CONODONT BIOSTRATIGRAPHY AND FACIES RELATIONS OF THE CHICKAMAUGA LIMESTONE (MIDDLE ORDOVICIAN) OF THE SOUTHERN APPALACHIANS, ALABAMA AND GEORGIA

A Thesis

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INTRODUCTION

Purpose and Nature of Investigation

The Middle Ordovician rocks of the southern Appalachians occur in two main facies belts: an eastern, clastic facies belt and a western, calcareous facies belt. Ordovician rocks are exposed in this area between northeast-trending thrust faults (see figs. 1, 2). Facies changes and horizontal interruption of sequences between the thrust belts have made tracing of lithic units and biostratigraphic correlation from west to east highly uncertain. Moreover, the geology of the Ordovician rocks in Alabama and Georgia has received relatively little attention.

Hayes (1894) named the Chickamauga Limestone for the strata between the Lower Ordovician Knox Group and the Silurian Rockwood Formation. Butts described the Chickamauga lithology and biostratigraphy in somewhat greater detail (Butts and Gildersleeve, 1948). However, he based his correlations on megafossils, the distribution of which is, in many cases, facies dependent. Subsequent attempts to correlate the Middle Ordovician sequences in the southern Appalachians have generally depended heavily upon brachiopods (Cooper, 1956) and other benthic fossils.

Because most graptoloids are believed to have been planktic organisms and are biostratigraphically important elsewhere, they have biostratigraphic potential also in the

Figure 1. Map of the Middle and Upper Ordovician age rocks in the study area. The collecting localities are indicated by stars. Notice that the Rockmart and Portland localities are marked by a single star.

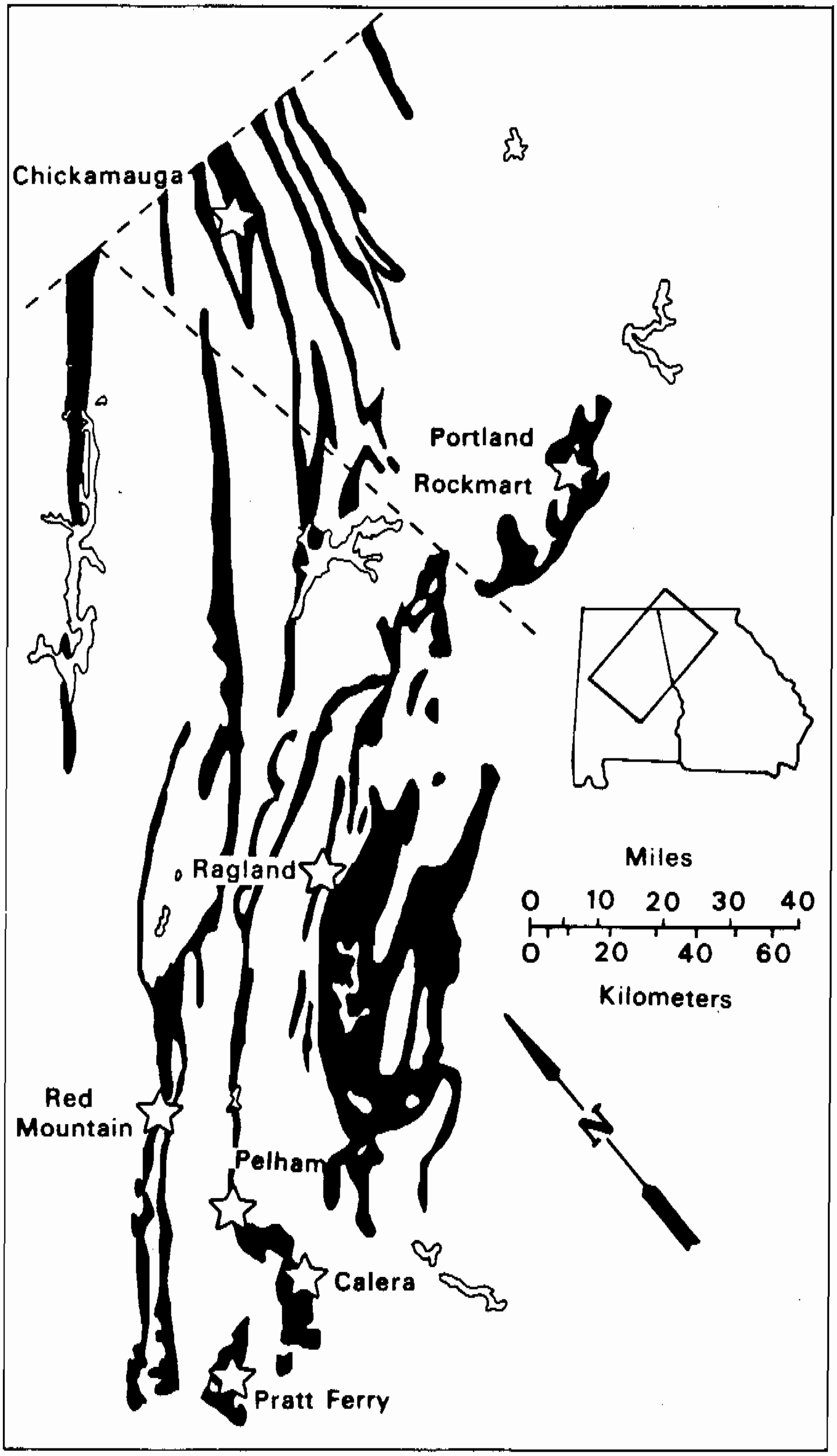

Chickamauga
Portland
Rockmart
Ragland
Red Mountain
Pelham
Calera
Pratt Ferry
Miles
0 10 20 30 40
0 20 40 60
Kilometers
N

Figure 1.

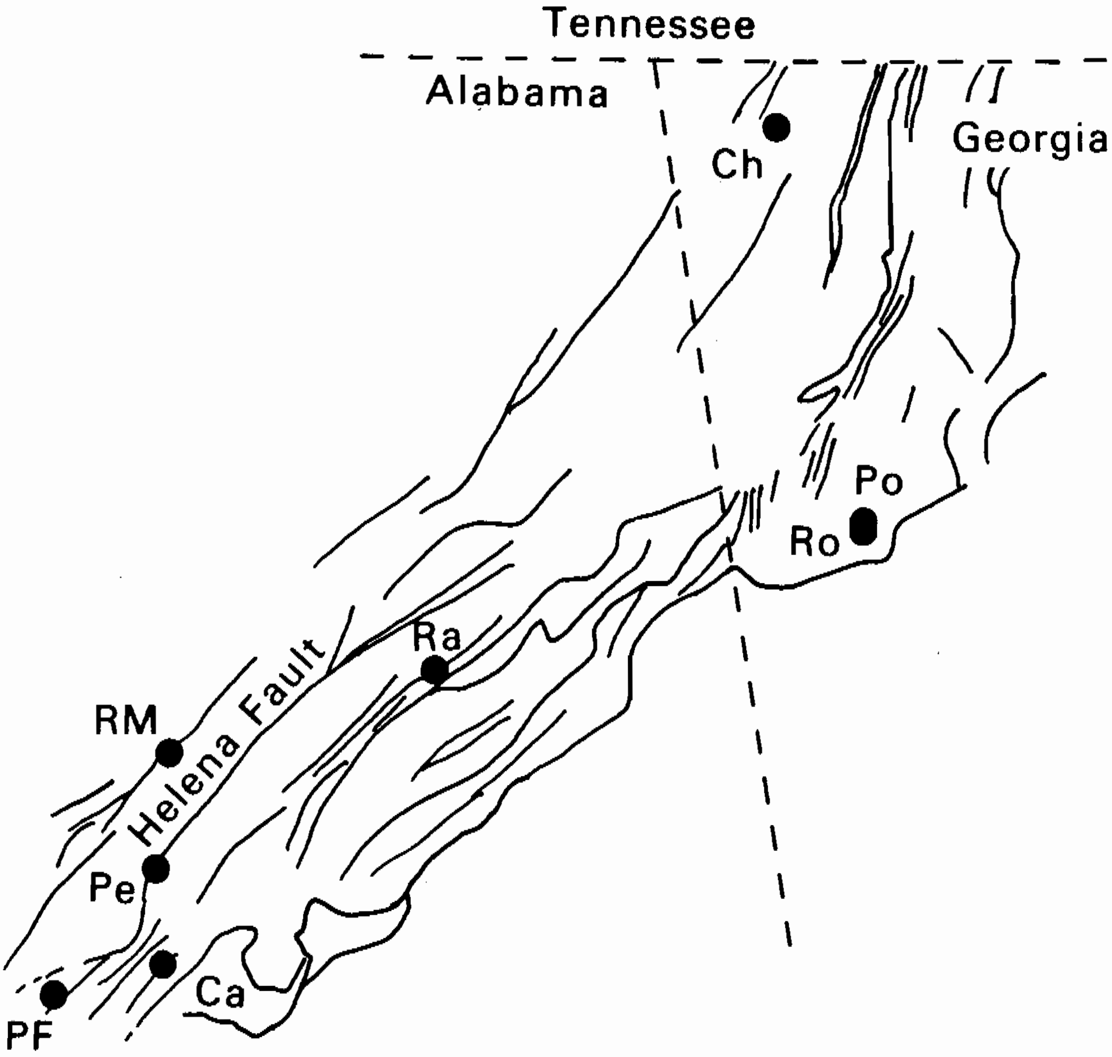


Figure 2. Thrust faults in the study area. Most dip to the southeast. Dots indicate sample localities in the present study. Ch= Chickamauga; RM= Red Mountain; PF= Pratt Ferry; Pe= Pelham; Ca= Calera; Ra= Ragland; Ro= Rockmart; Po= Portland.

lower Paleozoic rocks of the Appalachians. However, they are characteristically found in deep-water shales, and they have not proven useful for correlating rocks of the shallow-water, calcareous, western facies. Another planktic, or at least pelagic organism, the conodont, is quite abundant in many of the calcareous Ordovician rocks. However, except for Sweet and Bergström (1962), Bergström (1971a), Drahovzal and Neathery (1971), Raymond (1976), and Finney (1977), few researchers have extended their studies of lower Middle Ordovician conodonts in the Appalachians south of Tennessee.

Most conodonts are thought to have been pelagic, and they are relatively independent of facies (Seddon and Sweet, 1971). Nevertheless, conodonts occur in natural species associations as described by Bergström and Carnes (1976). The distribution of these Recurrent Species Associations (RSA's) is believed to be in part related to water depth. However, fairly little is known about the relations and occurrences of conodont RSA's with other fossils.

The purpose of this study is to refine the biostratigraphic classifiction and correlation of the lower Middle Ordovician carbonates in the southern Appalachians on the basis of conodonts. The biostratigraphic data are used to work out a model of the facies relations between units in different thrust belts. Furthermore, a study of skeletal and nonskeletal carbonate constituents, using thin sections, has been made in an attempt to clarify environmental parameters controlling the distribution of Recurrent Species Associations.

USAGE OF THE TERM "CHICKAMAUGA"

Hayes (1891) named the Chickamauga Limestone for massive, cherty, dolomitic limestone in northwestern Georgia. The Chickamauga of Hayes (1891) included all of the rocks between the Lower Ordovician Knox Dolomite and the Silurian Rockwood Formation.

In Ulrich's (1911) "Revision of the Paleozoic Systems" he distinguished the lowermost part of Hayes' Rockwood Formation as the Sequatchie Formation which is partly, or entirely, of Ordovician age. Subsequent definitions of the Chickamauga may or may not include the Sequatchie.

Butts (1926) mapped the Paleozoic rocks of Alabama. He considered the Chickamauga to extend to the base of the Silurian and therefore to include the Sequatchie Formation. Butts (1926) used "Chickamauga" as an informal group, which included the Mosheim Limestone, Lenoir Limestone, Athens Shale, Little Oak Limestone, Lowville Limestone, and Sequatchie Formation. Most current authors consider the Mosheim to be a facies or a member of the Lenoir since it occurs at various stratigraphic intervals within it.

Butts and Gildersleeve (1948) published a map of the Paleozoic rocks of northwest Georgia. They restricted the term "Chickamauga" to include only rocks below the Sequatchie. Furthermore, they mapped the Newala Limestone as being above the post-Knox unconformity despite the fact that Butts named the Newala in 1926 for a unit beneath the unconformity. As a result, there has been some confusion as to whether or not the Newala should be included with the Chickamauga Limestone. In keeping with the original definition of Newala, the present author considers the Newala to lie beneath the post-Knox unconformity. Because the unconformity is generally taken to be at the base of the Chickamauga, I do not consider any Newala Limestone to be a part of the Chickamauga.

Twenhofel et al. (1954) correlated the Ordovician rocks of North America. Their concept of the "Chickamauga" included also the Sequatchie and its lateral equivalents. Their correlatives in Alabama were taken to be, from oldest to youngest, the Lenoir Limestone, Effna Limestone, Athens Shale, and Little Oak Limestone in the Cahaba Valley, and the Ridley, Lebanon, Tyrone and Curdsville Limestones, and the "Cannon-Catheys", "Leipers", and "Fernvale equivalents" in the Birmingham area. The correlations of Twenhofel et al. (1954) are taken from Butts and Gildersleeve (1948).

Cooper (1956) described the stratigraphy and brachiopod paleontology of the lower Middle Ordovician rocks of North America. He suggested abandonment of the name "Chickamauga" and referred to units of the Chickamauga by separate formational names.

Allen and Lester (1957) mapped the Chickamauga of northwestern Georgia and subdivided it into zones numbered according to their position above or below a prominent bentonite.

Rogers (1961a, 1961b) investigated and correlated the Chickamauga of Alabama using the same divisions as Allen and Lester and numbering the sequences I through IV. Rogers considered "Chickamauga" to be a useful group name and used it as such, informally. He suggested, however, that "limestone" be dropped from the name "Chickamauga Limestone" since some of the units in it are predominantly clastic. Rogers' Chickamauga includes strata up to the base of the Silurian Red Mountain Formation.

Cressler (1963, 1964a, 1964b) and Croft (1964) mapped the Paleozoic rocks in northwestern Georgia. They recognized the Chickamauga as a formation underlying the Ordovician Sequatchie Formation.

In order to give the appropriate lithostratigraphic rank to the Chickamauga, Swingle (1969) proposed elevating it to formal group status in East Tennessee. His Chickamauga Group includes all of the sequence beteen the Knox Group and the Sequatchie (or Juniata) Formation.

Milici and Smith (1969) used Wilson's (1949) Tennessee nomenclature to map and describe the Chickamauga in its type area. They proposed elevation of the Chickamauga to supergroup status. This supergroup comprises the Stones River Group and the Nashville Group. However, they noted that the formations of the Stones River Group (Pond Spring, Murfreesboro, Ridley, Lebanon, and Carters) and of the Nashville Group (Hermitage, Cannon, and Catheys) are not distinguishable farther south into Alabama where the Stones River and Nashville were given formational status. Still farther south, beyond Gadsden, Alabama, these two formations are not easily separated lithologically and may be referred to simply as "Chickmauga Limestone".

Drahovzal and Neathery (1971) reviewed Middle and Upper Ordovician rocks in Alabama. In the calcareous western facies they subdivided the Chickamauga Group into the Stones River and Nashville Formations. They were not able to distinguish these two formations south of Gadsden. Lithologically, their Stones River limestones were generally similar to the Murfreesboro, Ridley, Lebanon, and Carters Limestones of the Stones River Group in Tennessee (Milici and Smith, 1969) but they could not be recognized as individual formational units. Similarly, Drahovzal and Neathery's "Nashville" was not separated into formations. Therefore, they assigned Nashville a formational status in Alabama. Above their Nashville Formation and below the Sequatchie Formation, they recognized the Inman Formation and Leipers Limestone which are typical of central Tennessee.

Raymond (1978) studied conodonts from the upper Chickamauga in the Birmingham, Alabama area. She was unable to distinguish the Stones River and the Nashville in that region. She therefore described the Chickamauga Limestone as a formation overlain by the Sequatchie.

In the present study, I will use the term "Chickamauga" as a group name for calcareous rocks between the post-Knox unconformity and the Sequatchie Formation. Although I have studied the lower Athens Shale at Calera in the present study, I consider it to be a lateral equivalent of, and not a part of, the Chickamauga.

LITHOSTRATIGRAPHIC CLASSIFICATION OF SECTIONS STUDIED

Chickamauga Creek

Hayes (1891) defined the Chickamauga as a massive-bedded limestone betwen the Knox Dolomite and the Rockwood Formation. He did not divide the unit into subordinate units.

In the Chickamauga area, Charles Butts (1948) mapped the rock above the Knox and below the Murfreesboro as Newala. His "Newala" overlies the post-Knox unconformity in the area near Chickamauga Creek. But when he defined the Newala (1926) as a rather thick-bedded, pure, sparsely fossiliferous, blue limestone he mapped a unit that underlies a major unconformity. Most subsequent authors, including myself, have chosen to restrict the name "Newala" to rocks underlying the post-Knox unconformity. On the basis of the molluscs *Hormotoma* sp. cf. *H*. *artemesia*, *Coelocaulus* cf. *cilinenta*, *Helicotoma*? sp., *Maclurites affinis*?, *Tarphyceras*, *Gonotelus* (*Goniurus*) sp. cf. *G*. *elongatus* Raymond and especially *Ceratopea*, Butts believed the Newala to be a Beekmantown equivalent. It is possible that his fossils indeed came from Beekmantown equivalents, but his locality was mislocated on the map or misidentified in the field.

Butts (1948) applied the name "Murfreesboro" to the partly red-mottled, moderately fossiliferous limestone overlying the "Newala". A number of fossils, including *Nicholsonella pulchra*, *Strophomena incurvata*, and *Helicotoma tennesseensis* occur in both the Chickamauga and the type Murfreesboro in Tennessee, and suggest a correlation of the two units.

Twenhofel et al. (1954), using Butts' information, correlated the "Newala" of Georgia with the Beekmantown of Virginia which is Canadian in age (see fig. 3). Also in the scheme of Butts, it was indicated that the Murfreesboro in Georgia belonged to the Champlainian and was deposited after a considerable hiatus.

Cooper (1956) proposed that the terms "Chickamauga" and "Stones River" be discarded because both had been used so broadly that they had lost their significance. His correlations show the post-Knox unconformity to be overlain by the Porterfieldian Long Savannah Formation (see fig. 4). The Long Savannah is a mixture of red beds and buff limestones with detrital chert. He reported that no fossils had been found in it and considered the Long Savannah to be regionally rather variable in age. Cooper indicated that the Long Savannah might range as high as the Peery and Rob Camp Formations and might be considerably younger than the lithologically very similar Blackford beds. According to Cooper (1956), the Long Savannah in the Chickamauga area is overlain by the Murfreesboro Limestone. He described the Murfeesboro as a moderately heavy-bedded, dark-gray, cherty

Twenhofel et al., 1954

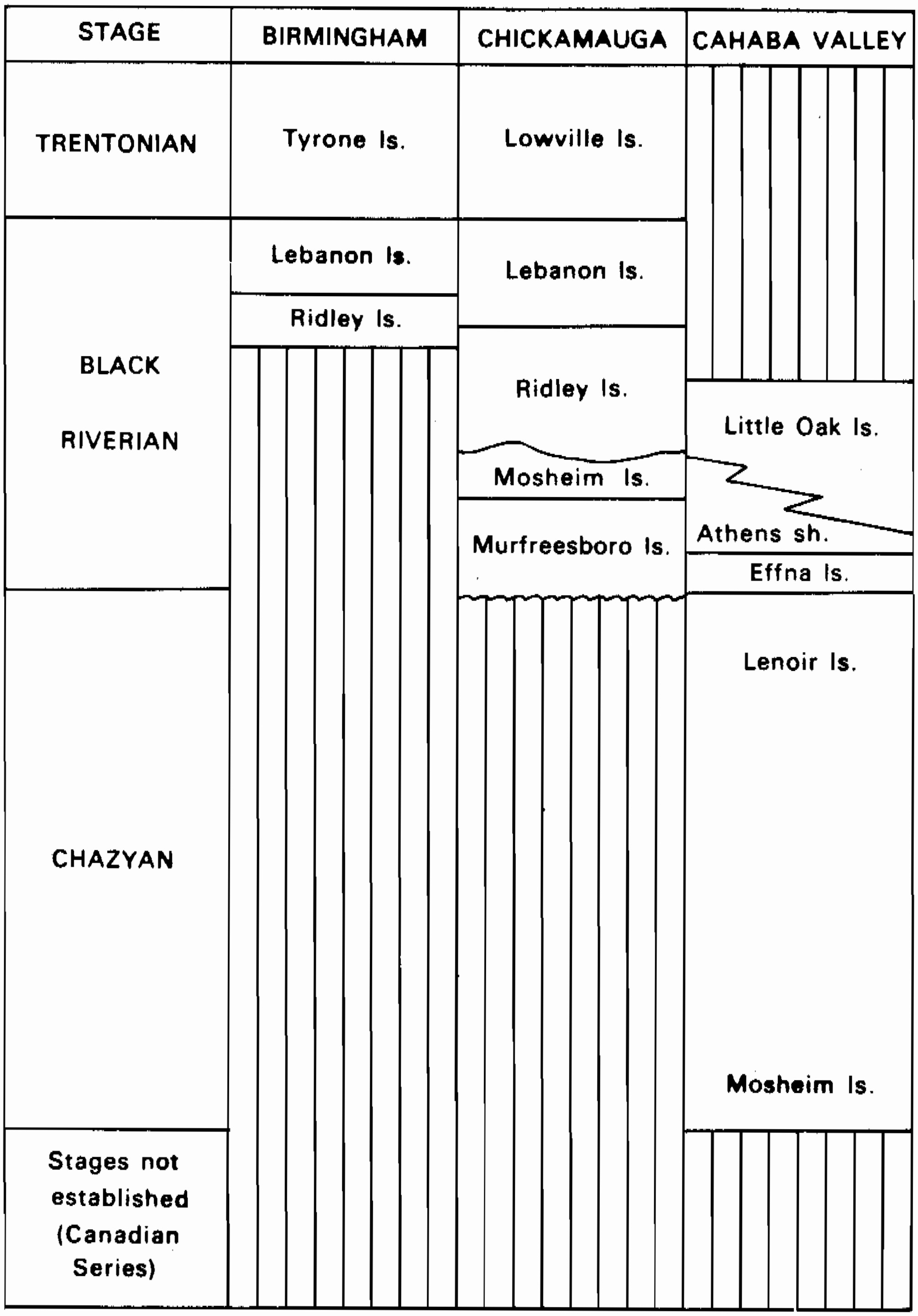


Figure 3. Stratigraphic interpretation of the Chickamauga Limestone in the study area made by Twenhofel et al. (1954).

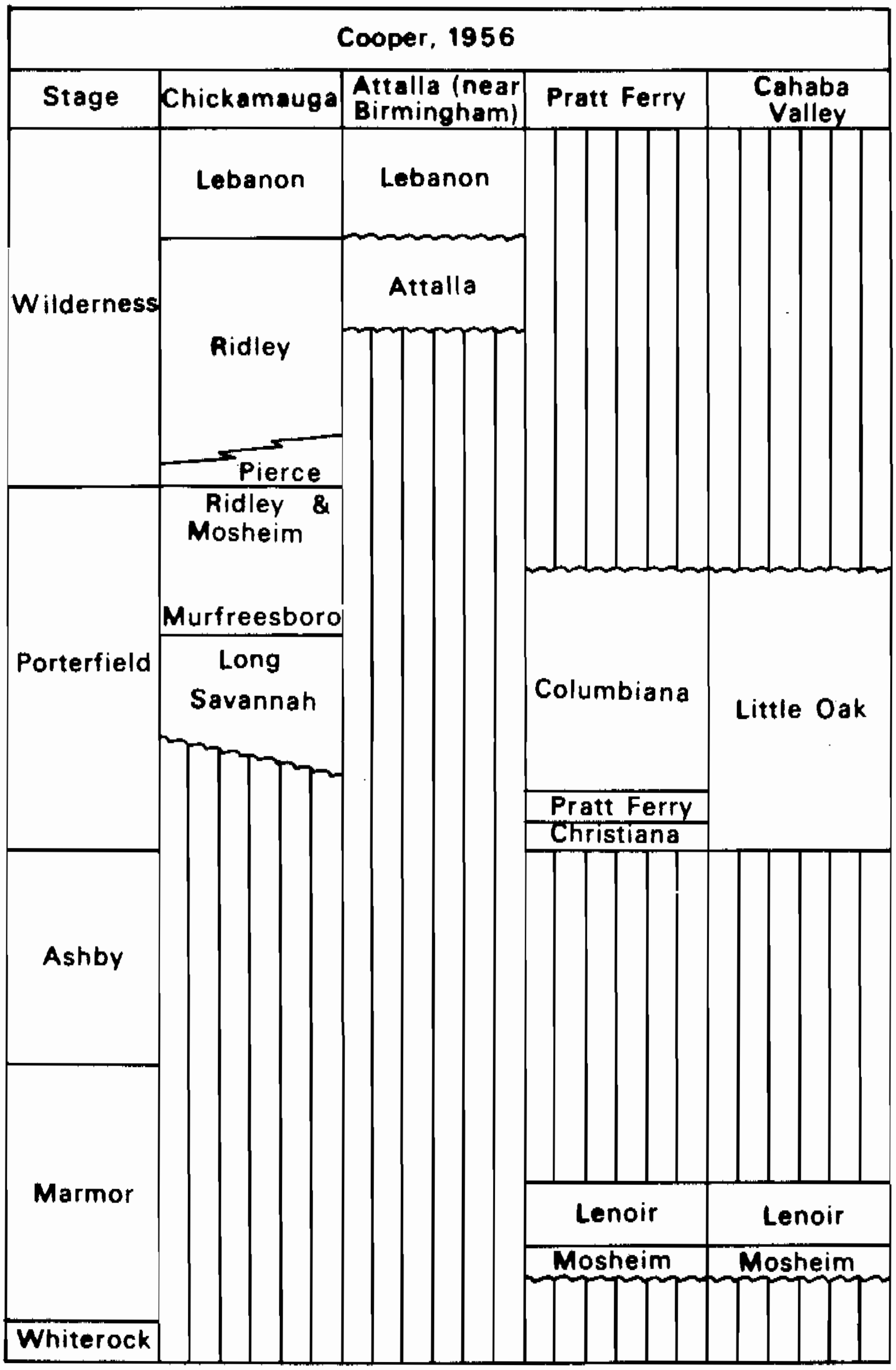


Figure 4. Stratigraphic interpretation of the Chickamauga Limestone in the study area made by Cooper (1956).

limestone. He conceded that Butts' *Leperditia*-bearing beds were indeed Murfreesboro, but assigned Butts' so-called Mosheim and overlying *Maclurites*-bearing beds to the Murfreesboro also.

Allen and Lester (1957) recognized a number of units, referred to by number. They referred to the lowest strata above the Knox as -13 in the Chickamauga area, as it is the 13th unit they discerned beneath a marker bentonite. Their -13 consists of alternating light gray limestone, darker gray dolomite, and massive dolomitic limestone. That unit contains the gastropods *Hormotoma*, *Lecanospira*, and *Maclurites*, as well as other fossils. Units -13 and -12 together correspond to Butts' (1948) Newala. Zone -12 is a calcilutite, which is pure and gray in the lower third, yellow and argillaceous in the middle, and fairly pure but very dark near the top. It contains the bryozoan *Monticulipora*, the brachiopod *Hesperorthis*, and the cephalopod *Orthoceras*. Overlying zone -12, and corresponding to Butts' Murfreesboro, is zone -11 which is yellow and red calcareous siltstone. Fossils are rare but include representatives of *Favistella*, *Strophomena planumbona* Hall, and *Orthoceras*. Because of the distinct lithologic change betwen Butts' Newala and Murfreesboro, Allen and Lester (1957) suggested that this level be considered the base of the Middle Ordovician.

In his study of the Chickamauga area, Cressler (1964) mapped the rocks beween the Knox and the Murfreesboro as Newala. He noted that the Newala "includes much dolomite in lower part." This, and the fact that he placed the Knox-Newala contact farther west on his map (stratigraphically lower) than in most previous interpretations, indicates that his lower Newala is probably Knox dolomite.

In an effort to alleviate the "Newala problem," Milici and Smith (1969) named the rocks between the Knox and the Murfreesboro in the Chickamauga area the Pond Spring Formation. The lower member of the Pond Spring Formation is a 140 to 170 foot thick, unfossiliferous, limestone locally divisible into a lower conglomerate and red bed unit, a middle calcilutite unit similar to the Mosheim of Tennessee, and an upper calcareous red-bed unit. The middle member of the Pond Spring consists of about 10 feet of thick-bedded gray calcilutite and calcisiltite, which contains few fossils and some argillaceous beds. The upper member consists of about 70 feet of thin-bedded, argillaceous calcisiltites with some reddish and greenish mottling. Milici and Smith noted that the Pond Spring Formation occupies the same stratigraphic position as the Wells Creek Dolomite of Tennessee. The Pond Spring Formation is the same as Allen and Lester's (1957) zones -13 through -11. Milici and Smith include the Pond Spring in the Stones River Group of northwestern Georgia. Conformably overlying the

Pond Spring Formation is the Murfreesboro Limestone, which consists of 275 feet of medium dark gray to dark-gray calcilutite and calcisilitite interbedded with gray limestones and greenish gray calcareous shales. The stratigraphic position of conodonts collected from the Chickamauga area in the present work is based upon the map and stratigraphic column in Milici and Smith (1969).

Red Mountain

In the Birmingham area, Butts (1926, 1927) included in the Chickamauga Limestone all of the rocks lying above the Copper Ridge Dolomite and below the Red Mountain Formation (including the Sequatchie). He described the Chickamauaga of the Red Mountain area as a limestone of variable thickness mottled with red and pink, overlain by a medium thick-bedded, blue, fine-grained limestone with local beds of cobbly limestone. Above follows a thin-bedded argillaceous limestone with shaly partings. Butts stated that the lower and middle parts of this succession are of Stones River through Black River age and that the argillaceous limestone is of Trenton age. According to Butts, the thickness of the Chickamauga in the Birmingham area is about 250 feet. He based his identification of the lower Chickamauga as Stones River on the presence of the ostracodes *Osichilina ottawensis*, *Leperditia fabulites*, *L. fabulites-pinguis*, and *Schmidtella crassimarginata*, the gastropods *Lophospira bicinta*, *L. perangulata*, and *Helicotoma tennesseensis*, the bryozoans *Rhindictya trentonensis*, *Pachydicta robusta*, and *Dekayella ridleyana*, and the brachiopods *Rhynchotrema plena*, *Herbertella bellarugosa*, *Plectambonites subcarinatus*, *Dalmanella stonensis*, *Rafinesquina* sp. aff. *R. deltoidea*, *R.* sp. aff. *R. minnesotensis*, *Cliftonia occidentalis*, and *Strophomena incurvata*. Butts correlated the Stones River portion of the Chickamauga Limestone of Red Mountain with the Lenoir Limestone of the Cahaba Valley and part of the Chazy section in New York.

Twenhofel et al. (1954) identified the lowermost Chickamauga in the Birmingham area as Ridley which was, in their opinion, correlative with the Ridley in the Chickamauga area (which overlies the Murfreesboro) and with the Ridley of Central Tennessee. Their correlations also indicate that most, if not all, of the Middle Ordovician rocks in the Cahaba Valley are older than those in the Birmingham area. Twenhofel et al. assigned the lower Chickamauga at Red Mountain to the Black River Stage based upon the presence of the brachiopods *Fascifera* and *Ancistrorhyncha*. The lower Chickamauga at Red Mountain, as well as many other units previously classified as Chazyan, were dated as Black River, partly due to the presence of fossils not present in the Chazy type section.

Wiley Rogers (1961a) investigated the Chickamauga

Limestone in the vicinity of Red Mountain, Alabama. He recognized four lithologic units which he referred to as units I, II, III, and IV, from oldest to youngest. Rogers considered his unit to be of Chazyan age in the Birmingham Valley (p. 21) and correlated it with the Lenoir Limestone in the Cahaba Valley. Rogers considered the overlying units II and III to be of Black Riverian age at Birmingham.

Rogers (1961b) also remarked (p. 26-27) that the Little Oak Limestone in the Cahaba Valley is equivalent to unit II in the Birmingham Valley and is of Black Riveran age. He also indicated (his fig. 3) that the Little Oak in the Cahaba Valley is younger than the Lenoir Limestone in the Knoxville, Tennessee, area.

Drahovzal and Neathery (1971) described the Chickamauga at Red Mountain as having a basal conglomerate with chert and green, possibly bentonitic shale, which is overlain by medium- to dark-gray limestone interbedded with shale, with some bentonites and locally abundant fossil horizons. They give a total thickness of the Chickamauga of 260 feet. They were unable to distinguish between the Stones River and Nashville there. Drahovzal and Neathery suggest that an interval containing gray-green or pink-green chert nodules in the lower part of the upper Stones River Formation may correspond to the cherty, fucoidal member of the Murfreesboro Limestone of Tennessee and Georgia. Representatives of _Sowerbyella_ _subcarinata_ (Ulrich) and

Favosites sp. aff. *F. placenta* Rominger occur in what they regard as a possible equivalent of the Lebanon of Georgia.

Taylor's (1971a) study of the paleontology and petrology of the Chickamauga Limestone in the Birmingham region showed that the Chickamauga consists of packstones and grainstones containing fragments of sponges, corals, bryozoans, echinoderms, and brachiopods. The presence of sparry cement and sheet-stratified layers of skeletal fragments indicate deposition in a shallow, open-shelf environment with strong current control. Taylor identified the bryozoan *Corynotrypa* in the Chickamauga but he did not discuss the correlation of the Chickamauga in his study.

Drahovzal and Neathery (1971) reported representatives of the conodonts *Amorphognathus tvaerensis* Bergström, *Phragmodus undatus* Branson and Mehl, *Belodina compressa* (Branson and Mehl), and possibly *Plectodina furcata* (Hinde) from limestones associated with bentonites in the upper part of the Stones River at Red Mountain, Alabama. They considered those beds to be of Wildernessian-Kirkfieldian age. Drahovzal and Neathery did not report any conodont occurrences from the lower Stones River at Red Mountain.

Cahaba Valley

Ulrich (1911) restricted the term "Stones River" in the Cahaba Valley to limestones beneath the Athens Shale and above the Beekmantown equivalents. He correlated the Stones

River of the Cahaba Valley with the Stones River Group in Tennessee, Virginia, and Maryland. Also, he correlated the Chazyan Crown Point Limestone in the Champlain Valley with the lower and middle Stones River in the Cahaba Valley. Ulrich indicated that the Stones River Group of Tennessee and Alabama is stratigraphically beneath the Holston Limestone of Tennessee and Alabama and above the Joachim Dolomite of Missouri.

Charles Butts (1926) recognized the Mosheim Limestone, the Lenoir Limestone, the Athens Shale, the Little Oak Limestone, and an unnamed limestone in the Cahaba Valley. He indicated that the Mosheim Limestone in the Cahaba Valley is slightly older than the oldest post-Beekmantown strata known elsewhere in Alabama. Butts reported representatives of the gastropods Lophospria and Euconia from the Mosheim in the Cahaba Valley. Butts (1926) correlated the Lenoir of the Cahaba Valley with the Ridley of Tennessee. He also indicated that the Lenoir is older in the Cahaba Valley than Chickamauga equivalents in the Coosa Valley, Alabama. Butts correlated the Athens and the Little Oak of the Cahaba Valley with the Athens and the Little Oak of the Coosa Valley and indicated that they were younger than the lowest Chickamauga equivalents in the Birmingham Valley. He considered the absence of the Holston Limestone between the Lenoir and the Athens in Alabama to be an indication of a major hiatus. Butts reported representatives of the graptolites *Nemagraptus gracilis*, *Dicellograptus smithi*, *Glossograptus ciliatus*, and *Diplograptus foliaceus*, the trilobites *Telephus gelasinesa* Ulrich, *Robergia athenia*, *Robergia major* Raymond, *Ceraurina glabra* Ulrich, and *Remipleurides grandis* Ulrich from the Athens in the Cahaba Valley.

Decker (1952) correlated the lower and middle parts of the Athens of Alabama with the Trenton of New York and the lower Viola of Oklahoma on the basis of the graptolites *Dicellograptus*, *Nemagraptus*, and *Didymograptus*. Decker stated that all of the Athens in Alabama is younger than Chazyan.

Twenhofel et al. (1954) recognized the Lenoir Limestone, followed upward by the Effna Limestone, the Athens Shale, and the Little Oak Limestone. They also correlated the Lenoir with the type Chazy, the Dutchtown and Joachim of Missouri, and the lower Simpson Group of the Arbuckle Mountains, Oklahoma. Twenhofel et al. (1954) correlated the Effna, Athens and Little Oak of the Cahaba Valley with the Murfreesboro and Ridley of Georgia, the lower Stones River group of the Central Basin of Tennessee, the Bromide of the Arbuckle Mountains, the lower Platteville of the upper Mississippi Valley, and the Black River of the Mohawk Valley. They indicated that the Chickamauga in the Birmingham area is younger than the youngest Chickamauga in the Cahaba Valley.

Cooper (1956) recognized the Lenoir Limestone, the Pratt Ferry Formation, and the Columbiana Shale at Pratt Ferry, Alabama, and the Lenoir Limestone and Little Oak Limestone farther north in the Cahaba Valley. Cooper indicated that the Lenoir is separated from the overlying formations by a major unconformity in the Cahaba Valley. He correlated the Lenoir in the area with the Lenoir of eastern Tennessee, the lower Chazy of the Champlain Valley, and the McLish of the Arbuckle Mountains, Oklahoma. Cooper (1956) identified representatives of the brachiopods *Rostricellula*, *Valcourea*, and *Mimella*, and the gastropod *Maclurea* from the Lenoir. He considered the Lenoir to be older than the *Christiania*-bearing Arline beds of Tennessee. Cooper also indicated that the Dutchtown and the Joachim in Missouri are younger than the Lenoir and older than the Pratt Ferry and the Little Oak in the Cahaba Valley. Cooper correlated the Little Oak, the Pratt Ferry, and the lower Columbiana in Alabama with the upper Long Savannah in Georgia and the lower Arline and the Athens in Tennessee. He identified the brachiopods *Christiania*, *Contreta*, *Lingulella*, and *Dictyonites*, and the trilobites *Telephus* and *Trinodus* from the Pratt Ferry, and the brachiopods *Eromotoechia*, *Christiania*, *Titanambonites*, and *Isophragma* from the Little Oak. Cooper indicated that the Lenoir belongs in the Marmor Stage and the Pratt Ferry and Columbiana belong in the Porterfield Stage.

Sweet and Bergström (1962) identified the conodonts *Pygodus anserinus* Lamont and Lindström, *Polyplacognathus rutriformis* Sweet and Bergström, *P. stelliformis* Sweet and Bergström, *Periodon aculeatus* Hadding, *Protopanderodus varicostatus* (Sweet and Bergström) and others from the Pratt Ferry Formation at Pratt Ferry, Alabama. Sweet and Bergström correlated the Pratt Ferry with the Upper Llandeilian Crassicauda Limestone of Sweden and indicated that the Pratt Ferry Formation is early Porterfieldian.

Bergström (1971a) described the conodonts *Pygodus serra* (Hadding) and *Polyplacognathus friendsvillensis* Bergström from the Lenoir Limestone at Pratt Ferry and correlated the upper part of the Lenoir with the base of the Columbiana (Athens) at Calera, Alabama. Bergström considered the Lenoir at Pratt Ferry to be of Marmor age and a correlative of the Lenoir at Friendsville, Tennessee, and the New Market Limestone at Strasburg, Virginia. Bergström identified the conodont *Eoplacognathus foliaceus* (Fåhraeus) from the base of the Columbiana Shale immediately above the Lenoir at Calera. Bergström also reported representatives of the conodont *Pygodus serra* Lamont and Lindström from the Little Oak at Pratt Ferry and suggested that it was at least partly correlative with the Little Oak at Ragland, Alabama. Bergström proposed that the term "Chazy" might be used as a stage name for the post-Marmorian, pre-Porterfieldian interval. Using this scheme, Bergström tentatively considered the Lenoir to be Marmorian and the Little Oak to be Chazyan at Pratt Ferry.

Taylor (1971a) reported on the petrology and micropaleontology of Ordovician rocks in central Alabama. Taylor identified the ostracodes *Aparchites suborcularis* Kraft, *Bairdiacypris incurvatus* Kraft, *Macrocyproides*, and *Shenandoia acuminulate* Kraft, and noted that the genera are identical to some of those found by Kraft (1962) in the Edinburg Formation of Virginia. Taylor (1971a) suggested that the Little Oak, which is a skeletal, burrow-mottled lime wackestone, was deposited in a shelf environment below regular wavebase. Taylor (1971b) interpreted the Little Oak as a deep-water equivalent of the shallow-water carbonates of the Chickamauga to the north and the deeper-water Athens to the south.

Coosa Valley

Butts identified the Athens Shale, the Little Oak Limestone, and an unnamed limestone in the Coosa Valley and correlated them with the same formations in the Cahaba Valley. However, Butts did not recognize the post-Beekmantown, pre-Athens Mosheim Limestone and Lenoir Limestone as he did in the Cahaba Valley. Butts did not specify which fossils he found in the Athens Shale or Little Oak Limestone in Coosa Valley. He indicated that bentonites of Lowville (early Black River) age occurred in the Little

Oak at Ragland and in the Chickamauga near Birmingham. His correlation of the Athens and Little Oak in Coosa Valley is apparently based either on fossil evidence, bentonites, or stratigraphic position.

Cooper (1956) indicated that the Little Oak at Ragland contains two layers of metabentonite. He apparently included Ragland in the Cahaba Valley sequence.

Drahovzal and Neathery (1971) indicated that the Lenoir and the Little Oak occur in the Ragland area of Coosa Valley. Drahovzal and Neathery identified the conodonts *Belodina compressa* (Branson and Mehl) and *Polyplacognathus sweeti* Bergström from the Little Oak Limestone at Ragland. On the basis of these conodonts they considered the Little Oak and adjacent bentonites at Ragland to be Porterfieldian in age. Drahovzal (p. 193) suggested that the bentonites at Ragland are older than similar bentonites associated with the Stones River and Colvin Mountain formations, which are at least as young as Rocklandian.

Etowah Valley

Hayes (1894 and 1902) mapped and described the Chickamauga in the Rockmart area. He recognized the Knox Dolomite, Chickamauga Limestone, and Rockmart Slate, in ascending order. He correlated the Chickamauga and the Rockmart in Etowah Valley with the lower and upper Chickamauga, respectively, in the area north of Coosa

Valley.

Spencer (1893) and Maynard (1912) mapped the Chickamauga in Georgia, using the same terminology as Hayes.

In Etowah Valley, Butts (1948) recognized only the "Newala" as representing the Chickamauga Limestone. He described the Newala as a thick-bedded, pure, blue limestone with some compact dove layers. He reported representatives of the gastropods *Hormotoma* sp. cf. *H. artemsia*, *Hormotoma*? sp., *Maclurites affinis*?, and *Ceratopea*, and the cephalopods *Tarphyceras* and *Eurystomites* from the Newala in Georgia. Butts correlated the Newala in Georgia with the Beekmantown of Tennessee and Virginia and the Bellefonte of central Pennsylvania on the basis of the occurrence of *Ceratopea*. Butts indicated that the overlying Rockmart Slate is "most probably Mississippian" due to the presence of the brachiopod *Spirifer* and the crinoid *Platycrinus* in chert fragments within the slates in Polk County.

Cressler (1970) mapped and described the geology of Floyd and Polk Counties. He identified Knox, Newala, Lenoir, and Rockmart, in ascending order. He indicated that the Newala is of Early Ordovician age as evidenced by the presence of *Ceratopea* opercula and he separated Newala from the overlying Lenoir on the basis of *Ceratopea*'s occurrence in the former. Cressler reported the gastropods *Ceratopea*, *Orisspira* sp. cf. *O. depressia* Cullison, "*Turritoma*", *Helicotoma unangulata* Hall, and others from the Newala.

Cressler tentatively recognized the Lenoir Limestone in the Rockmart area and described it as a medium to dark gray, finely crystalline to aphanitic limestone that is thickly to massively bedded and which breaks down into thin slabs and nodular pieces. He indicated that the Lenoir is of Middle Ordovician age and contains the gastropods *Maclurites*, *Lophospira* sp., *Helicotoma* sp., and others. Cressler disputed Butts' (1948) assignment of Mississippian age to the Rockmart Slate. Cressler stated that Butts found Mississippian fossils in chert overlying the Rockmart Slate and he assumed that the slate was of the same age. However, Cressler cited the presence of certain graptolites found, but not reported, by M. R. Campbell in 1890 and graptolites discovered in his own investigations as proof that the Rockmart is of Middle Ordovician age. Cressler reported the graptolites *Climacograptus* sp. cf. *C. riddellensis* Harris, *Glyptograptus* sp. cf. *G. teretiusculus* (Hisinger), *Didymograptus* sp. cf. *D. paraindentus* Berry, *Glossograptus* sp., and others from the Rockmart Slate in Floyd and Polk Counties.

