contrast S. sagitta bohemicus has a subrounded basal excavation under the third quarter of blade, with only 2 to 4 completely fused denticles over the basal excavation, also the height of the blade decreases over the posterior quarter of blade. Further, S. tillmani n. sp. has a subquadrate basal excavation extending from the midpoint not quite to the posterior end of the blade, with the denticles over the basal excavation fused to a knife-like ridge, and the height of the blade posterior to the basal excavation decreasing gradually to the end of the blade.

Occurrence. Upper Wills Creek-lowest upper Tonoloway Formations.

Material studied. Approximately 140 specimens.

Repository. Figured specimens, VPIL 1127-1136.

SPATHOGNATHODUS PRIMUS (BRANSON & MEHL)

SPATHOGNATHODUS PRIMUS HIGHLANDENSIS n. ssp.

Pl. 14, figs. 7, 10-12, 15, 17, 22, 23, 25, 26, 28, 29.

Spathognathodus primus (Branson & Mehl), Walliser, 1964, Pl. 22, figs.

21-25; Text-fig. 8m, n.

Holotype. Pl. 14, fig. 23.

Diagnosis. A subspecies of Spathognathodus primus with discrete high denticles. Height of denticles and blade decreases both anteriorly and posteriorly of nearly medial cusp-like denticle.

Oral view. Blade straight or slightly bowed laterally. Occasional specimens have posterior half of blade slightly twisted along longitudinal axis. Lateral lobes of basal excavation small.

Aboral view. Basal excavation small, flaring laterally, under midpoint to slightly anterior of midpoint of blade. Basal excavation constricted anteriorly and posteriorly to shallow, tapering trough, continuing toward both ends of blade.

Lateral view. Aboral margin straight or gently arched. Anterior and posterior margins straight or rounded, with aboral corners generally obtuse. Oral margin increases in height from anterior end of blade to cusp-like denticle over or slightly posterior to midpoint of blade and then decreases in height to posterior end. Posterior oral margin relatively lower than anterior half. In large specimens, posterior half of unit bar-like in contrast to blade-like anterior half.

Denticles, 8 to 14 in number, subequal to unequal, discrete to base, occasionally separated as much as width of one denticle over posterior end of blade. Cusp-like denticle over, or slightly posterior to, basal excavation. Cusp and denticles posterior to cusp inclined posteriorly as much as 20 degrees.

Bilateral symmetry in development of basal excavation apparently lacking. Viewed with the blade flat and posterior end of blade to left, margin of lateral lobe of basal excavation is drawn upward above aboral margin, making basal excavation visible. Viewed from opposite side, aboral margin and lateral lobe of basal excavation form a continuous straight line.

Comparisons. Spathognathodus primus highlandensis n. ssp. is probably conspecific with specimens of S. primus illustrated by Walliser (1964, Pl. 22, figs. 21-25) from the eosteinhornensis Zone. The posterior half of S. primus highlandensis n. ssp. is bar-like and considerably lower than the anterior half. It is thus distinguished from Spathognathodus interpositus Mashkova, in which the height of the blade is more uniform and the basal cavity is less conspicuously asymmetric.

Occurrence. Upper Wills Creek-lower Tonoloway Formations.

Material studied. Approximately 60 specimens.

Repository. Holotype, VPIL 1144; paratypes, VPIL 1137-1143, 1145-1148.

SPATHOGNATHODUS PRIMUS MULTIDENTATUS n. ssp.

Pl. 13, figs. 12-17; Pl. 16, fig. 26.

Spathognathodus primus (Branson & Mehl), Walliser, 1964, Pl. 22,
fig. 14, Text-fig. 8d.

Holotype. Pl. 13, fig. 14.

Derivation of name. Multidentatus, Lat., having many denticles,
referring to the large number of blade denticles.

Diagnosis. A subspecies of Spathognathodus primus with approxi-
mately 20 to 30 irregular blade denticles. Denticles acicular to
coarse and cusp-like, closely crowded, partially fused to discrete.

Comparisons. S. primus multidentatus n. ssp. appears to be con-
specific with the specimen pictured as S. primus by Walliser (1964,
Pl. 22, fig. 14) from the latialatus Zone in the Carnic Alps. Spatho-
gnathodus primus multidentatus n. ssp. has a large number of partially
fused to discrete, irregular blade denticles and is distinguished from
Spathognathodus primus primus (Branson & Mehl) which has approximately
12 to 15 denticles, generally fused except for discrete tips.

Occurrence. Lower Wills Creek Formation.

Material studied. Approximately 120 specimens.

Repository. Holotype, VPIL 1151; paratypes, VPIL 1149-1150, 1152-
1155.

SPATHOGNATHODUS PRIMUS PRIMUS (Branson & Mehl)

Pl. 2, figs. 2, 5, 8, 9; Pl. 3, figs. 1-12;

Pl. 11, fig. 11; Pl. 13, figs. 5, 10; Pl. 16, fig. 23.

Spathodus primus Branson & Mehl, 1933, p. 46, Pl. 3, figs. 25-30.