METHODS OF STUDY

Sample Locality Selection

Sample localities were chosen according to their geographic locations and the stratigraphic completeness of the exposed successions. Because I desired to relate biostratigraphic correlation to lateral facies changes, I collected along the best-available outcrops in an east-west direction. Collections were made in the areas of Chickamauga, Rockmart, and Aragon, Georgia; and Ragland, southern Birmingham, Alabaster, Calera, and Pratt Ferry, Alabama. The collection from Chickamauga is of particular interest because this is the type area of the Chickamauga Limestone. Pratt Ferry is also historically important and has been studied for brachiopods, conodonts, graptolites, and other fossils.

Field and Laboratory Methods

Samples were collected at approximately five-foot intervals, varying somewhat depending upon lithology. One hundred and ten samples were collected and processed for conodonts. Processing was done by first crushing samples to pea-sized lumps and digesting two to three kilograms of rock in 15 percent acetic acid. The insoluble residues were washed through 20-100 mesh screens. The insoluble fractions were then dried and further reduced through magnetic separation. The nonmagnetic portion was then separated in heavy liquid (tetrabromethane) in which conodonts and other heavy fragments settled out. The heavy residue was finally examined for conodonts with a binocular microscope.

Specimens to be photographed were mounted on aluminum stubs, coated with a film of gold, viewed by means of a Cambridge Stereoscan IV scanning-electron microscope, and photographed on 4x5 inch Polaroid film.

Hand specimens of each sample were reserved for thin sectioning. Samples were slabbed, polished, and mounted on petrographic slides. They were examined for fossil fragments under a petrographic microscope.

Sample Localities

1. Sections 80MS1, 80MS2, 80MS3, 80MS4, and 80MS14. Chickamauga, Kensington Co., Georgia. Kensington Quadrangle. 80MS1, 80MS2, and 80MS14 are in an abandoned quarry south of town, next to the Central of Georgia Railroad tracks. 80MS3 is next to the Owings Cemetery, 2.5 miles southeast of Chickamauga. 80MS4 is next to the road immediately south of Crawfish Spring Lake.
2. 80MS5. Alabaster, Shelby Co., Alabama. Helena Quadrangle. Road cut near chert pit, one mile northeast of county hospital.
3. 80MS6 and 80MS7. Pelham, Shelby Co., Alabama. Helena Quadrangle. 80MS6 adjacent to highway 31, 2 miles north

of Pelham. 80MS7 Pelham quarry, 2 miles north of Pelham; 202 feet of measured section.

4. 80MS8 and 64B2. Pratt Ferry, Bibb Co., Alabama. Brookwood Quadrangle, (30 minute). Road cut south of bridge over Cahaba River. 227 feet of measured section.
5. 80MS9. Ragland, St. Clair Co., Alabama. Ragland Quadrangle. Abandoned quarry two miles southeast of Ragland near confluence of Trout Creek and Coosa River. 46 feet of measured section.
6. 80MS10. Red Mountain, Jefferson Co., Alabama. Birmingham South Quadrangle. Road cut beneath Red Mountain Museum. 76 feet of measured section.
7. 80MS11, 71B19, and 68B10a. Martin Marietta plant. Shelby Co., Alabama. Montevallo Southwest Quadrangle. Two miles west of Calera. 80MS11 is from a drainage ditch at plant entrance north of Columbiana Road. 71B19 and 68B10a are inside the quarry. 80 feet of measured section.
8. 80MS12. Rockmart, Polk Co., Goergia. Rockmart North Quadrangle. Abandoned quarry one mile northeast of Rockmart. 70 feet of measured section.
9. 80MS13. Portland, Polk Co., Georgia. Rockmart North Quadrangle. Abandoned quarry one quarter of a mile northeast of Portland. 72 feet of measured section.

CONODONT BIOSTRATIGRAPHY

Two schemes of conodont zonation for rocks of Middle and Upper Ordovician age are currently used. Bergström (1971a) established a formal conodont zonation based primarily upon genera native to the North Atlantic Province, particularly upon *Prioniodus*, *Eoplacognathus*, *Amorphognathus* and *Pygodus*. It has been possible to relate this conodont zonation to standard European graptolite zones (Bergström, 1971a; 1971b; 1973b; 1976b; 1978). I have used Bergström's zonal scheme to establish the relative ages of rocks from Pratt Ferry, Pelham, Ragland, and Calera.

Sweet et al. (1971) recognized 12 conodont faunas for rocks of Middle and Upper Ordovician age in the North American Midcontinent. Because the sequence is not known to be complete, and because some of the faunas have long ranges, they did not attempt to establish formal conodont zones. However, the conodont faunas of Sweet et al. (1971) can be used for approximate correlation and comparison of sections. The predominance of Midcontinent conodont species at Chickamauga, Red Mountain, and Rockmart makes it possible to compare the faunas at those localities with the ones established by Sweet et al.

Sample localities are given in Appendix A.

Table I. Conodont species in the study area.

Genus and Species	Number of Specimens
1. "*Acodus*" *variabilis* (Webers)	141
2. *Acontiodus robustus* (Hadding)	22
3. "*Acontiodus*" sp.	1
4. *Appalachignathus delicatulus* (Bergström et al.)	30
5. *Belodella* n. sp. aff. *B. devonica* (Stauffer)	6
6. *Belodella nevadensis* (Ethington and Schumacher)	876
7. *Belodella*? aff. *B. nevadensis* (Ethington and Schumacher)	12
8. *Belodella* sp.	21
9. *Belodina* sp. cf. *B. compressa* (Branson and Mehl)	4
10. *Belodina monitorensis* Ethington and Schumacher	228
11. "*Bryantodina*" sp.	3
12. *Coelocerodontus*? *digonius* Sweet and Bergström	82
13. *Coelocerodontus lacrimosus* Kennedy, Barnes, and Uyeno	24
14. *Coelocerodontus*? sp. cf. *C. trigonious* Ethington	120
15. *Cordylodus*? sp.	3
16. *Curtognathus* sp. cf. *C. typus* Branson and Mehl	589
17. *Dapsilodus mutatus* (Branson and Mehl)	312
18. *Drepanoistodus suberectus* (Branson and Mehl)	350
19. *Eoplacognathus* sp. cf. *E. reclinatus* Hamar	128
20. *Eoplacognathus* sp.	2
21. *Erismodus* sp.	176
22. *Erraticodon* sp.	18
23. *Juanognathus variabilis* Serpagli	68
24. *Leptochirognathus* sp.	9
25. *New Genus* n. sp.	7
26. "*Oistodus*" *pseudoabundans* Schopf	83
27. "*Oistodus*" sp. cf. "*O.*" *venustus* Stauffer	52
28. "*Oistodus*" sp.	1
29. "*Ozarkodina*" sp.	4
30. *Paltodus* sp.	7
31. *Panderodus alabamensis* (Sweet and Bergström)	12
32. *Panderodus gracilis* (Branson and Mehl)	787
33. *Periodon aculeatus* Hadding	3867
34. *Periodon* sp.	29
35. *Phragmodus flexuosus* Moskalenko?	225
36. *Phragmodus inflexus* Stauffer	37
37. *Phragmodus*? n. sp.	53
38. *Plectodina aculeata* (Stauffer)	14
39. *Plectodina* sp.	3
40. *Polyplacognathus friendsvillensis* Bergström	317
41. *Polyplacognathus* sp. cf. *P. sweeti* Bergström	1
42. *Polyplacognathus rutriformis* Sweet and Bergström	8
43. *Polyplacognathus stelliformis* Sweet and Bergström	13
44. *Prioniodus* sp.	61

45.	"*Protopanderodus*" *giganteus* (Sweet and Bergström)	1
46.	*Protopanderodus varicostatus* (Sweet and Bergström)	431
47.	*Pygodus anserinus* Lamont and Lindström	207
48.	*Pygodus serra* (Hadding)	1794
49.	*Rhipidognathus* sp. cf. *R. discretus* Bergström and Sweet	3
50.	*Rhipidognathus* sp. cf. *R. paucidentatus* Branson et al	3
51.	"*Roundya*" *pyramidalis* Sweet anbd Bergström	80
52.	"*Scolopodus*" sp.	16
53.	*Staufferella falcata* (Stauffer)	17
54.	*Staufferella*? n. sp.	9
55.	"*Tetraprioniodus*" *lindstroemi* Sweet and Bergström	57
56.	*Triangulodus*? sp. cf. *T.*? *alatus* Dzik	1
57.	*Triangulodus*? *brevibasis* Sergeeva	76
58.	*Walliserodus tuatus* (Hamar)	264
59.	*Westergaardodina* sp. cf. *W. bicuspidata* Müller	3
60.	Genus and Species indet. A	1
61.	Genus and Species indet. B	3
62.	Genus and Species indet. C	2
63.	Genus and Species indet. D	2
64.	Genus and Species indet. E	1
65.	Genus and Species indet. F	13
66.	Genus and Species indet. G	8
67.	Indet. hyaline elements	662
68.	Reworked elements of Early Ordovician age	233

Chickamauga

Because there is no long, continuous exposure of Chickamauga Limestone at its type locality, my collections were taken from several separate localities. These locations were plotted on the map of Milici and Smith (1969) and converted to stratigraphic elevations which are given in Appendix A.

The Conodont Alteration Index (CAI of Epstein et al., 1977) of the conodont elements from Chickamauga is about 3.5. Abundant representatives of Curtognathus, Phragmodus, and Erismodus, and a few occurrences of Rhipidognathus at Chickamauga indicate that the conodont fauna belongs to the Midcontinent Province (Bergström and Sweet, 1966) and to the Lee Confacies Belt of Jaanusson and Bergström (1980).

At this point, it is appropriate to point out that a number of reports (Sweet et al., 1959; Sweet and Bergström, 1962; Bergström, 1964; Schopf, 1966; Bergström and Sweet, 1966; Kohut and Sweet, 1968; Bergström, 1971a; Sweet et al., 1971; Sweet, Thompson, and Satterfield, 1975; and Sweet, 1979a) have discussed the conodont provincialism of North America in some depth. However, most of these reports, except for Bergström, (1971a) and Sweet et al. (1971) are concerned with strata of Late or upper Middle Ordovician age, which have few species in common with rocks in the lower Chickamauga Limestone. Summary studies by Bergström (1973a), Barnes, Rexroad, and Miller (1973) and

Sweet and Bergström (1974) discuss conodont provincialism at the generic level, as does the study by Jaanusson and Bergström (1980). The latter study considers conodont provincialism in the Appalachian and Baltoscandic areas.

The lower member of the Pond Spring Formation at Chickamauga is dominated by representatives of *Curtognathus* sp. cf. *C. typus*, *Erismodus* sp., *Phragmodus flexuosus*?, *Phragmodus*? n. sp., and by indeterminate hyaline elements (see fig. 5 and Table III). The stratigraphically lowest sample (80MS4-1) yielded 205 conodont elements/kilogram of sample.

As discussed in the section on systematic paleontology, elements assigned to *P. flexuosus*? and *Phragmodus*? n. sp. might belong to the same conodont amd might be representatives of an early form of *P. flexuosus*. However, sample 80MS2-1, which is stratigraphically 48 foot higher than 1-1, contains elements referred tentatively to *Phragmodus inflexus*. If the elements referred to *Phragmodus*? n. sp. from 80MS1-1 are indeed early forms of *P. flexuosus*, I doubt that the sample 48 feet above it (80MS2-1) actually contains elements of *P. inflexus*, which is the successor to *P. flexuosus*. Although there is considerable overlap between the ranges of *P. flexuosus* and *P. inflexus* (Sweet, p. 256, *in* Ziegler, 1981), it seems unlikely that the vertical range of *P. flexuosus*? is as little as 48 feet at a locality where the Chickamauga

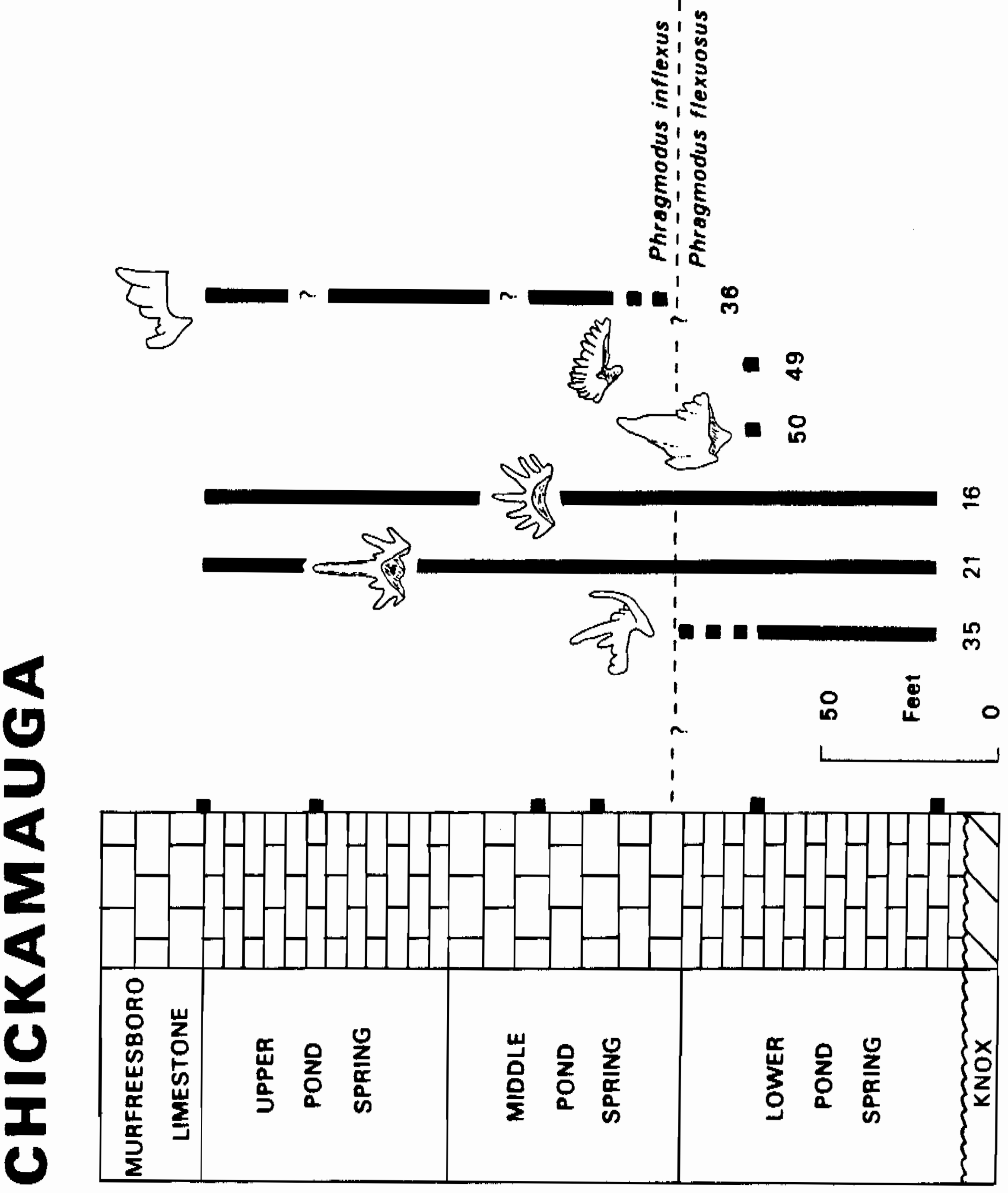


Figure 5. Stratigraphic distribution of conodont elements in the Chickamauga section. The numbers below vertical bars refer to conodont species given in Table I. The boundary between *Phragmodus flexuosus* and *P. inflexus* is arbitrarily placed halfway between the highest occurrence of *P. flexuosus* and the lowest occurrence of *P. inflexus*. The thickness of the lower member of the Pond Spring Formation is highly variable and might be somewhat thicker than indicated in this figure.

Limestone is as much as 1500 feet thick (Milici and Smith, 1969).

Stratigraphically higher samples from the Chickamauga type area are markedly less rich in conodont elements than the lower three samples and are relatively richer in hyaline elements.

Sample 80MS2-1 yielded 157 conodont elements/kilogram, but only 5 elements were nonhyaline. The other 3 samples from the upper part of the section at Chickamauga yielded 9 to 23 elements/kilogram. These samples contain elements primarily of *Curtognathus* sp. cf. *C. typus* and *Erismodus* sp., but 9 elements of *Phragmodus* also occur in the upper 4 samples.

Sample 80MS2-1 contains 5 elements of *Phragmodus*. One of these is a small dichognathiform element that appears to have a tiny denticle anterior to the cusp, as is characteristic of elements of *P. inflexus*, the successor of *P. flexuosus*. I therefore tentatively assign elements of *Phragmodus* from the middle and upper members of the Pond Spring and from the lowermost Murfreesboro to *P. inflexus*, which is characteristic of Fauna 7 of Sweet et al. (1971).

I interpret the lowermost Chickamauga Limestone at Chickamauga to be the same age as conodont Fauna 5 or 6 of Sweet et al. (1971), as shown in figure 6. The age of the upper part of the Chickamauga in my study (but still lower Chickamauga) is possibly equivalent to that of Fauna 7,

Figure 6. Known vertical range of diagnostically significant conodont elements in the study area. Broken lines, e.g. that beneath the Lenoir Limestone at Calera, indicate that the lower or upper limit of the unit is unknown in that area. The correlation of the Rockmart Slate at Rockmart with the *Eoplacognathus* sp. cf. *E. reclinatus* occurrence from Calera is speculative. Also the occurrences of *Juanognathus variabilis* and "*Scolopodus*" sp. at Rockmart might be somewhat older than the *Eoplacognathus foliaceus* Subzone. The boundary between *Phragmodus flexuosus* and *P. inflexus* at Chickamauga is approximate (see fig. 5). The correlation between Midcontinent Conodont Faunas of Sweet et al. (1977), North Atlantic conodont zones, and graptolite zones is based upon data of Sweet and Bergström (1976); Bergström (1977); and Harris et al. (1979).

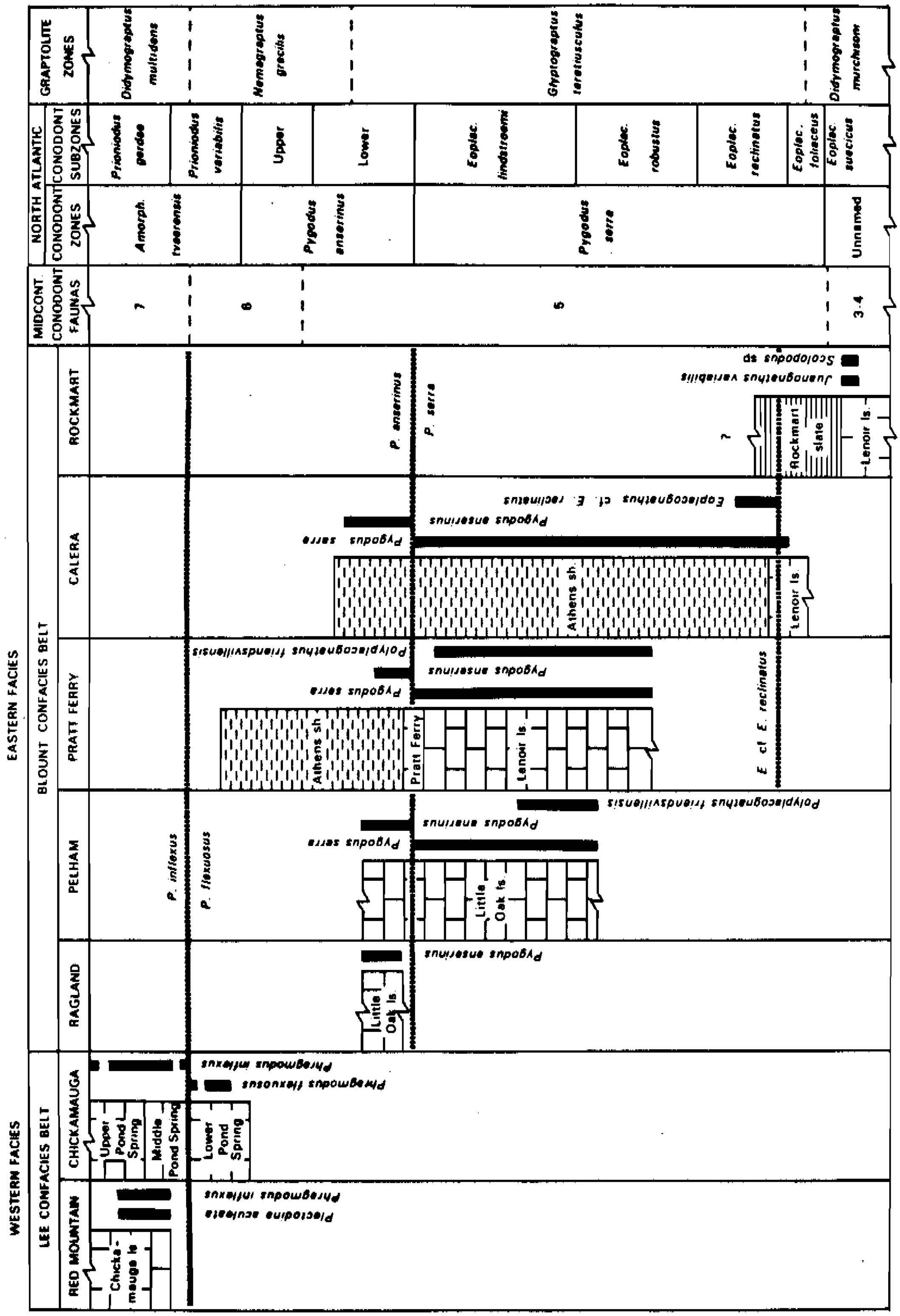

GRAPTOLITE ZONES
Didymograptus multidens
Nemagraptus gracilis
Glyptograptus teretiusculus
Didymograptus murchisoni
NORTH ATLANTIC CONODONT SUBZONES
Prioniodus gerdae
Prioniodus variabilis
Upper
Lower
Eoplac. lindstroemi
Eoplac. robustus
Eoplac. reclinatus
Eoplac. foliaceus
Eoplac. suecicus
NORTH ATLANTIC CONODONT ZONES
Amorph. tvaerensis
Pygodus anserinus
Pygodus serra
Unnamed
MIDCONT. CONODONT FAUNAS
7
6
5
3-4
EASTERN FACIES
BLOUNT CONFACIES BELT
ROCKMART
P. anserinus
P. serra
Scolopodus sp
Juanognathus variabilis
?
Rockmart slate
Lenoir ls.
CALERA
Eoplacognathus cf. E. reclinatus
Pygodus anserinus
Pygodus serra
Athens sh.
Lenoir ls.
PRATT FERRY
Polyplacognathus friendsvillensis
Pygodus anserinus
Pygodus serra
Athens sh
Pratt Ferry
Lenoir ls
E. cf. E. reclinatus
PELHAM
Polyplacognathus friendsvillensis
Pygodus anserinus
Pygodus serra
P. inflexus
P. flexuosus
Little Oak ls.
RAGLAND
Pygodus anserinus
Little Oak ls.
WESTERN FACIES
LEE CONFACIES BELT
CHICKAMAUGA
Phragmodus inflexus
Phragmodus flexuosus
Upper Pond Spring
Middle Pond Spring
Lower Pond Spring
RED MOUNTAIN
Phragmodus inflexus
Plectodina aculeata
Chickamauga ls

Figure 6.

based upon the presence of elements referred tentatively to *Phragmodus inflexus*.

Red Mountain

Conodont elements from the Red Mountain section have a CAI (Epstein et al., 1977) of 2. Conodont elements are relatively uncommon in the Red Mountain section (6 to 69 elements/kilogram), but diagnostic elements are abundant enough to permit reliable biostratigraphic determination. Hyaline elements predominate in the lower part of the section, but nonhyaline elements predominate in the upper part. Most of the conodont elements from the Red Mountain section are representative of the genera *Belodella*, *Belodina*, *Curtognathus*, *Drepanoistodus*, *Panderodus*, *Appalachignathus*, and *Phragmodus*. Representatives of *Belodina*, *Curtognathus*, *Phragmodus*, *Panderodus gracilis* and *Appalachignathus* are best known from the Midcontinent Province (Bergström and Sweet, 1966; Jaanusson and Bergström, 1980). The genera *Belodella*, *Belodina*, *Curtognathus*, *Appalachignathus*, and *Phragmodus* are characteristic of the Tazewell Confacies Belt of Jaanusson and Bergström (1980), as are the genera *Plectodina* and *Erismodus*, which are sparingly represented at Red Mountain. Specimens of the North Atlantic Province genera *Pygodus* and *Periodon* are absent at Red Mountain, and specimens of *Prioniodus* are rare.

Most of the elements from the lowest part of the Red Mountain section (80MS10-1, 11 feet above the base of the section) are hyaline (see Table IV) and are assignable to *Curtognathus* sp. cf. *C. typus*, *Erismodus* sp., or are indeterminate. Sample 10-1 contains 8 elements of *Plectodina aculeata* (see fig. 7) which indicates a correlation with Fauna 7 of Sweet et al. (1971). Sample 80MS10-1 is the second richest sample from Red Mountain, having about 48 elements/kilogram.

Samples 80MS10-2, 10-3, and 10-4 were collected above sample 80MS10-1 in the lower 50 feet of the Chickamauga Limestone. These three samples are poor in conodonts (6 to 11 elements/kilogram) but are relatively higher in nonhyaline elements than the lowest sample. Elements of *Appalachignathus delicatulus*, *Phragmodus inflexus*, and *Plectodina aculeata* are relatively common and stratigraphically significant from these samples.

At 54 feet above the base of the Chickamauga, sample 80MS10-5 contains the most abundant and diverse conodont fauna from my Red Mountain collection. The most common elements from this sample are representatives of *Belodella nevadensis*, *Belodina monitorensis*, *Panderodus gracilis*, and *Phragmodus inflexus*. The stratigraphically highest samples collected at Red Mountain (80MS10-6 and 10-7 at 64 feet and 74 feet, respectively) contain a relatively sparse fauna dominated by representatives of *Drepanoistodus suberectus*,

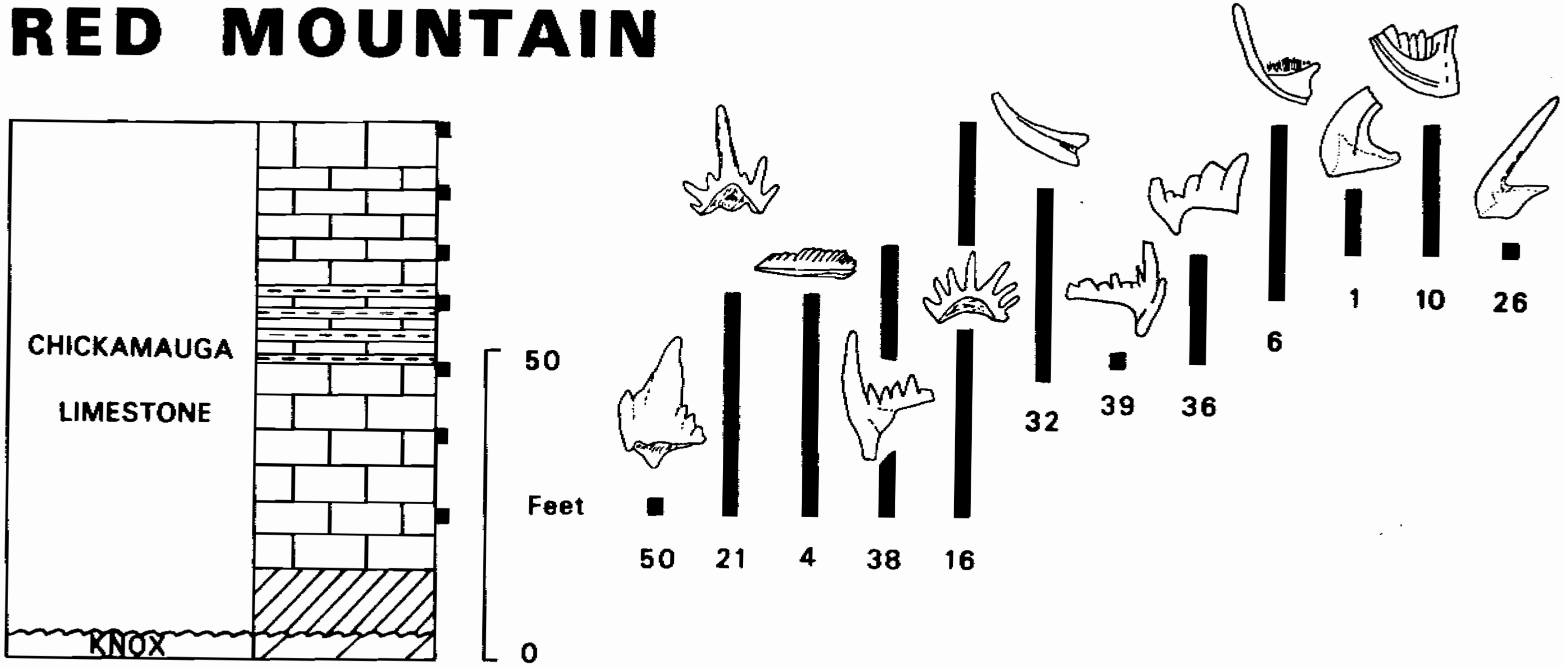

RED MOUNTAIN

Figure 7. Stratigraphic distribution of conodont elements in the Red Mountain section. The numbers beneath vertical bars indicate conodont species, as given in Table I.

Staufferella falcata, and *Belodella nevadensis*. No elements of *Phragmodus* or *Plectodina* occur in the upper two samples, but it seems reasonable to assume that these samples are not markedly younger than sample 80MS10-5, which contains elements of *Phragmodus inflexus* and *Plectodina aculeata*.

The lower 74 feet of the Chickamauga Limestone at Red Mountain is considered to be correlative with the interval of Fauna 7 of Sweet et al. (1971), as indicated in figure 6. However, the fact that the Chickamauga is relatively thin in this area might indicate that the section is "compressed" and might be expected to show relatively rapid faunal changes within short stratigraphic distances. The presence of elements of *Phragmodus inflexus* and *Plectodina aculeata* at Red Mountain indicate that the lower part of the Chickamauga Limestone in this area is younger than the lower Chickamauga at its type locality and possibly equivalent to the upper member of the Pond Spring and the lowermost Murfreesboro at Chickamauga.

Pratt Ferry

The conodont elements from the Pratt Ferry section have a CAI (Epstein et al., 1977) of approximately 2. Hyaline elements are present, but uncommon. The specimens are well preserved, but not abundant, ranging from 0 to 162 specimens/kilogram, but usually less than 30.

Representatives of *Pygodus* and *Panderodus* are abundant, and representatives of *Polyplacognathus*, *Belodella*, *Belodina*, and *Protopanderodus* are relatively common at Pratt Ferry. *Pygodus*, *Periodon*, and *Protopanderodus* are characteristic of the North Atlantic Province (Bergström, 1971a) and *Belodina* and *Panderodus gracilis* are characteristic of the Midcontinent Province (Bergström and Sweet, 1966). This association is typical of the Blount Confacies Belt of Jaanusson and Bergström (1980).

Conodont elements are uncommon in the lower 100 feet (Lenoir Limestone) of the Pratt Ferry section, typically fewer than 10 specimens/kilogram (see Table V). Representatives of *Panderodus gracilis* are the most abundant, followed by representatives of *Polyplacognathus friendsvillensis* and *Belodella nevadensis*. All of the elements of *Walliserodus tuatus* from my Pratt Ferry collections are in the lower 100 feet of the section (see figure 8). Conversely, elements of *Coelocerodontus*? *digonius*, "*Tetraprioniodus*" *lindstroemi*, and *Protopanderodus varicostatus*, which are fairly common in the upper part of the Pratt Ferry section, are absent in the lower 90 feet. However, the scarcity or absence of some elements in the lower part of the section is probably attributable, at least partly, to the low abundance of specimens there and to the fact that much of the lowest 100 feet of section is covered. The presence of elements of *Pygodus serra* and *Polyplacognathus friendvillensis* at the base of the Pratt

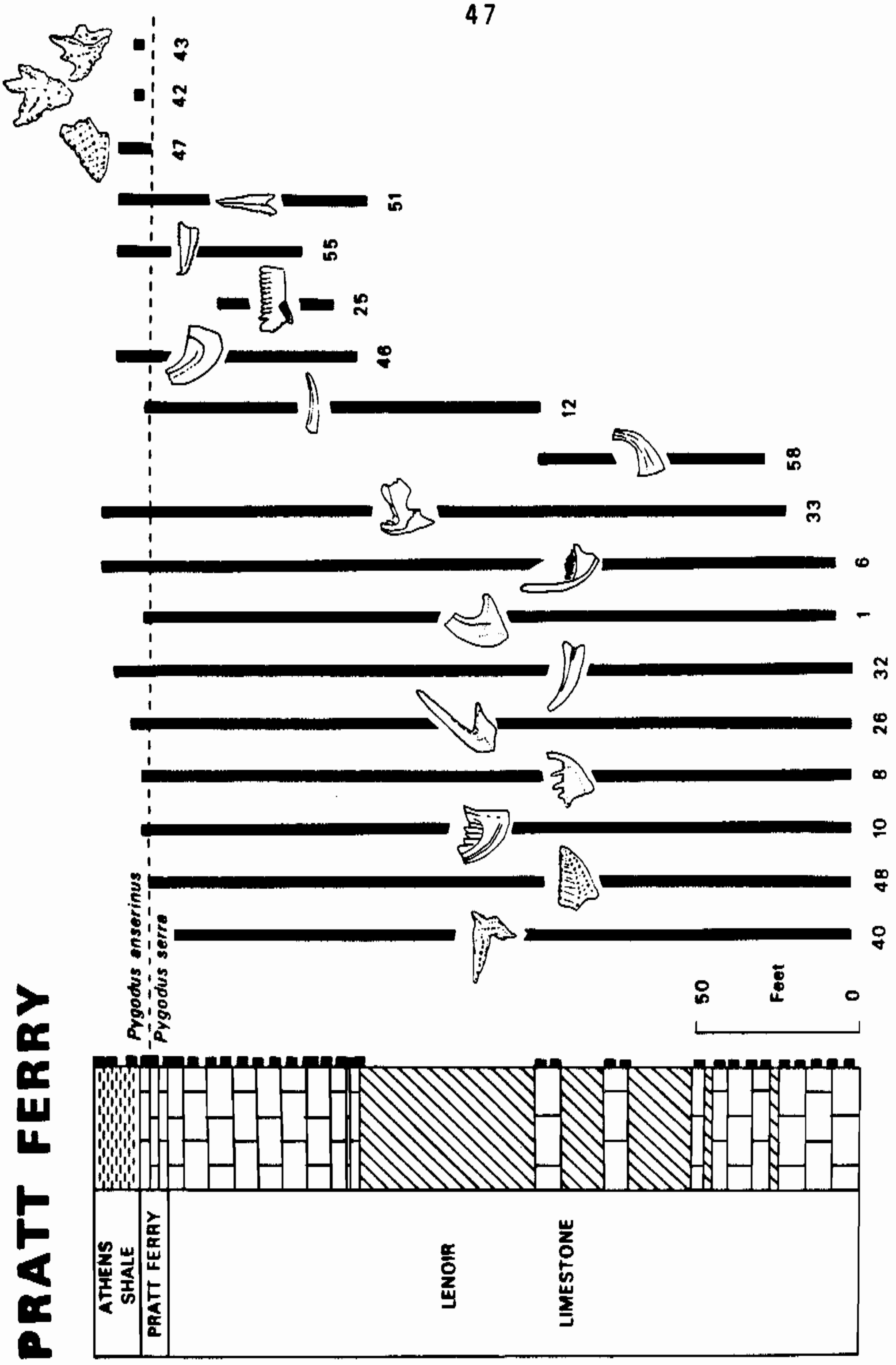


Figure 8. Stratigraphic distribution of conodont elements in the Pratt Ferry section. The numbers beneath vertical bars indicate conodont species, as given in Table I.

Ferry section indicate that the Lenoir at that locality belongs to the *Pygodus serra* Zone of Bergström (1971a). I found no elements of *Eoplacognathus* in my Pratt Ferry samples and therefore cannot determine to which of Bergström's subzones the lower part of the section belongs.

Approximately 57 consecutive feet, stratigraphically, of section are not exposed at Pratt Ferry between samples 80MS8-14 and 8-15 (95 to 152 feet above the base of the section). Although Cooper (1956) indicated that a hiatus is present within this covered interval (see fig. 4), I believe that the conodont evidence indicates that no such hiatus exists. Although the stratigraphically lowest occurrence of several species (e.g. "*Oistodus*" *pseudoabundans*, *Protopanderodus varicostatus*, and "*Roundya*" *pyramidalis*) at Pratt Ferry occur just above the covered interval, I believe that these first occurrences are mainly the result of increased abundance of elements higher in section and perhaps the result of facies changes. These facies changes (see the section on carbonate petrology in the present study) appear to be reflected by the loss of representatives of *Walliserodus tuatus* in the higher part of section, even though such elements are present in the stratigraphically higher *Pygodus anserinus* Zone at Pelham and Calera and elsewhere in the Appalachians (Bergström, 1973c; Carnes, 1975).

The upper part of the Lenoir Limestone at Pratt Ferry

(152 to 203.5 feet) is somewhat richer in conodont elements (typically 20/kilogram) than the lower part. The fauna of the upper Lenoir is much like that of the lower part, but differs in having a few elements of *Protopanderodus varicostatus*, New Genus n. sp., "*Tetraprioniodus*" *lindstroemi*, and "*Roundya*" *pyramidalis*, and in having no elements of *Walliserodus*. Samples 80MS8-19 and 8-20 are barren of conodonts.

The Pratt Ferry Formation overlies the Lenoir at Pratt Ferry and is about 8 feet thick. The Pratt Ferry Formation contains the stratigraphically lowest representatives of *Pygodus anserinus* at Pratt Ferry, which indicates that the *P. serra*-*P. anserinus* zonal boundary occurs in this formation (see fig. 6). The richest sample (80MS8-26) from this locality contains 162 conodont elements/kilogram. All of the specimens of *Polyplacognathus rutriformis* and *P. stelliformis* that I collected from Pratt Ferry, the location from which they were first described (Sweet and Bergström, 1962), came from the Pratt Ferry Formation.

The uppermost part of the exposure (215 to 227 feet above the base of the section) at Pratt Ferry is Athens Shale. The Athens contains a sparse fauna of *Pygodus anserinus*, *Periodon aculeatus*, and a few species whose elements also occur lower in the section.

Two samples (80MS8-101 and an unnumbered sample provided by Bergström) from the other (south) side of the Cahaba

River at Pratt Ferry were collected and processed for conodont elements. These samples contain elements similar to those found in the lower Lenoir on the north side of the Cahaba, including specimens of *Pygodus serra* and *Polyplacognathus friendsvillensis*. This indicates that the Lenoir Limestone on the south side of the Cahaba River at Pratt Ferry is not greatly, if at all, different in age from the Lenoir on the north side.

The conodont evidence from the Pratt Ferry section indicates that the Lenoir Limestone in that area belongs to the *Pygodus serra* Zone. The stratigraphically highest occurrence of *P. serra* and the lowest occurrence of *P. anserinus* is in the Pratt Ferry Formation, which indicates that the *P. serra*-*P. anserinus* boundary at Pratt Ferry is about 4 feet above the top of the Lenoir.

A recently proposed correlation (Harris et al., 1979, fig. 15) indicates that the boundary between the *Pygodus serra* Zone and the *P. anserinus* Zone is stratigraphically equivalent to the upper part of the interval of conodont Fauna 5 of Sweet et al. (1971). On the basis of this correlation, I believe that the Lenoir Limestone, the Pratt Ferry formation, and some or perhaps all, of the Athens Shale at Pratt Ferry are older than the lower Chickamauga Limestone in the more north-westerly belts at Red Mountain and Chickamauga (see fig. 6).

Pelham

The Little Oak Limestone at Pelham is in a more or less continuous exposure and is slightly more than 200 feet thick. The conodont fauna of the Little Oak at Pelham is similar to that of the Lenoir and Pratt Ferry at Pratt Ferry, but is slightly less diverse. The abundance of elements ranges from 0 to 50 elements/kilogram and is greater in the upper part of the section than in the lower part.

The specimens have a CAI (Epstein et al., 1977) of about 2. The fauna is dominated by representatives of the genera *Panderodus*, *Belodella*, *Pygodus*, *Belodina*, *Acodus*?, and in the lower part of the section, *Polyplacognathus* (see Table VI). The genera *Pygodus* and *Periodon* are characteristic of the North Atlantic Province (Bergström, 1971a). *Belodina* and *Panderodus gracilis* are characteristic of the Midcontinent Province (Bergström and Sweet, 1966). The genera *Pygodus*, *Polyplacognathus*, and *Periodon* are typical of the Blount Confacies Belt of Jaanusson and Bergström (1980).

The lower 115 feet of the exposure of the Little Oak at Pelham is an uninterrupted sequence. The lowermost sample from the section (80MS7-1) is barren of conodonts. The abundance of conodont elements in the next higher 22 samples ranges from 6 to 33 elements/kilogram. Elements of *Pygodus serra* and *Polyplacognathus friendsvillensis* in the lower part of the Pelham section (see fig. 9) indicate that the fauna belongs to the *Pygodus serra* Zone of Bergström (1971a). Representatives of "*Acodus*" *variabilis*, *Belodella nevadensis*, *Belodina monitorensis*, "*Oistodus*" *pseudoabundans*, *Panderodus gracilis*, *Polyplacognathus friendsvillensis*, and *Pygodus serra* are particularly common in the lower 115 feet of the Little Oak at Pelham.

All of the elements of *Polyplacognathus friendsvillensis* at Pelham occur in the lower part of the section, as is the case at Pratt Ferry, and they are not replaced upwards by representatives of *P. sweeti*. Similarly, no specimens of *Prioniodus* sp. were collected above the lower 55 feet of section. Conversely, elements of *Coelocerodontus*? *digonius* and "*Oistodus*" sp. cf. "*O.*" *venustus* occur only sparingly in the lower part of the Little Oak at Pelham and are most abundant in samples from the upper 100 feet of the quarry.

The Little Oak is sporadically covered in the upper 85 feet of section at Pelham, especially near the top of the section. In the upper part of the Pelham section, I attempted to collect samples from large blocks of limestone that have the same strike and dip as beds in the lower, well-exposed part of the section. I cannot rule out the possibility that some of the samples from the upper quarry came from slumped blocks. However, the precautionary measures that I took in the field and the conodont evidence from these samples indicate that no significant hiatus,

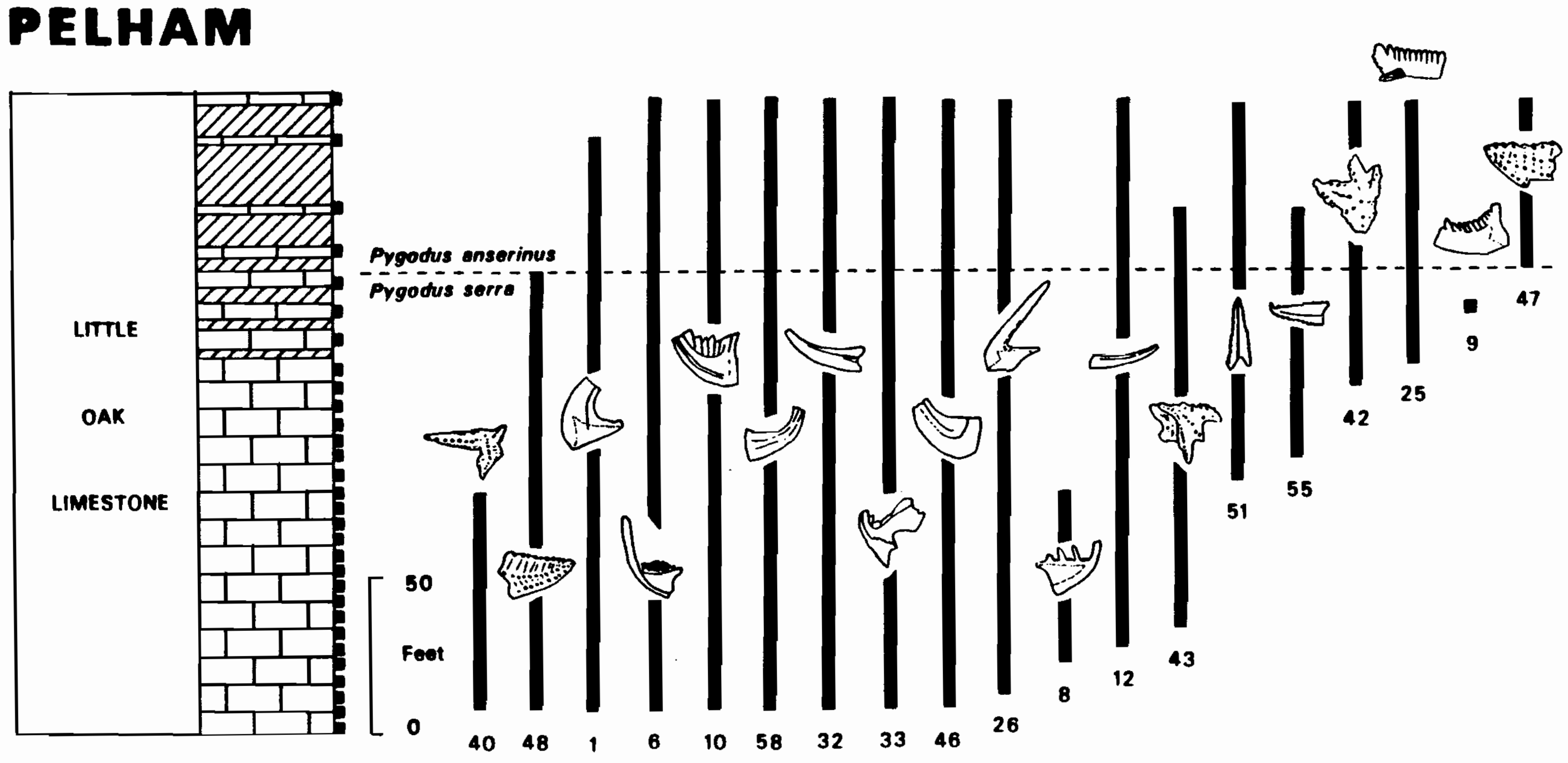


Figure 9. Stratigraphic distribution of conodont elements in the Pelham section. The numbers beneath vertical bars indicate conodont species, as given in Table I.

slumping, or other disturbance in the section is present.

The transition from *Pygodus serra* to *P. anserinus* occurs between samples 80MS7-26 and 7-28, between 142 and 187 feet above the base of the section. The upper 75 feet of section contains the richest sample (80MS7-25) from Pelham, which has 50 conodont elements/kilogram. Also in the upper part of the section is one barren sample (80MS7-27).

The conodont occurrences at Pelham are similar to those at Pratt Ferry in many respects. Both sections have representatives of essentially the same species, especially of *Panderodus gracilis*, *Belodella nevadensis*, *Pygodus serra*, *P. anserinus*, *Belodina monitorensis*, and *Periodon aculeatus*. Both sections contain specimens of *Polyplacognathus friendsvillensis* in the lower part and both contain representatives of *Polyplacognathus stelliformis*, *P. rutriformis*, and *Coelocerodontus*? *digonius* in the upper part. The distribution of conodont elements at Pelham differs from that at Pratt Ferry in that the *Pygodus serra*-*P. anserinus* boundary at Pelham occurs a minimum of 35 feet below the top of the Little Oak Limestone whereas the boundary occurs at least 4 feet above the top of the Lenoir Limestone at Pratt Ferry. This indicates that the Chickamauga Limestone at Pelham is slightly younger than that at Pratt Ferry, as shown in figure 6.

Calera

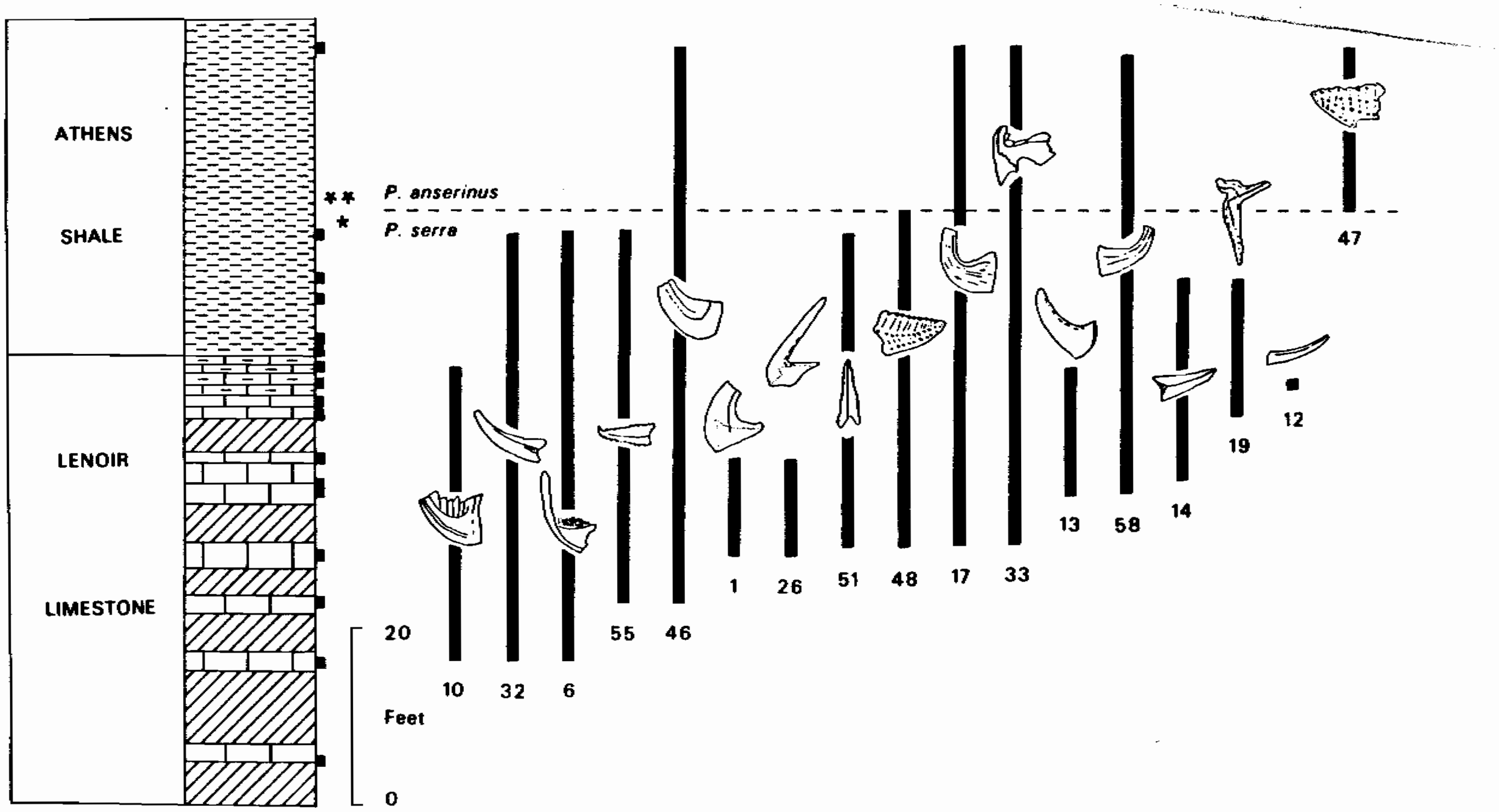
The conodont fauna at Calera is slightly less diverse than that at Pratt Ferry but the abundance of elements is far greater. Specimens are absent in the stratigraphically lowest sample from Calera (80MS11-11) but exceed 500 specimens/kilogram in the upper part of the section.

The CAI (Epstein et al., 1977) of conodont elements from Calera is higher than the CAI of those from the more northwesterly belts previously discussed. However, because the effects that host-rock lithology have on conodont coloration is not understood (Epstein et al., 1977), elements should be isolated from carbonates in order to evaluate their CAI. The abundance of conodont elements in the lower, calcareous part of the Calera section is very low compared to the abundance of elements in the upper shaly part, making it impossible to examine a large number of representative specimens from highly calcareous rocks. The conodont elements available from the lower, calcareous part of the Calera section appear to have a CAI of at least 3.

The conodont fauna from the Calera section is dominated by representatives of the North Atlantic province such as Periodon, Pygodus, Protopanderodus, and Eoplacoganthus (Bergström, 1971a). Elements assignable to Belodina and Phragmodus are present, but rare. The relatively high abundance of specimens of Pygodus, Periodon, Protopanderodus, Eoplacognathus, and Walliserodus is typical of outcrops in the Blount Confacies Belt (Jaanusson and Bergström, 1980).

The stratigraphically higher part of the Lenoir Limestone at Calera (31 to 44.5 feet above the base of the section) is distinctly more shaly and more thinly bedded than the lower part. The conodont fauna is dominated by *Periodon aculeatus* and *Pygodus serra*, but representatives of *Dapsilodus mutatus*, *Protopanderodus varicostatus*, *Coelocerodontus*? sp. cf. *C. trigonius*, *Eoplacognathus* sp. cf. *E. reclinatus*, and *Walliserodus tuatus* are also abundant (see Table VII and fig. 10). Conodont abundance ranges from 38 to more than 1000 elements/kilogram. The higher number (both relatively and absolutely) of elements assignable to the genera *Pygodus*, *Periodon*, *Eoplacognathus*, and *Walliserodus* in the upper part of the Lenoir at Calera indicates a shift to a more typical North Atlantic Province fauna (Bergström, 1971a).

As discussed elsewhere in the present study (see *Eoplacognathus* sp. cf. *E. reclinatus*), the elements of *Eoplacognathus* from the upper Lenoir at Calera are highly variable morphologically. However, they appear to be representatives of *E. reclinatus*, or possibly of *E. foliaceus*, the predecessor *E. reclinatus*, which Bergström (1971a, p. 117) reported from the Lenoir Limestone at Calera. I consider this to indicate that at least the upper part of the Lenoir Limestone at Calera belongs to the



CALERA

Figure 10. Stratigraphic distribution of conodont elements in the Calera section. The numbers beneath vertical bars indicate conodont species, as given in Table I. "*" marks the stratigraphically highest occurence of elements of P. serra; "**" marks the stratigraphically lowest occurrence of P. anserinus, according to Finney (1977).

E. reclinatus Subzone of the *Pygodus serra* Zone of Bergström (1971a).

The upper 35 feet of section at Calera is the Athens Shale. Samples from the Athens at Calera were collected and processed by Bergström, and were generously made available to me for use in the present study. The conodont fauna in the lower 15 feet of the Athens is essentially the same as that in the upper part of the Lenoir. It differs in having relatively fewer elements of *P. serra*, *Coelocerodontus lacrimosus*, and *C.*? sp. cf. *C. trigonius*. The stratigraphically highest sample from Calera (71B19-5), 80 feet above the base of the section) contains only one pygodiform element of *Pygodus*. Although this element is poorly preserved, it contains a distinct fourth row of denticles as is characteristic of elements of *P. anserinus*. This, and elements collected by Finney (1977, p. 49) indicate that the *Pygodus serra*-*P. anserinus* boundary occurs between 13 and 17 feet above the base of the Athens Shale at Calera (58 to 62 feet above the base of my section). This boundary occurs just above the Lenoir at Pratt Ferry, which indicates that the base of the Athens (and the top of the Lenoir) is progressively younger to the northwest, as was suggested by Bergström and Drahovzal (1972) and Finney (1977).

Based upon the presence of elements of *Pygodus anserinus*, *P. serra*, and *Eoplacognathus* sp. cf.

E. reclinatus, I interpret the Lenoir at Calera to be in part, if not entirely, older than the Lenoir at Pratt Ferry or the Little Oak at Pelham. The Athens Shale at Calera, where it contains the Pygodus serra-P. anserinus boundary is the same age as the upper part of the Little Oak at Pelham and the Pratt Ferry Formation at Pratt Ferry, as shown in figure 6.

Ragland

Only 46 feet of Little Oak Limestone is exposed at the Old North Ragland Quarry near Ragland. The three samples from Ragland have an average of 29 elements/kilogram of sample.

The conodont elements from Ragland have a CAI (Epstein et al., 1977) of 2 1/2 to 3, which is somewhat higher than at Pratt Ferry and Pelham. The conodont fauna is essentially the same as that in the upper parts of the Pelham and Pratt Ferry sections, but somewhat less diverse. This lower diversity is probably due merely to the small number of samples studied.

Representatives of the genera Pygodus, Periodon, and Prioniodus, which are typical of the North Atlantic Province (Bergström, 1971a), are common at Ragland. Representatives of Belodina, and of Panderodus gracilis are typical of the Midcontinent Province (Bergström and Sweet, 1966). These genera are also typical of the Blount Confacies Belt of

Jaanusson and Bergström (1980).

The most common conodont elements at Ragland are those belonging to *Belodella nevadensis*, *Panderodus gracilis*, *Belodina monitorensis*, *Coelocerodontus*? *digonius*, *Drepanoistodus suberectus*, *Triangulodus*? *brevibasis*, and *Pygodus anserinus* (see Table VIII).

Pygodiform elements of *P. anserinus* occur in all three of the samples from Ragland (see fig. 11), and indicate that the conodonts from the Little Oak at Ragland belong to the *P. anserinus* Zone of Bergström (1971a). However, because the fourth row of denticles on these elements is rather weakly developed, I believe that the Little Oak at Ragland occurs low in the *P. anserinus* Zone. Therefore I have correlated the Little Oak Limestone at Ragland with the lower part of the Athens Shale at Pratt Ferry, the upper part of the Little Oak at Pelham, and the upper part of the Athens exposed at Calera (see fig. 6).

Rockmart

Despite the fact that the Lenoir Limestone at Rockmart is overlain by slate, some of the conodont elements from that section are well enough preserved to be recognizable at the species level. The ability to determine the specific affinities of the other conodont elements from the Rockmart section is hampered partly by their state of preservation but perhaps as much by the fact that there are few studies on equivalent strata elsewhere in North America.

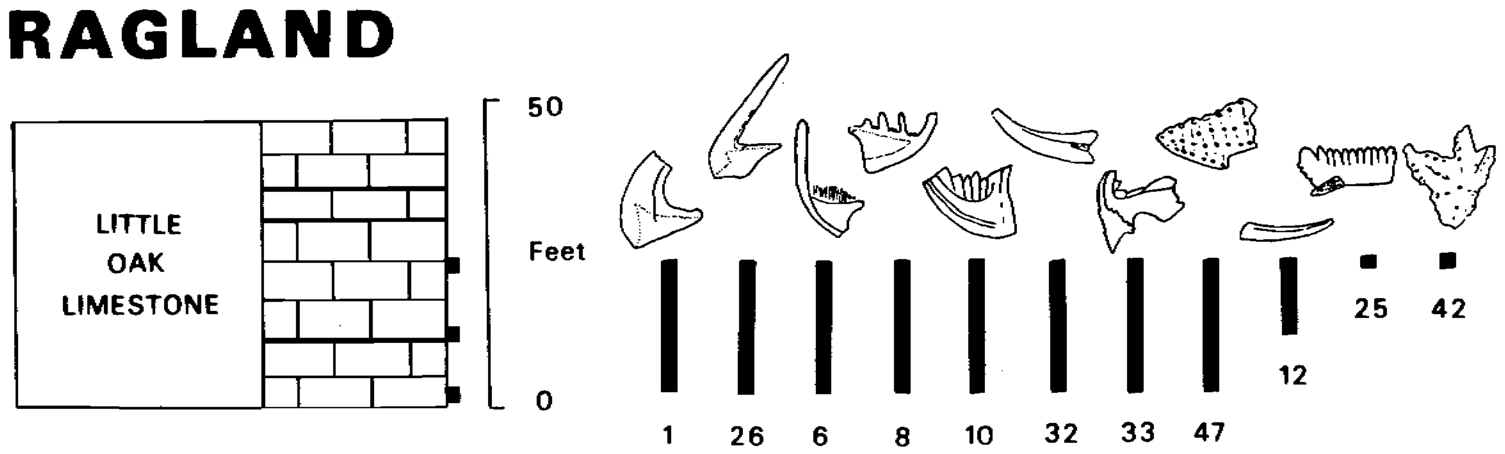


Figure 11. Stratigraphic distribution of conodont elements in the Ragland section. The numbers beneath vertical bars indicate conodont species, as given in Table I.

The stratigraphic section at Rockmart is a composite. The samples that I collected (80MS12-1 through 12-11) were collected from three separate levels in the Rockmart quarry that might be separated from each other by faults. The possibility of structural complications does not affect my interpretation, however, as my samples from the upper quarry are barren and those from the lower quarry contain what I believe to be specimens that were reworked from the underlying Knox Dolomite (see the section on carbonate petrology and the systematic paleontology for species 68). Stig Bergström collected, and generously made available to me, several samples from the Lenoir Limestone in the Rockmart area, which contain conodont elements that are similar or identical to those from rocks of Whiterockian age elsewhere in North America, especially those described by Bergström (1979) and Harris et al. (1979). My interpretation of the age of the Lenoir at Rockmart is based upon the presence of the elements collected by Bergström and is discussed below.

The conodont elements from the lower part of the Rockmart section (0 to 51 feet above the base of my section) have a CAI (Epstein et al., 1977) of 6 to 6.5. They are dark to nearly white and have a granular texture. The elements from the upper Lenoir, which were collected by Bergström, have a CAI of 5. The Lenoir exposed at Rockmart is about 70 feet thick. The difference in depth of burial between the lower and upper parts of the Lenoir is not sufficient to account for the higher CAI of conodonts from the lower part of my section (see Epstein et al., 1977 for a discussion on the effects of burial). The higher CAI of conodont elements and the petrology of samples from the lower part of the section suggest that these elements were reworked from underlying rocks of Early Ordovician age. Some elements from the lower 50 feet of section at Rockmart are assigned questionably to Drepanoistodus suberectus, as shown in Table IX. Elements of this long-ranging species may or may not have been reworked, but in neither case does their presence affect my interpretation of the section's age.

Elements of Leptochirognathus from the uppermost Lenoir Limestone at Rockmart are characteristic of the North American Midcontinent Province (Sweet et al., 1971). However, elements of Periodon, Prioniodus, and possibly Walliserodus, which are typical of the North Atlantic Province (Bergström, 1971a; and Jaanusson and Bergström, 1980) are also common. These North Atlantic Province genera are typical of the Blount Confacies Belt (Jaanusson and Bergström, 1980) and the genus Leptochirognathus is typical, in particular, of the Blount Confacies Belt during earliest Middle Ordovician time (Jaanusson and Bergström, 1980, p. 103).

The samples that I collected from the upper part of the

Lenoir at Rockmart were barren of conodont elements. However, Bergström's samples from a nearby locality (see Appendix A) contain specimens of diagnostic conodonts. Sample 72B16-1 was collected from the top of the Lenoir, beneath the Rockmart Slate, and sample 72B17-1 was collectd from 3 feet beneath the top of the Lenoir. Most of the conodont elements in those samples belong to *Juanognathus variabilis*, *Drepanoistodus suberectus*, *Periodon* sp., and *Leptochirognathus* sp. (see fig. 12). Elements assigned to *J. variabilis*, *Leptochirognathus* sp. and *Scolopodus* sp. in those samples are similar to, and probably conspecific with, those described from the Antelope Valley Limestone, Nevada (Harris et al., 1979) of Whiterockian age, and equivalent in age to Fauna 4 or possibly Fauna 3 of Sweet et al. (1971).

The falodiform elements of *Periodon* sp. appear to be weakly denticulate or in some cases, adenticulate. This weak denticulation suggests that the elements may belong to *Periodon flabellum*, the earliest-known species of *Periodon* (Lindström *in* Ziegler, 1981). However, the apparently weak denticulation might also be the result of the elements' poor state of preservation. Although they are poorly preserved and present in small numbers, elements assigned to *Cordylodus*? sp., Genus and Species indet. B, and Genus and Species indet. C also resemble elements reported from rocks of Whiterockian age (Sweet et al., 1971; Harris, 1972; Harris et al., 1979). Seven elements from Rockmart

Figure 12. Stratigraphic distribution of conodont elements in the Rockmart section. The stratigraphic lower limit of species whose ranges are indicated by dashes is not known. The numbers beneath vertical bars indicate conodont species, as given in Table I. Owing to structural complications, the exact thickness of some of the stratigraphic units is not known.

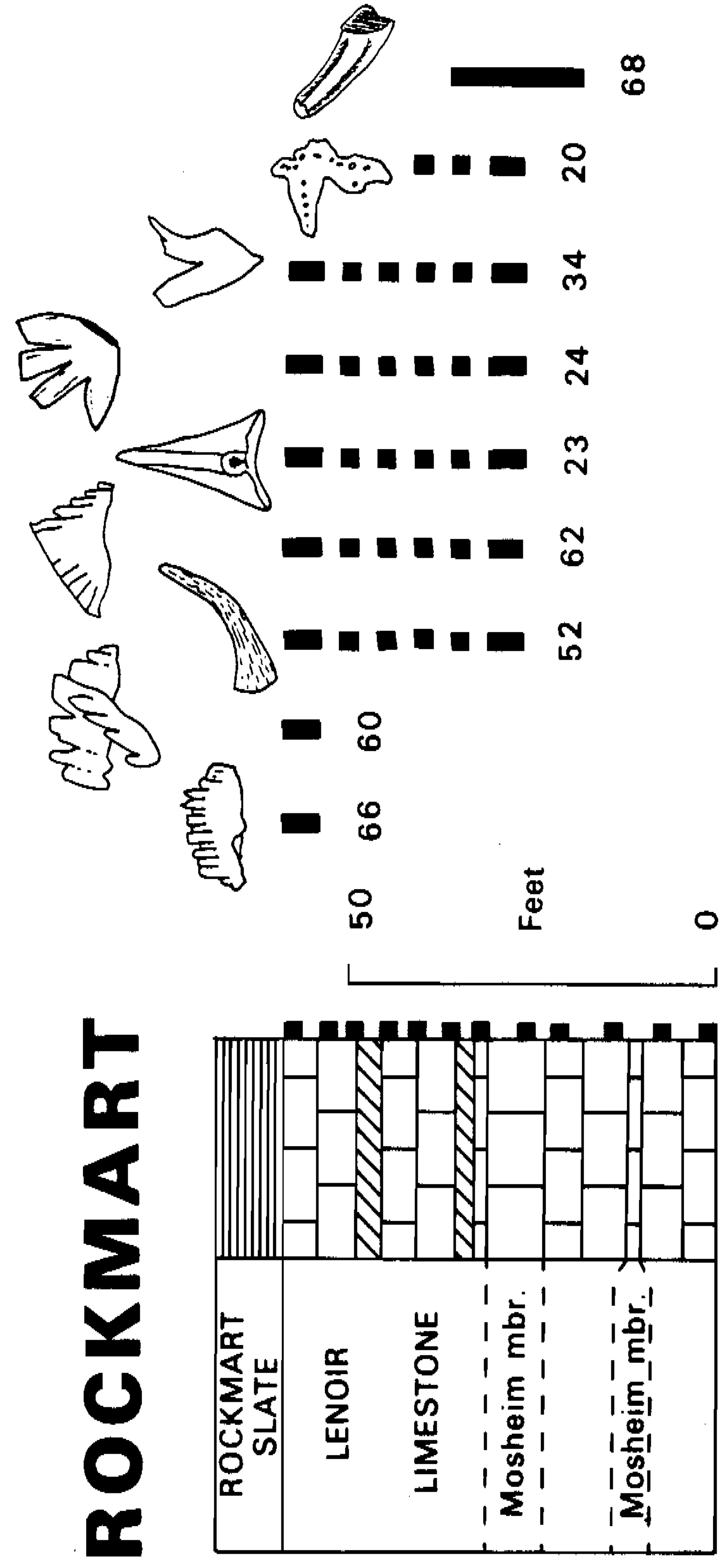

ROCKMART
ROCKMART SLATE
LENOIR
LIMESTONE
Mosheim mbr.
Mosheim mbr.
50
Feet
0
66
60
52
62
23
24
34
20
68

Figure 12.

assigned to genus and Species indet. G resemble, but are probably not conspecific with the forms that Mound referred to *Pravognathus idoneus* Stauffer.

Bergström's sample 72B18-1 was collected from an isolated outcrop of Lenoir Limestone near my Rockmart section. Its stratigraphic distance beneath the Rockmart Slate and its position relative to the other samples from Rockmart is unknown, except that it is probably somewhat lower than samples 72B16-1 and 17-1. The most abundant elements from sample 71B18-1 are representatives of *Juanognathus variabilis*, "*Scolopodus*" sp., and *Periodon* sp. The conodont fauna differs from that in the uppermost Lenoir at Rockmart in having far more elements of "*Scolopodus*" sp. and no elements of *Drepanoistodus* or Genus and Species indet. G. The conodont evidence suggests that this sample is not greatly different in age from the samples from the uppermost Lenoir at Rockmart.

The presence of specimens of *Juanognathus variabilis* and "*Scolopodus*" sp. implies that the Lenoir Limestone at Rockmart is older than any of the Chickamauga units in the more northwesterly belts of my study area, as shown in figure 6. The presence of elements of *Juanognathus variabilis* in the Deepkill Shale, New York (Landing, 1976) and in the Lenoir Limestone at Rockmart suggests that Cressler (1970, p. 30) is correct in interpreting the Athens Shale (Rockmart Slate) at Rockmart to be slightly younger than the Deepkill Shale in New York.

Portland

The conodont elements from the Portland Quarry, Georgia, have a CAI (Epstein et al, 1977) of about 6. Although the contact between the Lenoir Limestone and the underlying Knox Dolomite was not visible in the part of the section from which I made my collections, it was visible about 150 feet away at an elevation of 10 feet above my lowest sample. I collected samples from 69 feet, stratigraphically, of section at Portland. Samples 80MS13-1 through 13-6 from the lower 27 feet of section yielded conodont elements (see fig. 13 and Table X). The lowest three samples were collected from what I believe to be the Knox Dolomite. However, the conodont elements from these three samples are essentially the same as those that I collectd from the next three samples in the overlying Lenoir and the same as the conodont elements of Early Ordovician age from the lower part of my section at Rockmart. I believe, therefore, that the samples collected from the lowermost Lenoir at Portland (80MS13-4 through 13-6) contain only conodont elements that were reworked from the underlying Knox. The Lenoir is severely metamorphosed at Portland, but I believe that "pods" of dolomite in the lower Lenoir are reworked clasts of Knox Dolomite. The five samples collected from the upper Lenoir at Portland were barren of conodonts.

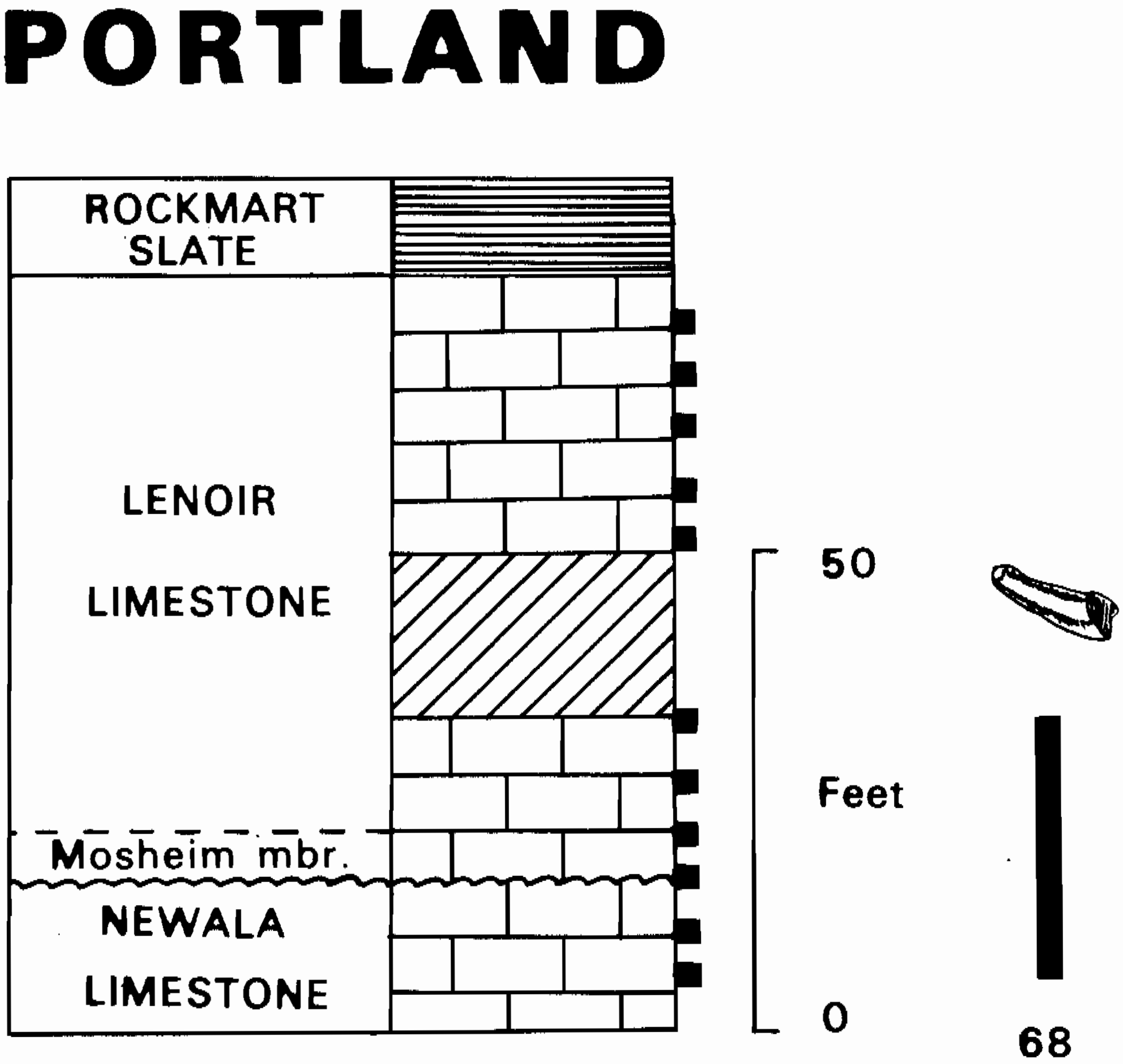


Figure 13. Stratigraphic distribution of conodont elements in the Portland section. The number beneath the vertical bar indicates the conodont species, as given in Table I.

I have not attempted to correlate the Lenoir Limestone at Portland, owing to the absence of indigenous conodont elements. I suspect that it is similar in age to the Lenoir at nearby Rockmart.

REGIONAL CORRELATION

Previous workers have correlated the units of the lower Middle Ordovician of Alabama and Georgia primarily on the basis of brachiopods and molluscs in the calcareous facies and graptolites in the clastic facies. The diagnostic conodont elements found in the present study have allowed a more precise correlation of these units with each other and with units elsewhere in North America.

Because of the pronounced difference in age of the formations across regional strike, I will discuss the correlation of the lower Chickamauga Limestone, and to a smaller degree, its clastic equivalent, the Athens Shale, as they occur in three separate northeast-trending belts. These are the Western Belt, which includes Chickamauga and Red Mountain, the Central Belt, which includes Pratt Ferry, Pelham, Ragland, and Calera, and the Eastern Belt, which includes Rockmart and Portland.

Western Belt--Chickamauga and Red Mountain.

Butts (1926) indicated that the lower and middle parts of the Chickamauga Limestone in the Red Mountain area is of Stones Riverian through Black Riverian age.

Twenhofel et al. (1954) included the "Newala" limestone at Chickauaga in the Chickamauga Limestone and correlated it with the Canadian Beekmantown Group of Virginia. Although I do not disagree with this correlation, I exclude their Newala from the Chickamauga Group (see Usage of the Term "Chickamauga" in the present study). So restricted, their "Murfreesboro" is the lowest Chickamauga Limestone at Chickamauga. They considered it to be of Black Riverian age (see fig. 3) and somewhat older than the basal Chickamauga at Red Mountain, which they also considered to be of Black Riverian age. Twenhofel et al. correlated the (restricted) lower Chickamauga in its type area with the Fort Peña in the Marathon region, the lower Bromide in the Arbuckle Mountains, the lower Black River Group, New York, and the Benbolt and Rockdell in Hogskin Valley, Tennessee. They correlated the basal Chickamauga at Red Mountain with the upper part of the Black River Group of New York, the Plattin Group of Missouri, the upper Bromide of Oklahoma, the upper Platteville of Minnesota, and the Wardell in Hogskin Valley, Tennessee.

Cooper (1956) correlated the lower Chickamauga at Chickamauga with the lower Bromide in the Arbuckle Mountains, the Rock Levee of Missouri, and the Rockdell in Hogskin Valley of Tennessee. He correlated the lower Chickamauga at Red Mountain with the Plattin of

Missouri, the upper Bromide of the Arbuckle Mountains, the lower Platteville of Minnesota, and the Wardell at Eidson, Tennessee.

Rogers (1961a, 1961b) considered the lower Chickamauga at Red Mountain and in the Cahaba Valley to be of Chazyan age.

Elements of *Phragmodus flexuosus*? occur in the lower Chickamauga at Chickamauga and elements of *P. inflexus* occur in the lower Chickamauga at Red Mountain and possibly in the upper part of my section at Chickamauga (see fig. 5). Representatives of *Plectodina aculeata* also occur in the lower Chickamauga at Red Mountain (see fig. 7). This indicates that the lower Chickamauga at Red Mountain, and perhaps the upper Pond Spring and lower Murfreesboro at Chickamauga, are correlative with the Black River Group, New York, and belong to the interval of Fauna 7 of Sweet et al. (1971), as shown in figure 6. The lowermost Chickamauga in its type area contains elements belonging to Fauna 6 of Sweet et al. and may be correlative with the Chazy Group of New York and Quebec.

On the basis of occurrences of *Phragmodus inflexus* and *Plectodina aculeata*, the lower Chickamauga Limestone at Red Mountain, and perhaps the upper Pond Spring and lowermost Murfreesboro at Chickamauga, can be broadly correlated with the Joachim of Missouri (Andrews, 1976), the lower Copenhagen of the Antelope Range, Nevada (Harris et al., 1979), the lower Bromide of Oklahoma (Sweet *in* Ziegler, 1981), the Eidson and Rockdell at Eidson, Tennessee (Carnes, 1975), and the Glenwood of Minnesota (Stauffer, 1935a). On the basis of occurrences of *Phragmodus flexuosus*?, the lower and lower middle Pond Spring at Chickamauga can be correlated with the lower Bromide of Oklahoma (Sweet et al., 1973), the Dutchtown of Missouri (Sweet *in* Ziegler, 1981), the Woods Hollow in the Marathon region (Bergström, 1978), and the Tumbez and lower Elway-Eidson in Hogskin Valley, Tennessee (Carnes, 1975).

I agree with the interpretation of Twenhofel et al. (1954) and Cooper (1956) that the basal part of the Chickamauga at Red Mountain is younger than that at Chickamauga. However, the basal Chickamauga at Birmingham (Red Mountain) is not nearly as young as indicated by them. For example, Twenhofel et al. (1954) correlated it with the upper Bromide in the Arbuckle Mountains, the Wardell at Eidson, Tennessee, and the lower Platteville of Minnesota, which are considerably younger than the Red Mountain sequence. The basal Chickamauga at Chickamauga is also younger than was indicated by these authors, and is Chazyan, rather than Black Riverian, in age, as indicated by Twenhofel et al. (1954).

Conodont elements of Fauna 7 (Sweet et al., 1971) indicate that Rogers' (1961a, 1961b) interpretation of the Chickamauga at Red Mountain as Chazyan in age is incorrect.

Central Belt--Pratt Ferry, Pelham, Ragland, and Calera.

The rocks of the central belt contain North Atlantic Province conodont elements. These rocks differ from those of the eastern belt in that they are not metamorphosed. My so-called central belt has been referred to as the "Cahaba Valley", with the Ragland area sometimes discussed separately as the "Coosa Valley" (Ulrich, 1911, Butts, 1926; Twenhofel et al., 1954; Cooper, 1956; Rogers, 1961a, 1961b). In keeping with tradition, I discussed the Cahaba Valley and Coosa Valey exposures in the introduction of the present study. For the sake of convenience, I am similarly discussing them here as the Central Belt. However, it is important to be aware that the Chickamauga Limestone in the Cahaba Valley is of the same age only within broad limits. To consider the Little Oak at Ragland as representing a separate geologic region from that at Pelham is misleading, as the Ordovician rocks from these localities are quite similar in age and lithology (see fig. 6). To separate these areas on the basis of present-day drainage patterns may obscure the close relations between these rock sequences.

Butts (1926) correlated the "lower Chickamauga Limestone" in the Cahaba Valley with that at Red Mountain and indicated that they were of Chazyan age.

Twenhofel et al. (1954) correlated the lowermost Chickamauga, which they termed Lenoir (see fig. 3) in the Cahaba Valley, with the lower Chazy Group in the Champlain Valley, the Joins, Oil Creek, and McLish in the Arbuckle Mountains, the middle Womble Shale of Arkansas, the Fort Peña of Texas, the New Market of Virginia, and the Blackford and Tumbez of Tennessee. They indicated that the Lenoir in the Cahaba Valley was overlain by the Effna, Athens, and Little Oak, in ascending order and considered these formations to be Black Riverian in age. They correlated this part of the Chickamauga in the Cahaba Valley with the lower Black River and upper Chazy of New York, the Platteville of Minnesota, the Plattin of Missouri, and Bromide in the Arbuckle Mountains, the Fort Peña of the Marathon region, the Womble Shale of Arkansas, the Lincolnshire of Virginia, and the Lincolnshire, Benbolt, and Rockdell of Hogskin Valley, Tennesee.

Cooper (1956) separated the Chickamauga at Pratt Ferry from the units in the rest of the Cahaba Valley due to differences in lithology (see fig. 4). He considered the basal Chickamauga at both localities to consist of the Mosheim and Lenoir and indicated that they are separated from the overlying Chickamauga by a major hiatus. He correlated the lower Chickamauga in the Cahaba Valley with the McLish in the Arbuckle Mountains, the Tumbez of Tennessee, the New Market and Row Park of Virginia, and the Crown Point and Day Point of the Chazy Group in the Champlain Valley. Cooper recognized the Little Oak Limestone in the upper Chickamauga of the Cahaba Valley and, in ascending order, the Christiania Bed, Pratt Ferry Formation, and Columbiana (Athens) Shale at Pratt Ferry. He correlated these with the Mountain Lake (lower Bromide) in the Arbuckle Mountains, the Rock Levee of Missouri, and the Womble Shale of Arkansas. Although Cooper suggested a revision of North American stage names and did not recognize the Chazyan or Black Riverian stages, he indicated that the upper Chickamauga in the Cahaba Valley and at Pratt Ferry is intermediate in age between the Chazy and Black River groups in the Champlain Valley.

As discussed in the chapter on conodont biostratigraphy, the exact relations between the intervals of the Midcontinent Faunas of Sweet et al. (1971) and North Atlantic Conodont Zones of Bergström

(1971a) are poorly known. However, based upon recent discussions by Sweet and Bergström (1976), Bergström (1977), and Harris et al. (1979), I interpret the interval of Fauna 5 to be broadly equivalent to the *Pygodus serra* Zone and the lower part of the *P. anserinus* Zone (see fig. 6).

Representatives of *Pygodus* in all of my sections in the Central Belt, and of *Eoplacognathus* at Calera, have enabled me to date the successions here. Elements of *P. serra* occur in the Little Oak at Pelham, in the Lenoir and Pratt Ferry at Pratt Ferry, and in the Lenoir and lower Athens at Calera. Elements of *Eoplacognathus* sp. cf. *E. reclinatus* in the uppermost Lenoir and the lower Athens at Calera (see fig 10) occur low in the *Pygodus serra* Zone as established by Bergström (1971a). Although elements of *Eoplacogathus* were not found in the Pelham or Pratt Ferry sections, the fact that the top of the *P. serra* Zone occurs high in these sections (see figs. 8, 9) suggests that the lower parts of these successions are equivalent in age to one of the lower subzones of the *P. serra* Zone. Furthermore, elements of *Polyplacognathus friendsvillensis* in the lower parts of these sections are typical of those from the middle or lower part of the *P. serra* Zone elsewhere.

The *Pygodus serra*-*P. anserinus* transition marks the base of the *P. anserinus* Zone and is present in the upper Little Oak at Pelham, the Pratt Ferry Formation at Pratt Ferry, and the upper part of the Athens at Calera. Although the zonal boundary occurs below the part of the Little Oak that is exposed at Ragland (see fig. 11), the apparently primitive elements of *P. anserinus* at that locality suggest a low position in the *P. anserinus* Zone.

The presence of *Pygodus serra* and *Polyplacognathus friendsvillensis* in the Lenoir and Pratt Ferry at Pratt Ferry, the lower Little Oak at Pelham, and the Lenoir and lower Athens at Calera suggests that these units can be correlated with the lower Cobbs Arm Limestone, Newfoundland (Bergström, Riva, and Kay, 1974), the Day Point of the Chazy Group (Raring, 1972) and the St. Dominique (Roscoe, 1973) of the Champlain Valley, the uppermost Antelope Valley Limestone in the Antelope Valley, Nevada (Harris et al., 1979), the Tulip Creek (Sweet and Bergström, 1973) and McLish (Bergström, 1971a) of Oklahoma, the Row Park and Pinesburg Station of West Virginia (Boger, 1976), and the lower Lenoir, Whitesburg, and Blockhouse of Tennessee (Carnes, 1975).

Elements of *P. anserinus* suggest a correlation of the upper Pratt Ferry and lower Athens at Pratt Ferry, the upper Little Oak at Pelham, the Little Oak at Ragland, and the upper Athens at Calera with the Woods

Hollow Shale of Texas (Bergström, 1978), the unnamed limestone overlying the Antelope Valley Limestone at the Nevada Test Site (Harris et al., 1979), Nevada, the Womble Shale of Arkansas (Repetski and Ethington, 1974), the Bromide of Oklahoma (Sweet and Bergström, 1973), the St. Dominique of the Champlain Valley (Roscoe, 1973), the upper Cobbs Arm in Newfoundland (Bergström, Riva, and Kay, 1974), the Youngman of Vermont (Bergström, 1971a), and part of the Holston, Blockhouse, Sevier, and upper Lenoir in Tennessee (Carnes, 1975).

The basal part of the Chickamauga in the central belt is older than that in the western belt, and it is probably oldest at Calera. The Athens is not present at Pelham and is absent at Ragland, but conodont evidence suggests that its basal part is older at Calera than at Pratt Ferry. All of the Chickamauga Limestone in the central belt is of Chazyan age.

The conodont evidence also suggests that the upper Chickamauga of Twenhofel et al. (1954) in the Cahaba Valley is not Black Riverian and is not as young as the basal Chickamauga in its type area. Also the lower Chickamauga in the Cahaba Valley is not earliest Chazyan, but somewhat younger. Although the Little Oak is largely younger than the Lenoir, I know of no evidence that supports the correlations (figs. 3, 4) of

Twenhofel et al. (1954) or Cooper (1956) in which the Little Oak directly overlies the Lenoir.

Eastern Belt--Rockmart and Portland.

Few attempts have been made to correlate the Chickamauga Limestone in the eastern belt where it has been metamorphosed. Butts (1948) correlated the Lenoir (which he called Newala) beneath the Rockmart Slate in the eastern belt with the Beekmantown of Virgina owing to the presence of specimens of *Maclurites* and *Ceratopea*. He indicated that the Rockmart Slate is of Mississippian age.

Cressler (1970) assigned a Middle Ordovician age to the Lenoir in the Eastern Belt. He disputed Butts' assignment of Mississippian age to the Rockmart Slate. He reported representatives of graptolites, including *Glyptograptus* cf. *G. teretiusculus* in the Rockmart which indicate that it is, at least partly, a metamorphic equivalent to the Ordovician-age Athens Shale.

Bergström (1973c) reported the occurrence of Whiterockian conodonts from the uppermost Lenoir at Rockmart. He suggested that graptolite occurrences from the *Didymograptuis murchisoni* Zone in the basal Rockmart (Athens) at Rockmart indicate that the shale in that area is older than that elsewhere in the

Southern Appalachians.

Although the conodont elements from the Eastern Belt are poorly preserved, representatives of the species Juanognathus variabilis and "Scolopodus" sp. from the Lenoir at Rockmart (see fig. 12) may be taken to suggest that this unit may be broadly equivalent with the upper Antelope Valley Limestone at Ikes Canyon, Nevada (Harris et al., 1979), the Table Head Formation of Newfoundland (Bergström, 1979), and the upper Deepkill Shale of New York (Landing, 1976). This correlation suggests that the upper Lenoir at Rockmart is of Whiterockian age. The conodont elements probably represent Fauna 4 or perhaps Fauna 3 of Sweet et al. (1971), as shown in figure 6.