Spathognathodus primus (Branson & Mehl). Rhodes, 1953, p. 325, Pl. 23, figs. 243, 256, 258, 259; Walliser, 1964, p. 80, Pl. 8, fig. 14; Pl. 22, figs. 9-13, 15-20; Pl. 23, figs. 1-4; Text-fig. 8; Philip, 1969, p. 295, Pl. 17, figs. 22, 24; Rexroad & Craig, 1971, p. 700, Pl. 82, figs. 11-15.

Oral view. Blade straight. Small asymmetric lateral lobe of basal excavation developed medially or slightly anterior of midpoint of blade.

Aboral view. Basal excavation small, consisting of a laterally produced pit located medially or slightly anterior to midpoint of blade. Basal excavation sharply constricted anteriorly and posteriorly, continued toward both ends of blade as shallow groove.

Lateral view. Posterior aboral margin commonly offset above anterior aboral margin. A few specimens with straight aboral margin or with anterior aboral margin curved upward across basal excavation as much as 25 degrees from line of posterior aboral margin. Posterior aboral margin commonly gently arched. Anterior aboral margin straight or gently rounded.

From anterior end, oral margin increases in height for as much as one-fifth length of blade, then is sharply offset downward as much as one-half height of anterior end of blade, and gently curves downward until oral margin joins aboral margin at posterior end of blade. Contrast in height of anterior and posterior denticles subdued on large specimens. Blade thickens slightly from oral margin downward to line continuous with upper surface of lateral lobes and parallel to aboral margin, then constricts sharply to aboral margin. Left side of blade and denticles flattened. Right side of blade and denticles gently convex. Elements lack mirror image symmetry.

Denticles, 10 to 19 in number, fused except for discrete tips, subequal to unequal in height, 1 or 2 denticles over or immediately posterior to basal excavation often prominent and cusp-like. Denticles erect or with those posterior to basal excavation increasingly inclined to posterior to as much as 30 degrees at end of blade.

Comparisons. A few specimens of S. primus have blade of relatively uniform height and resemble S. steinhornensis eosteinhornensis. These forms of S. primus have small lateral lobes in contrast to large flaring lateral lobes of S. steinhornensis eosteinhornensis.

Remarks. The absence of mirror image or bilaterally symmetrical pairs has been observed by the writer. If specimens are set upright with the posterior end of the blade oriented toward the observer, the flattened side is consistently to the left (symmetry class III a, Lane, 1968).

Occurrence. Cosner Gap Member of Mifflintown-Tonoloway Formations.

Material studied. More than 1100 specimens.

Repository. Figured specimens, VPIL 1156-1175.

SPATHOGNATHODUS SAGITTA BOHEMICUS Walliser

Pl. 1, figs. 2-4, 8, 12, 17, 20.

Spathognathodus sagitta bohemicus Walliser, 1964, p. 83, Pl. 7, fig. 4;

Pl. 18, figs. 23, 24.

Oral view. Blade straight or rarely bowed laterally. Basal excavation small to large. Lateral lobes of basal excavation begin medially and continue posteriorly a distance up to one-third length of blade. Inner lobe rounded to subquadrate, outer lobe subcircular. Transverse width of outer lobe as much as twice that of inner lobe. Blade thickens gradually from oral edge to longitudinal line continuous with upper surface of lateral lobes, then constricts sharply to aboral margin.

Aboral view. Basal excavation continues as narrow groove beyond lateral lobes to both anterior and posterior ends of blade.

Lateral view. Aboral margin straight or rarely arched, anterior and posterior aboral corners nearly rectangular. Oral profile of uniform height, decreasing in height posteriorly, or decreasing toward both ends of blade.

Denticles, 8 to 16 in number, fused except for discrete tips, 2 to 4 denticles over basal excavation commonly fused to form knife-like ridge. Denticles subequal in size or, posterior denticles twice as wide in plane of blade as anterior denticles.

Comparisons. The subcircular basal excavation of S. sagitta bohemicus distinguishes it from S. sagitta sagitta which has a symmetrical lanceolate basal excavation and from S. sagitta rhenanus which has an asymmetrical lanceolate basal excavation.

Discussion. A few specimens show the development of a cusp at one or both ends of the blade. These are interpreted as intermediate between S. sagitta bohemicus and S. bicornutus n. sp. Generally these specimens have several denticles over the basal excavation fused to form a knife-like ridge in the manner of S. sagitta bohemicus and are included in the total count of this subspecies.

Occurrence. Cosner Gap Member of Mifflintown Formation.

Material studied. Approximately 450 specimens.

Repository. Figured specimens, VPIL 1176-1182.

SPATHOGNATHODUS SNAJDRI Walliser

Pl. 2, figs. 3, 7, 10-15, 17.

Spathognathodus snajdri Walliser, 1964, p. 84, Pl. 9, fig. 2; Pl. 21, figs. 14, 15; Pl. 22, figs. 1-4; Rexroad & Craig, 1971, p. 700, Pl. 82, figs. 16, 17.

Oral view. Blade straight with asymmetric lateral lobes of basal excavation extending along third quarter of blade. Inner lobe subquadrate, offset anteriorly in relation to outer rounded lobe. Curvature of upper surface of inner lobe broken by two low ridges which diverge anteriorly and posteriorly toward outer edge of lobe, producing angular outer corners.

Perpendicular to blade, outer lobe as much as twice width of inner lobe. Curvature of outer lobe broken by single ridge directed to posterior corner, making posterior corner of lobe angular in appearance.

Aboral view. Posterior half of blade completely excavated. Excavation with widest development under third quarter of blade, constricted posteriorly, continued to posterior end of blade as wide, gradually tapering, V-shaped trough. Anteriorly, basal excavation constricted to narrow groove, continuing to anterior end of blade. Aboral surface of lateral lobes of basal excavation marked by angular breaks in curvature paralleling low ridges on upper surface.

Lateral view. Blade long relative to height. Aboral margin straight under posterior half of blade, arched under anterior half of blade. Anterior aboral corner on some specimens curved downward. Anterior margin straight on small specimens; on large specimens, blade lengthens anteriorly and oral edge curves down to join aboral margin. Oral profile increases in height from anterior end of blade along first quarter of blade, lowers slightly and continues parallel to aboral margin to middle of basal excavation, then curves downward over posterior quarter of blade to meet aboral margin.

Denticles, 11 to more than 18 in number, subequal in size, fused nearly to tips. Tips of denticles more prominent over anterior and posterior quarters of blade. Blade denticles of some specimens fused to form sharp, slightly crenulated ridge over middle part of basal excavation.

Occurrence. Upper third of McKenzie Member of Mifflintown Formation.

Material studied. Approximately 90 specimens.

Repository. Figured specimens, VPIL 1183-1191.

SPATHOGNATHODUS STEINHORNENSIS EOSTEINHORNENSIS Walliser

Pl. 11, figs. 1-10, 12-16; Pl. 14, figs. 5, 6.

Spathognathodus steinhornensis eosteinhornensis Walliser, 1964, p. 85,

Pl. 9, fig. 15; Pl. 20, figs. 7-16, 19-25; Text-fig. 9; Legault,
1968, p. 17, Pl. 1, figs. 1-3.

Oral view. Blade straight or gently bowed laterally. Lateral lobes of large asymmetric basal excavation extended under middle or third quarter of blade. Outline of lateral lobes strongly bilobate, subcircular, subquadrate, to heart-shaped with apex directed posteriorly. Perpendicular to blade, outer lateral lobe as much as twice width of inner lateral lobe.

Aboral view. Asymmetric, laterally expanded basal excavation, medial or under third quarter of blade, generally tapers to point posteriorly and continues to end of blade as narrow tapering V-shaped trough. Anteriorly basal excavation constricted sharply, continuing toward anterior end of blade as shallow groove.

Lateral view. Aboral margin straight or with anterior margin straight and posterior margin bent up out of line as much as 40 degrees across basal excavation.

A few specimens show slight arching of anterior or posterior aboral margin. Anterior and posterior margin straight and erect. Oral margin nearly regular in outline, subparallel to aboral margin. A few specimens with height of blade decreasing at oral corners.

Denticles, 9 to 13 in number, subequal to unequal in size, fused except for discrete tips. Denticles of large specimens of nearly uniform height with denticle over basal excavation and second denticle from anterior end of blade commonly wider in plane of blade. Denticles of small specimens irregular in size and development, with denticle over basal excavation cusp-like. Median denticle occasionally thickened on outer side to form convex ridge extending down to lobe of basal excavation.

Comparisons. S. steinhornensis eosteinhornensis shows considerable resemblance to S. steinhornensis remscheidensis. The difference between these two subspecies is one of degree of variation of the outline of the lateral lobes and of the oral margin. S. steinhornensis eosteinhornensis has a very variable lateral lobe outline but nearly regular oral margin and is distinguished from S. steinhornensis remscheidensis which according to Walliser has a more consistently heart-shaped lateral lobe outline, with the denticle over the basal excavation and the second denticle from the anterior end of the blade prominent and cusp-like.

Small specimens of S. steinhornensis eosteinhornensis have a remscheidensis-like oral margin. Larger specimens from the same samples show a gradual reduction in size of the cusp-like denticles to produce an eosteinhornensis-like oral margin.

Occurrence. Upper Tonoloway Formation-Keyser Limestone.

Material studied. About 425 specimens.

Repository. Figured specimens, VPIL 1192-1208.

SPATHOGNATHODUS TILLMANI n. sp.

Pl. 13, figs. 1-4, 6-9, 11.

Holotype. Pl. 13, fig. 6.

Derivation of name. After C. G. Tillman, Professor of Geology at Virginia Polytechnic Institute and State University.

Diagnosis. A species of Spathognathodus with large asymmetric, subquadrate basal excavation extending posteriorly from mid-point of blade approximately one-third length of blade. Denticles over basal excavation fused to knife-like ridge.