The Lenoir at Rockmart and Portland contains conodont elements which are apparently reworked from rocks of Early Ordovician age (see p. 63). Although I cannot determine tha age of the upper Lenoir at Portland, I suspect that it is not greatly different from that at nearby Rockmart.

Butts' correlation of the Lenoir at Portland with the Beekmantown of Virginia may have been based upon reworked fossils from the underlying Knox group. Cressler's report of the graptolite Glyptograptus cf. G. teretiusculus from the Rockmart Slate is consistent with the occurrence of Whiterockian age conodonts in the underlying Lenoir. The occurrence of conodonts in the upper Lenoir equivalent in age to Fauna 4 or 3 of Sweet et al. (1971) agrees with Bergström's (1973) report of graptolites from the basal Rockmart representing the *Didymograptus murchisoni* Zone.

CARBONATE PETROLOGY, SEDIMENTARY ENVIRONMENTS, AND THE OCCURRENCE OF RECURRENT SPECIES ASSOCIATIONS

Approximately one-third of the samples which I collected for conodont extraction were thin sectioned and examined with a petrographic microscope. A thorough petrographic investigation of the stratigraphic units would be useful and is currently being undertaken by students of The Ohio State University. Nevertheless, a preliminary examination of the carbonate petrology was undertaken in the present study in an attempt to clarify some aspects of the facies relations in the Chickamauga, and the relations between conodont occurrences and the environment of deposition. A description of the thin sections is given in Appendix B.

Lenoir Limestone and Pratt Ferry Formation.

The Lenoir Limestone occurs in the Eastern Belt and the southern part of the Central Belt (see fig. 6). Because the Lenoir at Rockmart and Portland has been metamorphosed, study of thin sections provides relatively little information about its depositional environment.

The presence of abundant mica in the Lenoir at Rockmart and Portland probably indicates that the Lenoir was originally argillaceous in this area. Dolomite clasts in the lower Lenoir at Rockmart, and apparently at Portland, were probably reworked from the underlying Knox. Abundant pellets (?) and what appears to be birdseye (fenestral) texture are present in the Lenoir and are typical of carbonates that have been deposited in an intertidal or subtidal environment (Fischer, 1964). Conodont elements have been reported from supratidal to intertidal mudflats (Bergström and Carnes, 1976) but are generally not abundant, and they are presumeably deposited under brief periods of high subtidal conditions. The absence of conodont elements and the presence of what appears to be fenestral fabric in the upper Lenoir at Rockmart and Portland may indicate that the Lenoir was deposited in very shallow water. However, this is difficult to reconcile with the ocurrence of deep-water, graptolitic shale which directly overlies the Lenoir. This abrupt lithologic change might be explained by a rapid increase in depth of deposition, a period of erosion or nondeposition between the deposition of the Lenoir and Rockmart, or possibly by the fact that what appears to be birdseye texture in the Lenoir was not caused by deposition in shallow water. Although the petrographic studies of the Lenoir at Rockmart have done little to clarify its depositional history, the presence of dolomite clasts in the lower Lenoir has proven useful in explaining the presence of Early Ordovician conodonts in it.

The Lenoir at all of the localities in the study area is a wackestone, mudstone, or pelletal packstone, which indicates that it was deposited in a low-energy environment (Dunham, 1962). Shaw (1964) noted that epeiric sea floors may have had a slope of less than one foot per mile. In Shaw's model of such a shallow sea, wave energy is dissipated in a relatively narrow zone where the water depth is approximately equal to that of wave base. The wave energy in areas both shoreward and seaward of this zone would have little or no effect on the sediment. Therefore, the abundance of calcareous mud in the Lenoir Limestone cannot be used to determine if it was deposited above or below wave base.

The change in the Lenoir at Pratt Ferry and Calera from a mudstone, pelletal wackestone, or packstone in the lower parts of the sections to an echinodermal wackestone in the upper parts of the sections, is accompanied by an increase in conodont abundance and diversity. Echinoderms are the dominant skeletal consituents at Pratt Ferry and Calera, and ostracodes, trilobites, and molluscs are also common. The abrasion of skeletal fragments in some samples of Lenoir might indicate that they were transported some distance. But the presence of burrow mottling, sworled textures, and, at Calera, small, abraded fragments occurring with large, complete fossils suggest that at least some of the abrasion was caused by bioturbation and not by transport.

Echinoderms are, by and large, the dominant skeletal contributor to the Lenoir in the study area, followed by arthropods and molluscs. The relative abundance of skeletal types in the lower Lenoir at Calera is similar to that in the upper Lenoir. But the change from a thick-bedded, moderately argillaceous, dolomitic limestone low in the section to a thin-bedded, highly argillaceous, low-dolomite limestone overlain by a graptolitic shale higher in the section indicates an increase in water depth with time.

The lower Lenoir at Pratt Ferry and Calera is lithologically similar to the Black River carbonates (Walker and LaPorte, 1970) and the Devonian-age Manlius Formation (LaPorte, 1969; Walker and LaPorte, 1970) which they interpret to be supratidal, intertidal, and shallow subtidal deposits. The lower Lenoir is similar to these units in having birdseye texture, dolomitic mud, and few fossils. The fauna of the upper Lenoir resembles the offshore community of Anderson (1971, p. 273) in that echinoderms are the dominant skeletal constituents. Anderson indicated that this offshore community occurs near to, but in slightly shallower water than, the wave base. The Devonian-age Kalkberg also has abundant pelmatozoan debris, but was deposited at a depth somewhat below wave base (LaPorte, 1969).

In a study of the Lenoir Limestone and associated strata in eastern Tennessee, Bergström and Carnes (1976) recognized several recurrent conondont species associations (RSA), the distribution of which seemed to be at least partly controlled by environmental conditions. Similar RSA's can be recognized in my study area.

Elements of *Phragmodus* are rare in the Lenoir, but elements of *Belodella* are common in the lower Lenoir at Calera and throughout the Lenoir at Pratt Ferry. Elements of *Polyplacognathus* are common in the Lenoir at Pratt Ferry. Representatives of *Eoplacognathus*, *Pygodus*, *Periodon*, and *Walliserodus* at Calera occur high in the Lenoir and low in the Athens where elements of *Belodella*, *Belodina*, *Polyplacognathus*, and *Phragmodus* are scarce. The change, upsection, at Calera from the *Belodella*-*Phragmodus*-*Polyplacognathus* RSA to the *Periodon*-*Pygodus* RSA of Bergström and Carnes parallels the change from shallow to deeper-water lithologies. No similar change in RSA's is obvious at Pratt Ferry.

The Pratt Ferry at Pratt Ferry differs from the underlying Lenoir in having more abundant skeletal matter relative to mud, which suggests that it was deposited in a higher-energy environment (Dunham, 1962). I believe that the change from muddy, poorly fossiliferous limestones upward to more clean-washed, fossiliferous limestones, and on to graptolitic shale at Pratt Ferry may have been caused by an increase in water depth corresponding to a change from slightly restricted subtidal or open-shelf, near wave-base to open shelf, below wave-base waters as described by Anderson (1971, p. 296). Perhaps the presence of pelmatozoan fragments in a calcareous mud matrix in the Lenoir and Pratt Ferry represents the stabilization of the substrate (Alberstradt and Walker, 1973), rather than a particular environment controlled by water depth or other environmental factors. It is also possible that the Pratt Ferry may represent a local shoal environment.

Little Oak

The Little Oak Limestone, which is present in my Central Belt, is lithologicaly similar to the Lenoir, but it has much less clay, and bryozoans are distinctly more abundant. Anderson (1971) suggested that the abundance of bryozoans relative to echinoderms is greater in the zone below wave base than in the zone above wave base. This might indicate that the Little Oak was deposited in deeper water than the Lenoir. However, the greater abundance of bryozoans in the Little Oak might be due to the lower clastic influx and not to a difference in water depth or temperature.

I interpret the change from dolomitic mudstones with low faunal diversity in the lower Little Oak at Pelham to packstones with higher faunal diversity to be an indication of increasing water depth with time. This interpretation agrees with my interpretation of the Chickamauga Limestone as a time-transgressive unit, as indicated in figure 6. The occurrence of elements of *Polyplacognathus friendsvillensis* in the lower Little Oak and its absence in the upper Little Oak at Pelham seems to indicate a shift from the *Belodella-Phragmodus-Prioniodus* RSA (Bergström and Carnes, 1976) toward the *Periodon*-*Pygodus* RSA.

The samples of the Little Oak at Ragland are a dolomitic, pelletal packstone with minor amounts of arthropods and other skeletal material. Petrologically, they are much like the lower Lenoir at Calera. The conodont faunas of the Little Oak at Ragland and the lower Lenoir at Calera are dominated by elements of *Belodella*, *Belodina*, and *Panderodus* and have a few elements of *Phragmodus*. These genera are characteristic of shallow-water deposits in eastern Tennessee according to Bergström and Carnes (1976).

Chickamauga Limestone (undifferentiated)

The Chickamauga Limestone at Red Mountain contains very little clay. It is petrographically similar to the Lenoir and Little Oak, except that pellets are a minor constituent in the samples that I studied. Like the Lenoir and Little Oak, the Chickamauga at Red Mountain contains minor amounts of skeletal material in the lower part of the section and abundant echinoderms and arthropods in the upper part of the section. Also, as in the case of the Lenoir and Little Oak, I interpret the smaller proportion of micrite mud in the upper part of my section at Red Mountain to be an indication of a higher-energy environment of deposition than that represented in the lower part of that section.

The increase upsection in depth of deposition of the Chickamauga at Red Mountain concurs with an increase in abundance of elements of *Belodina*, *Phragmodus*, *Belodella*, and *Panderodus*, and a decrease in hyaline conodont-elements. Elements of *Leptochirognathus* and *Polyplacognathus* are not present in my samples from Red Mountain. However, the conodont fauna changes from one resembling the *Leptochirognathus* RSA of Bergström and Carnes (1976) to one resembling the *Belodella*-*Phragmodus*-*Polyplacognathus* RSA, which Bergström and Carnes consider to be characteristic of very shallow and somewhat less-shallow water, respectively.

The occurrence of the lowermost Chickamauga in the Red Mountain section above the post-Knox unconformity also suggests that the lower Chickamauga was deposited in shallow water, which I presume became deeper as strata in the higher parts of the section were deposited. However, I cannot determine, on the basis of thin sections, at what depth the lower Chickamauga at Red Mountain was deposited relative to the lower Chickamauga in the Central Belt. The presence of elements of *Phragmodus* and *Plectodina* at Red Mountain and the absence of elements of *Periodon* and *Pygodus* might be the result of a difference in water temperature not caused by a difference in water depth.

The undifferentiated Chickamauga at Red Mountain and the Lenoir and Little Oak in the more easterly belts are similar to the Limestones in the Baltoscandia area described by Jaanusson (1972, p. 222-223) in that they contain abundant micrite with very little cement and their major skeletal constituents are echinoderms. My samples differ from his in having abundant pellets. Jaanusson (1973, p. 13) considered the preservation of fecal pellets to be an indication of deposition in warm water. However, he observed (p. 15) that it is normally not possible to determine the pellets are fecal in origin. At least some pellets probably are tiny fragments of fossils or limestone clasts. Therefore, the greater abundance of pellets in the Chickamauga compared with Jaanusson's samples from Baltoscandia does not necessarily indicate a significant difference in the temperature at which they were formed.

Pond Spring and lowermost Murfreesboro

Because the small number of samples collected from Chickamauga and the great vertical distance between samples precludes any discussion of changing environments with time, I will discuss the depositional environment of rocks at Chickamauga only in general terms.

Fenestral fabric, mudcracks, or abundant dolomite are present in 4 out of 5 samples that I thin sectioned from Chickamauga. The skeletal material in the rocks at Chickamauga is composed primarily of ostracodes and molluscs. LaPorte (1967) considers the presence of fenestral fabric, mudcracks, pelletal mudstone, and a restricted fauna, primarily of ostracodes, to be indicative of rocks that were deposited in supratidal and intertidal waters.

Hyaline conodont elements and elements of *Phragmodus* are abundant in the lower two samples from Chickamauga and are characteristic of the Midcontinent fauna which Sweet and Bergström (1974) suggested was present in relatively warm waters. Similarly, most of the elements of *Rhipidognathus* from the present study came from sample 80MS1-1, which has fenestral fabric indicative of shallow-water deposition (Shinn, 1968). Kohut and Sweet (1968) suggested that *Rhipidognathus symmetricus symmetricus* inhabited shallow water.

Based on the evidence at hand, which is admittedly not very conclusive, it may be suggested that, in general, the conodonts of the Lenoir, Pratt Ferry, and Little Oak represent subtidal environments below the wave base, whereas those of the Chickamauga at Chickamauga and Red Mountain represent shallow-water environments in the upper subtidal to intertidal zone. However, the difference between the conodont faunas of the Chickamauga (Pond Spring and Murfreesboro) and that in the Central Belt (Lenoir and Little Oak) can probably not be attributed entirely to differences in water depth. As Bergström (1971a, p. 129) pointed out, distances between the areas inhabited by the Midcontinent and European faunas might have been much greater in the Ordovician than they are today. Thrusting in the Appalachians of Alabama and Georgia has shortened the distance between the eastern and western belts considerably, although the precise amount of displacement cannot be determined at the present time. Obviously, this shortening across the mountain chain tends to make the faunal changes across the Middle Ordovician shelf seem more abrupt than they may have been, but the conspicuous faunal differentiation is nevertheless both a striking and interesting feature in the Middle Ordovician paleobiogeography of this region.

SUMMARY AND CONCLUSIONS

The Chickamauga Limestone is a time-transgressive unit that is oldest in the southeast and youngest in the northwest (see fig. 14). This interpretation is in general agreement with the interpretations of Twenhofel et al. (1954) and Cooper (1956), but differs in some important respects.

The basal Chickamauga at Chickamauga is not Black Riveran in age, as suggested by Twenhofel et al. (1954), but Chazyan. The upper Chickamauga Limestone in the Cahaba Valley is Chazyan, not Black Riveran, and is wholly older than the lower Chickamauga in its type area. Although conodont evidence suggests that the Little Oak is in part younger than the Lenoir, I know of no evidence that the Little Oak actually overlies the Lenoir, as suggested by Twenhofel et al. Futhermore, the lower Chickamauga in the Cahaba Valley is not earliest Champlainian in age, but is early Chazyan.

Cooper (1956) suggested that the lower Chickamauga at Chickamauga might be correlated with the upper Chickamauga in the Cahaba Valley. Conodont evidence indicates that this is not correct. Cooper proposed that a major hiatus exists between the upper and lower Chickamauga in the Cahaba Valley. Conodont biostratigraphy does not support this interpretation.

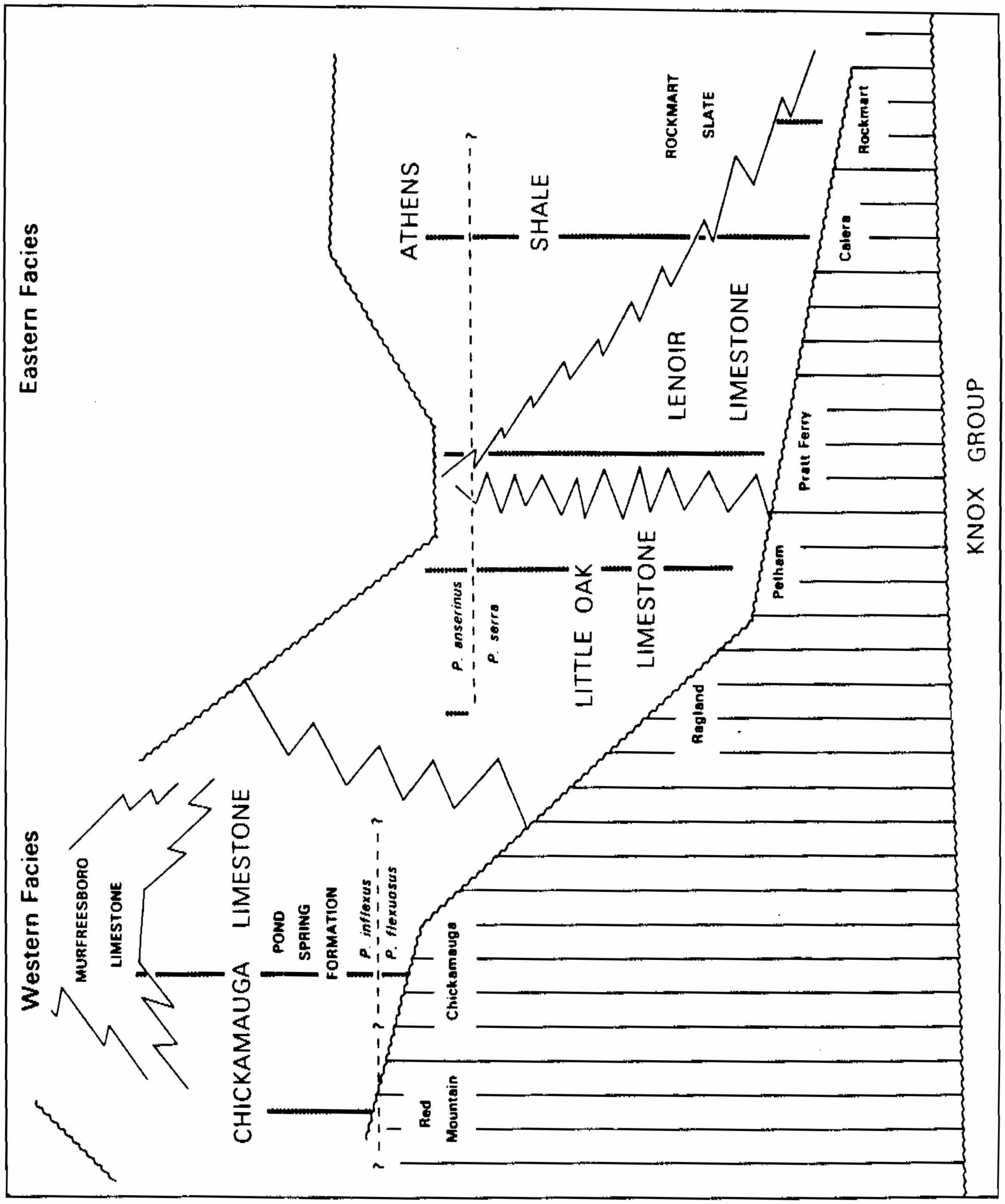


Figure 14. Suggested facies relations of Chickamauga equivalents in the study area. The dashed vertical lines indicate the stratigraphic interval from which samples were collected. The interfingering relationship of the Lenoir Limestone with the Little Oak Limestone is not observable in the field.

I disagree with the interpretation of Rogers (1961a, 1961b) that the lower Chickamauga is of the same age (Chazyan) across the thrust belts in Alabama. The lower Chickamauga is Black Riveran in age at Red Mountain and Chazyan in the Cahaba Valley. Furthermore, the Little Oak does not overlie the Lenoir in the Cahaba Valley and is definitely not younger (Black Riveran) than the lower Chickamauga at Red Mountain.

The Chickamauga Limestone (Lenoir) at Rockmart is of Whiterockian age and is older than the Chickamauga elsewhere in the study area. The Chickamauga is progressively younger at Calera, Pratt Ferry, Pelham, Chickamauga, and Red Mountain. The Little Oak at Ragland is similar in age to the upper Little Oak, but lithologically similar to the lower Little Oak, at Pelham. This suggests that the Chickamauga at Ragland was deposited, in part, later than that at Pelham.

The lowermost Chickamauga Limestone in the study area was deposited in supratidal, intertidal, or shallow-subtidal water. The Chickamauga higher in section was deposited in somewhat deeper water in an open-shelf environment. Increase in the depth of deposition coincides with a shift from shallow-water conodont RSA's (Bergström and Carnes, 1976) to deeper-water RSA's. The higher clay content of the Lenoir, and, in particular, the Athens, compared to that of the Little Oak, might be due to a closer proximity to an eastern clastic source, rather than to a difference in the environment of deposition.

SYSTEMATIC PALEONTOLOGY

All figured and reference specimens with OSU numbers are stored in the Orton Geological Museum at The Ohio State University. Figured specimens are coated with gold so that they may be photographed by means of scanning-electron microscopy.

The general acceptance of multielement taxonomy for conodonts in recent years has resulted in the use of a number of terms to indicate individual types of elements. Most authors in the 1970's have appended the suffix "iform" or "dontiform" to the form-genus name of the element, e.g., "phragmodiform" or "phragmodontiform".

More objective terms for discrete elements have been proposed in recent years. Sweet (_in_ Robison, 1981) provides a description of each of the major shape categories and a discussion of the multielemental composition of skeletal apparatuses of condonts. I believe that the terms used by Sweet (geniculate, alate, angulate) will soon be widely used in place of form-genus names (oistodiform, trichonodelliform, ozarkodiniform). However, because Sweet's discussion in the Treatise on Invertebrate Paleontology became available (January, 1981) after I had written much of the present text, I have used form-genera terms in my "descriptions" and "remarks" sections, and both form-genera and shape-category terms in my "collections" sections and in my plate descriptions. I hope that this will familiarize both myself and the reader with shape-category terms and their equivalent form-genera terms.

Genus ACODUS Pander, 1956

Acodus Pander, 1856, p. 21.

Type Species: *Acodus erectus* Pander, 1856.

Remarks: Bergström and Sweet (1966) included acodiform and acontiodiform (or distacodiform) elements in the multielement genus *Acodus*, but they questioned the use of the generic name *Acodus* for a multielement species because of the uncertain affinities of *Acodus erectus*. One of the species assigned by them and some subsequent authors (Carnes, 1975; Löfgren, 1978) to *Acodus* has been referred to *Dapsilodus mutatus* (Branson and Mehl) in the present study.

A second species with acodiform elements occurs in my collections. It is probably the same as elements that Webers (1966) referred to as *Distacodus variabilis*. Because I believe that it might have included oistodiform elements, I do not consider it to be congeneric with *Dapsilodus mutatus*. Moreover, because the possible inclusion of an oistodiform element in the "*A*." *variabilis* apparatus further confuses its proper generic assignment, I have included it with the genus *Acodus* only becuase one of its elements fits the classical description of that genus.

"ACODUS" VARIABILIS (Webers, 1966)

(Pl. II, figs. 26, 27)

Distacodus variabilis Webers, 1966, p. 28-29, Pl. 2, figs. 15, 18; Atkinson *in* Clark, 1971, p. 128, Pl. 5, figs. 1, 2, 6.

Acontiodus semisymmetricus Hamar, 1966, p. 51, Pl. 7, figs. 5, 6, Text-fig. 3, no. 6.

Acontiodus nevadensis Ethington and Schumacher, 1969, p. 450-452, Pl. 67, figs. 20, 21, Text-fig. 40.

Distacodus aff. *D. bigdoeyensis* Hamar; Ethington and Schumacher, 1969, p., 460-461, Pl. 68, fig. 23, Text-fig. 4G.

Acodus mutatus (Branson and Mehl) Votaw, 1971, p. 52-54, Pl. 3, figs. 1-3, Text-fig. 4A-C; Uyeno, 1974, p. 16, Pl. 1, fig. 23; Palmieri, 1978, p. 6-7, Pl. 2, figs. 17-19.

"*Acodus*" *variabilis* (Webers) Carnes, 1975, p. 104-106, Pl. II, figs. 15, 16.

Dapsilodus variabilis (Webers) Line, 1978, Pl. 1, fig. 11.

Paltodus semisymmetricus (Hamar) Dzik, 1976, Fig. 18B, C, F, *not* Fig. 18A, D, E.

Dapsilodus? nevadensis (Ethington and Schumacher) Ethington and Clark, 1982, p. 35, Pl. 3, fig. 1.

?*Acontiodus procerus* (Ethington) Serpagli, 1967, Pl. 9, figs. 9-11, *not* figs. 6-8.

?*Acodus* sp. s. f. Bolton and Nowlan, 1979, p. 16, Pl. 8, figs. 3-5.

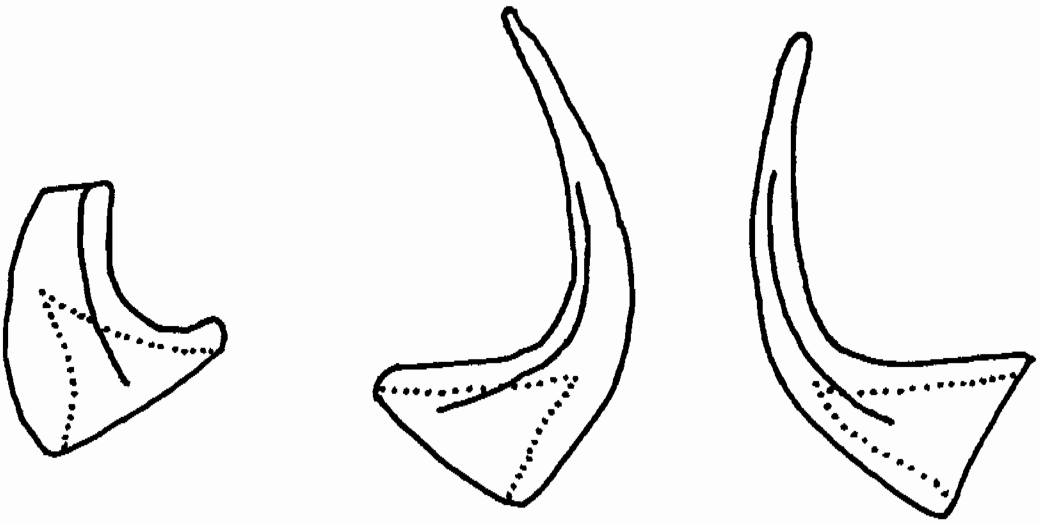
Remarks: Webers (1966) noted that elements which he referred to *Distacodus variabilis* Webers were remarkably similar to those of *Acodus mutatus* (Branson and Mehl). Carnes (1975, p. 105) suggested that elements assigned to "*Acodus*" *mutatus* and "*Acodus*" *variabilis* are similar in morphology and elemental composition and are probably congeneric. Carnes further suggested that both species had acodiform, acontiodiform (distacodiform), and perhaps oistodiform elements. I agree with Carnes that the acodiform and acontiodiform elements of his "*Acodus*" *mutatus* and "*Acodus*" *variabilis* are similar morphologically. However, I believe that the former species has been proven to contain no oistodiform elements and should therefore be assigned to the genus *Dapsilodus* Cooper (see remarks for *D. mutatus* in the present study).

Dzik (1976, p. 403, 435) suggested that elements of *Distacodus variabilis* Webers and of *Oistodus pseudoabundans* Schopf might belong in a single multielement apparatus which he referred to as *Paltodus semisymmetricus* (Hamar). He remarked that the evidence for this reconstruction is weak. The similar occurrences of these species in the present study indicate that Dzik's reconstruction may be correct, but since my evidence is also weak, I have described "*A.*" *variabilis* and "*O.*" *pseudoabundans* separately.

I have encountered two major problems involved with reconstructing the apparatus of "*A.*" *variabilis*. First, several similar species whose acodiform elements resemble those of "*A.*" *variabilis* have been described, including *Paltodus inconstans* Lindström, *Acodus similaris* Rhodes, and *Dapsilodus mutatus* (Branson and Mehl). Second, the oistodiform element which I refer to as "*O.*" *pseudoabundans* resembles the oistodiform element of *Phragmodus undatus*

Branson and Mehl. The oistodiform element in my study does not belong to *P. undatus*, as evidenced by the lack of associated elements of that species. Elements of "*O*." *psuedoabundans* with a short cusp and a sinuous base may also be confused with elements of "*O*." *venustus* Stauffer. I believe that Palmieri (1978), for example, combined elements of "*O*." *psuedoabundans* and "*O*." *venustus* and referred to them collectively as *Oistodus* spp. s.f. It is therefore difficult to assess the significance of the numerical ratios of oistodiform elements to acodiform and acontiodiform elements of "*Acodus*" in the conodont literature.

I am able to distinguish between elements of "*A*." *variabilis* and *D. mutatus* on the basis of the placement of costae on the acontiodiform elements. The costa on the outer lateral surface of *D. mutatus* is close to the posterior margin and extends nearly to the basal margin. The costa on the inner lateral side is generally equally close to the anterior and posterior margins and ends near the midheight of the base. Costae on the acontiodiform element of "*A*." *variabilis* are close to, and parallel to, the posterior edge of the cusp, but continue onto the base in a straight line and terminate midway betwen the anterior and posterior ends of the base close to the basal margin (see fig. 15). I believe that this characteristic, together with those described by Webers (1966), allow a more consistent separation of elements of "*A*." *variabilis* from



Either side
"*Acodus*" *variabilis*

Inner side Outer side
Dapsilodus *mutatus*

Figure 15. Acontiodiform elements of "*Acodus*" *variabilis* and *Dapsilodus* *mutatus*.

those of *D. mutatus* in the samples at hand. Furthermore, elements which I have assigned to "*A*." *variabilis* using this criterium lack striated surfaces which are nearly universally present on elements which I assign to *D. mutatus*. However, I am not certain that the placement of costae is truly significant taxonomically. Notably, elements which Serpagli (1967, Pl. 9, figs. 9-11) referred to as *Acontiodus procerus* (Ethington) have high, broad base like that characteristic of *D. mutatus* but have costae like those which I regard as characteristic of "*A*." *variabilis*. Serpagli's elements might belong to some sort of intermediate form, if one exists.

Occurrence: Within the present study area--Little Oak at Pelham, Pratt Ferry, and Ragland; and the Chickamauga Limestone at Red Mountain. Elsewhere in North America--The Hull Formation, Ottawa and Quebec (Uyeno, 1974); the Copenhagen Formation, Nevada (Ethington and Schumacher, 1969); the Crystal Peak Dolomite, Utah (Ethington and Clark, 1982); the Platteville Formation, Minnesota (Webers, 1966); the Platteville Formation, Wisconsin (Atkinson, *in* Clark, 1971); the Pierce, Ridley, Lebanon, and lower Carters Formations, Tennessee and the Platteville Formation in Iowa (Votaw, 1971); the Rockdell, Eidson, and Hogskin Formations in Tennessee (Carnes, 1975); and the Holston and Chota Formations, Tennessee (Bergstrom and Carnes, 1976). Also, a questionable occurrence of "*A*." *variabilis* has been reported from an outlier in the District of Keewatin, Canada (Bolton and Nowlan, 1979).

Collection: 141 specimens--99 acontiodiform (nongeniculate); 42 acodiform (geniculate).

Figured specimens: OSU 36201; OSU 36202.

Reference specimens; OSU 36203 (acontiodiform), OSU 36204 (acodiform).

Genus ACONTIODUS Pander, 1856

Acontiodus Pander, 1856, p. 28.

Type Species: *Acontiodus latus* Pander, 1856.

ACONTIODUS ROBUSTUS (Hadding, 1913)

(Pl. II, fig. 24)

Drepanodus robustus Hadding, 1913, p. 31, Pl. 1, fig. 1.

Acontiodus robustus (Hadding) Barnes and Poplawski, 1973, p. 768-769, Pl. 2, fig. 15 (synonomy to 1972); Landing, 1976, p. 629-630, Pl. 1, fig. 8.

Remarks: Nearly all of my elements of *A. robustus* are preserved with basal funnels.

Occurrence: Within the present study--Elements of *Acontiodus robustus* occur in the Lenoir Limestone and Athens Shale at Calera. Sweet and Bergström (1962) reported elements of *A. robustus* from the Pratt Ferry Formation at Pratt Ferry, but I have not found any at that locality. Elsewhere in North America--Representatives of *A. robustus* have also been reported from the Fort Peña Shale, Texas (Bradshaw, 1969); the Lévis Formation, Quebec (Uyeno and Barnes, 1970); the Mystic Conglomerate, Quebec (Barnes and Poplawski, 1973); and the Deep Kill Shale, New York (Landing, 1976).

Collection: 22 specimens (nongeniculate).

Figured specimen: OSU 36205.

Reference specimen: OSU 36206.

"ACONTIODUS" sp.

(not illustrated)

Description: The element of "Acontiodus" sp. is a smoothly curved, nonhyaline cone with a slightly proclined to erect cusp. The element is thin, flat, and somewhat laterally flexed. The cusp has a sharp anterior edge and no costae except for the posterolateral ones diagnostic of the genus. These costae are small but distinct. The base is wider than the cusp but is not distinctly set off from it. The basal cavity is not visible in my specimen.

Occurrence: An element of "Acontiodus" sp. has been found in the lower Little Oak Limestone at Pelham.

Collection: 1 specimen (nongeniculate).

Reference specimen: OSU 36207.

Genus APPALACHIGNATHUS Bergström, Carnes, Ethington, Votaw, and Wigley, 1974

Appalachignathus Bergström, Carnes, Ethington, Votaw, and Wigley, 1974, p. 227-228.

Type Species: *Appalachignathus delicatulus* Bergström, Carnes, Ethington, Votaw, and Wigley, 1974.

APPALACHIGNATHUS DELICATULUS Bergström, Carnes, Ethington, Votaw, and Wigley, 1974

(Pl. IV, figs. 19-22)

Appalachignathus delicatulus Bergström, Carnes, Ethington, Votaw, and Wigley, 1974, p. 228-234, Pl. 1, figs. 1-10, Text-figs. 1L-T, 2, 3 (synonomy to 1974), Tipnis et al., 1978, Pl. VI, figs. 5-10; Robison, 1981, Fig. 82, no. 19 a-j.

?*Appalachignathus* sp. Barnes, 1977, p. 105, Pl. 4, fig. 1; Repetski and Ethington, 1977, Pl. 2, fig. 13.

Remarks: Barnes (1977) and Repetski and Ethington (1977) reported elements of *Appalachignathus* but they did not assign them to *A. delicatulus* owing to their fragmentary nature. Because there is to date only one described species of *Appalachignathus*, I have questionably included both of these as occurrences of *A. delicatulus*.

Bergström et al. (1974) recognized eoligonodiniform, ozarkodiniform, spathognathiform, trichonodelliform and zygognathiform elements in the multielement species *A. delicatulus*. They noted that this apparatus is similar to that of *Ozarkodina* as described by Jeppson (1969) except that it lacks neoprioniodiform elements. Carnes (1975) reported neoprioniodiform elements with *A. delicatulus* and thereby amended the multielement description.

Elements of *A. delicatulus* from the present study include ozarkodiniform, spathognathiform, trichonodelliform, and eoligonodiniform elements.

Occurrence: Within the study area--Chickamauga at Red Mountain and Lenoir at Pratt Ferry. Occurrences elsewhere in North America are summarized by Bergström et al. (1974). Recently reported occurrences include the New Market Limestone, West Virginia and Maryland, Row Park Limestone, Maryland (Boger, 1976); the Tumbez, Elway-Eidson, Hogskin, Benbolt, and Marcem Formations in Tennessee (Carnes, 1975); the Esbataottine Formation, District of Mackenzie, Canada (Tipnis, et al., 1978); the Cobbs Arm Limestone, Newfoundland (Bergström, Riva, and Kay, 1974); and possibly the Bad Cache Rapids Formation, District of Franklin, and the Baillarge Formation, Somerset Island, Canada (Barnes, 1977); and the Womble Shale, Arkansas (Repetski and Ethington, 1977).

Carnes (1975) retracted the mistaken report of an occurrence of *A. delicatulus* in the Lincolnshire Formation, Tennessee, as reported by Bergström et al. (1974).

Collection: 30 specimens--27 spathognathodiform and ozarkodiniform, mostly fragments (segminate, Pa and Pb); 2 trichonodelliform (alate, Sa); 1 eoligonodiniform (bipenate?, S).

Figured specimens: OSU 36208, OSU 36209, OSU 36210, OSU 36211.

Reference specimens: OSU 36212 (spathognathodiform), OSU 36212 (trichonodelliform).

Genus BELODELLA Ethington, 1959

Belodella Ethington, 1959, p. 271-272.

Type Species: Belodus devonicus Stauffer, 1940.

BELODELLA n. sp. cf. B. DEVONICA (Stauffer, 1940)

(Pl. III, fig. 9)

aff. Belodus devonicus Stauffer, 1940, p. 240, Pl. 59, figs. 47, 48.

aff. Belodella devonica (Stauffer), Serpagli, 1967, p. 53-54, fig. 6.

Belodella sp. aff. B. devonica (Stauffer), Carnes, 1975, p. 115-116, Pl. III, fig. 3.

Description: The base is long, thin-walled, biconvex, and is surmounted by 11-12 small, discrete denticles of varying size. The basal cavity extends to the base of the proclined cusp. Each lateral face has an anterolateral carina which extends from the base of the cusp to the basal opening. The costae are best developed beneath the base and are somewhat weak near the basal opening. There are two types of elements in my collections. One is not bilaterally symmetrical in having one flat and one convex surface. The element is gently bowed towards the flattened side which has the more pronounced anterolateral costa. The other element is bilaterally symmetrical and has two flattened sides with equally strongly developed costae. Both of these variations are described by Carnes (1975) as part of a symmetry transition. As noted by Carnes (1975), elements of *Belodella* n. sp. aff. *B*. *devonica* (Stauffer) from the Holston Formation, Tennessee, have fewer and less slender denticles than *Belodella devonica* or *B*. *triangularis* (Stauffer). My elements differ from those of Stauffer in the same way.

Occurrence: Little Oak at Pelham and the Lenoir at Rockmart and Calera. Elsewhere in North America--Holston Formation, Tennessee (Carnes, 1975).

Collection: 6 specimens.

Figured specimen: OSU 36213.

Reference specimen: OSU 36214.

BELODELLA NEVADENSIS (Ethington and Schumacher, 1969)

(Pl. III, figs. 10-13)

Belodella nevadensis (Ethington and Schumacher), Harris et *al., 1979, Pl. 3*, figs. 10-13; Carnes, 1975, p. 111-113, Pl. IV, figs. 3-5, 10-13 (synonomy to 1974); *not* Bergström, 1978, Pl. 79, figs. 9, 10.

?*Belodella* sp. B s.f., Tipnis, et al., 1978, Pl. X, figs. 12, 13.

?*Belodella* n. sp. s.f. Barnes, 1977, P. 101, Pl. 2, figs. 5, 6.

Remarks: Carnes (1975) included triangular and biconvex elements with fine, hair-like denticles, oepikodiform elements with or without distinct denticulation, and oistodiform elements with an inflated base and a short cusp in the multielement species _Belodella_ _nevadensis_. Carnes reported finding belodelliform, oepikodiform and oistodontiform elements in numbers of 13, 35, and 34, respectively. Ethington and Schumacher (1969) reported 12 belodelliform, 24 oepikodiform, and 28 oistodiform elements. Residues from the present study contain 259 belodelliform, 331 oepikodiform, and 286 oistodiform elements. Carnes recognized both triangular and biconvex belodelliform elements but he did not report their abundances separately. Triangular and biconvex elements occur in the present study in more or less equal numbers. Based on these data, I believe that the apparatus of _B_. _nevadensis_ contains triangular belodelliform, biconvex belodelliform, oepikodiform, and oistodiform elements in a ratio of 1:1:2:2. Oistodiform elements in the present study are present in somewhat smaller numbers than are oepikodiform elements. This might indicate that the ratio of 1:1:2:2 is not correct. But owing to the smaller size and greater fragilty of the oistodiform elements, I believe that a greater number of them may have been lost through winnowing or laboratory processing. I suspect no other element of belonging to the apparatus of _B_. _nevadensis_ except for

Belodella? aff. *B*. *nevadensis* which is discussed elsewhere in the present study.

I have excluded the specimen illustrated by Bergström (1978) from the synonomy for *B*. *nevadensis* due to the different size of denticles on the belodelliform element. I am not certain as to the possible relation of such elements to *B*. *nevadensis* and have provisionally assigned them to *Belodella* sp.

Occurrence: Within the present study area--Lenoir at Calera; Little Oak at Pratt Ferry, Pelham, and Ragland; Chickamauga at Red Mountain. Also the Pratt Ferry Formation at Pratt Ferry (from Sweet and Bergström, 1962). Elsewhere in North America--Sunblood Formation, District of Mackenzie, Canada (Tipnis et al., 1978); Ship Point Formation, District of Franklin, Canada (Barnes, 1977); Antelope Valley Limestone, Eureka Quartzite, and Lehman Formation, Nevada (Harris et al., 1979); Womble Shale, Arkansas (Repetski and Ethington, 1977); Row Park Limestone, Maryland and West Virginia (Boger, 1976); and the Rockdell and Holston Formations, Tennessee (Carnes, 1975). Other occurrences are summarized by Carnes (1975).

Collection: 876 elements--331 oepikodiform (nongeniculate, P?); 286 oistodiform (geniculate, M?); 146 triangular belodelliform (Alate, Sa?); 113 biconvex belodelliform (asymmetrical ramiform, Sb and Sc?).

Figured specimens: OSU 36215, OSU 36216, OSU 36217, OSU

36218.

Reference specimens: OSU 36219 (oepikodiform), OSU 36220 (oistodiform), OSU 36221 (triangular belodelliform), OSU 36222 (biconvex belodelliform).

BELODELLA? sp. aff. B. NEVADENSIS (Ethington and Schumacher, 1969)

(Pl. III, fig. 19)

New Genus B, Ethington and Schumacher, 1969, p. 479, Pl. 67, fig. 18, Text-fig. 4H.

Remarks: A description of this element was given by Ethington and Schumacher (1969) and there is no need to repeat it here. Ethington and Schumacher observed that denticulation and basal-cavity morphology of this element resemble that of *Oepikodus* aff. *O. copenhagensis* Ethington and Schumacher which is the biconvex belodelliform element of the multielement species *B. nevadensis*. Owing to the small number of elements of *Belodella*? sp. aff. *B. nevadensis* collected by Ethington and Schumacher, they did not assign it formally to a named genus.

Specimens of *Belodella*? sp. aff. *B. nevadensis* are always associated with those of *B. nevadensis* in my samples and this is also the case in residues from the Lenoir Limestone, Tennessee, provided by Stig Bergström, and in the type area of *B. nevadensis* (Ethington and Schumacher, 1969). I therefore believe that further study will prove

Belodella? aff. B. nevadensis to be an element of B. nevadensis.

Occurrence: Within the present study area--Little Oak at Pelham, Pratt Ferry, and Ragland; Chickamauga at Red Mountain. Also in the Pratt Ferry Formation at Pratt Ferry (Sweet and Bergström, 1962). Elsewhere in North America--Lenoir Limestone, Tennessee (from samples provided by S. Bergström); and the Copenhagen Formation, Nevada (Ethington and Schumacher, 1969).

Collection: 12 specimens.

Figured specimen: OSU 36223.

Reference specimen: OSU 36224.

BELODELLA sp.

(Pl. III, figs. 14,15)

Belodella erecta (Rhodes and Dinely), Serpagli, 1967, p. 54-55, Pl. 11, Text-fig. 6a-c; Löfgren, 1978, Text-fig. 24-H1, H2 (figure from Serpagli, 1967); not Rhodes and Dinely, 1957, p. 359, Pl. 38, fig. 8.

Belodella sp. A, Tipnis, et al., 1978, Pl. VI, fig. 12.

Belodella nevadensis (Ethington and Schumacher), Bergström, 1978, Pl. 79, fig. 9, not Pl. 79, fig. 10.

Belodella n. sp. A Bergström, 1971a, p. 118, fig. 10; Bergström, 1973c, p. 269-280, figs. 3, 4, 6.

Remarks: Belodella sp. has elements which resemble the belodelliform elements of B. nevadensis (Ethington and Schumacher) except that they have alternating large and small denticles. Both triangular and biconvex belodelliform elements are present.

Carnes (1975) described *Belodella* sp. as having associated oepikodiform and oistodiform elements. He also included in *Belodella* sp. elements with coarse, equal-sized, discrete denticles. However, all of the coarsely-denticulated elements of *Belodella* from the present study show a distinct alternation in denticle size. Moreover, I am unable to distinguish oistodiform and oepikodiform elements of *Belodella* sp. as distinct from those of *B. nevadensis*. Carnes remarked that elements of *Belodella* sp. are typically more robust than those of *B. nevadensis*. However, elements of *Belodella* sp. are typically more graceful than those of *B. nevadensis* in samples from the present study and from the Lenoir Limestone at Saint Clair, Tennessee, generously loaned to me by Stig Bergström.

Boger (1976) found elements of *Belodella* sp. in the Row Park Limestone in West Virginia and Maryland. She reported only belodelliform elements. Although she did not comment on the alternating character of denticle size, the only figure from Carnes (1975) that she accepted in her synonomy had alternating denticles of different sizes.