Oral view. Blade straight, strongly compressed laterally. Large asymmetric, subquadrate lateral lobes of basal excavation extend posteriorly from midpoint of blade for distance approximately one-third length of blade. Perpendicular to blade, outer lobe as much as twice width of inner lobe. Outer lateral lobe of basal excavation slightly offset to posterior in relation to inner lateral lobe.

Aboral view. Basal excavation strongly constricted anteriorly and posteriorly to lateral lobes, continuous as shallow narrow groove to both ends of blade.

Lateral view. Blade rectangular in outline, with straight aboral margin. Anterior margin straight, erect or slightly inclined to posterior.

Oral margin relatively straight from anterior end of blade to posterior end of basal excavation, then decreasing in height sharply at anterior end of blade. A few specimens with anterior end of oral margin reduced in height also. Posterior blade only one-half as high as blade over midpoint. Blade increases slightly in thickness from oral margin to line continuous with upper surface of lateral lobes of basal excavation, then constricts to aboral margin. Both sides of blade compressed and flattened.

Denticles, 13 to 18 in number, subequal, fused except for discrete tips. Denticles over basal excavation completely fused to knife-like ridge.

Comparisons. Spathognathodus tillmani n. sp. shows considerable resemblance to S. sagitta bohemicus and to S. snajdri. S. tillmani n. sp. is distinguished by its subquadrate basal excavation and the strong lateral compression of the blade. S. sagitta bohemicus has a subrounded basal excavation and is not compressed strongly laterally. S. snajdri has a relatively longer blade and the posterior half of the blade is excavated.

Occurrence. Lower Wills Creek Formation.

Material studied. 37 specimens.

Repository. Holotype, VPIL 1213; paratypes, VPIL 1209-1212, 1214-1217.

SPATHOGNATHODUS WALLISERI n. sp.

Pl. 1; figs. 1, 9, 10, 19, 21.

Spathognathodus n. sp. Walliser, 1964, p. 88, Pl. 22, fig. 8.

Holotype. Pl. 1, fig. 21.

Derivation of name. After Dr. Otto H. Walliser.

Diagnosis. A species of Spathognathodus with large asymmetric posterior basal excavation, and with a lateral blade developed at approximately 90 degrees to main blade on outer, larger lobe of basal excavation.

Oral view. Blade straight to near posterior end where blade over posterior third of basal excavation is bent inward about 30 degrees. Lateral denticulated blade extends at right angle to blade over posterior third of outer, larger lobe of basal excavation. Lobes of basal excavation begin slightly posterior to midpoint of blade. Basal excavation subquadrate, anterior corners rounded, posterior corners rectangular. Greatest dimension of basal excavation at right angle to blade, with outer lobe as much as twice as wide as inner lobe.

Aboral view. Basal excavation broadest and deepest under posterior half of blade, continuing as trough to anterior end of blade, but terminating posteriorly at point under junction of blade and auxiliary lateral blade.

Lateral view. Blade rectangular in outline, aboral and anterior margins straight, posterior margin concave, oral profile lower anteriorly and posteriorly.

Denticles 7 to 13 in number from anterior end of blade to junction with lateral blade. Denticles erect or with 3 to 4 denticles at anterior and posterior end of blade inclined as much as 30 degrees toward anterior and toward posterior respectively. Inwardly flexed portion of blade and outer lateral blade increase in length by addition of discrete denticles on lobes of basal excavation, with observed number of denticles increasing up to 6 and 8 respectively. These discrete denticles increase in size and fuse to form the blade-like processes.

Comparisons. The specimens studied appear to be conspecific with Spathognathodus n. sp. Walliser (1964, Pl. 22, fig. 8) from the sagitta Zone near Giessen.

Discussion. Nicoll and Rexroad (1968) noted that specimens identified by them as Spathognathodus ranuliformis Walliser sometimes had a denticle on the outer lobe of the basal excavation and questioned whether S. n. sp. Walliser (1964, Pl. 22, fig. 8) might be a gerontic form of that species. None of the specimens of S. ranuliformis illustrated by Walliser or Rexroad show a row of denticles over the basal excavation in the position of the lateral blade. This lateral blade, or a row of discrete denticles is present on all but the smallest of the specimens from the Cosner Gap Member of the Mifflintown Formation. However, the secondary addition of denticles on the basal excavation to form the lateral process of the Appalachian form indicates that the two species are probably part of a direct evolutionary lineage.

Occurrence. Lower Cosner Gap Member of Mifflintown Formation.

Material studied. 14 specimens.

Repository. Holotype, VPIL 1222; paratypes, VPIL 1218-1221.

SPATHOGNATHODUS sp.

Pl. 7, figs. 2, 3.

Description. A species of Spathognathodus with slightly expanded basal excavation situated posterior to midpoint of blade and continued toward posterior about one-quarter of length of blade. Blade straight in oral view, slightly arched over midpoint of basal excavation in lateral view. Denticles, closely set, discrete to near base, with 2 or 3 denticles over basal excavation twice as wide in plane of blade as remaining denticles.

Occurrence. Lower Cosner Gap Member of Mifflintown Formation.

Material studied. 2 specimens.

Repository. Figured specimens, VPIL 1223-1224.

Genus SYNPRIONIODINA Bassler, 1925

SYNPRIONIODINA BICURVATA (Branson & Mehl)

Pl. 9, figs. 1, 17-19, 24; Pl. 12, figs. 4, 12, 13.

Prioniodus bicurvatus Branson & Mehl, 1933, p. 44, Pl. 3, figs. 9-12.

Prioniodina bicurvata pronoides Walliser, 1960, p. 33, Pl. 8, figs. 8-10.

Neoprioniodus bicurvatus (Branson & Mehl). Walliser, 1964, p. 46,
Pl. 9, fig. 13; Pl. 29, figs. 27-33; Text-fig. 5d; Barnett,
Kohut, Rust, & Sweet, 1966, Pl. 58, fig. 22; Philip, 1969,
p. 292, Pl. 17, fig. 15; Mashkova, 1970, p. 217, Pl. 3, fig. 8;
Pl. 4, fig. 5; Pl. 7, figs. 6, 8-10; Text-fig. 1, fig. 17.

Synprioniodina bicurvata pronoides (Walliser). Moskalenko, (1966)
1967, p. 202, Pl. 1, figs. 16-18.

Synprioniodina bicurvata (Branson & Mehl). Pollock, Rexroad, & Nicoll,
1970, p. 762, Pl. 114, figs. 16, 17; Rexroad & Craig, 1971, p. 700,
Pl. 80, figs. 13-18.

Oral view. Cusp curved inward as much as 45 degrees. Posterior
blade gently bowed.

Aboral view. Basal excavation deepest under cusp and expanded
inward with rounded inner margin. Basal excavation constricted pos-
teriorly and anteriorly, continued under posterior blade as shallow,
tapering V-shaped trough and under anticusp as shallow groove.

Lateral view. Posterior blade gently arched, nearly twice as
long as cusp. Anticusp increasing in length with size of specimen
from short non-denticulate ridge on anterior edge of cusp to denticulate
process more than half as long as cusp on large specimens. Angle be-
tween posterior blade and anticusp approximately 80 degrees. Posterior
blade diverges about 50 degrees from line of development of cusp.
Anticusp diverges about 30 degrees from line of development of cusp.

Basal excavation expressed on inner side of cusp as conical ridge extending to height of blade. Outer face of blade flattened, inner face gently convex to rounded.

Cusp long, subtriangular in cross-section with sharp edges in plane of blade, outer face plane to gently convex with inner face angular to broadly rounded.

Denticles of posterior blade, 10 to 20 in number, subequal in size, subparallel to cusp, crowded, discrete or partially fused.

Denticles of anticusp, increasing in number with size of specimen from none visible to as many as 8, partially or almost completely fused. A few specimens have denticles fused entirely into anterior edge of cusp making cusp appear asymmetric in cross-section and in relation to position of basal cavity.

Remarks. This species is fairly consistent in overall form; two changes do occur, however, which could prove useful stratigraphically. Specimens from the Cosner Gap Member typically have finer, more numerous, closely set denticles; while specimens from the Tonoloway Formation have fewer denticles which are discrete or slightly separated.

Occurrence. Cosner Gap Member of Mifflintown-Tonoloway Formations.

Material studied. Approximately 275 specimens.

Repository. Figured specimens, VPIL 1225-1232.

SYNPRIONIODINA LOWRYI n. sp.

Pl. 9, figs. 20, 23, 26, 28-32; Pl. 12, figs. 10, 11; Pl. 16, fig. 11.

Holotype. Pl. 9, fig. 30.

Derivation of name. After Dr. W. D. Lowry, Professor of Geology at Virginia Polytechnic Institute and State University.

Diagnosis. A species of Synprioniodina with long rounded, gently curved posterior blade. Cusp stout, rounded, gently curved inward. Anticusp blade-like, laterally compressed, denticulated, strongly produced downward from outer anterior edge of cusp.

Oral view. Posterior blade slightly curved inward. Anticusp strongly compressed laterally, produced from outer anterior edge of cusp. Cusp curved inward 20 to 45 degrees.

Aboral view. Basal excavation deepest under cusp, and expanded inward to form a conical pit. Basal excavation constricted slightly posteriorly and continuous under posterior blade as gradually tapering shallow V-shaped trough. Basal excavation constricted strongly anteriorly and continuous under anticusp as tapering V-shaped groove.

Inner lateral view. Posterior blade strongly bent downward adjacent to cusp, then continued straight or in a gentle arch. Anticusp produced strongly downward, straight, makes angle of 60 to 80 degrees with posterior blade. In vertical plane, posterior blade diverges 40 to 50 degrees from axis of cusp, and anticusp diverges 20 to 30 degrees from axis of cusp. Basal excavation expressed on inner side of blade beneath cusp as rounded conical ridge rising approximately the height of the blade.

Cusp circular in cross-section or occasionally with sharp edges in plane of blade.