Although the original description of *Bellodella erecta* (Rhodes and Dinely, 1967) lacks elements whose denticles alternate in size, Serpagli's (1967) species of the same name has this characteristic. Bergström's (1978) illustration of _Belodella_ sp. was labeled as "_Belodella nevadensis_" with which it is usually associated. However, because the former species is often not present in large populations of _B. nevadensis_, I believe that _Belodella_ sp. may be a variant form of, if not a separate species, from _B. nevadensis_.

Occurrence: Within the present study area--Lenoir at Calera; Little Oak at Pelham and Pratt Ferry. Elsewhere in North America--Esbataottine Formation, District of Mackenzie, Canada (Tipnis et al., 1978); Woods Hollow Shale, Texas (Bergström, 1978); and the Row Park Limestone, West Virginia and Maryland (Boger, 1976). Other occurrences are summarized by Carnes (1975).

Collection: 21 specimens--16 triangular belodelliform (symmetrical ramiform, Sa?); 5 biconvex belodelliform (asymmetrical ramiform, Sb and Sc?).

Figured specimens: OSU 36225, OSU 36226.

Reference specimens: OSU 36227 (triangular belodelliform), OSU 36228 (biconvex belodelliform).

Genus BELODINA Ethington, 1959
emend. Sweet, 1979b

Belodina Ethington, 1959, p. 271.

Eobelodina Sweet, Turco, Warner, and Wilkie, 1959, p. 1050.

Type Species: _Belodus compressus_ Branson and Mehl, 1933.

BELODINA sp. cf. B. COMPRESSA (BRANSON AND MEHL, 1933)

(Pl. III, fig. 8)

Belodus compressus n. sp. Branson nd Mehl, 1933, p. 114, Pl. 9, figs. 15, 16.

Belodina compressa (Branson and Mehl), Webers, 1966, p. 24-25, Pl. 6, figs. 2, 6, 7, 13, 15; Votaw, 1971, p. 64-66, Pl. 3, figs. 36, 40, 41; Uyeno, 1974, p. 15, Pl. 1, figs. 10-13; Harris et al., 1979, Pl. 5, fig. 7; Sweet, in Ziegler, 1981, p. 65-69, Pl. 2 (includes partial synonomy). Robison, 1981, Fig. 88, no. 6a-c.

Remarks: Bergström and Sweet (1966) observed that juvenile elements of B. compressa may have 6 or 7 small, proclined denticles and thus resemble Belodina dispansa (Glenister). Ethington and Schumacher (1969) observed the same "dispansiform" condition in belodiniform elements of B. monitorensis Ethington and Schumacher. A small number of dispansiform elements of Belodina occur in my collections, but I am not certain to which species they belong. These elements occur within the stratigraphic range of both B. compressa and B. monitorensis. Because some of the elements from the Pelham section have as many as 8 denticles and represent rather extreme cases of the dispansiform condition, I suspect that they are juvenile elements of B. compressa, whose elements characteristically have more denticles than those of B. monitorensis. In one of my samples (80MS7-25), four dispansiform elements occur with one typical grandiform element of B. monitorensis.

Drahovzal and Neathery (1971) reported occurrences of B. compressa and Polyplacognathus sweeti Bergström from the

Little Oak at Ragland. On this basis, they believed the Little Oak at Ragland to be of Porterfieldian age. In the present study, the Little Oak at Ragland has produced typical elements of *B. monitorensis*. It is possible that Drahovzal and Neathery mistook elements of *B. monitorensis* (which was at that time a newly-named species) for *B. compressa*. In any case, the occurrence of *B. monitorensis* with early forms of *Pygodus anserinus* in my collections suggests that the Little Oak at Ragland is of very early Porterfieldian or latest Chazyan age, in the scheme used by Drahovzal and Neathery (1971).

Occurrence: Within the study area--Little Oak at Pelham. Occurrences elsewhere in North America are discussed by Sweet (*in* Ziegler, 1981). Other North American occurrences include the Hanson Creek Formation, Nevada (Harris et al., 1979); and the Maravillas Formation, Texas (Bergström, 1978).

Collection: 4 specimens (rastrate, P?).

Figured specimen: OSU 36229.

Reference specimen: OSU 36230.

BELODINA MONITORENSIS Ethington and Schumacher, 1969
emend. Sweet, 1981
(Pl. III, figs. 16-18)

Belodina monitorensis Ethington and Schumacher, 1969, p. 455-456; Sweet, *in* Ziegler, 1981, p. 79-84, Pl. 1, figs. 10, 11, Pl. 2, figs. 5-7; Bergström, 1978, Pl. 79, figs. 18, 19; Repetski and Ethington, 1977, Pl. 2, fig. 23.

Belodina cf. *B. monitorensis marginata* Ethington and Schumacher, *Tipnis et al., 1978, Pl.* IX, fig. 14.

"*Belodina*" *monitorensis monitorensis* Ethington and Schumacher, Tipnis, *1978, Pl. 13*.1, fig. 11.

Belodina sp. cf. *B. inornata* (Branson and Mehl), Bergström and Sweet, 1966, *p. 315*-317, Pl. 32, figs. 6-8.

Occurrence: Within the study area--Elements of *B. monitorensis* occur in the Lenoir Limestone at Calera; the Little Oak Limestone at Ragland, Pratt Ferry, and Pelham; the lower Chickamauga at Red Mountain; and the Pratt Ferry Formation at Pratt Ferry. Occurrences elsewhere in North America are summarized by Sweet (*in* Ziegler, 1981).

Collection : 228 specimens--84 grandiform (rastrate, P?); 80 compressiform (rastrate, P?); 64 eobelodiniform (geniculate. Sc?).

Figured specimens: OSU 36231, OSU 36232, OSU 36233.

Reference specimens: OSU 36234 (compressiform), OSU 36235 (grandiform), OSU 36236 (eobelodiniform).

Genus BRYANTODINA Stauffer, 1935a

Bryantodina Stauffer, 1935a, p. 131.

Type Species: *Bryantodina typicalis* Stauffer, 1935a.

"BRYANTODINA" sp.

(Pl. V, fig. 5)

Description: The element of "Bryantodina" sp. is a moderately asymmetrical, slightly arched blade. The base isrobust, dark in color, and is surmounted 9 erect to somewhat reclined denticles. The denticles are white, apically pointed, laterally compressed, and discrete. The slitlike basal cavity extends beneath the entire length of the blade and is open towards the blade's concave side. The largest denticle (cusp?) is situated above the blade's point of greatest arching and the basal cavity's point of greatest width. The basal cavity does not deepen beneath the largest denticle.

Remarks: One complete and two broken elements of "Bryantodina" sp. occur in my collections. These elements are morphologically similar to elements of "Ozarkodina" sp. may belong to the same multielement species. However, elements of "Bryantodina" sp. occur 50 feet stratigraphically above elements of "Ozarkodina" sp. Furthermore, each of the species is represented by only a few elements. Therefore, I have assigned these elements to their respective form genera.

Occurrence: Three elements of "Bryantodina" sp. occur in a sample from the lower member of the Pond Spring Formation, Chickamauga.

Collection: 3 specimens (carminate).

Figured specimen: OSU 36237.

Reference specimen: OSU 36238.

Genus COELOCERODONTUS Ethington, 1959

Coelocerondontus Ethington, 1959, p. 273.

Type Species: Coelocerodontus trigonius Ethington, 1959.

COELOCERODONTUS? DIGONIUS Sweet and Bergström, 1962

(Pl. II, fig. 3)

Coelcerodontus digonius Sweet and Bergström, 1962, p. 1224, Pl. 168, fig. 1, Text-fig. 1F; Raring, 1972, p. 70-71, Pl. 3, fig. 11.

?Prooneotodus tenuis s. f. Müller, Tipnis et al., 1978, Pl. I, fig. 6.

?Herzina? sp. s. f. Tipnis et al., 1978, Pl. I, fig. 16.

not Coelocerodontus digonius Sweet and Bergström, Hamar, 1964, p. 261, Pl. 2, fig. 13; Oberg, 1966, p. 137, Pl. 16, figs. 5, 6; Seddon, 1970, Pl. 2, fig. 5.

not Coelocerodontus sp. cf. C. digonius Sweet and Bergström, Winder, 1966, p. 55, Pl. 9, fig. 1, Text-fig. 3-1.

Description: A simple, hollow cone with a smoothly curved, proclined cusp. Lateral curvature slight or absent. The element has a longitudinal furrow on one side that runs parallel to the posterior edge along the entire length. The other side (referred to hereafter as the unfurrowed side) has a shallow groove near the posterior edge that extends about one quarter of the distance from the basal opening, and is conspicuous only on larger specimens.

The posterior edge of the longer furrow may meet the posterior surface of the cone to form a subangular edge. However, the posterior edge is not keeled and appears to be rounded when viewed from the unfurrowed side. Anterior edge rounded. Length to width ratio as great as 7:1 in well-preserved specimens. Apparently, no other element occurs in the apparatus.

Remarks: Sweet and Bergström (1962) found a single element of *Coelocerodontus digonius* at Pratt Ferry and described it as having anterior and posterior keels. However, none of the elements of *C*.? *digonius* found in the present stuidy, including those from Pratt Ferry, have anterior keels. The posterior edge may appear to be keeled when vieweed from the furrowed side, but I do not regard this as a true keel. All of the elements at hand are nearly transparent. As a result, the anterior and posterior surfaces of the wall, as viewed through the lateral surface, may appear to be keels. I have found no element of *Coelocerodontus* from Pratt Ferry with anterior or posterior keels like those described by Sweet and Bergström, but all of my elements appear to match their illustration (Pl. 168, fig. 1 and Text-fig. 1F, exclusive of cross section). Although I am unable to examine the type specimen of *C. digonius*, Bergström (pers. comm., 1982) believes that it is conspecific with the elements described herein.

Considerable confusion has resulted from what I believe to be differences between the type specimen and the description of *C. digonius* given by Sweet and Bergström. Several authors (Hamar, 1964; Oberg, 1966; Winder, 1966; and Seddon, 1970) assigned, at least tentatively, keeled elements of *Coelocerodontus* to *C. digonius* which match the original description, but not the illustration of *C. digonius* in Sweet and Bergström (1962). I have assigned these keeled elements to *Coelocerodontus lacrimosus* Kennedy, Barnes, and Uyeno. The element of *C.*? *digonius* may be distinguished from that of *C. lacrimosus* by its furrowed lateral surface, greater length to width ratio, and its unflared base.

Elements of *C.*? *digonius* differ from those of *Herzina bisulcata* Müller (1959) in that they are furrowed on one, rather than both, sides.

The longitudinal furrow on one side of *C.*? *digonius* suggests to me that it may be a panderodid. However, the genus *Panderodus* has, in the reconstruction of Bergström and Sweet (1966), at least two types of elements. I cannnot distinguish more than a single type of element in *C.*? *digonius*. Furthermore, my elements lack the basal striae characteristic of *Panderodus*.

Elements of *C.*? *digonius* occur with both Midcontinent and North Atlantic conodonts, but they are most abundant in the uppermost sample at Ragland (80MS9-1) where the remaining fauna is dominated by *Panderodus gracilis*, *Belodina monitorensis*, and *Belodella nevandensis*. I have found *Coelocerodontus lacrimosus* only at Calera, where it occurs in association with *Pygodus serra*, *Periodon aculeatus*, and *Eoplacognathus* sp. cf. *E. reclinatus*. Therefore, I believe that *C.*? *digonius* belongs to the Midcontinent province (Sweet et al., 1959) and *C. lacrimosus* belongs to the North Atlantic province. (See Bergström, 1973a and Sweet and Bergström, 1974 for a more recent discussion of conodont provinces). This difference in occurrences further strengthens my suspicion that these species may not be congeneric.

Occurrence: Within the present study--Elements of *Coelocerodontus digonius* have been found in the Little Oak Limestone at Pelham and Ragland, the Lenoir and Pratt Ferry Formations at Pratt Ferry, and the Lenoir Limestone at Calera. Elsewhere in North America--Elements of *C. digonius* have also been reported from the Valcour and Crown Point Formations in Vermont and New York (Raring, 1973). Questionable occurrences of *C. digionius* have been reported from the Rabbitkettle Formation in the District of Mackenzie, Canada (Tipnis et al., 1978).

Collection: 82 specimens (nongeniculate).

Figured specimen: OSU 36239.

Reference specimen: OSU 36240.

COELOCERODONTUS LACRIMOSUS Kennedy, Barnes and Uyeno, 1979

(Pl. II, figs. 5, 6)

Coelocerodontus? lacrimosus Kennedy, Barnes, and Uyeno, 1979, p. 540-541, Pl. 1, figs. 20, 23; Nowlan, 1981, p. 11, Pl. 5, fig. 12.

Coelocerodontus digonius Sweet and Bergström, Hamar, 1964, p. 261, Pl. 2, fig. 13; Oberg, 1966, Pl. 16, fig. 5, ?Pl 16, fig. 6; Seddon, 1970, Pl. 2, fig. 5.

Coelocerodontus sp. cf. *C. digonius* Sweet and Bergström, Winder, 1966, p. 55, Pl. 9, fig. 1, Text-fig. 3-1.

?*Coelocerodontus variabilis* Van Wamel, 1974, p. 57-58, Pl. 1, figs. 4A, B, *not* fig. 3A, B.

Description: This species contains two elements which are in symmetry transition.

The asymmetrical element is smoothly curved, hollow, and has a proclined to suberect cusp. The inner lateral face is somewhat concave, the outer face is convex. The anterior edge is angular to keeled. The element is widest anterolaterally.

The symmetrical element is also smoothly curved, hollow, and has a proclined to suberect cusp. Both lateral faces are convex. The anterior edge is rounded, the posterior edge is subrounded.

Length to width ratio for both elements is typically 3:1.

Remarks: Two of the illustrations (Pl. 1, figs. 4A, B) of *Coelocerodontus variabilis* Van Wamel (1974) are nearly identical to elements assigned herein to *C. lacrimosus*.

These elements differ from those in the present study only in being somewhat less curved. The other elements illustrated by Van Wamel (Pl. 1, figs. 3A, B) are distinctly shorter than any from the present study and are probably not conspecific with them.

Sweet and Bergström (1962) named *Coelocerodontus digonius* and described it as an element with anterior and posterior keels. However, I believe that the element which they described lacks keels (see the discussion on *C*.? *digonius* in the present study). Subsequenty, Hamar (1964); Winder (1966); Oberg (1966); and Seddon (1970) have assigned keeled elements to *C*. *digonius* which match Sweet and Bergström's description of that species but which are not the same as the type specimen of that species. Elements of *C*. *lacrimosus* differ from those of *C*. *digonius* in that they are far shorter, wider, and more rapidly tapering, they lack a posterolateral groove, they have a posterior keel and, in some cases, a subangular anterior edge, and they are more strongly laterally deflected (refers only to the asymmetrical element).

Webers (1966) suggested that *Coelocerodontus* *trigonius* Ethington includes trigoniform and tetragoniform elements. As discussed elsewhere in the present study, elements of *C*. *trigonius* are common at Calera, but tetragoniform elements are absent. *C*. *lacrimosus* is associated with *C*. *trigonius* at Calera and may represent a variation of the tetragoniform element. However, I doubt that this is the case, as neither Winder (1966) and Kennedy et al. (1979), nor Nowlan (1981) reported elements of *C. trigonius* from samples containing elements referable to *C. lacrimosus*.

Occurrence: Within the present study area-- elements of *Coelocerodontus lacrimosus* occur in the Lenoir Limestone at Calera. Elsewhere in North America--elements of *C. lacrimosus* have also been reported from the Tetagouche Group, New Brunswick (Kennedy et al., 1979); and the Cobourg Formation, Ontario (Winder, 1966). Seddon (1970) reported *C. lacrimosus* and other reworked conodonts of Ordovician age in the Pillar Bluff Limestone, Texas.

Collection: 24 specimens--87 symmetrical (nongeniculate); 16 asymmetrical (nongeniculate).

Figured specimens: OSU 36241.

Reference specimens: OSU 36242 (symmetrical), OSU 36243 (asymmetrical).

COELOCERODONTUS? sp. cf. C. TRIGONIUS Ethington, 1959

(Pl. II, fig. 12)

Coelocerodontus trigonius Ethington, 1959, p. 273, Pl. 39, fig. 14; Hamar, 1964, p. 261, Pl. 2, fig. 15, Text-fig. 4, no. 10; Schopf, 1966, P. 45, Pl. 5, fig. 8; Winder, 1966, Pl. 9, fig. 14; Webers, 1966, p. 25, Pl. 2, figs. 13a, b, *not* Pl. 2, figs. 12, 14; Globensky and Jauffred, 1971, p. 54, Pl. II, fig. 2.

Remarks: Elements of *Coelocerodontus*? sp. cf. *C. trigonius* are identical morphologically to those of *C.*

trigonius as described by Ethington (1959). However, Webers (1966, p. 25) considered the species *C*. *trigonius* to be a multielement species which also included elements previously referred to as *C*. *tetragonius* Ethington. My samples from Calera contain 66 elements of *C*.? sp. cf. *C*. *trigonius* but no elements of the *C*. *tetragonius* type. It is possible that the 19 elements which I assigned to *Coelocerodontus lacrimosus* Kennedy, Barnes, and Uyeno are variant forms of the tetragoniform elements in the apparatus which Webers described. However, as discussed elsewhere in the present study (see *C*. *lacrimosus*), elements of *C*. *lacrimosus* and the similar species, *C*. *variabilis* Van Wamel have been reported in several studies in which elements of *C*. *trigonius* are absent. Because trigoniform and tetragoniform elements of *Coelocerodontus* occur together in a number of stratigraphic units (Ethington, 1959; Webers, 1966; Schopf, 1966; Winder, 1966) and because they are strikingly similar morphologically, I believe that Webers' reconstruction is correct. If this is so, elements here referred to as *C*.? sp. cf. *C*. *trigonius* are not conspecific with those which Ethington called *C*. *trigonius*. My trigoniform elements might, in fact, belong to a separate multielement genus.

Occurrence: Within the present study--Elements of *C*.? sp. cf. *C*. *trigonius* occur in the Lenoir and Athens at Calera. Elsewhere in North America--Elements of *C*. *trigonius* (but possibly not conspecific with *C*.? sp. cf. *C*.

trigonius) have been reported from the Cobourg Formation, Ontario (Winder, 1966); the Saint Casimir Limestone, Quebec (Globensky and Jauffred, 1971); the Galena Formation, Missouri (Ethington, 1959); the Platteville Formation, Minnesota (Webers, 1966); and the Trenton Group, New York and Ontario (Schopf, 1966).

Collection: 120 specimens (nongeniculate).

Figured specimen: OSU 36244.

Reference specimen: OSU 36245.

Genus CORDYLODUS Pander, 1856

Cordylodus Pander, 1856, p. 33.

Type Species: Cordylodus angulatus Pander, 1856.

CORDYLODUS? sp.

(Pl. II, fig. 2)

Remarks: Three broken elements of Cordylodus? sp. occur in the residues from the Lenoir Limestone at Rockmart. Owing to the scarcity and the poor preservation of the elements, their specific assignment is indeterminable. They might, in fact, be cordylodiform elements of a genus other than Cordylodus, possibly Multioistodus Cullison.

Collection: 3 specimens.

Figured specimen: OSU 36246.

Reference specimen: OSU 36247.

Genus CURTOGNATHUS Branson and Mehl, 1933

Curtognathus Branson and Mehl, 1933, p. 87.

Type Species: Curtognathus typus Branson and Mehl, 1933, p. 87.

Remarks: Sweet and Bergström (1972) suggested that elements assigned to Curtognathus, Cardiodella, Polycaulodus, and Trucherognathus might belong together in a single multielement genus. This association has been recognized by several authors (Votaw, 1971; Carnes, 1975; and Boger, 1976) and it also occurs in my collections. Votaw (1971) included erismodiform and microcoelodiform elements in some species of Curtognathus. However, none of the other above-mentioned authors included erismodiform or microcoelodiform elements in Curtognathus nor do I in the present study.

CURTOGNATHUS sp. cf. C. TYPUS Branson and Mehl, 1933

(Pl. I, figs. 21-14)

cf. Curtognathus typus Branson and Mehl, Votaw, 1971, p. 76-85, Pl. I, fig. 16, 20-22, 24, 25, Text-figs. 9A, D, E-K, not Pl. 1, figs. 23, 26, Text figs. 9B, C (synonomy to 1971); Boger, 1976, p. 70-72, Pl. V, figs. 6-9.

?Curtognathus sp., Repetski and Ethington, 1977, Pl. 1, fig. 21.

?Cardiodella sp., Repetski and Ethington, 1977, Pl. 1, fig. 25.

Remarks: Elements of Curtognathus sp. and Cardiodella sp. of Repetski and Ethington, 1977, resemble elements here referred to as *C.* sp. cf. *C. typus* and they are associated with trucherognathiform and polycaulodiform elements which they did not illustrate. I do not hesitate to assign these to the multielement genus *Curtognathus* but I am not certain as to their specific assignment.

Occurrence: Within the present study area--Pond Spring and Murfreesboro Formations, Chickamauga and the lower part of the Chickamauga Limestone, Red Mountain. Elsewhere in North America--Summarized by Boger (1976). Other occurrences include the Esbataottine and Sunblood Formations, District of Mackenzie, Canada (Tipnis et al., 1978); and the Womble Shale, Arkansas (Repetski and Ethington, 1977).

Collection: 589 specimens--27 curtognathiform, 28 cardiodelliform, 305 polycaulodiform, 229 trucherognathiform.

Figured specimens: OSU 36248, OSU 36249; OSU 36250; OSU 36251.

Reference specimens: OSU 36252 (curtognathiform), OSU 36253 (cardiodelliform), OSU 36254 (polycaulodiform), OSU 36255 (trucherognathiform).

Genus DAPSILODUS Cooper, 1976

Dapsilodus Cooper, 1976, p. 211.

Type Species: *Distacodus obliquicostatus* Branson and Mehl, 1933.

Remarks: I have assigned only one species from my collections to the genus *Dapsilodus* Cooper. This species, *D. mutatus* (Branson and Mehl), has elements which resemble those of "*Acodus*" *variabilis* Webers and is often considered to be congeneric with it. I believe that these two species are not conspecific and refer the reader to the remarks for genus *Acodus* for a discussion of the matter.

DAPSILODUS MUTATUS (Branson and Mehl, 1933)

(Pl. II, figs. 22, 23)

Belodus (?) *mutatus* Branson and Mehl, 1933, p. 126, Pl. 10, fig. 17.

"*Acodus*" *mutatus* (Branson and Mehl) Carnes, 1975, p. 103-104, Pl. II, figs. 13, 14; Sweet, Thompson, and Satterfield, 1975, Pl. 1, fig. 14.

Acodus? *mutatus* (Branson and Mehl) Löfgren, 1978, p. 44-46, Pl. 2, figs. 9-21, Text-fig. 23 (synonomy to 1976).

?*Acodus* cf. *A. numaltipes* s.f. Schopf, Tipnis et al., 1978, Pl. VII, fig. 20.

not *Acodus* *mutatus* (Branson and Mehl) Votaw, 1971, p. 52-54, Pl. 3, figs. 1-3, figs. 1-3, Text-fig. 4A-C; Palmieri, 1978, p. 6-7, Pl. 2, figs. 17-19.

Remarks: Barnes and Poplawski (1973, p. 779) suggested that elements referred to *Oistodus* *venustus* Stauffer might belong to the same multielement species as *Acodus* *mutatus* sensu Branson and Mehl. Several subsequent authors (Carnes, 1975; Cooper, 1976; Sweet, 1979a; and McCracken and Barnes, 1981) agreed, at least tentatively, with this reconstruction. However, Löfgren (1978) reported more than

2500 elements assignable to *D*. *mutatus*, and she proved numerically (p. 45) that there is no relationship between the number of elements of *D*. *mutatus* and those of "*O*." *venustus* within a given sample. In the present study, samples from the upper 12 feet of the Lenoir at Calera contain 191 elements of *D*. *mutatus* and only 2 elements of "*O*." sp. cf. "*O*." *venustus*. The petrology of the rocks in the Calera section (described elsewhere in this study), and the ubiquitous preservation of basal fillings in elements of *Dapsilodus* and *Protopanderodus*, indicate that little or no sorting of elements occurred. I believe that elements referred to as *Oistodus* *venustus* are not part of the same apparatus as those of *Dapsilodus* *mutatus*.

McCracken and Barnes (1981) reported elements from the Ellis Bay Formation, Quebec, which are similar to those of *D*. *mutatus*. They referred them to *Paroistodus*? *mutatus* (Branson and Mehl) and included an oistodiform element in the apparatus. However, the acontiodiform element more nearly resembles that of "*Acodus*" *variabilis* Webers, and as previously discussed, cannot belong to *D*. *mutatus* if it is conspecific with an oistodiform element. Similarly, elements which Palmieri (1978) assigned to *Acodus* *mutatus* resemble elements of "*Acodus*" *variabilis* in having a low, wide base which is strongly developed posteriorly. Notably, these elements occur with elements of "*Oistodus*" *pseudoabundans*.

Occurrence: Within the study area--Representatives of *D. mutatus* occur in the upper part of the Lenoir at Calera. Elsewhere in North America--*D. mutatus* has also been reported from the Whittaker Formation, District of Mackenzie, Canada (Tipnis et al., 1978); the Vauréal Formation, Anticosti Island, Quebec (Nowlan and Barnes, 1981); the Cobbs Arm Limestone, Newfoundland (Bergström et al., 1974); the Davidsville Group, Newfoundland (Stouge, 1980); the Tetagouche Group, New Brunswick (Kennedy et al., 1979); the Maravillas Formation, Texas (Bergström, 1978); the Galena Dolomite, Iowa (Ethington, 1959); the Thebes Formation, Missouri (Branson and Mehl, 1933); the Cape and Maquoketa Formations, Missouri (Sweet et al., 1975); the Trenton Group in New York and Ontario (Schopf, 1966); the Lexington and Kope Formations, Ohio and Kentucky (Bergström and Sweet, 1966); the Tumbez and Elway-Eidson in Tennessee (Carnes, 1975); and the Holston, Lenoir, Chota, and Sevier Formations in Tennessee (Bergström and Carnes, 1976).

Collection: 312 specimens--233 acontiodiform (nongeniculate); 219 acodiform (geniculate). (nongeniculate).

Figured specimens: OSU 36256; OSU 36257.

Reference specimens: OSU 36258 (acontiodiform), OSU 36259 (acodiform).

Genus DREPANOISTODUS Lindström, 1971

Drepanoistodus Lindström, 1971, p. 42.

Type Species: *Oistodus forceps* Lindström, 1955.

DREPANOISTODUS SUBERECTUS (Branson and Mehl, 1933)

(Pl. I, figs. 3-5)

Oistodus suberectus Branson and Mehl, 1933, p. 111, Pl. 9, fig. 7.

Drepanoistodus suberectus (Branson and Mehl) Carnes, 1975, p. 129-132, Pl. II, figs. 1-5, Text-fig. 16A-C (synonomy to 1974); Barnes, 1977, p. 106, Pl. 3, figs. 18-20 (synonomy to 1971); Votaw, 1978, p. 20-21, Pl. 5, figs. 14-13, Pl. 6, figs. 1a-6b; Tipnis et al., 1978, Pl. I, figs. 25-27; Bolton and Nowlan, 1979, p. 18, Pl. 7, figs. 11, 15, 16; Sweet, 1979b, fig. 7, nos. 21, 23, 30; Nowlan and Barnes, 1981, p. 77, Pl. 3, figs. 1-6 (synonomy to 1978).

?*Drepanoistodus*? cf. *D*. *venustus* (Stauffer) Nowlan, 1981, p. 11, Pl. 3, fig. 7, not Pl. 3, fig. 17, Pl. 1, fig. 13.

Remarks: The apparatus of *Drepanoistodus suberectus* (Branson and Mehl) contains suberectiform, inclinatiform, and homocurvatiform elements according to the reconstructions of Bergström and Sweet (1966) and Lindström (1971). Variations in the elements of *D*. *suberectus* have been discussed by these authors and by Carnes (1975).

Löfgren (1978, p. 57) suggested that oistodiform elements which she referred to as *Drepanoistodus*? cf. *D*.? *venustus* (Stauffer) might be associated with other types of elements (presumably drepanodiform ones) in the apparatus of a distinct species. Nowlan (1981) tentatively included oistodiform elements referable to *O. venustus* Stauffer with homocurvatiform elements in the multielement species *Drepanoistodus*? cf. *D.*? *venustus* (Stauffer). Although *D. suberectus* and "*O.*" *venustus* are associated in many samples in the present study, their cooccurrence is not so regular as to suggest to me that they belong to the same apparatus. Further complicating matters is the possiblity that all elements which resemble "*O.*" *venustus* may not belong to the same species. Some may be associated with drepanodiform elements while others may not. "*Oistodus* sp. cf. "*O.*" *venustus* is described as a separate species elsewhere in this study.

Occurrence: Elements of *D. suberectus* occur in all of the units studied except for the Lenoir Limestone at Portland. They are extremely common in rocks of Ordovician age in the Midcontinent and North Atlantic Provinces.

Collection: 350 specimens--44 suberectiform (nongeniculate); 219 homocurvatiform (nongeniculate); 87 oistodiform (geniculate).

Figured specimens: OSU 36260, OSU 362611, OSU 36262.

Reference specimens: OSU 36263 (suberectiform), OSU 36264 (homocurvatiform), OSU 36265 (oistodiform).

Genus EOPLACOGNATHUS HAMAR, 1966

emend. Bergström, 1971a

Eoplacognathus Hamar, 1966, p. 58.

Type Species: *Ambalodus lindstroemi* Hamar, 1964.

EOPLACOGNATHUS sp. cf. E. RECLINATUS Hamar, 1964

(Pl. V, figs. 6-9)

cf. *Eoplacognathus reclinatus* (Fåhraeus, 1966) Lindström, *in* Ziegler, 1977, p. 137-138, Pl. 2, figs. 1-3 (synonomy *to* 1974).

cf. *Eoplacognathus lindstroemi reclinatus* (Fåhraeus), Dzik, 1976, fig. 31 g-k.

Remarks: Most of the elements of *Eoplacognathus* in the present study occur at Calera. Elements of *Eoplacognathus* within a given sample show considerable ontogenetical variation. Elements at Calera resembling those of *E. foliaceus* or *E. suecicus* are probably juvenile specimens of *E. reclinatus*. Elements show no signs of reworking and are contained in thinly bedded rocks which were probably deposited in quiet water.

Bergström's (1971a) revised description of *Eoplacognathus reclinatus* describes the polyplacognathiform elements as having a straight anterior-posterior axis. He describes the same axis of the stratigraphically older *E. foliaceus* as being curved. Polyplacognathiform elements of *Eoplacognathus* in my collections range from straight to moderately strongly curved. Dzik (1976) observed that the inner lateral process of this element is directed posteriorly in early species of *Eoplacognathus*, anteriorly in late species of *Eoplacognathus*, and laterally in *E. reclinatus*. The inner lateral process of the placognathiform element from the present study diverges from the posterior process at an angle ranging from approximately 70° - 90°.

Lindström (*in* Ziegler, 1977) distinguished the dextral ambalodiform element of *E. reclinatus* on the basis of its Y-shape. That is, the anterior process is somewhat longer than the subequal anterior and lateral processes. The lateral process of *E. foliaceus* is somewhat smaller than the posterior process. All three processes of *E. suecicus* are approximately equal in length. Dextral ambalodiform elements of *Eoplacognathus* from my samples resemble those of *E. suecicus*, *E. foliaceus*, or *E. reclinatus*. The elements which resemble those of *E. suecicus*, the earliest of these three species, are distinctly smaller than elements typical of the later *E. reclinatus*.

The lateral process of sinistral ambalodiform elements of *E. foliaceus* are typically more anteriorly directed than that of *E. reclinatus*. Most of the sinistral ambalodiform elements of *Eoplacognathus* from my samples have lateral processes which are not directed strongly anteriorly. My sinistral ambalodiform elements do not vary markedly. Most of them look like those of typical *E. reclinatus*.

Löfgren (1978) reported that among polyplacognathiform elements of *E. foliaceus*, she found 28 sinistral elements but only one dextral element. Löfgren suggested that dextral polyplacognathiform elements were probably more fragile than sinistral ones and were therefore less frequently preserved. She further observed no overrepresentation of sinistral polyplacognathiform elements over dextral ones in the predecessor of *E. foliaceus*, *E. suecicus*. In my collections of *Eoplacognathus* sp. cf. *E. reclinatus*, there is no marked difference in the abundance of dextral polyplacognathiform elements and sinistral ones.

Occurrence: Representatives of *E.* sp. cf. *E. reclinatus* occur in the upper Lenoir Limestone and the Athens Shale at Calera. Elsewhere in North America, elements of *E. reclinatus* have been reported from the Fetzer Member of the Blockhouse Formation, Tennessee (Bergström, 1973c).

Collection: 128 specimens--58 polyplacognathiform (stelliplanate, Pa); 70 ambalodiform (pastiniplanate, Pb).

Figured specimens: OSU 36266, OSU 36267, OSU 36268, OSU 36269.

Reference specimens: OSU 36270 (polyplacognathiform), OSU 36271 (sinistral ambalodiform), OSU 36272 (mature dextral ambalodiform), OSU 36273 (immature dextral ambalodiform).

EOPLACOGNATHUS sp.

(Pl. V, fig. 10)

Remarks: Two elements of Eoplacognathus sp. have been found in residues from the Lenoir Limestone at Rockmart. The poor preservation of the specimens precludes specific determination. Both are polyplacognathiform elements.

Collection: 2 specimens, polyplacognathiform (stelliplanate, Pa).

Figured specimen: OSU 36274.

Reference specimen: OSU 36275.

Genus ERISMODUS Branson and Mehl, 1933

Erismodus Branson and Mehl, 1933, p. 25.

Type Species: Erismodus typus Branson and Mehl, 1933.

Remarks: A number of authors have considered members of the form genera Erismodus Branson and Mehl, Microcoelodus Branson and Mehl, and Ptilconus Sweet (=Pteroconus Branson and Mehl) to be parts of a single multielement genus (Lindström, 1964; Andrews, 1967; Votaw, 1971; Sweet and Bergström, 1972; Carnes, 1975; and Boger, 1976). Carnes (1975) recogized two species of Erismodus, each consisting of 7 distinct elements belonging to a symmetry transition. These are symmetrical and asymmetrical trichonodelliform, zygognathiform, eoligonodiniform, prioniodiniform, oulodontiform, and modified falodiform elements. All 7 types of elements occur in my collections, but I am unable to distinguish more than one species among the elements, and to determine to which of Carnes' species, if either, my elements belong.

Although Carnes (1975) included microcoelodiform and erismodiform elements in the same multielement species, he remarked that some erismodids and some microcoelodids might indeed belong to separate genera as suggested by Sweet and Bergström (1972). Carnes also discussed the problem in compiling a list of synonomies for Erismodus and instead provided a list of similar elements which are synonomous only in the form-species sense. I refer the reader to Carnes' (1975) discussion and list of elements of Erismodus.

ERISMODUS sp.

(Pl. I, figs. 14-20)

Remarks: As previously discussed, I have not provided a list of synonyms for Erismodus and instead refer the reader to the list of similar elements provided by Carnes (1975).

Occurrence: Within the present study area--Pond Spring Formation and lower Murfreesboro at Chickamauga; Chickamauga Limestone at Red Mountain. Elsewhere in North America--Similar elements occur in the Esabataottine and Sunblood Formations, District of Mackenzie, Canada (Tipnis et al., 1978); the Bromide Formation of Oklahoma (Branson and Mehl, 1943); the Womble Shale, Arkansas (Repetski and Ethington, 1977); the Dutchtown and Plattin Formations, Missouri (Branson and Mehl, 1933); the Joachim Dolomite, Missouri (Andrews, 1977); the Glenwood Formation, Minnesota (Webers, 1966); the Black River Group in the Eastern Midcontinent (Votaw, 1971); the Row Park Limestone and Pinesburg Station Dolomite and New Market Limestone, West Virginia (Boger, 1976); the basal Chambersburg and upper New Market, Pennsylvania (Boger, 1976); and the Tumbez, Elway-Eidson, Holston, and Hogskin Formations, Tennessee (Carnes, 1975).

Collection: 176 specimens--60 trichonodelliform (alate, Sa and Sb); 38 eoligodiniform (digyrate, Sc); 37 prioniodiniform (digyrate, Pa); 26 zygognathiform (bipennate, Sd); 6 oulodontiform (angulate, Pb); 9 modified falodiform (Dolabrate, M).

Figured specimens: OSU 36276, OSU 36277, OSU 36278, OSU 36279, OSU 36280, OSU 36281, OSU 36282.

Reference specimens: OSU 36283 (symmetrical trichonodelliform), OSU 36284 (asymmetrical trichonodelliform), OSU 36285 (eoligonodiniform), OSU 36286 (prioniodiniform), OSU 36287 (zygognathiform), OSU 36288 (oulodontiform), OSU 36289 (modified falodiform).

Genus ERRATICODON Dzik, 1978

Erraticodon Dzik, 1978, p. 64-66.

Type Species: _Erraticodon_ _balticus_ Dzik, 1976.

ERRATICODON sp.

(Pl. I, figs. 6-9)

Remarks: Dzik named the genus *Erraticodon* for hyaline conodonts which have, in mature specimens, denticles with an oval cross-section and distinct anterior and posterior keels. Although he did not indicate it in his description, three of the elements ("ozarkodiniform, hindeodelliform, and trichonodelliform," in his terminology) are characterized by a laterally deflected anterior process and a denticle on the posterior process which rivals the cusp in size. These characteristics, and those described by Dzik as diagnostic of *Erraticodon*, are present in a few of my conodont elements. Furthermore, my elements resemble those of *Phragmodus* n. sp. of Fåhraeus (1966), "Fibrous conodonts" of Fåhraeus (1966), and "*Chirognathus*" sp. of Viira (1974) which Dzik included in his synonymy for *Erraticodon balticus* Dzik. However, representatives of *Erraticodon* are scarce in samples from the present study (and in those of previous reports) and they apparently are rather highly variable. Furthermore, *E. balticus* is, in my opinion, inadequately described by Dzik, and I cannnot determine the specific affinities of my elements.

Occurrence: Within the present study--*Erraticodon* sp. occurs in the Lenoir Limestone at Pratt Ferry and in the Little Oak Limestone at Pelham and Ragland. Elsewhere in North America--Elements referable to *Erraticodon* (but not necessarily conspecific with mine) occur in the Davidsville Group, Newfoundland (Stouge, 1980); the Antelope Valley Limestone, Nevada (Harris et al. 1979); and in the Lenoir Limestone, Tennessee (Schmidt, 1979).

Collection: 18 specimens--2 type A; 6 type B; 2 type C; 8 type D.

Figured specimens: OSU 36290, OSU 36291, OSU 23292, OSU 36293.

Reference specimens: OSU 36294 (type A), OSU 36295 (type B), OSU 36296 (type C), OSU 36297 (type D).

Genus JUANOGNATHUS Serpagli, 1974

Juanognathus Serpagli, 1974, p. 49.

Type species: *Juanognathus* variabilis Serpagli, 1974.

JUANOGNATHUS VARIABILIS Serpagli, 1974

(Pl. II, figs. 7-9)

Juanognathus variabilis Serpagli, Landing, 1976, p. 634, Pl. 2, figs. 15-17, 19-23 (synonomy to 1974); Bergström, 1979, p. 303, fig. 4H; Ethington and Clark, 1982, p. 50-51, Pl. 5, figs. 8-10, 17.

Juanognathus cf. *J. variabilis* Serpagli, Harris et al., 1979, Pl. 1, figs. 3-5.

Occurrence: Within the study area--Specimens of *Juanognathus variabilis* occur in the Lenior Limestone at Rockmart. Elsewhere in North America--The Antelope Valley Limestone, Nevada (Harris et al., 1979); the Fillmore and the Wah Wah Formations, Nevada (Ethington, 1979); and the Deepkill Shale, New York (Landing, 1976).

Collection: 68 specimens--4 ramiform, 36 nongeniculate, 28 geniculate.

Figured specimens: OSU 36298, OSU 36299, OSU 36300.

Reference specimens: OSU 36301 (ramiform), OSU 36302 (nongeniculate), OSU 36303 (geniculate).

Genus LEPTOCHIROGNATHUS Branson and Mehl, 1943

Leptochirognathus Branson and Mehl, 1943, p. 377.

Type Species: _Leptochirognathus_ _quadrata_ Branson and Mehl, 1943.

LEPTOCHIROGNATHUS sp.

(Pl. II, fig. 1)

Remarks: Nine elements of _Leptochirognathus_ have been found in the Lenoir at Rockmart. The elements closely resemble those of _Leptochirognathus_ n. sp. of Harris et al., 1979 from the Antelope Valley Limestone, Nevada.

Collection: 10 specimens.

Figured specimen: OSU 36304.

Reference specimen: OSU 36305.

NEW GENUS n. sp.

(Pl. IV, fig. 18)

Thrincodus palaris Raring, 1972, p. 123-126, Pl. 2, fig. 8, Pl. 4, fig. 25.

New Genus B n. sp., Carnes, 1975, p. 152-153, Pl. 2, figs. 6, 7.

New Genus A n. sp., Boger, 1976, p. 119, Pl. V, figs. 17, 18. Gen. et sp. nov. Raring, Bergström, 1978, Pl. 79, fig. 8. N. gen. n. sp. Raring; Harris et al., 1979, Pl. 3, fig. 8.

Remarks: The elements of New Genus n. sp. have been described by Raring (1972) and Carnes (1975). Elements from the present study agree closely with their descriptions.

As noted by Carnes (1975), new elements of New Genus n. sp. resembles spathognathodiform elements of *Appalachignathus delicatulus*. He observed, however (p. 153), that spathognathodiform elements of *A. delicatulus* do not have denticles on the posterior margin of the cusp and that the denticles are more reclined, and the base is less flared, than on elements of New Genus n. sp. Raring (1972), Carnes (1975), and Boger (1976) all reported specimens of New Genus n. sp. but none was able to determine if other elements are associated with it.

All reported occurrences of New Genus n. sp. are from stata equivalent in age to the type Chazy. New Genus n. sp. appears to have considerable biostratigraphic significance.

Occurrence: Within the study area--Elements of New Genus n. sp. occur in the Little Oak at Ragland and Pelham and the Lenoir at Pratt Ferry. Elsewhere in North America--Representatives of New Genus n. sp. have been reported from the upper Antelope Valley Limestone, Nevada (Harris et al., 1979); Woods Hollow Shale, Texas (Bergström, 1978); Row Park Limestone, Maryland and West Virginia (Boger, 1976); Holston in Tennessee (Carnes, 1975); Chazy Group, Champlain Valley and equivalent strata in Montreal (Raring, 1972); Lenoir in Tennessee (Raring, 1972, found by Bergström); and Copenhagen Formation, Nevada (Boger, 1976, found by Bergström).

Collection: 7 specimens (carminate).

Figured specimen: OSU 36306.

Reference specimen: OSU 36307.

Genus OISTODUS Pander, 1856

Oistodus Pander, 1856, p. 27.

Type Species: Oistodus lanceolatus Pander, 1856.

Remarks: "Oistodus" is here used in the form-genus sense rather than in the multielement sense as described by Lindström (1971).

"OISTODUS" PSEUDOABUNDANS Schopf, 1966
(Pl. II, fig. 21)

Oistodus pseudoabundans Schopf, 1966, p. 61-62, Pl. 1, fig. 13.

"*Oistodus*" *pseudoabundans* Schopf, Carnes, 1975, p. 154-155, Pl. I, figs. 25, 26.

Paltodus semisymmetricus (Hamar) Dzik, 1976, Fig. 18A, D, E, *not* Fig. 18B, C, F.

"*Oistodus*" spp. Palmieri, 1978, p. 21, Pl. 5, figs. 1, 3, 4, 6-8, 10, *not* Pl. 5, figs. 2, 5, 9, 11.

?*Oistodus abundans* Branson and Mehl, Winder, 1966, Pl. 9, fig. 10; Ethington and Schumacher, 1969, p. 466, Pl. 68, fig. 13.

?*Oistodus venustus* Stauffer, Atkinson *in* Clark, 1971, Pl. 5, fig. 10.

Remarks: Dzik (1976) tentatively included "*Oistodus*" *pseudoabundans* Schopf in a multielement apparatus with elements referred to as "*Acodus*" *variabilis* (Webers). Although I believe that this reconstruction may be correct, owing to the lack of firm evidence, I provisionally consider these to be separate species. I refer the reader to the remarks on "*Acodus*" *variabilis* for further discussion.