Denticles of posterior blade, 5 to 10 or more in number, unequal in size, discrete, irregularly spaced. Denticles nearly circular in cross-section adjacent to cusp, becoming laterally compressed distally. Denticles adjacent to cusp inclined in direction of cusp and nearly parallel to cusp. Distally the denticles become erect.

Denticles of anticusp, 2 to 5 in number, otherwise developed exactly as denticles of posterior blade.

Comparisons. Synprioniodina lowryi n. sp. shows some similarities to S. bicurvata. S. lowryi n. sp. has strongly rounded blade, cusp, and denticles and is thus distinguished from S. bicurvata which is strongly compressed laterally.

Remarks. Specimens from the McKenzie Member of the Mifflintown have approximately 10 denticles on the posterior blade and 3 to 5 denticles on the anticusp. Specimens of S. lowryi n. sp. from the Wills Creek Formation have as few as 5 blade denticles and 2 to 3 denticles on the anticusp. The Wills Creek specimens are small in comparison to the McKenzie specimens, and the differences noted may be due to different growth stages or represent stratigraphic change.

Occurrence. McKenzie Member of Mifflintown-Wills Creek Formations.

Material studied. Approximately 100 specimens.

Repository. Holotype, VPIL 1238; paratypes, VPIL 1233-1237, 1239-1243.

SYNPRIONIODINA n. sp.

Pl. 9, fig. 33.

Description. A species of Synprioniodina with deep, curved, laterally compressed, posterior blade which in lateral view makes an angle of approximately 70 degrees with anticusp. Denticles of posterior blade and anticusp, partially fused, compressed in plane of blade, inclined toward cusp. Cusp short, curved inwardly, unequally biconvex in cross-section, with sharp edges in plane of blade. Basal excavation deepest under cusp, expanded posteriorly to form conical pit, constricted anteriorly and posteriorly, continued under posterior blade and anticusp as shallow V-shaped trough.

Occurrence. Upper McKenzie Member of Mifflintown Formation.

Material studied. 5 specimens.

Repository. Figured specimen, VPIL 1244.

SYNPRIONIODINA sp.

Pl. 10, fig. 11.

Description. A species of Synprioniodina with inwardly curved, ovate, apical cusp. Posterior blade, arched, rounded on inner face. Anticusp strongly compressed, offset to outer anterior margin of cusp. Denticles of posterior blade closely set, subparallel to cusp adjacent to cusp, becoming erect toward posterior end of blade. Denticles of anterior process, 2 in number, subcircular, subparallel to cusp, slightly curved inward.

Occurrence. Upper Cosner Gap Member of Mifflintown Formation.

Material studied. 1 specimen.

Repository. Figured specimen, VPIL 1245.

Genus TRICHONODELLA Branson & Mehl, 1948

TRICHONODELLA EXCAVATA (Branson & Mehl)

Pl. 8, figs. 1, 4, 5, 7, 9, 10, 14, 17, 23-25, 27, 28,
30, 31; Pl. 15, figs. 9, 12, 16.

Trichognathus excavata Branson & Mehl, 1933, p. 51, Pl. 3, figs. 35, 36.

Trichonodella aborflexa Rhodes, 1953, p. 312, Pl. 23, figs. 231, 241,
242.

Trichonodella excavata (Branson & Mehl). Walliser, 1957, p. 48, Pl. 3,
figs. 3, 4, 6-8; Text-fig. 2, 3; Ethington & Furnish, 1962, p. 1287,
Pl. 173, fig. 8; Serpagli & Greco, 1964, p. 209, Pl. 37, fig. 12;
Walliser, 1964, p. 89, Pl. 8, fig. 2; Pl. 31, figs. 26, 27; Barnett,
Kohut, Rust, & Sweet, 1966, Pl. 58, fig. 14; Nicoll & Rexroad, 1968,
p. 63, Pl. 4, fig. 2; Mashkova, 1970, p. 226, Pl. 4, fig. 11; Pl. 14,
figs. 15-16, 18, 21; Rexroad & Craig, 1971, p. 701, Pl. 79, figs. 43-46.

Oral view. Lateral blades extended slightly anteriorly from antero-
lateral margins of cusp and then extended laterally or curved slightly
to posterior as much as 30 degrees from transverse vertical plane.

Aboral view. Base of cusp strongly developed to posterior of lateral blades. Basal excavation developed transverse to cusp and continuous under lateral blades as narrow, gradually tapering groove, and posteriorly under cusp as broad V-shaped trough as wide as base of cusp.

Posterior view. Aboral margin of lateral blades nearly straight to continuously curved with angle between lateral blades varying from 80 to 140 degrees. Basal excavation produced vertically along posterior face of cusp as elongate tapering trough or as elongate parallel-sided trough with rounded apical margin.

Cusp continuously curved or straight and inclined posteriorly as much as 45 degrees. Cusp ovate in cross-section distally with longest axis of oval directed laterally. At junction of cusp with lateral blades, cusp cross-section subtriangular to subrectangular. These two cross-sectional shapes are gradational into one another in specimens from the same sample. Many specimens have incised grooves on lateral faces of cusp parallel to antero-lateral edges; grooves originate on upper surface of lateral blades and extend nearly to tip of cusp.