Schopf described *O*. *psuedoabundans* as having a lower margin which is "straight or nearly so." Many elements of "*O*." *pseudoabundans* from the present study have basal margins which I would desribe as "sinuous." However, as the basal margins of my elements vary gradationally from sinuous to straight, I believe that my elements are conspecific with Schopf's.

Occurrence: Within the present study area--Chickamauga Limestone at Red Mountain Little Oak at Pelham, Pratt Ferry, and Ragland, Pratt Ferry at Pratt Ferry. Elsewhere in North America--The Platteville in Wisconsin (Atkinson *in* Clark, 1971); the Trenton Group in New York and Ontario (Schopf, 1966); and the Hogskin, Rockdell and Eidson Formations, Tennessee (Carnes, 1975). Questionable occurrences of "*O*." *pseudoabundans* have been reported from the Cobourg Formation, Ontario (Winder, 1966) and the Copenhagen Formation, Nevada (Ethington and Schumacher, 1969).

Collection : 83 specimens (geniculate).

Figured specimen: OSU 36308.

Reference specimen: OSU 36309.

"OISTODUS" sp. cf. "O." VENUSTUS Stauffer, 1935a

(Pl. II, fig. 25)

Remarks: A number of different elements have been referred to as "*Oistodus venustus* Stauffer". Some elements referable to "*O*." *venustus* or to the similar *Oistodus forceps* Lindström are associated with drepanodiform elements species of the multielement genus *Drepanoistodus* Lindström, but some such oistodiform elements are not. Lindström (1971), Löfgren (1978), and Lindström *in* Klapper et al. (1973) have discussed the apparatus of *Drepanoistodus* in considerable depth. Because of the unsolved taxonomic questions regarding "*Oistodus*" *venustus* and the rather low frequency of such elements in the present study, I am referring such elements to "*O*." sp. cf. "*O*." *venustus* in the form-species sense only.

Occurrence: Within the present study--Elements referred to herein as "O." sp. cf. "O." venustus occur in the Little Oak at Pelham and Ragland; the Lenoir and Athens at Calera and Pratt Ferry; the Pratt Ferry at Pratt Ferry; and in the Chickamauga at Red Mountain.

Collection: 52 specimens (geniculate).

Figured specimen: OSU 36310.

Reference specimen: OSU 36311.

"Oistodus" sp.

(Pl. III, fig. 4)

Description: "Oistodus" sp. is a nonhyaline element with a straight, reclined cusp that has a sharp anterior edge and a thin, bladelike posterior edge. The base projects a short distance posteriorly, but not anteriorly beyond the cusp. The base is very small in the vertical direction, and has a strongly sinuous lower edge. The upper edge of the base is sinuous and is parallel to the lower edge, and is marked by a dark line which separates the base from the cusp. The basal cavity apparently is small, but its depth cannnot be determined owing to the fact that one side of the element is broken.

Occurrence: One element of "Oistodus" sp. occurs in a sample from the upper Lenoir Limestone at Pratt Ferry.

Collection: 1 specimen (geniculate).

Figured specimen: OSU 36312.

Genus OZARKODINA Branson and Mehl, 1933

Ozarkodina Branson and Mehl, 1933, p. 51.

Type Species: *Ozarkodina typica* Branson and Mehl, 1933.

"OZARKODINA" sp.

(Pl. V, fig. 1)

Description: "*Ozarkodina*" sp. is an arched, nonhyaline, bladelike element with a slightly reclined cusp which is distinctly wider than surrounding denticles. The anterior and posterior processes are nearly equal in length and meet to form an angle of 130 degrees. The anterior process is stout and is surmounted by 9 blunt denticles which are fused through most of their height. The denticles are approximately twice as high as the blade; both decrease in height distally.

The posterior process is distinctly less robust, and about half as high, as the anterior one. It is surmounted by 6 pointed denticles which are subtriangular in side view. Denticles are laterally compressed and are fused only near their bases.

The basal cavity is a moderately deep slit which extends through the full length of both processes and is open towards the inner (concave) side. The cavity flares beneath the cusp on the outer side.

Occurrence: Four specimens of "*Ozarkodina*" sp. were found in the lower member of the Pond Spring Formation at

Chickamauga.

Collection---4 specimens (angulate).

Figured specimen: OSU 36313.

Reference specimen: OSU 36314.

Genus PALTODUS Pander, 1856

Paltodus Pander, 1856, p. 24.

Type Species: _Paltodus_ _subaqualis_ Pander, 1856.

PALTODUS sp.

(Pl. III, fig. 6)

Remarks: The genus _Paltodus_, according to Lindström's (1971a) emended diagnosis, includes drepanodiform elements with a triangular base and a suberect to recurved cusp and oistodiform elements with a base that may flare to the inner side. A small number of elements that fit Lindström's general description for _Paltodus_ occur in my collections. Because the oistodiform elements of _Paltodus_ are similar to those of _Triangulodus_ Van Wamel, some of the oistodiform elements of _Paltodus_ may have been reported as elements of _Triangulodus_ in the present study.

Occurrence: Elements of _Paltodus_ sp. occur in the Lenoir Limestone at Pratt Ferry.

Collection: 7 specimens, paltodiform (nongeniculate).

Figured specimen: OSU 36315.

Reference specimen: OSU 36316.

Genus PANDERODUS Ethington, 1959

Panderodus Ethington, 1959, p. 284.

Type species: *Paltodus unicostatus* Branson and Mehl, 1933.

PANDERODUS ALABAMENSIS (Sweet and Bergström, 1962)

(Pl. III, fig. 3)

Belodina alabamensis Sweet and Bergström, 1962, p. 1223-1224, Pl. 170, figs. 10, 11.

Panderodus? alabamensis (Sweet and Bergström), Ethington and Schumacher, 1969, p. 469, Pl. 69, fig. 8.

?*Belodina compressa* (Branson and Mehl), form species *Belodina diminutiva*, Moskalenko, 1972, fig. 7-2.

Remarks: Sweet and Bergström (1962) assigned *Panderodus alabamensis* to the genus *Belodina* but noted that apart from its denticulate margin it is similar to a simple cone. Subsequent authors (Ethington and Schumacher, 1969), (Bergström and Carnes, 1976) have included "*B*." *alabamensis* (the former authors, tentatively) with *Panderodus*. The species description of Sweet and Bergström (1962) need not be repeated here.

Serrate panderodids have also been reported from Upper Ordovician and Silurian rocks by Rexroad (1967), Aldridge (1972), Cooper (1975), Nowlan and Barnes (1981), and others. The element of *P*. *alabamensis* differs from that of *P*.

serratus Rexroad in having somewhat larger, more reclined denticles. Additionally, the lateral groove at the base of the denticles is on the outer (convex) lateral face of the element of *P. alabamensis* and on the inner (concave) lateral face of that of *P. serratus*. Specimens of *P. alabamensis* also resemble some juvenile "dispansiform" elements of *B. compressa* (see Bergström and Sweet, 1966). Dispansiform elements of *Belodina* differ from those of *P. alabamensis* in having sharp, discrete, proclined denticles.

The form species *Belodina diminutiva* illustrated by Moskalenko (1972) and considered by her to be a possible element of *B. compressa* (Branson and Mehl) may be a representative of *P. alabamensis*. However, the lack of detail in her line drawing makes it impossible to determine with certainty the affinities of the *B. dimunitiva* form element to *P. alabamensis*.

Occurrence: Within the study area--Lenoir and Athens at Calera; Pratt Ferry at Pratt Ferry (Sweet and Bergström, 1962). Elsewhere in North America--Collierstown section (including the Whistle Creek through the Edinburg Formations), Virginia (Fetzer, 1973); Chota Formation, Tennessee (Bergström and Carnes, 1976); and Lenoir of Tennessee (Schmidt, 1979).

Collection: 12 specimens (nongeniculate).

Figured specimen: OSU 36317.

Reference specimen: OSU 36318.

PANDERODUS GRACILIS (Branson and Mehl, 1933)

(Pl. III, fig. 1, 2)

Paltodus gracilis Branson and Mehl, 1933, p. 108, Pl. 8, figs. 20, 21.

Panderodus gracilis (Branson and Mehl) Bergström and Sweet, 1966, p. 355-359, Pl. 35, figs. 1-6 (synonomy to 1966); Votaw, 1978, Pl. 1, fig. 25; Tipnis et al., 1978, Pl. VI, fig. 23, Pl. IV, figs. 22-24; Harris et al., 1979, Pl. 5, figs. 1-3; Faber, 1979, Pl. 1, fig. 2; Bolton and Nowlan, 1979, p. 20, Pl. 7, figs. 9, 21-23; McCracken and Barnes, 1981, p. 85-86, Pl. 1, figs. 1-12, 15 (synonomy to 1978); Nowlan and Barnes, 1981, p. 16, Pl. 6, figs. 20, 23, 27 (synonomy to 1977).

?Panderodus cf. P. gracilis (Branson and Mehl) Nowlan, 1981, p. 12, Pl. 1, figs. 14, 17, 18.

Remarks: Bergström and Sweet (1966) described Panderodus gracilis (Branson and Mehl) as a multielement species containing elements previously assigned to P. gracilis and Panderodus compressus (Branson and Mehl). Carnes (1975) recognized five form-species of the genus Panderodus as did Barrick (1977) and Sweet (1979b). Although I do not disagree with the interpretation of Panderodus as having a quinquemembrate apparatus, I have distinguished only graciliform and compressiform elements of P. gracilis.

Occurrence: Within the present study--Panderodus gracilis occurs in all of the units within the present study except for the Lenoir at Portland and Rockmart. Elsewhere in North America--P. gracilis is extremely widespread in rocks of Middle and Upper Ordovician age and is particularly common in rocks of the Midcontinent province (Bergström and Sweet, 1966).

Collection: 1211 specimens: 424 compressiform (nongeniculate, M); 787 graciliform (nongeniculate, S).

Figured specimens: OSU 36319, OSU 36320.

Reference specimens: OSU 36321 (compressiform), OSU 36322 (graciliform).

Genus PERIODON Hadding, 1913
Emend. Bergström and Sweet, 1966

Periodon Hadding, 1913, p. 33.

Type species: *Periodon aculeatus* Hadding, 1913.

PERIODON ACULEATUS Hadding, 1913
(Pl. III, figs. 20-25)

Periodon aculeatus Hadding, 1913, p. 33, Pl. I, fig. 14; Bergström, 1978, Pl. 79, figs. 3-5; Löfgren, 1978, p. 74-75, Pl. X, figs. 1A, B, Pl. XI, figs. 12-26 (synonomy to 1976); Fåhraeus and Nowlan, 1978, p. 462, Pl. III, figs. 7-10, Text-figs. 5G-L; Lindström *in* Ziegler, 1981, p. 237-238, Pl. I, figs. 1-6; Nowlan, 1981, p. 12, Pl. 2, figs. 7-10, Pl. 4, figs. 1-9; Tipnis, 1978, Pl. 13.1, figs. 1-5; Robison, 1981, Fig. 76, 1a-f.

?*Periodon* cf. *P. aculeatus* Hadding, Simes, 1980, fig. 5; Kennedy et al., 1979, p. 544-546, Pl. 1, figs. 1-8, 35.

Periodon cf. *P. aculeatus* m.s. Hadding *sensu* Uyeno and Barnes, 1970, Tipnis et al., 1978, Pl. VIII, figs. 13-15.

Occurrence: Specimens of _P_. _aculeatus_ occur in all of the units within the present study except for those at Red Mountain, Rockmart, Portland, and Chickamauga. Occurrences elsewhere in North America are summarized by Lindström (_in_ Ziegler, 1981).

Collection: 3867 specimens--785 prioniodiniform (digyrate, Pa?); 408 eoligonodiniform (bipennate, Pb?); 990 falodiform (geniculate, M); 151 trichonodelliform (alate, Sa?); 662 roundyaform (tertiopedate, Sb?); 871 phragmodiform (bipennate, Sc?).

Figured specimens: OSU 36323, OSU 36324, OSU 36325, OSU 36326, OSU 36327, OSU 36328.

Reference specimens: OSU 36329 (prioniodiniform), OSU 36330 (eoligonodiniform), OSU 36331 (falodiform), OSU 36332 (trichonodelliform), OSU 36333 (roundyaform), OSU 36334 (phragmodiform).

PERIODON sp.

(Pl. IV, fig. 1)

Remarks: Residues from the Lenoir Limestone at Rockmart contain 29 elements referable to _Periodon_. Due to metamorphism, the elements are poorly preserved. However, the falodiform elements appear to be adenticulate or only weakly denticulate as is characteristic of _Periodon flabellum_ (Lindström), the earliest known species of

Periodon. However, I hesitate to assign a specific name to the elements from Rockmart because of both poor preservation and the fact that the basal edge of the falodiform elements is markedly more sinuous than those of P. flabellum as described by Lindström (in Ziegler, 1981).

Occurrence: Representatives of Periodon sp. occur in the Lenoir Limestone at Rockmart.

Collection: 29 specimens--7 prioniodiniform (digyrate, Pa?); 5 eoligonodiniform (bipennate, Pb?); 7 falodiform (geniculate, M); 3 roundyaform (tertiopedate, Sb?); 7 phragmodiform (bipennate, Sc?).

Figured specimen: OSU 36335.

Reference specimen: OSU 36336.

Genus PHRAGMODUS Branson and Mehl, 1933
emend. Sweet, 1981

Phragmodus Branson and Mehl, 1933, p. 98.

Type Species: Phragmodus primus Branson and Mehl, 1933.

PHRAGMODUS FLEXUOSUS Moskalenko, 1973?

(Pl. IV, figs. 7-11)

?Phragmodus flexuosus Moskalenko, 1972, n. sp., 1973, p. 73-74, Pl. 11, figs. 4-6; Bergström, 1978, Pl. 79, fig. 16; Harris et al., 1979, Pl. 2, figs. 1-4; Sweet in Ziegler, 1981, p. 255-257, Pl. 2, figs. 1-6 (synonomy to 1978); ?Ethington and Clark, 1982, p. 79-82, Pl. 9, figs. 2, 3, 5-7, not fig. 4.

Remarks: Samples from the lower part of the Pond Spring at Chickamauga contain oistodiform elements which are referred to herein as *Phragmodus*? n. sp. These elements are identical to the cyrtoniodiform elements of *Phragmodus flexuosus* except that they are adenticulate or weakly denticulate and they lack a posterior process. As discussed elsewhere in the present study (see *Phragmodus*? n. sp.), these oistodiform elements may belong to the apparatus referred to here as *P*. *flexuosus*?. If this is the case, then elements of *P*. *flexuosus*? from the lowermost sample at Chickamauga may actually belong to a separate species, or an early form of *P*. *flexuosus*.

Carnes (1975) considered the *P*. *flexuosus* apparatus to include phragmodiform, subcordylodiform, dichognathiform, and cyrtoniodiform elements. His collection included 97 phragmodiform, 130 subcordylodiform, 136 dichognathiform, and 135 cyrtoniodiform elements. My samples contain relatively fewer dichognathiform elements. As they are the most fragile elements of the *P*. *flexuosus*? apparatus, they might have been destroyed before deposition or during laboratory preparation.

Occurrence: Within the study area--Elements of *Phragmodus* *flexuosus*? occur in the Pond Spring Formation at Chickamauga. Elsewhere in North America--Occurrences of *P*. *flexuosus* (some of which might not be conspecific with mine) are summarized by Sweet *in* Ziegler, (1981). Elements of *P. flexuosus* have also been reported from the Crystal Peak Dolomite, Utah (Ethington and Clark, 1982).

Collection: 225 specimens--70 phragmodiform (alate and tertiopedate, Sa and Sb); 77 subcordylodiform (bipennate, Sc); 51 cyrtoniodiform (dolabrate, M); 20 dichognathiform (pastiniplanate, Pa); 7 breviform (pastiniplanate, Pb).

Figured specimens: OSU 36337, OSU 36338, OSU 36339, OSU 36340, OSU 36341.

Reference specimens: OSU 36342 (phragmodiform), OSU 36343 (subcordylodiform), OSU 36344 (cyrtoniodiofrm), OSU 36345 (dichognathiform), OSU 36346 (breviform).

PHRAGMODUS INFLEXUS Stauffer, 1935

(Pl. IV, figs. 13-16)

Phragmodus inflexus Stauffer, 1935a, p. 151, Pl. 11, figs. 9, 16, 20, 25, 26, *not* Pl. 11, figs. 15, 17, 19, 21, 22, 24; Webers, 1966, p. 40-41, Pl. 3, fig. 8, Pl. 11, figs. 1, 2, 4 (synonomy to 1966); Sweet et al. 1971, p. 175, Pl. 1, figs. 1, 15; Votaw, 1978, Pl. 1, figs. 1-3; Harris et al., 1979, Pl. 3, fig. 9; Sweet *in* Ziegler, 1981, p. 261-263, Pl. 2, figs. 7-12.

Dichognathus? *typica* Branson and Mehl, Andrews, 1967, p. 889, Pl. 114, fig. 12.

Remarks: Sweet (*in* Ziegler, 1981) observed that elements of *Phragmodus inflexus* are typically much less robust than elements of *P. flexuosus* Moskalenko and that the dichognathiform elements of the former species have a denticle on the anterior side of the cusp. Elements of *Phragmodus* from the lower member of the Pond Spring Formation at Chickamauga are abundant and are clearly assigned to *P. flexuosus*?. The middle and upper members of the Pond Spring at the same locality contain few elements of *Phragmodus*. The lower sample from the middle member of the Pond Spring contains a dichognathiform elements of *Phragmodus* which appears to have a small but distinct denticle on the anterior edge of the cusp. This, and the fragility of specimens of *Phragmodus* in the middle and upper members of the Pond Spring at Chickamauga, might indicate that the highest occurrence of *Phragmodus flexuosus* and the lowest occurrence of *P. influexus* are near the boundary between the lower and middle members of the Pond Spring Formation at Chickamauga.

Occurrence: Within the study area--Elements of *P. inflexus* occur in the Chickamauga at Red Mountain. Questionable occurrences of *P. inflexus* were found in the middle and upper members of the Pond Spring and possibly the Murfreesboro, at Chickamauga. Occurrences elsewhere in North America are summarized by Sweet (*in* Ziegler, 1978).

Collection: 37 specimens--3 dichognathiform (pastiniscaphate, Pa); 16 cyrtoniodiform (dolabrate, M); 12 phragmodiform (alate and tertiopedate, Sa and Sb); 6 subcordylodiform (bipennate, Sc).

Figured specimens: OSU 36347, OSU 36348, OSU 36349, OSU 36350.

Reference specimens: OSU 36351 (dichognathiform), OSU 36352 (cyrtoniodiform), OSU 36353 (cyrtoniodiform), OSU 36354 (subcordylodiform).

PHRAGMODUS? n. sp.

(Pl. IV, fig. 12)

Phragmodus flexuosus Moskalenko; ?Ethington and Clark, 1982, p. 78-82, Pl. 9, fig. 4, *not* figs. 2-3, 5-7.

?*Oistodus abundans* Branson and Mehl, 1933, p. 109, Pl. 9, figs. 11, 17; Moskalenko, 1973, p., 35-36, Pl. 1, figs. 8, 9.

Description: *Phragmodus*? n. sp. is a nonhyaline simple cone with an erect to suberect cusp. The cusp is straight above its midheight and smoothly, but strongly, curved beneath its midheight. The cusp is acostate, sharp edged, and lenticular in cross section. The adenticulate to weakly denticulate base is strongly flared to the inner side and contains a triangular basal cavity.

Remarks: Elements of *Phragmodus*? n. sp. are identical to cyrtoniodiform elements of *P. flexuosus* Moskalenko, with which they occur, except that they are adenticulate or weakly denticulate and they lack the poorly developed posterior process present on some cyrtoniodiform elements. Harris et al. (1979) discussed a species of *Phragmodus* that is identical to *P. flexuosus* except that an oistodiform element occupies the position of the cyrtoniodiform element. The weak denticulation on some elements of *Phragmodus* n. sp. may indicate that they are transitional forms between those discussed by Harris et al. and *P. flexuosus*.

Ethington and Clark (1982) referred oistodiform elements to *Phragmodus flexuosus* which apparently occupied the same position as that occupied by cyrtoniodiform elements in some species of *Phragmodus*. They pointed out (p. 81) that elements referred to *P. flexuosus* probably include two species, one with oistodiform elements and one with cyrtoniodiform ones. However, since Moskalenko's holotype was taken from a sample containing both kinds of elements, it is not presently possible to determine whether the species with an oistodiform element belongs to *P. flexuosus* or to a second, unnamed species. My cyrtoniodiform and oistodiform elements may belong to two separate species. But the weak denticulation on some cyrtoniodiform elements may indicate that they belong to a species transitional between that containing oistodiform elements and that containing cyrtoniodiform ones.

My elements may be conspecific with those which Moskalenko (1972) referred to *Oistodus abundans* Branson and Mehl. The elements that she illustrated differ in having relatively shorter cusps than those in my elements.

Occurrence: Within the present study--Elements of *Phragmodus*? n. sp. occur in the lower member of the Pond Spring Formation at Chickamauga. Elsewhere in North America--Elements of *Phragmodus*? n. sp. have been reported from the Antelope Valley Limestone, Nevada (Harris et al., 1979); and the Crystal Peak Dolomite, Utah (Ethington and Clark, 1982). Questionable occurrences of *Phragmodus*? n. sp. have been reported from the Plattin of Missouri (Branson and Mehl, 1933).

Collection: 53 specimens (geniculate).

Figured specimen: OSU 36355.

Reference specimen: OSU 36356.

Genus PLECTODINA Stauffer, 1935

Plectodina Stauffer, 1935a, p. 152.

Type species: *Prioniodus* *aculeatus* Stauffer, 1930.

PLECTODINA ACULEATA (Stauffer, 1930)

(Pl. IV, figs. 2-5)

Prioniodus *aculeatus* Stauffer, 1930, p. 126, Pl. 10, fig. 12.

Plectodina *aculeata* (Stauffer), Bergström and Sweet, 1966, p. 373-377, Pl. 32, figs. 15, 16, Pl. 33, figs. 22, 23, Pl. 34, figs. 5, 6, Text-figs. 9A-F (synonomy to 1966); Votaw, 1971, p. 117-121, Pl. 3, figs. 24-28, 31, Text-figs. 13A-F (synonomy to 1971); Carnes, 1975, p. 185-187, Pl. VI, figs. 1-7 (synonomy to 1974); Sweet, *in* Ziegler, 1981, p. 227-280, Pl. 1, figs. 1-9.

Plectodina aculeata m.s. Stauffer, Tipnis et al., 1978, Pl. VI, figs. 1-4.

Remarks: Only 14 elements of Plectodina aculeata have been found in the present study. However, well-preserved trichonodelliform, zygognathiform, cordylodiform, and prioniodiniform elements occur in the lowermost sample from the Red Mountain section. Although elements of P. aculeata are poorly represented in the present study, the presence of a prioniodiniform element and the cooccurrence of Phragmodus inflexus Stauffer, which has a similar lower stratigraphic limit and geographic range (Sweet et al., 1971, p. 175), leaves little doubt as to the specific assignment of the Plectodina elements. Two elements referred to as Plectodina sp. occur in the Red Mountain samples and are discussed under that designation.

Occurrence: Within the study area--Lower Chickamauga at Red Mountain. Occurrences elsewhere in North America are summarized by Sweet (in Ziegler, 1981).

Collection: 14 specimens--1 prioniodiniform (angulascaphate, Pb); 5 trichonodelliform (alate, Sa); 4 zygognathiform (tertiopedate, Sb); 4 cordylofiform (bipennate, Sc).

Figured specimens: OSU 36357, OSU 36358, OSU 36359, OSU 36360.

Reference specimens: OSU 36361 (trichonodelliform), OSU 36362 (zygognathiform), OSU 36363 (cordylodiform).

PLECTODINA sp.

(Pl. IV, fig. 6)

cf. *Plectodina* sp. nov. Bergström, 1978, Pl. 80, figs. 18, 19, *not* figs. 17, 20.

aff. *Plectodina florida* Sweet, 1979b, p. 65-66, fig. 8(16), *not* figs. 8(6, 9-11, 15, 17); Sweet, *in* Ziegler, 1981, p. 285-286, Pl. 2, figs. 8, 9, *not* figs. 7, 10-13.

aff. *Ozarkodina flabellum* Lindström; Baranowski and Urbanek, 1972, Pl. 1, fig. 4.

aff. *Plectodina bidentata* Nowlan and Barnes, 1981, p. 21-11, Pl. 3, figs. 1, 4, *not* figs. 21, 3, 5-8.

Description: Three specimens of *Plectodina* sp. occur in the present study. The cordylodiform element has an erect cusp with sharp anterior and posterior edges. The posterior process is a slender bar with seven pointed, laterally compressed denticles which are confluent only near their bases. The anterior edge of the cusp projects downward as a blade-like "anticusp" which is different from that of *P. aculeata* Stauffer in having one denticle on the proximal end of the anterior process directly adjacent to the cusp, as opposed to having denticles on its distal end.

The cyrtoniodiform element is fragmentary but differs from that typical of *P. aculeata* in having what appears to be a germ denticle (a fracture?) on the lower part of the anterior edge of the cusp.

Remarks: Specimens of *Plectodina* sp. occur with, and may belong to, *P. aculeata*, but differ from those of *P. aculeata* in the manner described. I am not able to distinguish associated trichonodelliform and zygognathiform elements from those of _P_. _aculeata_ and have therefore assigned them to _P_. _aculeata_.

Plectodina sp. resembles _Plectodina_ _florida_ Sweet, 1979b, and _Plectodina_ _bidentata_ Nowlan and Barnes, 1981, but occurs in markedly older strata and is probably not, in my opinion, conspecific with them. _Plectodina_ sp. also resembles _Plectodina_ sp. nov. of Bergström (1978) which occurs in strata of approximately the same age as that of _Plectodina_ sp. in the present study.

Occurrence: Within the study area--Elements of _Plectodina_ sp. occur in the Chickamauga Limestone at Red Mountain and the Little Oak Limestone at Pelham. Elsewhere in North America--Elements similar to, and perhaps conspecific with, _Plectodina_ sp. have been reported from the Maravillas Formation, Texas (Bergström, 1978).

Collection: 3 specimens--2 cordylodiform (Sc), 1 cyrtoniodiform (M?).

Figured specimen: OSU 36364.

Reference specimens: OSU 36365 (cordylodiform), OSU 36366 (cyrtoniodiform).

Genus POLYPLACOGNATHUS Stauffer, 1935
Emend. Bergström and Sweet, 1966

Polyplacognathus Stauffer, 1935, p. 615.

Type Species: *Polyplacognathus ramosus* Stauffer, 1935.

POLYPLACOGNATHUS FRIENDSVILLENSIS Bergström, 1971a

(Pl. V, figs. 20, 21)

Polyplacognathus friendsvillensis Bergström, 1971a, p. 142-143, Pl. I, figs. 3, 4; Raring, 1972, p. 113-116. Pl. 2, figs. 12, 13, Pl. 4, figs. 18, 24; Roscoe, 1973, p. 90-91, Pl. 3, fig. 9; Boger, 1976, p. 106-107, Pl. IV, figs. 16-18; Tipnis et al., 1978, Pl. IX, figs. 1, 3, 5; Harris et al. 1979, Pl. II, figs. 16, 17.

Remarks: As Bergström (1971a) observed, *Polyplacognathus friendsvillensis* is known only from the *Pygodus serra* zone. Elements of *Polyplacognathus* are common in the lower part but absent in the upper part of the Pratt Ferry and the Pelham sections. Nevertheless, the *Pygodus serra*-*P. anserinus* boundary in these sections is taken to be approximately equivalent to the *Polyplacognathus friendsvillensis*-*P. sweeti* boundary, based upon occurrences in areas outside of the present study area (see Bergström and Carnes, 1976).

Occurrence: Within the study area--Little Oak at Pelham; Lenoir at Pratt Ferry. Elsewhere in North America--Antelope Valley Limestone, Nevada (Harris et al., 1979); Road River Formation, District of Mackenzie, Canada (Tipnis, et al., 1978); McLish Formation, Oklahama and Lenoir Limestone, Tennessee (Bergström, 1971a); Tulip Creek Formation, Oklahama (Sweet and Bergström, 1973); St.

Dominique Limestone of the Chazy Group, Quebec (Roscoe, 1973); Day Point Formation of the Chazy Group in New York and Vermont (Raring, 1972); Row Park Limestone and Pinesburg Station Dolomite, West Virginia (Boger, 1976).

Collection: 371 specimens--156 polyplacognathiform (stelliplanate, Pa); 215 ambalodiform (pastiniplanate, Pb).

Figured specimens: OSU 36367, OSU 36368.

Reference specimens: OSU 36369 (polyplacognathiform), OSU 36370 (ambalodiform).

POLYPLACOGNATHUS sp. cf. P. SWEETI Bergström, 1971a

(Pl. V, fig. 14)

cf. *Polyplacognathus sweeti* Bergström, 1971a, p. 143-144, Pl. 1, figs. 1, 2, Fig. 14c, d; Raring, 1972, p. 116-117, Pl. 2, figs. 15, 18, 19; Fetzer, 1973, Pl. 1, figs. 17, 18; Carnes, 1975, p. 197-202, Pl. VIII, figs. 10-15; Repetski and Ethington, 1977, Pl. 2, fig. 3; Bergström, 1978, Pl. 79 figs. 14, 15; Harris, et al., 1979, Pl. 2, figs. 12, 13.

cf. *Petalognathus bergstroemi* Drygant, 1974, p. 54-55, Pl. 1, figs. 1, 2.

cf. *Polyplacognathus* sp. Hamar, 1966, Pl. 5, figs. 10, 11.

cf. *Polyplacognathus* sp. aff. *P. sweeti* Bergström, Roscoe, 1973, p. 93, Pl. 3, fig. 8.

Occurrence: Within the present study--One ambalodiform element of *Polyplacognathus* sp. cf. *P. sweeti* occurs in the uppermost sample from the Athens Shale at Calera. Elsewhere in North America--*P. sweeti* has been reported from the Antelope Valley Limestone, the Eureka Quartzite, the

Copenhagen Formation, and the unnamed limestone overlying the Antelope Valley Limestone, Nevada, and the Eureka Quartzite and the upper part of the Antelope Valley Limestone in California (Harris et al., 1979); the Woods Hollow Shale, Texas (Bergström, 1978); the Womble Shale, Arkansas (Repetski and Ethington, 1977); the Lower Bromide in Oklahama (Sweet and Bergström, 1973); the Isle La Motte and St. Dominique Formations, Upper Lake Champlain Valley (Roscoe, 1973); the lower Chickamauga Group and the Holston in Tennessee (Bergström and Carnes, 1976); and the Lenoir, Blockhouse, and Sevier Formations, Tennessee (Fetzer, 1973).

Collection: 1 specimen, ambalodiform (pastiniplanate, Pb).

Figured specimen: OSU 36371.

POLYPLACOGNATHUS RUTRIFORMIS Sweet and Bergström, 1962

(Pl. V, fig. 19)

Polyplacognathus _rutriformis_ Sweet and Bergström, 1962, p. 1237-1239, Pl. 171, figs. 4, 5.

Remarks: Elements of _Polyplacognathus_ _rutriformis_ have been reported from the Southern Appalachians (Sweet and Bergström, 1962) and from Nevada (Harris et al., 1979) and apparently have a wide distribution. However, they are not common. All published occurrences of _P_. _rutriformis_ indicate that it is present in the upper part of the _Pygodus_ *serra* Zone and the lower part of the *Pygodus anserinus* Zone. The potential biostratigraphic usefulness of *Polyplacognathus rutriformis* is limited by its scarcity.

The similarity in morphology and occurrence of *P. rutriformis* and *P. stelliformis* suggest that they are elements of the same conodont species (Bergström, 1981, personal communication). Sweet and Bergström (1962) identified 14 elements of *P. rutriformis* and 19 elements of *P. stelliformis*, compared to 8 and 13 elements, respectively, in the present study. This may indicate that these elements occur in a ratio of 1:1 in a multielement species.

That *P. rutriformis* occurs somewhat lower in my sections, and is more abundant than *P. stelliformis*, could indicate alternatively, that the elements evolved at separate times. Elements of *P. stelliformis* may be less durable than those of *P. rutriformis* and are therefore less commonly preserved. However, several studies (Bergström, 1973c; Bergström, 1976; and Harris et al., 1979) reported the occurrences of *P. rutriformis* but not *P. stelliformis*. Differences in the number of elements of *P. stelliformis* compared to *P. rutriformis* are probably not significant in light of the small number of elements reported.

Occurrence: Within the study area--Elements of *P. rutriformis* occur in the Little Oak at Pelham; Pratt Ferry at Pratt Ferry. Elsewhere in North America--Representatives of *P. rutriformis* have also been reported from the upper part of Antelope Valley Limestone and lower part of Copenhagen Formation, Nevada (Harris et al., 1979); Holston Formation, Tennessee (Bergström and Carnes, 1976); and the Lenoir Formation, Tennessee (Bergström, 1973c).

Collection: 8 specimens (stelliplanate).

Figured specimen: OSU 36372.

Reference specimen: OSU 36373.

POLYPLACOGNATHUS STELLIFORMIS Sweet and Bergström, 1962

(Pl. V, fig. 18)

Polyplacognathus stelliformis Sweet and Bergström, 1962, p. 1239-1240, Pl. 171, figs. 1, 2.

Remarks: See the discussion of *Polyplacognathus rutriformis* for remarks on possible affinities to that species.

Dzik's (1976) illustration of *Complexodus pugionifer* (Drygant, 1974) shows an element which is morphologically similar to *P. stelliformis*. The element of *P. stelliformis* differs from that of *C. pugionifer* in that the lateral processes on the convex side of the anterior-posterior axis are directed anteriorly rather than posteriorly. Also, the more anterior of these lateral processes is the larger of the two in *P. stelliformis* but not in *C. pugionifer*.

Dzik (1976) remarked that *C. pugionifer* contains only amorphognathiform elements and that the origin of the species is not clear. Morpohological similarity suggests to me that *C. pugionifer* might have evolved from *P. stelliformis*. However, clear evidence of the origin of either species is lacking due to the small number of elements that have been described.

Occurrence: In the study area--Specimens of *P. stelliformis* occur in the Little Oak at Pelham; and the Pratt Ferry at Pratt Ferry.

Collection: 13 specimens (stelliplanate).

Figured specimen: OSU 36374.

Reference specimen: OSU 36375.

Genus PRIONIODUS Pander, 1856

Prioniodus Pander, 1856, p. 29.

Type Species: *Prioniodus elegans* Pander, 1856.

PRIONIODUS sp.

(Not illustrated)

Remarks: Elements of *Prioniodus* occur in several of my sections. However, as amorphognathiform elements of *Prioniodus* do not occur in my collections, specific determination of the elements is not possible. Furthermore, elements of *Prioniodus* are scattered in the several sections in which they occur and may or may not be conspecific.

Occurrence: Elements of *Prioniodus* sp. occur in the Lenoir at Rockmart, Calera, and Pratt Ferry, the Little Oak at Pelham and Ragland, the Chickamauga at Red Mountain, the Athens at Calera, and the lower member of the Pond Spring Formation at Chickamauga.

Collection: 61 specimens--39 ramiform; 19 oistodiofrm (geniculate); 3 platform (fragments).

Genus PROTOPANDERODUS Lindström, 1971

Protopanderodus Lindström, 1971, p. 50.

Type Species: *Acontiodus* *rectus* Lindström, 1955.

"PROTOPANDERODUS" GIGANTEUS (Sweet and Bergström, 1962)

(Pl. III, fig. 5)

Scolopodus giganteus Sweet and Bergström, 1962, p. 1247, Pl. 169, fig. 14, Text-fig. 15; Landing, 1976, p. 639-640, Pl. 4, fig. 13 (synonomy to 1973); Repetski and Ethington, 1977, Pl. 1, figs. 11, 19.

"*Protopanderodus*" *giganteus* (Sweet and Bergström,) Bergström, 1978, p. 735.

"*Scolopodus*" *giganteus* Sweet and Bergström s.f., Nowlan, 1981, p. 13, Pl. 3, fig. 14.

Occurrence: Within the study area--One element of "*Protopanderodus*" *giganteus* occurs in samples from the Pratt Ferry Formation at Pratt Ferry. Sweet and Bergström (1962) reported and named "*P*." *giganteus* from the same unit.

Elsewhere in North America--"Protopanderodus" giganteus has also been reported from the Tetagouche Group, New Brunswick (Nowlan, 1981); the Mystic Conglomerate, Quebec (Barnes and Poplawski, 1973); the Lévis Formation, Quebec (Uyeno and Barnes, 1970); the Fort Peña Shale, Texas (Bradshaw, 1969); the Maravillas Shale, Texas (Bergström, 1978); the Womble Shale, Arkansas (Repetski and Ethington, 1977); and from the Deepkill Shale, New York (Landing, 1976).

Collection: 1 specimen.

Figured specimen: OSU 36376.

PROTOPANDERODUS VARICOSTATUS (Sweet and Bergström, 1962)

(Pl. II, fig. 7)

Scolopodus varicostatus Sweet and Bergström, 1962, p. 1247-1248, Pl. 168, figs. 4-9, Text-fig. 1A, C, K.

Protopanderodus varicostatus (Sweet and Bergström) Carnes, 1975, p. 208-210, Pl. II, figs. 10-12 (synonomy to 1974); Bergström, 1978, Pl. 79, figs. 6. 7; Tipnis et al., 1978, Pl. VIII, figs. 8, 12; Simes, 1980, Pl. 1, fig. 6.

Protopanderodus cf. varicostatus (Sweet and Bergström) Löfgren, 1978, p. 91, Pl. 3, figs. 26-31 (synonomy to 1974).

Occurrence: Within the present study--Elements of Protopanderodus varicostatus occur in the Lenoir and Athens at Calera, in the Lenoir, Pratt Ferry, and Athens at Pratt Ferry, and in the Little Oak at Pelham. Elsewhere in North America--Elements of P. varicostatus also occur in the Cobbs

Arm Limestone, Newfoundland (Bergström et al., 1974); the Davidsville group, Newfoundland (Stouge, 1980); the Cobourg Formation, Ontario (Winder, 1966); the Woods Hollow Shale, Texas (Bergström, 1978); the Fort Peña Shale, Texas (Bradshaw, 1969); the Lenoir Limestone, Tennessee and the Effna Formation, Virginia (Bergström, 1971a); the Tumbez Formation, Tennessee (Carnes, 1975); and the Holston Formation, Tennessee (Bergström and Carnes, 1976). A questionable occurrence of *P. varicostatus* has been reported from the Caesar Canyon Limestone, Nevada (Harris et al., 1979).

Collection: 431 specimens (nongeniculate).

Figured specimen: OSU 36377.

Reference specimen: OSU 36378.

Genus PYGODUS Lamont and Lindström, 1957

Pygodus Lamont and Lindström, 1957, p. 679.

Type species--*Pygodus anserinus* Lamont and Lindström, 1957.

Remarks: Bergström (1973, p. 148) observed that the element of "*Tetraprioniodus*" *lindstroemi* Sweet and Bergström, 1962, is morphologically similar to the haddingodiform element of *Pygodus*. He also noted that elements of "*T*." *lindstroemi* occur with elements of *Pygodus*, but in a much lower frequency. Löfgren (1978) tentatively included "ramiform" elements described as *T. lindstroemi* and

R. pyramidalis in *Pygodus serra*.

Studies which report large numbers of *Pygodus* elements often show a more or less consistent ratio of "*Tetraprioniodus*" *lindstroemi* (plus "*Roundya*" *pyramidalis*) to haddingodiform elements of approximately 1:8. The number of "ramiform" elements and of haddingodiform elements of *Pygodus* from several studies are given in Table I.

The common occurrence of "*Tetraprioniodus*" *lindstroemi* and "*Roundya*" *pyramidalis* with *Pygodus* and the similarity of ratios between them seem to confirm Bergström's suggestion that they are elements of the same multielement species. However, Tipnis et al. (1978) reported the occurrence of 110 elements of *P. serra* but failed to find a single element of roundyaform or tetraprioniodiform elements. Tipnis (1978) suggested that *P. serra* and *P. anserinus* might have differed in elemental composition, with *P. serra* lacking roundyaform and tetraprioniodiform elements for at least part of its stratigraphic range.

While I believe that the evidence suggests that "*T.*" *lindstroemi* and the variant "*R.*" *pyramidalis* are indeed elements of *Pygodus*, evidence of the evolution of tetraprioniodiniform and roundyaform elements during *P. serra* time is currently scant. Furthermore, Bergström (*in* Clark et al., 1981) observed that the low frequency of elements of "*T.*" *lindstroemi* and "*R.*" *pyramidalis* is

Table II. Ratio of haddingodiform elements of *Pygodus* to elements of "*Tetraprioniodus*" *lindstroemi* and "*Roundya*" *pyramidalis*.

Study	haddingodiform: "ramiform" elements
Sweet and Bergström (1962)	464:27
Hamar (1964)	419:57
Repetski and Ethington (1977)	97:11
Schmidt (1979)	566:62
The present study	985:137

difficult to explain if they are part of the *Pygodus* apparatus.

Fåhraeus and Hunter (1981, p. 1662) suggested that the pronounced cyclical occurrence of *P. serra* and *P. anserinus* in some of their sections from the Cobbs Arm Formation, Newfoundland, may reflect a benthic or nektobenthic mode of life. Based upon these cyclic occurrences they (p. 1664) did not believe that the *P. serra*-*P. anserinus* transition, as presently defined, is suitable as a time line for purposes of precise, detailed time correlations.

Fåhraeus and Hunter (1981, p. 1653) cited evidence by McKerrow and Cocks (1978) that the Cobbs Arm sequence is a huge block preserved in an olistrostrome of Silurian age. They remarked that this evidence has "no bearing on this study." They also described (p. 1653) the depositional setting of the Cobbs Arm Formation as "an island arc waning in volcanic activity." One might expect the distribution of conodont elements in such a tectonic setting to be affected largely by structural complications. However, Fåhraeus and Hunter (1981, p. 1654) found no indications of sedimentological or structural disturbances that could have caused the distribution of conodonts which they described.

Fåhraeus and Hunter (1981, p. 1662) remarked that "There does not seem to be any obvious correlation with particular facies types for the two *Pygodus* species."

However, they suggested that *P. anserinus* preferred the deeper, open marine water. According to Sloss (1963, p. 98) the Lenoir Limestone in the Appalachian Basin (and, I presume, its time-equivalent, the Cobbs Arm Limestone) was deposited during a time of transgression over the North American continent. I suspect that the seeming preference of *P. anserinus* for deeper water merely reflects the fact that the marine depth at any given place was probably greater during *P. anserinus* time than during the earlier *P. serra* time.

Fåhraeus and Hunter (1981, p. 1664) observed what they believed to be inconsistencies in the occurrences of particular species of *Eoplacognathus* relative to the *P. serra*-*P. anserinus* transition. However, elements of the multielement genus *Eoplacognathus* are morphologically rather variable within a given population, which sometimes makes specific determination difficult (see *Eoplacognathus* in the present study). The apparent inconsistency between occurrences of species of *Pygodus* and *Eoplacognathus* might have been the result of the authors' difficulty in making specific determinations of *Eoplacognathus*. In any event, the *Eoplacognathus* problem at this locality may be a moot point, considering the tectonic environment in which the conodonts of the Cobbs Arm were deposited.

I believe that it is a mistake to ignore the possibility of sedimentological and structural disturbances in a volcanic-arc sequence, just bcause thin sections fail to show evidence of them. The vertical change from the older *Pygodus serra* to the younger *P. anserinus* has been observed at numerous localities in Sweden, Great Britain, Alabama, Tennessee, and Vermont (Bergström, 1971a); and Nevada (Harris et al., 1979). Furthermore, although the *P. serra*-*P. anserinus* transition is not directly observable in many sections, evidence that rocks containing elements of *P. anserinus* are younger than those containing elements of *P. serra* is abundant. I doubt that the apparent fluctuations in populations of *Pygodus* in rocks of an island-arc sequence is a valid indication that the *P. serra*-*P. anserinus* boundary is environmentally controlled. Also, it is difficult to make a case for the benthic or nektobenthic habit of a genus whose elements occur in open-shelf carbonates and black shales, as *Pygodus* does in the rocks studied by me (see fig. 6). I have seen no substantial evidence that the *P. serra*-*P. anserinus* boundary is not the essentially isochronous surface that Bergström (1973b, p. 268) suggested it is. I consider this transition to be valid for detailed correlations and have so used it in the present study.