Blade denticles, 5 to 12 in number per blade, unequal in size, rounded to subovate, occasionally with sharp lateral edges. Blade denticles decrease in size adjacent to cusp and at ends of blades. Denticles curved slightly to posterior and separated by space equal to single denticle or closely set at base. A few specimens have denticles adjacent to cusp fused into antero-lateral edges of cusp.

Comparisons. Specimens of Trichonodella excavata with triangular cusp show considerable similarity to T. symmetrica. T. excavata has the cusp strongly developed posteriorly of the lateral blades and strongly inclined posteriorly, and is distinguished from T. symmetrica which has the base of the cusp largely in the plane of the lateral blades.

Remarks. Variation is wide in all samples, however, most specimens from the Cosner Gap Member of Mifflintown Formation have cusp with concave anterior face near base, sharp lateral edges, subtriangular cross-section, and lateral blades with straight aboral margins. Specimens from the McKenzie Member of Mifflintown and Wills Creek Formations have a cusp with a convex anterior face, a subtriangular to subrectangular cross-section near base, and grooves on the antero-lateral edges; the lateral blades have curved aboral margins.

Close affinity with Roundya is shown by the development of a denticle on the apex of the posterior margin of basal excavation of a few specimens.

Occurrence. Cosner Gap Member of Mifflintown-Wills Creek Formations.

Material studied. Approximately 625 specimens.

Repository. Figured specimens, VPIL 1246-1263.

TRICHONODELLA INCONSTANS Walliser

Pl. 8, figs. 6, 11-13, 16, 20, 21; Pl. 16, figs. 19, 20.

Trichonodella inconstans Walliser, 1957, p. 50, Pl. 3, figs. 10-17;

Text-fig. 3; 1960, p. 35, Pl. 7, figs. 11, 12; Ethington & Furnish, 1962, p. 1287, Pl. 173, fig. 7; Walliser, 1964, p. 90, Pl. 8, fig. 8, Pl. 30, figs. 10-12; Barnett, Kohut, Rust, & Sweet, 1966, Pl. 58, fig. 12; Nicoll & Rexroad, 1968, p. 64, Pl. 4, fig. 1; Legault, 1968, p. 18, Pl. 1, figs. 7-9; Philip, 1969, p. 295, Pl. 18, figs. 9, 12, 14, 15; Pollock, Rexroad, & Nicoll, 1970, p. 762, Pl. 113, figs. 26, 27; Rexroad & Craig, 1971, p. 701, Pl. 79, figs. 39-42.

Oral view. Cusp gently to strongly curved toward posterior, lateral blades compressed to rounded, extended straight laterally or curved posteriorly as much as 30 degrees from transverse vertical plane.

Aboral view. Basal excavation deepest under cusp, expanded posteriorly with rounded or angular margin, continued to ends of lateral blades as shallow V-shaped trough.

Posterior view. Lateral blades arched with interior angle varying from 80 to 140 degrees. Posterior margin of basal excavation straight or with slight vertical emargination.

Cusp nearly straight or curved posteriorly as much as 30 degrees, subcircular to subtriangular in cross-section, with sharp or rounded lateral edges.

Denticles, 5 to 9 in number per blade, ovate to rounded with sharp or rounded lateral edges, unequal in size, generally discrete, and regularly to irregularly spaced.

Denticles generally smallest adjacent to cusp and at end of lateral blades, a few specimens with small needle-like denticles inserted between larger denticles along the length of the blade. A few specimens with one or two pairs of coalesced blade denticles.

Comparisons. Some specimens of Trichonodella inconstans are grossly similar to T. excavata and T. symmetrica. However, T. inconstans has the cusp developed largely in the plane of the blades, with the basal excavation extended to the ends of the lateral blades as a shallow V-shaped trough. In contrast, T. excavata has the cusp strongly developed posteriorly of the plane of the lateral blades and the basal excavation extended under the lateral blades as a narrow groove. T. inconstans has discrete, ovate to rounded, irregularly separated denticles and is distinguished in this way from T. symmetrica which has closely set or partially fused, strongly compressed blade denticles.

Remarks. Specimens from the lower McKenzie Member of the Mifflintown Formation associated with Spathognathodus bicornutus n. sp. show no vertical emargination of the posterior margin of the basal excavation. Stratigraphically higher specimens generally have the posterior margin slightly emarginated vertically.

Occurrence. McKenzie Member of Mifflintown-lower Tonoloway Formations.

Material studied. Approximately 85 specimens.

Repository. Figured specimens, VPIL 1264-1272.

TRICHONODELLA SYMMETRICA (Branson & Mehl)

Pl. 8, figs. 2, 3, 15, 19, 26, 29; Pl. 16, figs. 8, 12, 17.

Trichognathus symmetrica Branson & Mehl, 1933, p. 50, Pl. 3, figs. 33, 34.

Trichonodella symmetrica (Branson & Mehl). Rhodes, 1953, p. 315, Pl. 23, figs. 232, 246; Walliser, 1964, p. 90, Pl. 9, fig. 11; Pl. 31, figs. 28-30; Philip, 1969, p. 295, Pl. 18, fig. 24; Pollock, Rexroad & Nicoll, 1970, p. 763, Pl. 113, figs. 22-24; Rexroad & Craig, 1971, p. 701, Pl. 79, figs. 47-51.

Oral view. Lateral blades straight to slightly curved posteriorly. Cusp slightly inclined posteriorly or occasionally strongly bent posteriorly at point above lateral blades.

Aboral view. Basal excavation triangular, deep under cusp, continuous under lateral blades as shallow grooves or barely noticeable striae.

Posterior view. Aboral margin of lateral blades straight or gently curved with angle between blades varying between 90-150 degrees.

Cusp subtriangular in cross-section along its entire length, with sharp lateral edges, and with sharp or rounded posterior edge. Anterior face of cusp concave to convex, lateral faces plane to convex. Posterior basal margin slightly emarginated vertically.

Denticles of lateral blades, 7 to 9 in number per blade, compressed in plane of blade, closely set or partially fused at base with sharp lateral edges. Denticles subequal to unequal in size, smallest adjacent to cusp and at ends of blade.

Comparisons. Trichonodella symmetrica shows considerable similarity to some specimens of T. excavata. T. symmetrica has a cusp which is subtriangular in cross-section along its entire length and nearly erect or bent posteriorly above point of attachment of the lateral blades. It is distinguished from T. excavata in which the cusp has an ovate cross-section distally, and is offset posteriorly from lateral blades so that the base is almost wholly behind the plane of the lateral blades, with the basal excavation elongated posteriorly under the base of the cusp.

Occurrence. Cosner Gap Member of Mifflintown-lower Tonoloway Formations.

Material studied. Approximately 100 specimens.

Repository. Figured specimens, VPIL 1273-1281.

TRICHONODELLA n. sp.

Pl. 8, figs. 18, 22.

Description. A species of Trichonodella with deep lateral blades; interior angle between blades in posterior view approximately, 60 degrees. Blade denticles biconvex in cross-section, with sharp edges in plane of blade. Cusp short, unequally biconvex in cross-section, with sharp lateral edges, curved posteriorly. Basal excavation deepest under cusp, slightly expanded posteriorly, constricted laterally, continued under lateral blades as shallow V-shaped trough.

Occurrence. Upper McKenzie Member of Mifflintown Formation.

Material studied. 3 specimens.

Repository. Figured specimens, VPIL 1282-1283.

TRICHONODELLA sp.

Pl. 8, fig. 8.

Description. A species of Trichonodella with stout triangular cusp, with straight lateral blades meeting at angle of approximately 120 degrees, and with 3 erect denticles on each blade. Antero-basal margin of cusp rounded and projected below base of lateral blades.

Occurrence. Upper Cosner Gap Member of Mifflintown Formation.

Material studied. 1 specimen.

Repository. Figured specimen, VPIL 1284.

Gen. et. sp. indet. A.

Pl. 12, fig. 26.

Description. A simple cone, recurved, bilaterally symmetrical in cross-section with single costa on each side originating approximately at midpoint of basal lateral margin. Basal excavation rises approximately one-fourth of height of cusp.

Occurrence. Lower Tonoloway Formation.

Material studied. 1 specimen.

Repository. Figured specimen, VPIL 1289.

Gen. et sp. indet. B.

Pl. 12, figs. 7, 8, 22.

Description. A laterally compressed, asymmetric, cone-like form, with base elongated in antero-posterior plane. Cusp, long, strongly curved toward posterior, twisted distally, with costate ridge on inner antero-lateral margin. With several small vertically directed denticles on lower part of antero-lateral costate ridge. With several needle-like, erect denticles arranged in vertical row on posterior margin toward base of cusp.

Remarks. The specimens bear some resemblance to the form genus Cordylodus.

Occurrence. Lower Tonoloway Formation.

Material studied. 3 specimens.

Repository. Figured specimens, VPIL 1290-1292.

Gen. et sp. indet. C.

Pl. 16, fig. 10

Description. A laterally compressed form with base elongated in antero-posterior plane. Cusp long, strongly curved toward posterior, with 5 denticles in a vertical row on lower posterior margin.

Occurrence. Lower Tonoloway Formation.

Material studied. 1 specimen.

Repository. Figured specimen, VPIL 1293.

N. Gen. et n. sp.

Pl. 16, figs. 1-3, 6.

Description. A form with anterior blade and posterior platform. Anterior blade spathognathodid-like in development; posterior half, elongate, ovoid platform, completely excavated. Basal excavation deepest medially, rises approximately one-third height of platform. Platform rises from margin of basal excavation to height of blade or slightly higher. Denticle row of anterior blade continued across platform as row of small denticles or carina. A series of ridges extends outward from both sides of carina. Vertical faces of platform concave.

Occurrence. Upper Tonoloway Formation.

Material studied. 4 specimens.

Repository. Figured specimens, VPIL 1285-1288.