PYGODUS ANSERINUS Lamont and Lindström, 1957

(Pl. V, figs. 16, 17)

Pygodus anserinus Lamont and Lindström, 1957, p. 67-69, Pl. V, figs. 12, 13, fig. 1 A-D; Bergström, 1971a, p. 149, Pl. 2, figs. 20, 21 (synonomy to 1969); Viira, 1974, p. 115, Pl. XI, figs. 26, 27; Bergström, Riva, and Kay, 1974, Pl. 1, figs. 16, 17; Bergström, 1978, Pl. 79, figs. 1, 2; Harris et al., 1979, Pl. 2, fig. 18, Pl. 3, figs. 16, 127, Pl. 4, fig. 17; Simes, 1980, figs. 2, 3, 7; Robison, 1981, Fig. 80, no. 3a-d.

Remarks: Pygodiform elements of Pygodus anserinus at Ragland have a rather weakly developed fourth row of denticles. I interpret this to indicate that the Little Oak at Ragland contains early forms of P. anserinus which occur in the lower part of the Pygodus anserinus Zone.

Occurrence: Within the study area--Little Oak at Pelham; Little Oak at Ragland; Lenoir at Pratt Ferry; Pratt Ferry at Pratt Ferry; Athens at Calera. Elsewhere in North America--The Davidsville Group, Newfoundland (Stouge, 1980); the Klamath Mountains, Northern California (Bergström et al., 1980); Copenhagen Formation in Nevada (Ethington and Schumacher, 1969); Eureka Quartzite and an unnamed limestone overlying the Antelope Valley Limestone, Nevada (Harris et al., 1979); Woods Hollow Shale, Texas (Bergström, 1978); Cobbs Arm Limestone, Newfoundland (Bergström, Riva, and Kay, 1974); Youngman Formation in Vermont, Lincolnshire Limestone in Virginia, Lenoir in Tennessee (Bergström, 1971a); Holston Limestone, Tennessee

(Carnes, 1975); and the Blockhouse Formation in Tennessee (Bergström, 1973c).

Collection: 207 specimens--99 pygodiform (stelliscaphate); 108 haddingodiform (tertiopedate).

Figured specimens: OSU 36379, OSU 36380.

Reference specimens: OSU 36781 (pygodiform), OSU 36382 (haddingodiform).

PYGODUS SERRA (Hadding), 1913

(Pl. V, figs. 12, 13)

Arabellites serra Hadding, 1913, p. 33, Pl. 1, figs. 12, 13.

Pygodus serra (Hadding), Bergström, 1971a, p. 149-150, Pl. 2, figs. 22, 23 (synonomy to 1969); Bergström, Riva, and Kay, 1974, Pl. 1, fig. 18; Löfgren, 1978, p. 98, figs. 32 D, E, ?F; Tipnis et al., 1978, Pl. IX, figs. 2, 4, 7-9; Harris et al., 1979, Pl. 2, fig. 18.

?*Pygodus* sp., Tipnis, 1978, Pl. 13.1, figs. 7, 9.

Pygodus cf. *P. serrus* (Hadding), Nowlan, 1981, p. 12, Pl. 3, figs. 14, 16-20.

Occurrence: Within the study area--Little Oak at Pelham; Lenoir at Pratt Ferry; Lenoir at Calera. Elsewhere in North America--Ellesmere Island, Canada (Tipnis et al., 1978); Road River Formation in the District of Mackenzie, Canada (Tipnis, 1978); Waterville Limestone, New Brunswick (Nowlan, 1981); Cobbs Arm Limestone in Newfoundland (Bergström, Riva and Kay, 1974); Davidsville Group, Newfoundland (Stouge, 1980); Antelope Valley Limestone, Nevada (Harris et al., 1979); Youngman Formation, Vermont (Bergström, 1971a); Chazy Group, Upper Lake Champlain Valley (Roscoe, 1973); Lenoir in Tennessee (Bergström, 1971a); and Whitesburg and Blockhouse Formations in Tennessee (Bergström, 1973c).

Collection: 1794 specimens--859 pygodiform (stelliscaphate); 935 haddingodiform (tertiopedate).

Figured specimens: OSU 36383, OSU 36384.

Reference specimens: OSU 36385 (pygodiform), OSU 36386 (haddingodiform).

Genus RHIPIDOGNATHUS Branson, Mehl, and Branson, 1951

Rhipidognathus Branson, Mehl, and Branson, 1951, p. 10.

Type Species: *Rhipidognathus symmetricus* Branson, Mehl, and Branson, 1951.

RHIPIDOGNATHUS sp. cf. R. DISCRETUS Bergström and Sweet, 1966

(Pl. I, fig. 25)

cf. *Rhipidognathus discretus* Bergström and Sweet, 1966, p. 389-392, Pl. 30, figs. 13-20, *not* pl. 30, figs. 17-20.

cf. *Rhipidognathus symmetrica* Branson, Mehl, and Branson, 1951, p. 10, Pl. 2, figs. 29, 30, 34, 36, Pl. 3, fig. 31, *not* Pl. 2, figs. 31-33, 35, 37; Robison, 1981, Fig. 81, no. 3a-b, *not* 3c-f.

cf. *Rhipidognathus symmetricus* Branson, Mehl, and Branson, McCracken and Barnes, 1981, p. 89, Pl. 4, fig. 45, *not* Pl. 4, fig. 46; Sweet, 1979b, Pl. 10, fig. 7, *not* Pl. 10, fig. 5.

cf. Rhipidognathus symmetrica discreta Bergström and Sweet, Kohut and Sweet, 1968, p. 1473, Pl. 185, fig. 9, not Pl. 185, figs. 18, 19.

Remarks: Bergström and Sweet (1966) named Rhipidognathus discretus for a multielement species which includes elements similar to R. symmetricus Branson, Mehl, and Branson, but which have fewer, larger, and more discrete denticles in mature specimens. Kohut and Sweet (1968) recognized R. symmetricus discretus as a subspecies of R. symmetricus. They also observed that elements of the R. discretus type range lower stratigraphically and have a more southerly distribution than those of the R. symmetricus type.

Elements of Rhipidognathus resembling both R. discretus and R. paucidentatus Branson, Mehl, and Branson occur in my collections. Because of the small number of specimens at hand, I cannot be certain as to the subspecific affinities of R. sp. cf. R. discretus or R. sp. cf. R. paucidentatus.

The element of R. symmetricus illustrated by McCracken and Barnes (1981) resembles R. sp. cf. R. discretus of the present study except that it has shorter, possibly broken, processes with fewer denticles.

Occurrence: Within the study area--Lower member of the Pond Spring Formation, Chickamauga. Elsewhere in North America--Lower member of the Ellis Bay Formation, Quebec, Canada (McCracken and Barnes, 1981); Lexington-Kope sections, Ohio, Indiana, and Kentucky (Bergström and Sweet, 1966); Upper Maysville and Richmond Groups, Ohio, Indiana, and Kentucky (Kohut and Sweet, 1968); Pinesburg Station Dolomite, Maryland (Boger, 1976); and the Trenton Limestone, Virginia (Fetzer, 1973).

Collection: 3 specimens (ramiform).

Figured specimen: OSU 36387.

Reference specimen: OSU 36388.

RHIPIDOGNATHUS sp. cf. R. PAUCIDENTATUS
Branson, Mehl, and Branson, 1951

(Pl. I, fig. 26)

cf. *Rhipidognathus paucidentata* Branson, Mehl, and Branson, 1951, p. 10, Pl. 2, figs. 18, 19, 23, 26, 28, *not* Pl. 2, figs. 20-22, 24, 25, 27, Pl. 3, fig. 30; Palmieri, 1978, p. 26, Pl. 12, figs. 7, 8.

cf. *Rhipidognathus symmetrica symmetrica* Branson, Mehl, and Branson, Kohut and Sweet, 1968, p. 1474, Pl. 185, figs. 21, 25, *not* Pl. 185, figs. 22, 26, 29-31.

cf. New Genus new species, Tipnis, et al., 1978, Pl. IV, fig. 9.

Remarks: Elements of New Genus new species, Tipnis et al. (1978) from the Whiterockian Sunblood Formation closely resemble those of *Rhipidognathus* sp. cf. *R.* *paucidentatus*. If this is, in fact, a *Rhipidognathus*, it is perhaps the oldest known occurrence of this genus. Tipnis et al. remarked that their specimen may be ancestral to *Appalachignathus* Bergström et al. However, their New Genus new species differs from *Appalachignathus* in having a distinct aboral boss as is typical of elements of *Rhipidognathus*.

Bergström and Sweet (1966) regarded *R. paucidentatus* as a juvenile element of *R. symmetricus* Branson, Mehl and Branson. *R.* sp. cf. *R. paucidentatus* probably belongs to the same multielement species as *Rhipidognathus* sp. cf. *R. discretus* Bergström and Sweet with which it occurs in the study area. However, because of the small number of elements of *Rhipidognathus* available to me, I discuss them in the form-species sense.

Occurrence: Within the study area--Lower Member of the Pond Spring Formation, Chickamauga and the lower part of the Chickamauga Limestone, Red Mountain. Elsewhere in North America--Sunblood Formation, District of Mackenzie, Canada (Tipnis et al., 1978); Upper Maysville Group and the Richmond Group, Ohio, Indiana, and Kentucky (Kohut and Sweet, 1968); and the New Market Limestone, Maryland (Boger, 1976).

Collection: 3 specimens (ramiform).

Figured specimen: OSU 36389.

Reference specimen: OSU 36390.

Genus ROUNDYA Hass, 1953

Roundya Hass, 1953, p. 88.

Type species: *Roundya barnettana* Hass, 1953.

"ROUNDYA" PYRAMIDALIS Sweet and Bergström, 1962

(Pl. V, fig. 15)

Roundya pyramidalis Sweet and Bergström, 1962, p. 1243, Pl. 170, figs. 7-9; Hamar, 1964, p. 280, Pl. 5, figs. 15, 16, 20, 21; Viira, 1974, Pl. XI, figs. 7, 8, 11; Tipnis, 1978, Pl. 13.1, figs. 15, 16.

Pygodus serra (Hadding), Löfgren, 1978, p. 98, Text-fig. 32 F.

?*Rhynchognathus pyramidalis* (Sweet and Bergström), Hamar, 1966, p. 71.

Remarks: There is evidence that "*Roundya*" *pyramidalis* is an element of *Pygodus*. This evidence is discussed in the remarks on genus *Pygodus*.

Occurrence: Within the study area--Lenoir and Athens at Calera; Little Oak at Pelham; Lenoir at Pratt Ferry; and the Pratt Ferry at Pratt Ferry. Elsewhere in North America--Ellesmere Island, Canada (Tipnis, 1978).

Collection: 80 specimens (tertiopedate).

Figured specimen: OSU 36391.

Reference specimen: OSU 36392.

Genus SCOLOPODUS Pander, 1856
emend. Lindström, 1971

Scolopodus Pander, 1856, p. 25.

Type species: *Scolopodus sublaevis* Pander, 1856.

"SCOLOPODUS" sp.

(Pl. II, fig. 13)

cf. *Scolopodus gracilis* Ethington and Clark; Uyeno and Barnes, 1970, p. 116, Pl. XXII, figs. 9, 10; Barnes and Poplawski, 1973, p. 786-787, Pl. 3, figs. 6-8.

cf. *Scolopodus* sp. Barnes and Poplawski, 1973, p. 787, Pl. 5, figs. 12, 13.

"*Scolopodus*" sp. Bergström, 1979, p. 302-303, Figs. 4B, D.

Occurrence: Within the study area--Elements of *Scolopodus* sp. occur in the Lenoir Limestone at Rockmart. Elsewhere in North America--Representatives of *Scolopodus* sp. have been reported from the Mystic Conglomerate, Quebec (Barnes and Poplawski, 1973); Zone D1 at Lévis, Quebec (Uyeno and Barnes, 1970); the Table Head Formation, Newfoundland (Bergström, 1979); and the Antelope Valley Limestone, Nevada (Harris et al., 1979).

Collection: 16 specimens (nongeniculate).

Figured specimen: OSU 36393.

Reference specimen: OSU 36394.

Genus STAUFFERELLA Sweet, Thompson, and Satterfield, 1975 Satterfield, 1975

Staufferella Sweet, Thompson, and Satterfield, 1975, p. 43-44.

Type Species: Distacodus falcatus Stauffer, 1935a.

STAUFFERELLA FALCATA (Stauffer, 1935a)

(Pl. II, figs. 17, 18)

Distacodus falcatus Stauffer, 1935a, p. 142, Pl. 12, fig. 16; Votaw, 1971, p. 85-87, Pl. 3, figs. 4-5; Rust, 1968, Pl. II, figs. 12-14.

Staufferella falcata (Stauffer) Sweet, Thompson, and Satterfield, 1975, p. 44-46, Pl. 1, figs. 10, 11, 18 (synonomy to 1972).

Acontiodus alveolaris Stauffer, Atkinson in Clark, 1971, Pl. 3, fig. 1; Votaw, 1971, p. 55-56, Pl. 2, figs. 15, 21; Rust, 1968, Pl. I, figs. 3-5.

"Acontiodus" sp. A, Uyeno, 1974, p. 16, 217, Pl. 1, figs. 24, 25.

"Distacodus" falcatus Stauffer, Carnes, 1975, p. 123-124, Pl. III, fig. 4.

aff. Staufferella sp. aff. S. falcata (Stauffer) Harris et al., 1979, Pl. 3, fig. 6.

Remarks: Sweet et al. (1975) named the multielement genus Staufferella for a conodont apparatus containing symmetrical, slightly asymmetrical, and strongly asymmetrical elements. I refer to this work for a description and discussion of S. falcata.

The element which Harris et al. (1979) assigned to Staufferella sp. aff. S. falcata resembles the symmetrical elements of S. falcata from the present study, but the former elements lack a posterior groove. Globensky and Jauffred (1971) illustrated a lateral view of what they called Distacodus falcatus Stauffer. However, I cannot confirm their identification as they provided no description or posterior view of the element. Moreover, I disagree with their inclusion of *Scolopodus cornuformis* Sergeeva in their list of synonoms of "*D. falcatus*".

Occurrence: Within the present study--Elements of *Staufferella falcata* occur in the undifferentiated Chickamauga Limestone at Red Mountain. Elsewhere in North America--Elements of *S. falcata* also occur in the Hull Formation, Ontario and Quebec (Uyeno, 1974); the Kimmswick Formation, Missouri (Branson, 1944); the Decorah Shale, Minnesota (Stauffer, 1935b); the Glenwood Shale, Minnesota (Stauffer, 1935a); the Dubuque Formation, Minnesota (Webers, 1966); the Lexington and Kope Formations in Ohio and Kentucky (Bergström and Sweet, 1966); the Martinsburg Formation, Virginia (Rust, 1968); the Carters, Pierce, Ridley, and Lebanon Formations of Tennessee, the Nachusa Formation in Illinois, the Platteville, Decorah, and Galena Formations in Wisconsin and Iowa (Votaw, 1971); and in the Hogskin in Tennessee (Carnes, 1975). Questionable occurrences of *S. falcata* have been reported from the Copenhagen Formation, Nevada (Ethington and Schumacher, 1969); and the Denmark and Cobourg Formations, New York, Ontario, and Quebec (Schopf, 1966).

Collection: 17 specimens--2 symmetrical (nongeniculate); 15 asymmetrical (nongeniculate).

Figured specimens: OSU 36395, OSU 36396.

Reference specimens: OSU 36397 (symmetrical), OSU 36398 (asymmetrical).

STAUFFERELLA? n. sp.

(Pl. II, figs. 19, 20)

Acontiodus? sp. Ethington and Schumacher, 1969, p. 453, Pl. 68, fig. 24, Text-fig. 4D, E.

Acontiodus staufferi Furnish; Ethington and Clark, 1971, Pl. 1, fig. 14.

"*Distacodus*" n. sp. Carnes, 1975, p. 124-128, Pl. III, figs. 6-9, Fig. 15A-C.

?*Scandodus nevadensis* Ethington and Schumacher, 1969, p. 476, Pl. 68, figs. 20-21, Pl. 69, fig. 10.

?*Distacodus* aff. *D. falcatus* Stauffer; Ethington and Schumacher, 1969, p. 460, Pl. 67, fig. 14.

Remarks: Elements of *Staufferella*? n. sp. occur in a sample from the upper part of the Lenoir Limestone at Pratt Ferry, and from the Chickamauga Limestone at Red Mountain. Five symmetrical elements and four asymmetrical elements conform to the descriptions of acontiodiform and distacodiform elements, respectively, of "*Distacodus*" n. sp. by Carnes (1975).

The symmetrical element of *Staufferella*? n. sp. is similar to, and perhaps congeneric with, that of *Scolopodus cornuformis* Sergeeva (1963). My elements, and the more numerous elements described by Carnes (1975), differ in having a flat, rather than rounded, posterior surface and a midposterior carina rather than a groove.

The elemental composition of this species is similar to that of Staufferella Sweet, Thompson, and Satterfield (1975). However, my symmetrical element has no basal alae as distinct from the lateral costae and it appears to lack a depressed base.

Occurrence: Within the study area--Elements of Staufferella? n. sp. occur in the Lenoir Limestone at Pratt Ferry. Elsewhere in North America--Staufferella? n. sp. has also been reported from the Copenhagen Formation, Nevada (Ethington and Schumacher, 1969); the Manitou Formation, Colorado (Ethington and Clark, 1971); and from the Blue limestone and the Holston Formation at Cuba, Tennessee (Carnes, 1975).

Collection: 9 specimens--5 symmetrical (nongeniculate); 4 asymmetrical (nongeniculate).

Figured specimens: OSU 36399, OSU 36400.

Reference specimens: OSU 36401 (symmetrical), OSU 36402 (asymmetrical).

Genus TETRAPRIONIODUS Lindström, 1955a
emend. Bergström and Sweet, 1966

Tetraprioniodus Lindström, 1955a, p. 596.

Type species: Tetraprioniodus robustus Lindström, 1955a.

"TETRAPRIONIODUS" LINDSTROEMI Sweet and Bergström, 1962

(Pl. IV, fig. 11)

Tetraprioniodus lindstroemi Sweet and Bergström, 1962, p. 1248-1249, Pl. 170, figs. 5, 6; Hamar, 1964, p. 285, Pl. 6, figs. 4, 5, Text-fig. 4 (14); Viira, 1974, Pl. XI, figs. 9, 10, 12; Tipnis, 1978, P. 13.1, fig. 12.

Pygodus sp. C Löfgren, 1978, p. 97, Pl. 16, fig. 4, Text-fig. 32 C.

Remarks: As Bergström (1971) noted, there is evidence that "Tetraprioniodus" lindstroemi and "Roundya" pyramidalis are elements of Pygodus. I have discussed further evidence in support of this idea in the remarks on Pygodus.

Occurrence: Within the study area--Lenoir at Calera; Little Oak at Pelham; Lenoir and Pratt Ferry at Pratt Ferry. Elsewhere in North America--Ellesmere Island, Canada (Tipnis, 1978).

Collection: 57 specimens (tertiopedate).

Figured specimen: OSU 36403.

Reference specimen: OSU 36404.

Genus TRIANGULODUS Van Wamel, 1974

Triangulodus Van Wamel, 1974, p. 86.

Type Species: Paltodus volchovensis Sergeeva, 1963.

Remarks: As discussed elsewhere in the present study (see Triangulodus? brevibasis), elements assigned to Multioistodus (Cullison, 1938) and Triangulodus may be congeneric. Sweet et al. (1971) considered Eoneoprioniodus

Mound (1965) to be synonomous with *Multiostodus*, but some authors (McHargue, 1974; Boger, 1976; Barnes, 1977) consider these genera to be separate. Ziegler (1981) and Bergström *in* Robison et al. (1981) consider *Multioistodus* and *Eoneoprioniodus* to be separate genera and list *Triangulodus* as a synonym of *Eoneoprionidus*.

Ethington and Clark (1981) consider the genus *Triangulodus* to be a synonym of *Tripodus* Bradshaw (1969). However, Dzik (person. comm., 1982) observed that *Pteracontiodus* Harris and Harris (1965) might be the same as *Tripodus* and has priority over that name.

Obviously, the correct generic name for elements assigned herein to *Triangulodus* is questionable. I have tentatively assigned my specimens to *Triangulodus* primarily because I accept Van Wamel's multielement reconstruction of that genus. An earlier-named genus might well have priority over *Triangulodus*, but I cannot address the problem on the basis of the material at hand.

TRIANGULODUS? sp. cf. T. ALATUS Dzik, 1976

(Pl. I, fig. 1)

?*Triangulodus* (?) *alatus* Dzik, 1976, p. 422, text-fig. 20h, not Pl. XLII, figs. 2-5, text-figs. 20f, g, i-k.

Remarks: The element herein referred to *Triangulodus*? sp. cf. *T. alatus* Dzik is quite similar to and, probably conspecific with Dzik's specimens from Poland. The trivial name *alatus* is Latin for "winged" which is an apt description of the element at hand. Regrettably, Dzik's description is extremely brief and states only that elements of the species have a short cusp and strongly developed ridges which are elongated in the basal part. However, my element does not have a particularly short cusp, and neither, in my opinion, does the element illustrated by Dzik.

Due to Dzik's too-brief description and owing to the fact that I have only one element of *T*.? sp. cf. *T*. *alatus*, the affinities of my element are difficult to evaluate. Nevertheless, this element is extremely distinctive and I am not aware of any other element that closely resembles it. The elements which Harris and Harris (1965) referred to *Pteracontiodus* *aquilatis* and to *P*. *exelis* (which McHargue, 1973, and Boger, 1976, consider to be synonomous) are somewhat similar to those of *T*.? cf. *T*. *alatus*, especially in the winglike development of the lateral edges. However, their elements differ from mine in having a flat anterior side and a bladelike posterior edge, whereas mine has a bladelike anterior edge and a flat posterior edge. Furthermore, their element has a distinct basal cavity and mine does not. Perhaps my specimen is another element of the multielement species which contains *P*. *aquilatus*.

Occurrence: One element of _Triangulodus_? sp. cf. _alatus_ occurs in the Lenoir Limestone at Pratt Ferry.

Collection: 1 specimen (nongeniculate).

Figured specimen: OSU 36405.

TRIANGULODUS? BREVIBASIS (Sergeeva, 1963)

(Pl. I, figs. 10-13)

Oistodus brevibasis Sergeeva, 1963, p. 95, Pl. VII, figs. 4, 5.

Triangulodus sp. cf. _T. brevibasis_ (Sergeeva) Carnes, 1975, p. 211-215, Pl. VII, figs. 1-6.

Triangulodus? sp. Boger, 1976, p. 116-117, Pl. V, figs. 14-15.

Scandodus brevibasis (Sergeeva) Löfgren, 1978, p. 104, Pl. 1, figs. 30-35 (synonomy to 1977); Fåhraeus and Nowlan, 1978, p. 467, Pl. 2, fig. 21.

?_Triangulodus_ sp. B, Tipnis et al., 1978, Pl. III, figs. 18, 20.

Remarks: Carnes (1975) recognized six elements of the species which he referred to as _Triangulodus_ sp. cf. _T. brevibasis_ (Sergeeva). These include symmetrical, slightly asymmetrical, and strongly asymmetrical costate elements, scandodiform, drepanodiform, and oistodiform elements. He observed that the costate and drepanodiform elements are remarkably similar to elements which Sweet et al. (1971) referred to _Multioistodus cryptodens_ (Mound) which is known from the Whiterockian Joins Formation, Oklahoma. Carnes (1975) suggested that if further study indicates that

M. cryptodens also contains oistodiform and scandodiform elements, it may be congeneric with *T. brevibasis*.

Occurrence: Within the study area--Elements of *Triangulodus*? *brevibasis* occur in the Little Oak at Pelham and Ragland, the Lenoir and Pratt Ferry at Pratt Ferry, and the Chickamauga at Red Mountain. Elsewhere in North America--Elements of *Triangulodus*? *brevibasis* also occur in the Mystic Conglomerate, Quebec (Barnes and Poplawski, 1973); the Lévis Formation, Quebec (Uyeno and Barnes, 1970); the Row Park and New Market Limestones in Maryland and West Virginia, and in the Eidson, Hogskin, Rockdell, Benbolt, Marcem, Holston, and Lenoir Formations in Tennessee (Carnes, 1975).

Collection: 76 specimens--27 acodiform (nongeniculate); 26 paltodiform (nongeniculate); 13 oistodiform (geniculate); 10 scandodiform (geniculate).

Figured specimens: OSU 36406, OSU 36407, OSU 36408, OSU 36409.

Reference specimens: OSU 36410 (acodiform), OSU 36411 (paltodiform), OSU 36412 (oistodiform), OSU 36413 (scandodiform).

Genus WALLISERODUS Serpagli, 1967

Walliserodus Serpagli, 1967, p 104.

Type Species: *Acodus curvatus* Branson and Branson, 1947.

WALLISERODUS TUATUS (Hamar, 1964)

(Pl. II, figs. 14-16)

Scolopodus tuatus Hamar, 1964, p. 283, Pl. 2, figs. 5, 9, Text-fig. 4, no. 13; Hamar, 1966, Pl. 3, fig. 3.

Walliserodus tuatus (Hamar) Carnes, 1975, p. 226-228, Pl. IV, figs. 20, 21, Pl. V, figs. 5, 6 (synonomy to 1974).

Remarks: Serpagli (1967), Cooper (1975), and Carnes (1975) included acodiform and paltodiform elements with scolopodiform elements in the *Walliserodus* apparatus. Löfgren (1978) did not find evidence which convinced her that these elements were associated in the same multielement species. Although *Walliserodus* is common only at Calera in the present study, the consistent occurrence of scolopodiform elements with paltodiform or acodiform elements leads me to believe that these elements belong in the same apparatus.

My scolopodiform elements do not show the same variation in the number of costae as those described by Löfgren (1978). However, the relative lack of variation might be due to the comparatively small number of elements in my samples.

Ocurrence: Within the present study area--*Walliserodus tuatus* occurs in the Lenoir Limestone and Athens Shale at Calera and in the Little Oak at Pelham. Elsewhere in North America--*W. tuatus* has been reported from the Davidsville Group, Newfoundland (Stouge, 1980); the Cobbs Arm Limestone, Newfoundland (Bergström et al., 1974); the Table Head Formation, Newfoundland (Fåhraeus, 1970); the Womble Shale, Arkansas (Repetski and Ethington, 1977); and in Tennessee, the Lenoir Limestone (Bergström, 1973); the Tumbez, Elway-Eidson, and Holston Formations (Carnes, 1975); and in the Chota Formation (Bergström and Carnes, 1976).

Collection: 264 specimens: 118 scolopodiform (nongeniculate); 98 paltodiform (nongeniculate); 48 scandodiform (geniculate).

Figured specimens: OSU 36414, OSU 36415, OSU 36416.

Reference specimens: OSU 36417 (scolopodiform), OSU 36418 (paltodiform), OSU 36419 (scandodiform).

Genus WESTERGAARDODINA Müller, 1959

Westergaardodina Müller, 1959, p. 465-467.

Type species: *Westergaardodina* *bicuspidata* Müller, 1959.

WESTERGAARDODINA sp. cf. W. BICUSPIDATA Müller, 1959
(Pl. II, fig. 4)

cf. *Westergaardodina* *bicuspidata* Müller, 1959, p. 468, Pl. 15, figs. 9, 10, *not* figs. 1, 4, 17, 14; Hamar, 1966, p. 80, Pl. 6, fig. 1; Müller, 1971, Pl. 2, fig. 8, *not* fig. 9; Druce and Jones, 1971, p. 100-101, Pl. 7, figs. 1a-4d, Text-fig. 32; Dzik, 1976, fig. 1, fig. 12a; Robison, 1981, Fig 66, no. 1.

cf. *Westergaardodina*? sp. cf. Tipnis et al., 1978, Pl. III, fig. 4.

cf. Problematicum I Westergård, 1953, p. 466, Pl. 5, figs. 1-5, 13.

Remarks: Lindström (1964, p. 32) observed that elements of Westergaardodina are usually black and may occur in rocks of Middle Ordovician age. Therefore, although the element of W. cf. W. bicuspidata from Pelham is very dark, it has not necessarily been reworked.

Occurrence: Within the present--Elements of Westergaardodina sp. cf. W. bicuspidata occur in the Lenoir at Pratt Ferry and Calera. Elsewhere in North America--Tipnis et al. (1978) reported elements similar to W. cf. W. bicuspidata from the Broken Skull Formation in the District of Mackenzie, Canada.

Collection: 3 specimens (geniculate).

Figured specimen: OSU 36420.

Reference specimen: OSU 36421.

Genus and Species Indet. A

(Pl. V, fig. 4)

Description: The element assigned to Genus and Species indet. A has an anterior, a posterior, and a lateral process. The denticles are erect and are subrounded in cross section. The three denticles on the anterior (?) process are fused and are smaller at the distal end than at the proximal end, but all of them are broken off. The three denticles on the posterior (?) process are discrete and are approximately equal in height. The lateral process diverges laterally from the posterior (?) process at an angle of approximately 65 degrees and is deflected downward at an angle of approximately 25 degrees. It is surmounted by 4 short, discrete denticles. None of the denticles on the element is conspicuously larger than the others or is in any other way distinct enough to be referred to as the cusp. Owing to the dark color and poor preservation of the element, I cannnot determine if the element is hyaline or nonhyaline, nor can I see the basal cavity.

Remarks: The element assigned to Genus and Species indet. A resembles that of *Prioniodus* sp. B of Sweet et al. (1971) from the Lehman Formation, Utah.

Occurrence: This element occurs in the Lenoir Limestone at Rockmart.

Collection: 1 specimen.

Figured specimen: OSU 36422.

Genus and Species indet. B

(Pl. I, fig 2)

Description: The element has a stout, reclined cusp and two (lateral?) processes. The cusp and denticles are discrete, subrounded in cross section, and have distinct flangelike edges. One process has 2 denticles. The other process, which is apparently broken, has 1 denticle, but might have originally had more. The basal cavity is moderately deep.

Remarks: The element assigned to Genus and Species indet. B is extremely dark, but resembles hyaline elements in having robust, discrete denticles with flangelike edges. The element resembles one from the Holønda Limestone in Norway which Bergström (1979, Fig. 4K) assigned to "*Erismodus*" *invurvenscens* Harris.

Collection: 1 specimen.

Figured specimen: OSU 36423.

Genus and Species indet. C.

(Pl. V, fig. 2)

Remarks: Two fragmentary elements of Genus and Species indet. C have been found in the Lenoir Limestone at Rockmart. Owing to the poor preservation of the specimens, the specific and the generic affinities of the elements are questionable. These elements resemble elements of the genus *Histiodella* Harris (1972).

Occurrence: Two elements of Genus and Species indet. C occur in the Lenoir Limestone at Rockmart.

Collection: Two specimens:

Figured specimen: OSU 36424.

Reference specimen: OSU 36425.

Genus and Species indet. D

(Pl. II, fig. 10)

Description: The element is a simple cone with an erect cusp and a laterally flaring base. The base does not project very far anteriorly or posteriorly and has a shallow basal cavity. A costa is present near the center of each lateral face of the cusp.

Remarks: The element assigned to Genus and Species indet. D occurs with, and may be an element (the suberectiform one) of, Drepanoistodus suberectus (Branson and Mehl). It differs from that element in having a distinct costa on each lateral surface.

Occurrence: One element of Genus and Species indet. D occurs in the uppermost Lenoir Limestone at Rockmart.

Collection: 1 specimen (nongeniculate).

Figured specimen: OSU 36426.

Genus and Species indet. E

(Pl. II, fig. 11)

Remarks: One element assigned to Genus and Species indet. E occurs in the lowermost Murfreesboro at Chickamauga. The element is a simple, proclined cone that is circular in cross section and has a deep, conical basal cavity.

Collection: 1 specimen (nongeniculate).

Figured specimen: OSU 36427.

Genus and Species indet. F

(Pl. V, fig. 3)

Description: The element of Genus and Species indet. F is a straight, nonhyaline, denticulate blade which appears to be the broken-off process of a larger element. The blade is surmounted by about 20 blunt, laterally compressed, slightly reclined denticles which are fused for somewhat more than half of their height. Denticles are shorter on the distal end of the process, but no denticle appears to be the cusp. The lower margin of the blade has a carina on one side, but no basal cvity is present.

Occurrence: Elements assigned to Genus and Species indet. F occur in the Lenoir Limestone at Pratt Ferry and the Little Oak Limestone at Pelham.

Collection: 13 specimens.

Figured specimen: OSU 36428.

Reference specimen: OSU 36429.

Genus and Species indet. G

(Pl. IV, fig. 17)

Description: This element is an unarched, laterally flexed blade with anterior and posterior processes and a somewhat reclined cusp. The cusp and all denticles are laterally flattened and apically pointed. The anterior process has 6 or 7 erect, crowded denticles which are fused to each other, and at the proximal end, to the cusp. The posterior process has 2 to 5 discrete, reclined denticles. All denticles decrease in height distally and are distinctly, but not conspicuously, smaller than the cusp.

The base has a basal cavity which flares widely beneath the cusp, particularly on the inner (concave) side of the blade. The basal cavity may or may not continue beneath the processes as a slit. However, the extent of the basal cavity, and the hyaline or nonhyaline composition of the element, cannot be determined on the black, poorly preserved specimens at hand.

Remarks: Three elements assigned herein to Genus and Species indet. G were collected from the Lenoir Limestone at Rockmart. Although none of the elements is complete, they are probably conspecific with better-preserved elements in undescribed collections of Bergström from the Lenoir Limestone in the vicinity of Rockmart. The better-preserved elements are similar to those which Mound (1965) assigned to _Pravognathus idoneus_ Stauffer. However, the elements at hand differ from those described by Stauffer in that the apical (proximal) denticles of my elements are only slightly longer and no wider than the other denticles on the posterior process. Most of the elements illustrated by Stauffer have apical denticles which are markedly longer and wider than the other denticles.

Occurrence: Elements of Genus and Species indet. G occur in the Lenoir Limestone at Rockmart.

Collection: 7 specimens.

Figured specimen: OSU 36430.

Reference specimen: OSU 36431.

Indet. Hyaline Elements

(not illustrated)

Remarks: A number of simple, hyaline cones and unidentifiable hyaline fragments occur in my samples, especially in those from Chickamauga and the lower part of the Red Mountain section. Most all of my specimens are too fragmentary, too simple, or too poorly understood to have significant biostratigraphic utility.

Occurrence: Indet. hyaline elements occur in the Lenoir at Pratt Ferry, the Little Oak at Pelham, Pratt Ferry, and Ragland, the Chickamauga at Red Mountain, and the Pond Spring and Murfreesboro at Chickamauga.

Collection: 622 specimens.

Reworked Elements of Early Ordovician Age
(not illustrated)

Remarks: A number of conodont elements from the lower part of the Rockmart and Portland sections are apparently reworked elements from the underlying Knox Dolomite. The elements most nearly resemble those described by Furnish (1938) from the Prairie du Chien Group of Early Ordovician age in Minnesota, Wisconsin, and Iowa. Although many of the elements are not well preserved, a number of them are identical, morphologically, to elements of _Scolopodus quadraplicatus_ Branson and Mehl or to elements of _Clavohamulus densus_ Furnish. Because these elements occur only in the lower part of the Lenoir at Rockmart and Portland, they occur in rocks containing dolomite clasts, and at Rockmart, they have a markedly higher CAI (Epstein, et al., 1977) than elements from slightly higher in the section, I have no reason to doubt that they were derived from the underlying Knox Dolomite.

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APPENDIX A

Measured Sections and Sample Locations

The descriptions and measurements of the sections are given below. The unit numbers are the author's. Sections were measured, when possible, directly with a yard stick. Covered intervals were measured horizontally with a steel tape and corrected for dip. Collecting localities are given on pages 31 and 32. T=thickness, CT=cumulative thickness, in feet.

Chickamauga Section

Sample designations 80MS1, 80MS2, 80MS3, 80MS4, and 80MS14.

The section from Chickamauga is a composite. Sample localities were plotted on the map of Milici and Smith (1969) and converted to equivalent stratigraphic elevations.

Pond Spring Formation

Unit	T	CT	Description
1.	140	140	Lower member of the Pond Spring Formation; unconformably overlies the Knox Dolomite. Much of the unit is covered. Limestone, medium-bedded, gray, very fine-grained; breaks with a conchoidal fracture. Fossils abundant, but visible only with a hand lens or microscope. 80MS4-1. Approximately 20' above the base of the Chickamauga. Sample taken from outcrop in

Unit	T	CT	Description
			abandoned bend in road on west side of present-day highway, southeast of Chickamauga High School. 80MS1-1. Approximately 118' above base of the Chickamauga. Sample taken from north end of abandoned quarry, immediately next to railroad tracks.
2.	66	206	Middle member of Pond Spring Formation. Exposed at north end of pond in quarry. Limestone, thick-bedded, light-gray calcilutite. 80MS2-1. 165' above base of Chickamauga. 80MS2-2. 183' above base of Chickamauga.
3.	67	273	Upper Member of Pond Spring Formation. Argillaceous calcisiltite that weathers to shale. Generally thin-bedded with thicker-bedded, calcareous layers. Sample taken from southeast end of quarry. 80MS14-1. 245' above base of Chickamauga.

Murfreesboro Limestone

Unit	T	CT	Description
4.	10	283	Lowermost Murfreesboro Limestone. Limestone, moderately thick-bedded, gray, fine-grained. 80MS3-1. 283' above base of Chickamauga. Sample collected across road from Owings Cemetery.

Pelham Section

Sample designation 80MS7.

Samples from 80MS5 and 80MS6 are from the Odenville Limestone, near Pelham. These samples were processed for conodonts, but the results are not reported in the present study because the Odenville is not part of the Chickamauga Limestone.

Little Oak Limestone

Unit	T	CT	Description
1.	115	115	Limestone, thick-bedded, dark gray, somewhat fossiliferous. Contains chert nodules. Samples are from the south end of the quarry wall. Base of Little Oak not exposed at this locality. 80MS7-1. Bottom of section. 80MS7-2. 5' above base of section. 80MS7-3. 10' above base of section. 80MS7-4. 15' above base of section. 80MS7-5. 20' above base of section. 80MS7-6. 25' above base of section. 80MS7-7. 30' above base of section. 80MS7-8. 35' above base of section. 80MS7-9. 40' above base of section. 80MS7-10. 45' above base of section. 80MS7-11. 50' above base of section. 80MS7-12. 55' above base of section. 80MS7-13. 60' above base of section. 80MS7-14. 65' above base of section. 80MS7-15. 70' above base of section. 80MS7-16. 75' above base of section. 80MS7-17. 80' above base of section. 80MS7-18. 87' above base of section. 80MS7-19. 92' above base of section. 80MS7-20. 97' above base of section. 80MS7-21. 103' above base of section. 80MS7-22. 108' above base of section. 80MS7-23. 114' above base of section.
2.	7	122	Covered interval.
3.	4	126	Limestone. Similar to lower Little Oak, but more argillaceous and thinner-bedded.

Unit	T	CT	Description
4.	6	132	Covered interval.
5.	2	152	Limestone. Same as unit 3, partially covered.
			80MS7-25. 133' above base of section.
			80MS7-26. 142' above base of section. 80MS7-27. 152' above base of section.
6.	12	164	Covered interval.
7.	2	166	Limestone. Same as unit 3.
			80MS7-28. 165' above base of section.
8.	20	186	Covered interval.
9.	3	189	Limestone. Same as unit 3.
			80MS7-29. 187' above base of section.
10.	10	199	Covered interval.
11.	3	202	Limestone. Same as unit 3.
			80MS7-30. 200' above base of section.

Pratt Ferry Section

Sample designations 80MS8 and 64B2.

Lenoir Limestone

Unit	T	CT	Description
1.	21	21	Limestone. Medium-bedded; bedding distinct. Dark gray, fine-grained, argillaceous. Distinct cobbly weathering. Some fossil fragments exposed on weathered surfaces. Base of formation not exposed. At least a few feet of limestone at the base of the section are covered by dense vegetation.

Unit	T	CT	Description
			80MS8-1. Base of section. 80MS8-2. 5' above base of section. 80MS8-3. 10' above base of section. 80MS8-4. 15' above base of section. 80MS8-5. 20' above base of section.
2.	3	24	Covered interval. Possible fault contact.
3.	22	46	Limestone. Same as unit 1.
			80MS8-6. 25' above base of section. 80MS8-7. 30' above base of section. 80MS8-8. 35' above base of section. 80MS8-9. 40' above base of section. 80MS8-10. 45' above base of section.
4.	21	67	Covered interval.
5.	6	73	Limestone. Same as unit 1.
			80MS8-11. 68' above base of section. 80MS8-12. 73' above base of section.
6.	16	89	Covered interval.
7.	7	96	Limestone. Same as unit 1.
			80MS8-13. 90' above base of section. 80MS8-14. 95' above base of section.
8.	55	151	Covered interval.
9.	56	207	Limestone. Same as unit 1.
			64B2-1. 152' above base of section. 80MS8-15. 152' above base of section. 64B2-2. 155' above base of section. 80MS8-16. 157' above base of section. 64B2-3. 160' above base of section. 80MS8-17. 162' above base of section. 64B2-4. 165' above base of section. 80MS8-18. 167' above base of section. 80MS8-19. 172' above base of section. 64B2-5. 172' above base of section. 80MS8-20. 177' above base of section. 80MS8-21. 182' above base of section. 80MS8-22. 187' above base of section.

Unit	T	CT	Description
			64B2-6. 192' above base of section. 80MS8-23. 192' above base of section. 64B2-7. 197' above base of section. 80MS8-24. 197' above base of section. 64B2-8. 200.5' above base of section. 80MS8-25. 202' above base of section. 64B2-9. 203.5' above base of section. 80MS8-26. 206' above base of section.

Pratt Ferry Formation

Unit	T	CT	Description
10.	8	215	Limestone. Dark gray, calcarenitic, thin-bedded, richly fossiliferous. Weathers to a dark, crumbly rubble. 64B2-10. Base of Pratt Ferry Formation. 207' above base of section. 64B2-11. 214' above base of section. 64B2-12. 215' above base of section.

Athens Shale

Unit	T	CT	Description
11.	12	227	Shale. Black, very fissile, thin-bedded. Contains graptolites. 64B2-13. 6' above base of Athens. 221' above base of section. 64B10a-1. 227' above base of section.

Ragland Section

Sample designation 80MS9.

Little Oak Limestone

Unit	T	CT	Description
1.	11.5	11.5	Limestone. Thick-bedded, light gray, fine-grained. Base of formation not exposed. 80MS9-3. 2' above base of section.

Unit	T	CT	Description
2.	0.5	12	Bentonite. Light green, soft. Several inches thick.
3.	19	31	Limestone. Same as unit 1.
			80MS9-2. 11' above base of section. 80MS9-1. 23' above base of section.
4.	-	31	Bentonite. Light green, soft. One inch thick.
5.	5	36	Limestone. Same as unit 1.
6.	0.5	36.5	Bentonite. Light green, soft. Several inches thick.
7.	11	46.5	Limestone. Same as unit 1, but contains chert nodules.

Red Mountain Section

Sample designation 80MS10.

Chickamauga Limestone (undifferentiated)

Unit	T	CT	Description
1.	11	11	Covered interval. Knox Dolomite at base of unit. Red Clay cover contains fragments of green, mottled shale and of chert.
2.	34	45	Limestone, light gray, very fine-grained calilutite. Thick-bedded. Upper part of unit darker gray. Unit largely covered by concrete.
			80MS10-1. 11' above base of Chickamauga. 80MS10-2. 24' above base of Chickamauga. 80MS10-3. 35' above base of Chickamauga.
3.	1	46	Calcareous shale. Dark, thin-bedded, only moderately fissile. Upper and lower contacts abrupt.

Unit	T	CT	Description
4.	2	48	Limestone, dark gray, massive-bedded, fine grained. 80MS10-4. 46' above base of Chickamauga.
5.	2	50	Calcareous shale; same as unit 3.
6.	2	52	Limestone, grayish-yellow, fairly thin-bedded, slightly fossiliferous.
7.	1.5	53.5	Calcareous shale, dark, more fissile and thin-bedded than unit 3.
8.	2	55.5	Limestone; same as unit 6. 80MS10-5. 54' above base of Chickamauga.
9.	1.5	57	Shale; same as unit 7.
10.	19	76	Limestone, grayish-yellow, moderately thin-bedded to medium-bedded. Thicker beds are fossiliferous. 80MS10-6. 64' above base of Chickamauga. 80MS10-7. 74' above base of Chickamauga. Unit 10 is overlain by massive- to thick-bedded limestone. No samples collected from this unit.

Calera Section

Sample designations 80MS11, 71B19, and 68B10a.

Lenoir Limestone

Unit	T	CT	Description
1.	3	3	Limestone. Medium- to thick-bedded. Light to medium gray. Not fossiliferous. Somewhat argillaceous. Base of Lenoir not exposed.

Unit	T	CT	Description
			80MS11-11. 1' above base of section.
2.	7	10	Covered interval.
3.	2	12	Limestone. Same as unit 1.
			80MS11-10. 11' above base of section.
4.	4	16	Covered interval.
5.	7	23	Limestone. Same as unit 1, but more argillaceous.
			80MS11-9. 18' above base of section. 80MS11-10. 23' above base of section.
6 .	15	30	Covered interval.
7.	15	45	Limestone. Thin bedded, dark gray, highly argillaceous. Becomes more shaly upsection. Contact with overlying Athens Shale gradational.
			80MS11-7. 30.5' above base of section. 80MS11-5. 31.5' above base of section. 80MS11-6. 33.5' above base of section. 80MS11-4. 39' above base of section. 80MS11-3. 40.5' above base of section. 80MS11-2. 42.5' above base of section. 80MS11-1. 44.5' above base of section.

Athens Shale

Unit	T	CT	Description
8.	35	80	Shale. Thin-bedded, highly fissile, black. Contains graptolites.
			71B19-1. 0.5' above base of Athens. 45.5' above base of section. 68B10a-1. 46.5' above base of section. 71B19-3. 51.5' above base of section. 71B19-2. 54' above base of section. 71B19-4. 59' above base of section. 71B19-5. 80' above base of section.

Rockmart Section

Sample designations 80MS12, 72B16, 72B17, and 72B18.

Lenoir Limestone

Unit	T	CT	Description
1.	5	5	Limestone. Light gray, medium-bedded, fine-grained calcilutite; breaks with conchoidal fracture. Base of Lenoir not exposed at this locality.
			80MS12-11. 3' above base of section.
2.	2.5	7.5	Limestone. Dove-gray, calcilutite, with distinct birdseye texture. Beds one to several inches thick.
3.	4	11.5	Limestone. Dark gray, thin-bedded calcilutite. Breaks with conchoidal fracture.
			80MS12-10. 8' above base of section.
-	-	-	Traverse. Offset is only about 5' laterally, but sections are separated by a vertical fault. Displacement of fault appears to be only a few feet. The stratigraphic measurements are continued from the stratigraphic level at which sample 80MS12-10 was collected, relative to the gray birdseye unit near the base of the section, which appears to be the same as unit 2 in the lower section.
4.	7	18.5	Limestone. Light gray, same as unit 1.
			80MS12-9. 14.5' above base of section.
5.	1	19.5	Limestone. Medium gray, banded calcilutite. Thin-bedded, breaks with conchoidal fracture. Fresh surfaces have soap-like texture.
6.	5	24.5	Limestone. Light gray, medium- to thick-bedded calcilutite.
			80MS12-08. 22' above base of section.

Unit	T	CT	Description
7.	8	32.5	Birdseye limestone. Same as unit 2.
			80MS12-7. 27' above base of section.
8.	0.5	33	Limstone. Light gray, massive to thick-bedded calcilutite.
			80MS12-6. 33' above base of section.
9.	14?	47	Covered interval. Lateral offset 140'. Faults may separate the sections on either side of the covered interval.
10.	5.5	52.5	Limestone. Light gray, same as unit 8.
			80MS12-5. 47' above base of section. 80MS12-4. 51.5' above base of section.
11.	3	55.5	Birdseye limestone. Same as unit 2.
			80MS12-3. 55.5' above base of section.
12.	5?	60.5	Covered interval. Lateral offset 110'. Same possible structural complications as in the case of unit 9.
13.	9.5	70	Limestone. Same as unit 8.
			80MS12-2. 60.5' above base of section. 80MS12-1. 63.5' above base of section. 72B17-1. 67' above base of section. 72B16-1. 70' above base of section.
?	?	?	Limestone. Light gray calcilutite. Isolated outcrop at north end of quarry. Stratigraphic elevation relative to other samples not known, but taken to be some distance beneath the base of the Rockmart Slate.
			72B18-1. Top surface of outcrop.

Rockmart Slate

Unit	T	CT	Description
14.	10+	80+	Slate. Dark, highly fissile. No fossils visible.

Portland Section

Sample designation 80MS13.

Newala Limestone

Unit	T	CT	Description
1.	10	10	Limestone. Light gray, massive to thick-bedded, fine-grained, clean. Base of formation not exposed. 80MS13-1. Collected 10' below base of Lenoir; considered to be base of section. 80MS13-2. 5' above base of section. 80MS13-3. 10' above base of section.

Lenoir Limestone

Unit	T	CT	Description
2.	27	37	Limestone. Dark gray, medium- to thin-bedded, fine-grained, argillaceous calcilutite to calcisiltite. Unconformably overlies the Newala, but contact not visible in section. Contact assumed to be at same level as where it is clearly visible, about 100' away. 80MS13-4. 5' above base of section. 80MS13-5. 20' above base of section. 80MS13-6. 25' above base of section.
3.	127	44	Covered interval.
4.	28	72	Limestone. Same as unit 2. 80MS13-7. 45' above base of section. 80MS13-8. 50' above base of section. 80MS13-9. 57' above base of section. 80MS13-10. 63' above base of section. 80MS13-11. 68' above base of section.

Rockmart Slate

5.	10+	82+	Slate. Black, highly fissile.

APPENDIX B

Thin-Section Descriptions

Description of thin sections from the study area. The carbonate classification is that of Dunham (1962). Stratigraphic and geographic location of samples are given in Appendix A.

Chickamauga

80MS1-1. Ostracodal mudstone. Micrite matrix with abundant (up to 40%) dolomite. Dolomite rhombs small, uniform in size, darker at center. Fenestral fabric, voids filled with 2 generations of cement; 1st generation small, equant, sparry calcite, 2nd generation large, often monocrystalline spar. Poorly sorted. Skeletal fragments dominantly ostracodes, many whole with void-filling spar. Also gastropods, minor crinoid columnals, bryozoans.

2-2. Ostracodal mudstone. Micrite with about 5% dolomite rhombs. Rhombs very small, clear, moderately well formed, uniform in size. Weakly-developed fenestral fabric; fenestrae filled with massively crystalline spar. Skeletal fragments mostly ostracodes, also trilobites, gastropods, crinoids. Most are fairly large or whole. Minor burrowing with dolomite rhombs in burrows.

3-1. Mudstone. Extremely fine-grained micrite with mudcracks. Cracks are filled with mud clasts and sparry cement.

4-1. Molluscan wackestone. Matrix of micrite with as much as 50% dolomite. Rhombs variable in size, dark at centers, well formed. Skeletal fragments fairly large but broken; dominantly molluscs, also trilobites and ostracodes, some of which are whole. 1 nautiloid cephalopod (?). Grains angular and strongly micritized.

14-1. Pelletal packstone. Pellets well rounded, uniform in size, and cemented with pseudospar. Minor dolomitization; rhombs very small, well formed, dark, and uniform in size.

Pelham

80MS7-1. Mudstone. Pseudospar nearly 100%. Minor quantities of ostracodes, molluscs, crinoids. Skeletal material nearly whole.

7-5. Skeletal wackestone (pelletal packstone?). Pseudospar (poorly preserved pellets?) greater than 80%, by volume. Tiny, poorly formed rhombs of dolomite in layers. Skeletal material moderately well preserved, mostly echinoderms and ostracodes, some molluscs. Stylolites present in dolomite layers.

7-9. Pelletal packstone (?). Pellets (?) poorly preserved, cemented with pseudospar. Dolomite rhombs moderately small, poorly formed, occur in stylolitic layers. Skeletal material under 10% by volume; dominantly echinoderms, also bryozoans and ostracodes. Skeletal material fragmented, but not severely so. Minor burrowing.

7-13. Pelletal wackestone. Pellets vary in size. Pseudospar cement. Skeletal material mostly crinoids and molluscs, also ostracodes, trilobites, sponge spicules. Skeletal material well preserved but not abundant. Void-filling spar and geopetal structure in some ostracodes. Minor burrowing.

7-17. Pelletal packstone. Pseudospar cement. Pellets well rounded, variable in size. Trilobites, crinoids, gastropods, minor bryozoans not abundant, but well preserved. Abundant burrows filled with mud-supported pellets.

7-21. Pelletal packstone. Pseudospar cement. Pellets fairly well rounded, variable in size. Gastropods, pelecypods, bryozoans common, echinoderms, brachiopods, ostracodes, trilobites present. Gastropod infillings (?) also common. Void-filling spar in some ostracodes. Many bryozoans are encrusting. Some grains have oncolitic coating. Intense burrowing, fossils largely broken.

7-25. Pelletal packstone. Pseudospar cement. Pellets well rounded and variable in size. Skeletal material under 10% by volume. Mostly echinoderms; also mulluscs, arthropods, bryozoans, sponges. Skeletal material fragmented. Strongly burrowed sediment. Abundant stylolites in layers containing well-formed, moderately large dolomite rhombs.

7-27. Pelletal wackstone (packstone?). Pseudospar cement. Pellets well formed and uniform in size. Skeletal material not severely abraded; mostly trilobites, molluscs, ostracodes, bryozoans. Ostracode infillings (?) fairly common. Slightly stylolitic.

7-29. Pelletal packstone. Pseudospar cement. Pellets well rounded, variable in size. Skeletal material over 20% by volume; abraded. Ostracodes abundant; also contains trilobites, echinoderms, molluscs, bryozoans, brachiopods. Intraclasts (infillings?) present. Moderately stylolitic with poorly-formed dolomite rhombs in stylolitized layers. Moderately burrowed.

Pratt Ferry

80MS8-2. Pelletal packstone. (Grapestone). Pseudospar cement. Pellets vary in size, pelletal clasts fairly large. Skeletal material under 5% by volume. Bryozoans, echinoderms, molluscs, ostracodes. Skeletal fragments fairly large.

8-5. Pelletal wackestone (packstone?). Pseudospar cement. Peloids not well rounded; may be micritized skeletal matter. Micrite instraclasts (infillings?), broken mollusc fragments under 5% by volume. Minor burrowing.

8-9. Pelletal packstone (grapestone). Pseudospar cement. Pellets variable in size, well formed. Intraclasts, probably infillings of microspar present. Skeletal material fairly large particles; molluscs, echinoderms, brachiopods, bryozoans. Micritized particles. Intensely stylolitic with well-formed, moderately dark dolomite rhombs between stylolites. Intensely burrowed.

8-13. Pelletal wackestone. Pseudospar cement. Pellets poorly preserved, but apparently variable in size. Skeletal fragments abraded, mostly echinoderms, gastropods, brachiopods, arthropods, minor bryozoans. Burrowed; burrows filled with light-colored pseudospar and pellets.

8-17. Crinoidal wackestone. Pseudospar cement. Pellets poorly preserved. Skeletal fragments abraded; mostly echinoderms, also brachiopods, molluscs, bryozoans, sponges, arthropods. Some light colored micritic instraclasts (infillings?). Moderately stylolitic with pyrite in stylolites. Intensely burrowed.

8-21. Crinoidal wackestone. Pseudospar cement. Skeletal particles abraded; mostly echinoderms. Trilobites, minor amounts of brachiopods, molluscs also present. Small but abundant stylolites with fine dolomite rhombs that are dark in color.

8-25. Skeletal wackestone. Pseudospar cement. Pellets moderately abundant. Skeletal material not abraded; mostly echinoderms and molluscs, minor arthropods and brachiopods.

Unnumbered sample from middle of the Pratt Ferry at Pratt Ferry. Crinoidal wackestone. Micrite and pseudospar cement. Skeletal material abundant, may be grain supported, but lack of void-filing spar suggests that it is not. Skeletal matter mostly echinoderms. Trilobites and ostracodes common; molluscs, bryozoans, brachiopods uncommon. Skeletal matter moderately abraded. Blocky cement in fractures and in some solution cavities.

Ragland
80MS9-2. Pelletal packstone. Pseudospar cement. Abundant dolomite rhombs, well formed, clear, variable in size. Pellets uniform in size, well formed. Skeletal fragments under 5% by volume; mostly trilobites and ostracodes, minor molluscs, echinoderms. Skeletal material fairly well preserved. Some stylolites.

Red Mountain
80MS10-1. Mudstone. Minor molluscan fragments; under 5%. Appears to have minor burrowing.

10-3. Skeletal wackestone. Micrite cement. Most skeletal fragments tiny, apparently of molluscs, sponge spicules, arthropods; larger skeletal material mostly molluscs, sponges, crinoids, arthropods, minor brachiopods. Burrows filled with microspar and pellets. Some burrows have void-filling cement. Slightly stylolitic.

10-5. Skeletal wackestone. Micrite cement. Moderately fossiliferous; skeletal material around 20%, by volume. Skeletal material mostly abraded crinoids; trilobites, ostracodes, sponges, brachiopods, bryozoans also fairly common. Pellets present, but not abundant. Stylolitic and intensely burrowed.

10-7. Skeletal wackestone. Description the same as 10-5, but skeletal material around 40%, by volume.

Calera
80MS11-1. Skeletal wackestone/packstone. Micrite cement. Crinoids dominant skeletal matter. Molluscs, arthropods, minor brachiopods also present. Skeletal matter well preserved. One large, whole gastropod has

geopetal filling. Packstone layer contains skeletal fragments with sutured contacts. Pyrite abundant. Dark, stylolitic, moderately burrowed.

11-5. Skeletal wackestone. Micrite cement. Skeletal fragments severely abraded (probably bioturbated), but some large fossils, including whole brachiopod with geopetal filling present. Echinoderms most common, also trilobites, brachiopods, molluscs. Strongly stylolitic. Pyrite abundant.

11-7. Skeletal wackestone. Dolomitic. Dolomite rhombs small, variable in size, poorly formed, light in color. Skeletal material somewhat fragmentary; composed mostly of echinoderms, but trilobites, gastropods, ostracodes, brachiopods also present.

11-9. Dolomitic mudstone. Dolomite rhombs small, variable in size, very poorly formed, light in color. Skeletal material fragmentary; composed mostly of echinoderms. Brachiopods common; arthropods, molluscs, sponges also present. Stylolitic.

11-11. Pelletal packstone. Pseudospar cement. Pellets uniform in size, well formed. Skeletal particles under 10% by volume, moderately broken. Echinoderms and ostrocodes common; molluscs and brachiopods present. Burrowed, stylolitic, dark. Small, dark, poorly-formed dolomite rhombs in stylolitic areas.

Rockmart

80MS12-1. Mudstone? Depositional texture appears to be obliterated by metamorphism. About 80% micrite and 20% spar with pressure twinning. Spar may be fenestral. Some skeletal matter appears to be molluscan.

12-3. Dolomitic mudstone. Micrite with tiny, well-formed, uniform-size dolomite rhombs throughout. Microstylolites throughout.

12-5. Dolomitic, pelletal wackestone (?). Micrite cement with cloudy, well-formed dolomite rhombs of varying size throughout. Dolomitic clasts well rounded, contain well-formed dolomite rhombs of equal size wtih dark centers. Pelletal clasts well rounded, contain pellets of equal size. Fenestrae (?) pressure twinned. Small pellets in micrite are flattened, similar in size. A few echinoderm fragments present.

12-7. Pelletal packstone. Pseudospar cement. Pellets uniform in size, flattened horizontally. Fenestrae (?) pressure twinned. Echinoderm fragments up to 2%, by volume.

Portland

80MS13-3. Depositional texture obliterated by metamorphism. Micrite with fine layers of mica and "pods" (flattened clasts?) of dolomite. Dolomite rhombs rounded, moderately dark, up to 15% of total volume. Sparry areas may be fenestrae (echinoderms?); around 3%, by volume.

13-10. Depositional texture obliterated by metamorphism. Micaceous, micrite around 75%, by volume. Mica present in tiny, wavy layers. Remaining 25% composed of flattened "pods" of spar and microspar; "pods" oriented parallel to mica layers (horizontally). Appears to be stylolitic.

APPENDIX C

Distribution and Frequency of Conodont Elements in the Sections Investigated

Each species represented in the study area is indicated by a number as given in Table I (p. 34). Species numbers are listed at the top of Tables III - X. Sample numbers are listed in stratigraphically ascending order in the left column of Tables III - X, and correspond to designations given in Appendix A. Question marks indicate that the identification is not certain.

Table III. Distribution and frequency of conodont elements in the Chickamauga section.

species	11	16	18	21	29	35	36	37	44	49	50	57	64
Sample													
80MS 3-1	-	12	-	6	-	-	1	-	-	-	-	-	1
80MS14-1	-	8	-	4	-	-	1	-	-	-	-	-	-
80MS 2-2	-	50	-	9	-	-	2	-	-	-	-	-	-
80MS 2-1	-	95	-	32	-	-	5	-	-	-	-	-	-
80MS 1-1	3	70	3	17	-	174	-	49	1	3	2	-	-
80MS 4-1	-	325	-	85	4	44	-	4	-	-	-	2	-

Table IV. Distribution and frequency of conondont elements in the Red Mountain section.

species	1	4	6	7	10	16	18	21	26	27	32	36	38	39	44	50	53	54	57	58	67
Sample																					
80MS10-7	-	-	8	-	4	1	22	-	-	3	-	-	-	-	2	-	6	-	-	-	-
80MS10-6	1	-	5	-	-	-	6	-	-	-	1	-	-	-	-	-	6	-	2	-	-
80MS10-5	5	-	71	1	52	-	14	-	9	-	24	23	2	-	1	-	5	1	1	-	1
80MS10-4	-	10	1	-	-	-	-	1	-	-	4	-	-	-	-	-	-	-	2	1?	-
80MS10-3	-	13	-	-	-	-	1	-	-	-	3	5	3	2	-	-	-	-	1	-	5
80MS10-2	-	1	-	-	-	4	-	-	-	-	-	1?	1	-	-	-	-	-	-	-	9
80MS10-1	-	5	-	-	-	27	-	18	-	-	-	-	8	-	-	1	-	-	-	-	68

Table V. Distribution and frequency of conodont elements in the Pratt Ferry section.

species	1	4	6	7	8	10	12	18	22	25	26	27	28	30	32	33	35	40	42	43	44	45	46	47	48	51	54	55	56	57	58	59	65
Sample																																	
64B2- 14	-	-	-	-	-	-	-	2	-	-	-	-	-	-	1	2	-	-	-	-	-	-	4	1	-	1	-	1	-	-	-	-	-
64B2- 13	-	-	-	-	-	-	-	1	-	-	-	-	-	-	2	2	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-
64B2- 12	-	-	1	-	-	-	-	20	-	-	2	1	-	-	8	23	-	-	2	7	-	1	17	56	-	5	-	3	-	1	-	-	-
64B2- 11	2	-	16	-	-	1	1	12	-	-	4	2	-	-	4	19	-	-	-	-	-	-	7	50	-	-	-	6	-	-	-	-	-
64B2- 10	-	-	2	-	-	-	-	3	-	-	-	-	-	-	19	1?	-	-	-	-	-	-	1	-	12	1	-	1	-	-	-	-	-
80MS8-26	7	-	8	3	1	13	7	12	1	-	3	1	1	2	92	32	-	47	-	-	12	-	1	-	238	15	5	13	-	1	-	-	-
64B2- 9	1	-	3	-	-	1	-	6	1	-	1	-	-	1	14	7	-	-	-	-	-	-	6	-	31	3	-	-	-	1?	-	-	-
80MS8-25	1	-	1	1	-	1	-	1?	-	-	-	-	-	-	1	1	-	2	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-
64B2- 8	2	-	5	-	-	4	2	3	-	-	9	2	-	-	55	10	-	-	-	-	-	-	3	-	55	3	2	2	-	1	-	-	-
80MS8-24	2	-	8	1	-	6	2	1	1	-	-	-	-	-	12	-	-	12	-	-	-	-	3	-	5	-	-	-	-	1	-	-	-
64B2- 7	1	-	4	1	-	-	-	2	-	1	1	-	-	-	19	7	-	11	-	-	2	-	-	-	46	1	1	2	-	1	-	-	-
80MS8-23	5	-	4	-	-	2	1	-	-	-	3	-	-	-	5	1	-	3	-	-	-	-	-	-	4	1	-	-	-	1	-	1	-
64B2- 6	-	-	-	-	-	-	3	2	-	-	1	-	-	-	23	4	-	12	-	-	-	-	1	-	10	1	-	-	-	-	-	-	-
80MS8-22	2	-	3	-	-	2	-	-	-	-	1	-	-	-	8	1	-	13	-	-	1	-	-	-	5	-	-	1	-	-	-	-	-
80MS8-21	9	-	18	-	1	9	7	5	1	-	2	-	-	-	25	-	-	13	-	-	-	-	6	-	3	-	-	-	-	2	-	-	3
80MS8-20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
64B2- 5	1	-	5	-	-	-	1	-	-	-	-	-	-	2	5	-	-	4	-	-	-	-	-	-	3	-	-	1	-	-	-	-	-
80MS8-19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
80MS8-18	2	-	22	-	-	9	1	-	-	-	2	1	-	-	25	-	-	22	-	-	2	-	1	-	14	-	-	-	-	2	-	-	-
64B2- 4	-	-	2	1	1	2	2	1	-	1	-	-	-	1?	4	-	-	4	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
80MS8-17	1	1	7	-	-	5	1	-	2	1	3	-	-	-	31	1	-	5	-	-	-	-	-	-	5	-	-	-	1	1	-	-	-
64B2- 3	2	-	37	-	-	4	1	2	-	-	1	-	-	-	15	1	-	11	-	-	2	-	1	-	14	1	-	-	-	-	-	-	-
80MS8-16	-	-	3	-	-	6	-	-	2	-	-	-	-	-	3	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
64B2- 2	-	-	2	1	-	-	-	-	-	-	-	-	-	-	7	-	-	10	-	-	-	-	1	-	10	-	-	-	-	1	-	-	-
80MS8-15	3	-	8	-	-	-	1	-	-	-	2	-	-	-	11	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
64B2- 1	3	-	10	2	-	5	-	-	-	-	-	-	-	-	7	-	1?	18	-	-	-	-	-	-	11	1	-	-	-	-	-	-	-
80MS8-14	-	-	6	-	2	2	2	-	1	-	1	-	-	-	19	-	-	2	-	-	-	-	-	-	1	-	-	-	-	1	-	-	-
80MS8-13	3	-	7	-	-	1	-	-	2	-	-	-	-	-	33	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
80MS8-12	-	-	2	-	2	-	-	1	-	-	-	-	-	-	9	1	-	2	-	-	-	-	-	-	1	-	-	-	-	-	8	-	-
80MS8-11	-	-	1	-	1	1	-	1	1	-	-	-	-	-	6	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
80MS8-10	2	-	2	-	-	-	-	-	-	-	-	-	-	-	-	1	-	3	-	-	-	-	-	-	2	-	-	-	-	1?	2	-	-
80MS8- 9	-	-	-	-	-	1	-	-	-	-	-	-	-	-	4	1	-	1	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-
80MS8- 8	-	-	-	-	-	-	-	-	1?	-	-	-	-	-	4	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-
809MS8-7	-	-	-	-	1	1	-	-	-	-	-	-	-	-	5	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-
80MS8- 6	1	-	1	-	1	1?	-	1	-	-	-	-	-	-	1	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
80MS8- 5	1	-	4	-	-	1	-	-	-	-	-	-	-	-	2	1	-	4	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
80MS8- 4	1	-	2	-	-	1	-	1	-	-	-	-	-	-	12	-	-	3	-	-	1	-	-	-	1	-	-	-	-	-	-	-	-
80MS8- 3	-	-	2	-	-	-	-	1	-	-	-	-	-	-	6	-	-	1	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
80MS8- 2	1	-	1	-	-	1	-	-	-	-	-	-	-	-	2	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
80MS8- 1	-	-	-	-	4	2	-	-	-	-	1	-	-	-	3	-	-	1	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
80MS8-101	1	-	3	-	-	3	-	2	-	-	1	-	-	-	14	2	-	4	-	-	-	-	-	-	-	-	-	-	-	1?	-	-	-
*	3	-	6	-	-	-	1	-	1	-	1	-	-	-	5	1	-	2	-	-	-	-	-	-	4	-	-	-	-	2	-	-	1

*Unnumbered specimen collected by Bergström. See Appendix A.

Table VI. Distribution and frequency of conodont elements in the Pelham section.

species	1	3	5	6	7	8	9	10	12	18	22	25	26	27	32	33	39	40	42	43	44	46	47	48	51	55	57	58	65	67
Sample																														
80MS7-30	-	-	-	12	2	-	-	3	1	9	-	1	-	2	37	2	-	-	2	-	-	1	3	-	1	-	2	2	-	3
80MS7-29	2	-	-	19	-	-	-	6	3	3	2	-	1?	1	21	3	-	-	1	-	-	-	10	-	-	-	5	-	-	-
80MS7-28	2	-	-	16	1?	-	-	6	2	2	1	1	-	1	45	-	-	-	-	1	-	-	11	-	-	1	1	2	-	-
80MS7-27	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
80MS7-26	3	-	-	5	2	-	-	4	3	6	-	-	1	3	31	2	-	-	-	-	-	2	-	3	1	-	6	-	-	1
80MS7-25	4	-	1	47	-	-	1	1	-	6	-	-	-	4	41	3	1	-	-	1	-	1	-	11	-	-	5	-	-	-
80MS7-24	4	-	-	19	-	-	-	1	2	5	-	-	-	2	20	1	-	-	-	-	-	-	-	2	-	1	-	-	-	-
80MS7-23	3	-	-	31	-	-	-	3	2	3	-	1	-	2	18	2	-	-	-	1	-	1	-	14	1	-	1?	-	-	1
80MS7-22	1	-	-	11	-	-	-	-	1	2	-	-	1	2	22	2	-	-	1	1	-	-	-	5	1	1	-	-	-	-
80MS7-21	1	-	-	8	-	-	-	-	3	-	-	-	-	-	16	-	-	-	-	-	-	-	-	2	-	1	-	-	-	-
80MS7-20	3	-	-	9	-	-	-	5	3	-	-	-	-	-	48	3	-	-	-	1	-	-	-	14	-	-	-	-	-	5
80MS7-19	1	-	-	7	-	-	-	5	1	-	-	-	-	-	17	1?	-	-	-	-	-	-	-	4	-	1	-	-	-	3
80MS7-18	1	-	-	12	-	-	-	1	4	3	-	-	-	4	34	3	-	-	-	-	-	2	-	15	-	1	1	1	-	-
80MS7-17	-	-	-	2	-	1	-	1?	-	3	-	-	-	-	8	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-
80MS7-16	1	-	-	3	-	-	-	-	2	-	-	-	-	-	17	1	-	-	-	-	-	-	-	4	-	-	-	-	-	-
80MS7-15	1	-	-	6	-	-	-	3	-	-	-	-	2	-	19	-	-	1	-	-	-	-	-	9	-	-	-	1	-	-
80MS7-14	2	-	-	9	-	-	-	-	-	1	-	-	3	-	11	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-
80MS7-13	-	-	-	4	-	-	-	2	-	-	-	-	-	-	6	-	-	5	-	-	-	-	-	2	-	-	-	-	-	-
80MS7-12	2	-	-	10	-	-	-	2	-	1	-	-	-	-	23	2	-	14	-	-	2	-	-	5	-	-	-	1	-	1
80MS7-11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-	5	-	-	-	-	-	3	-	-	-	-	-	-
80MS7-10	1	-	-	2	-	-	-	2	-	6	-	-	2	-	20	-	-	14	-	-	1	2	-	1	-	-	-	2	2	-
80MS7- 9	3	-	-	8	-	1	-	1	-	2?	-	-	1	2	8	4	-	27	-	-	3	1	-	3	-	-	-	1	-	-
80MS7- 8	4	-	-	13	-	-	-	1	1	-	-	-	3	-	10	-	-	20	-	1	5	-	-	10	-	-	1	-	-	-
80MS7- 7	6	-	-	8	1	-	-	-	-	1	-	-	3	-	13	3	-	10	-	1	-	1	-	3	-	-	2	1	-	-
80MS7- 6	-	-	-	5	-	-	-	4	1	-	-	-	2	-	4	-	-	11	-	-	2	1	-	2	-	-	-	2	1	-
80MS7- 5	2	1	-	2	-	1	-	3	-	-	-	-	3	-	-	1	-	8	-	-	-	1	-	2	-	-	-	1	-	-
80MS7- 4	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	2	-	16	-	-	1	2	-	1	-	-	-	3	-	-
80MS7- 3	-	-	-	-	-	-	-	-	-	-	-	-	2	-	1	1	-	4	-	-	-	-	-	2	-	-	-	-	-	-
80MS7- 2	4	-	-	1	-	-	-	3	-	2	-	-	-	-	2	2	-	10	-	-	1	2	-	3	-	-	-	1	-	-
80MS7- 1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table VII. Distribution and frequency of conodont elements in the Calera section.

species Sample	1	2	5	6	10	12	13	14	17	18	19	26	27	30	31	32	33	35	40	41	44	46	47	48	51	55	57	58	59
71B19- 5	-	4	-	-	-	-	-	-	7	3	-	-	1	-	-	-	154	-	-	1	-	2	6	-	1	-	-	2	-
71B19- 4	-	-	-	9	-	-	-	-	45	37	-	-	4	-	-	5	1061	-	-	-	-	16	-	87	-	2	2	90	-
71B19- 2	-	1	-	8	-	-	-	1	13	-	6	-	-	-	1	-	183	-	-	-	-	2	-	32	4	-	-	4	-
71B19- 3	-	1	-	-	-	-	-	-	15	5	3	-	-	-	-	3	146	-	-	-	-	3	-	18	-	1	-	2	-
68B10a- 1	-	-	-	5	-	-	-	-	15	11	41	-	2	-	-	2	238	-	1	-	12	20	-	29	1	1	2	4	-
71B19 - 1	-	1	-	-	-	-	7	40	23	18	18	-	7	1	1	8	418	-	1	-	1	40	-	124	2	1?	1	13	-
80MS11- 1	-	12	-	4	3	-	6	42	67	10	25	-	1	-	4	3	461	-	-	-	-	39	-	217	2	3	-	10	-
80MS11- 2	-	-	-	2	-	1	5	18	10	5	25	-	1	-	4	6	293	-	-	-	-	64	-	271	5	3	1	31	-
80MS11- 3	-	3	-	4	-	-	2	10	96	4	3	-	-	-	2	6	397	2?	5	-	-	99	-	423	5	1	4	45	-
80MS11- 4	-	-	-	2	-	-	-	-	18	3	6	-	-	-	-	1	133	-	-	-	-	25	-	56	2	1	1?	19	-
80MS11- 6	2	-	-	46	-	-	1	-	-	4	-	1	-	-	-	16	12	-	-	-	-	6	-	4	-	1	-	-	-
80MS11- 5	5	-	1	5	-	-	2	9	-	8	-	1	1	-	-	14	166	-	-	-	-	18	-	41	3	-	2	6	1
80MS11- 7	-	-	-	72	1	-	1	-	-	3	-	1	1	-	-	5	11	-	-	-	-	13	-	12	-	2	-	1	-
80MS11- 8	1	-	-	53	-	-	-	-	1	2	-	2	-	-	-	3	4	-	-	-	-	3	-	1	1	-	3	-	-
80MS11- 9	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
80MS11-10	-	-	-	1	1	-	-	-	-	4	-	-	-	-	-	22	-	-	-	-	-	2	-	-	-	1	-	-	-
80MS11-11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table VIII. Distribution and frequency of conodont elements in the Ragland section.

species Sample	1	6	8	10	12	18	22	25	26	27	32	33	35	42	44	47	57	67
80MS9-1	1	32	1	14	14	4	-	1	2	-	21	1	2?	1	-	4	8	2
80MS9-2	-	14	1	3	6	2	-	-	-	1	23	-	-	-	-	1	-	-
80MS9-3	1	31	2	3	-	2	1?	-	2	-	16	2	-	-	1	2	-	1

Table IX. Distribution and frequency of conodont elements in the Rockmart section.

species	5	15	17	18	20	23	24	34	44	52	55	57	58	60	61	62	63	66	68
Sample																			
72B16 - 1	-	-	-	-	-	-	7	16	1	-	-	-	-	-	-	-	-	3	-
72B17 - 1	4	1	1?	32	-	48	-	3	-	2	-	2?	3?	-	1	1	-	4	-
80MS12- 1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
80MS12- 2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
80MS12- 3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
80MS12- 4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3
80MS12- 5	-	-	-	3?	-	-	1	-	-	-	-	-	-	-	-	-	-	-	6
80MS12- 6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
80MS12- 7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	23
80MS12- 8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
80MS12- 9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
80MS12-10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
80MS12-11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
72B18 - 1	-	2	-	-	2	20	2	10	-	14	1?	1?	-	1	-	-	1	-	-

Table X. Distribution and frequency of conodont elements in the Portland section.

species	68
Sample	
80MS13-11	-
80MS13-10	-
80MS13- 9	-
80MS13- 8	-
80MS12- 7	-
80MS13- 6	18
80MS13- 5	137
80MS13- 4	28
80MS13- 3	9
80MS13- 2	6
80MS13- 1	3

APPENDIX D

Plates

DESCRIPTION OF PLATE I.

Figure

1. *Triangulodus*? sp. cf. *T.*? *alatus* Dzik, 1976. Alate ramiform element. Lateral view, X89. Lenoir Limestone at Pratt Ferry (80MS8-17). OSU 36405.

2. Genus and Species indet. B. Lateral view, X52. Lenoir Limestone at Rockmart (72B17-1). OSU 36423.

3-5. *Drepanoistodus suberectus* (Branson and Mehl, 1933).

   3. Oistodiform (geniculate) element. Lateral view, X94. Lenoir Limestone at Calera (80MS11-5). OSU 36260.

   4. Suberectiform (nongeniculate) element. Lateral view, X106. Lenoir Limestone at Pratt Ferry (80MS8-24). OSU 36061.

   5. Homocurvatiform (nongeniculate) element. Lateral view, X47. Chickamauga Limestone at Red Mountain (80MS10-4). OSU 36062.

6-9. *Erraticodon* sp.

   6. Element type C. Lateral view, X46. Little Oak Limestone at Pelham (80MS7-29). OSU 36290.

   7. Element type D. Lateral view, X53. Lenoir Limestone at Pratt Ferry (80MS8-11). OSU 36291.

   8. Element type A. Lateral view, X45. Little Oak Limestone at Pelham (80MS7-28). OSU 36292.

   9. Element type B. Lateral view, X34. Lenoir Limestone at Pratt Ferry (80MS8-24). OSU 36293.

10-13. *Triangulodus*? *brevibasis* (Sergeeva, 1963).

   10. Oistodiform (geniculate) element. Lateral view, inner side, X89. Little Oak Limestone at Ragland (80MS9-1). OSU 36406.

   11. Paltodiform (nongeniculate) element. Lateral view, outer side, X51. Little Oak Limestone at Pelham (80MS7-16). OSU 36407.

Figure

12. Acodiform (nongeniculate) element. Posterolateral view, X102. Little Oak Limestone at Pelham. (80MS7-015). OSU 36408.

13. Scandodiform (geniculate) element. Lateral view, outer side, X39. Chickamauga Limestone at Red Mountain (80MS10-4). OSU 36409.

14-20. *Erismodus* sp.

14. Asymmetrical trichonodelliform (alate, Sa) element. Posterior view, X43. Pond Spring Formation at Chickamauga (80MS4-1). OSU 36276.

15. Symmetrical trichonodelliform (alate, Sb) element. Posterior view, X33. Pond Spring Formation at Chickamauga (80MS4-1) OSU 36277.

16. Zygognathiform (bipennate, Sd) element. Lateral view, X29. Pond Spring Formation at Chickamauga (80MS4-1). OSU 36278.

17. Oulodontiform (angulate, Pb) element. Lateral view, inner side, X39. Pond Spring Formation at Chickamauga (80MS4-1). OSU 36279.

18. Prioniodiniform (digyrate, P) element. Lateral view, inner side, X41. Pond Spring Formation at Chickamauga (80MS4-1). OSU 36281.

20. Eoligonodiniform (digyrate, Sc) element. Lateral view, X52. Pond Spring Formation at Chickamauga (80MS4-1). OSU 36282.

21-24. *Curtognathus* sp. cf. *C. typus* Branson and Mehl, 1933.

21. Curtognathiform element. Posterior view, X82. Pond Spring Formation at Chickamauga (80MS2-2). OSU 36248.

22. Polycaulodiform element. Lateral view, X57. Pond Spring Formation at Chickamauga (80MS2-2). OSU 36249.

23. Cardiodelliform element. Anterior view, X47. Pond Spring Formation at Chickamauga (80MS2-1). OSU 36251.

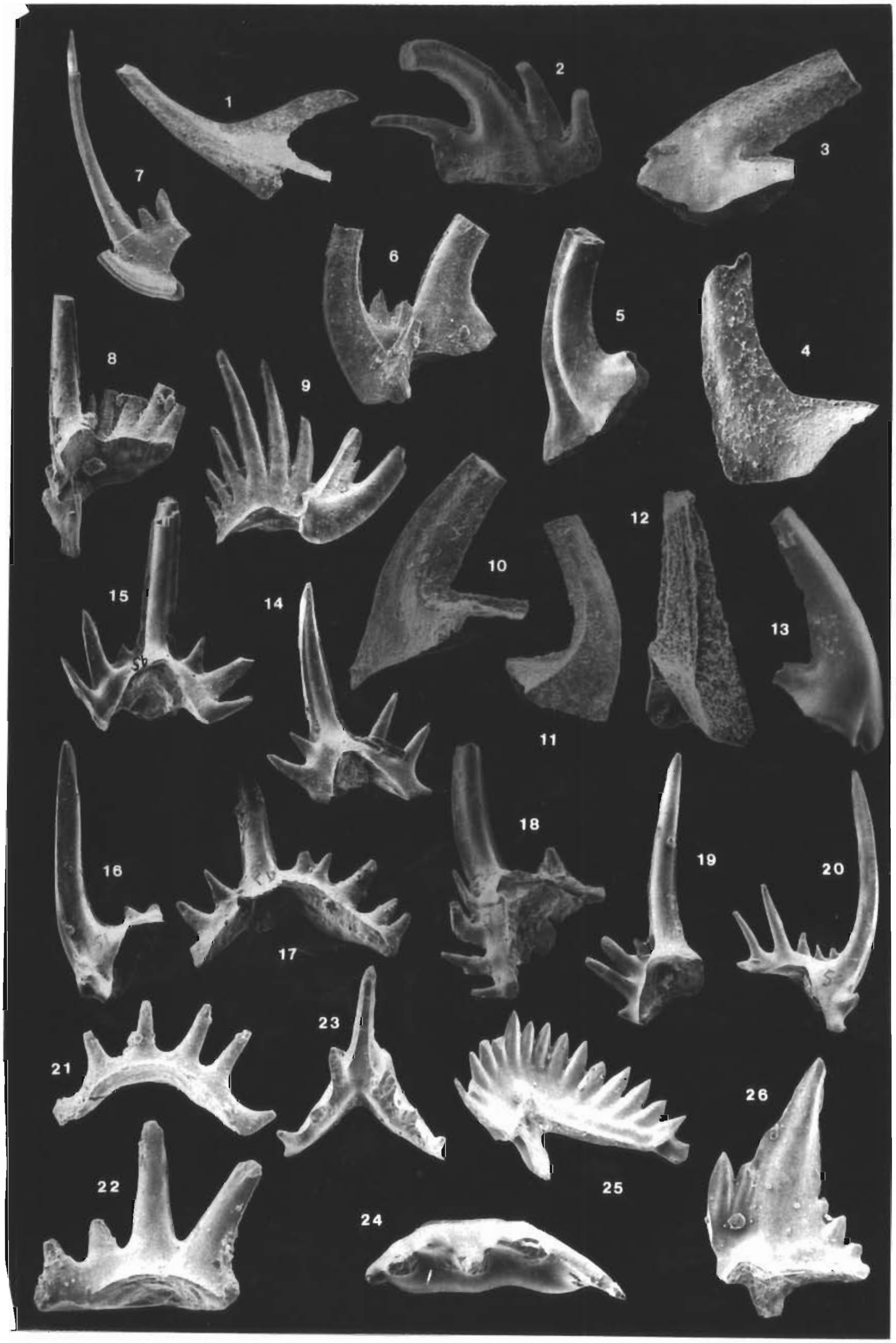
Figure

24. Trucherognathiform element. Anterior view, X49. Pond Spring Formation at Chickamauga (80MS1-1). OSU 36252.

25. *Rhipidognathus* sp. cf. *R*. *discretus* Bergström and Sweet, 1966. Posterior view, X27. Pond Spring Formation at Chickamauga (80MS1-1). OSU 36387.

26. *Rhipidognathus* sp. cf. *R*. *paucidentatus* Branson, Mehl, and Branson, 1951. Posterior view, X52. Pond Spring Formation at Chickamauga (80MS1-1). OSU 36389.

PLATE I.



DESCRIPTION OF PLATE II.

Figure

1. *Leptochirognathus* sp. Lateral view, inner side, X98. Lenoir Limestone at Rockmart (72B18-1). OSU 36304.

2. *Cordylodus*? sp. Lateral view, X46. Lenoir Limestone at Rockmart (72B18-1). OSU 36246.

3. *Coelocerodontus*? *digonius* Sweet and Bergström, 1962. Lateral view, furrowed side, X35. Lenoir Limestone at Pratt Ferry (80MS8-26). OSU 36239.

4. *Westergaardodina* sp. cf. *W*. *bicuspidata* Müller, 1959. Lateral view, X71. Lenoir Limestone at Calera (80MS11-1). OSU 36420.

5-6. *Coelocerodontus* *lacrimosus* Kennedy, Barnes, and Uyeno, 1979.

  5. Symmetrical (nongeniculate) element. Lateral view, X68. Lenoir Limestone at Calera (80MS11-2). OSU 36241.

  6. Asymmetrical (nongeniculate) element. Lateral view, inner side, X41. Lenoir Limestone at Calera (80MS11-1). OSU 36421.

7-9. *Juanognathus* *variabilis* Serpagli, 1974.

  7. Ramiform element. Posterior view, X35. Lenoir Limestone at Rockmart (72B17-1). OSU 36298.

  8. Nongeniculate element. Lateral view, inner side, X34. Lenoir Limestone at Rockmart. (72B17-1). OSU 36299.

  9. Geniculate element. Lateral view, inner side, X37. Lenoir Limestone at Rockmart. (72B17-1). OSU 36300.

10. Genus and Species indet. D. Lateral view, X53. Lenoir Limestone at Rockmart (72B18-1). OSU 36426.

11. Genus and Species indet. E. Posterolateral view, X65. Lowermost Murfreesboro Formation at Chickamauga (80MS3-1). OSU 36427.

Figure

12. *Coelocerodontus*? sp. cf. *C. trigonius* Ethington, 1959. Lateral view, X58. Lenoir Limestone at Calera (80MS11-1). OSU 36244.

13. "*Scolopodus*" sp. Lateral view, X39. Lenoir Limestone at Rockmart (72B17-1). OSU 36393.

14-16. *Walliserodus tuatus* (Hamar, 1964).

    14. Paltodiform (nongeniculate) element. Lateral view, X82. Lenoir Limestone at Calera (80MS11-2). OSU 36414.

    15. Scolopodiform (geniculate) element. Lateral view, X82. Lenoir Limestone at Calera (80MS11-2). OSU 36415.

    16. Scandodiform (geniculate) element. Lateral view, X76. Lenoir Limestone at Calera (80MS11-1). OSU 37416.

17-18. *Staufferella falcata* (Stauffer, 1935a).

    17. Symmetrical (nongeniculate) element. Posterior view, X74. Chickamauga Limestone at Red Mountain (80MS10-7). OSU 36395.

    18. Asymmetrical (nongeniculate) element. Lateral view, X81. Chickamauga Limestone at Red Mountain (80MS10-7). OSU 36396.

19-20. *Staufferella*? n. sp.

    19. Symmetrical (nongeniculate) element. Posterior view, X89. Lenoir Limestone at Pratt Ferry (80MS8-26). OSU 36399.

    20. Asymmetrical (nongeniculate) element. Lateral view, X75. Lenoir Limestone at Pratt Ferry (80MS8-26). OSU 36400.

21. "*Oistodus*" *pseudoabundans* Schopf, 1966. Lateral view, X94. Little Oak Limestone at Pelham (80MS7-5). OSU 36308.

22-23. *Dapsilodus mutatus* (Branson and Mehl, 1933).

Figure

22. Acodiform (geniculate) element. Lateral view, inner side, X98. Lenoir Limestone at Calera (80MS11-1). OSU 36256.

23. Acontiodiform (nongeniculate) element. Lateral view, inner side, X82. Lenoir Limestone at Calera (80MS11-1). OSU 36257.

24. *Acontiodus robustus* (Hadding, 1913). Lateral view, X82. Lenoir Limestone at Calera (80MS11-1). OSU 36205.

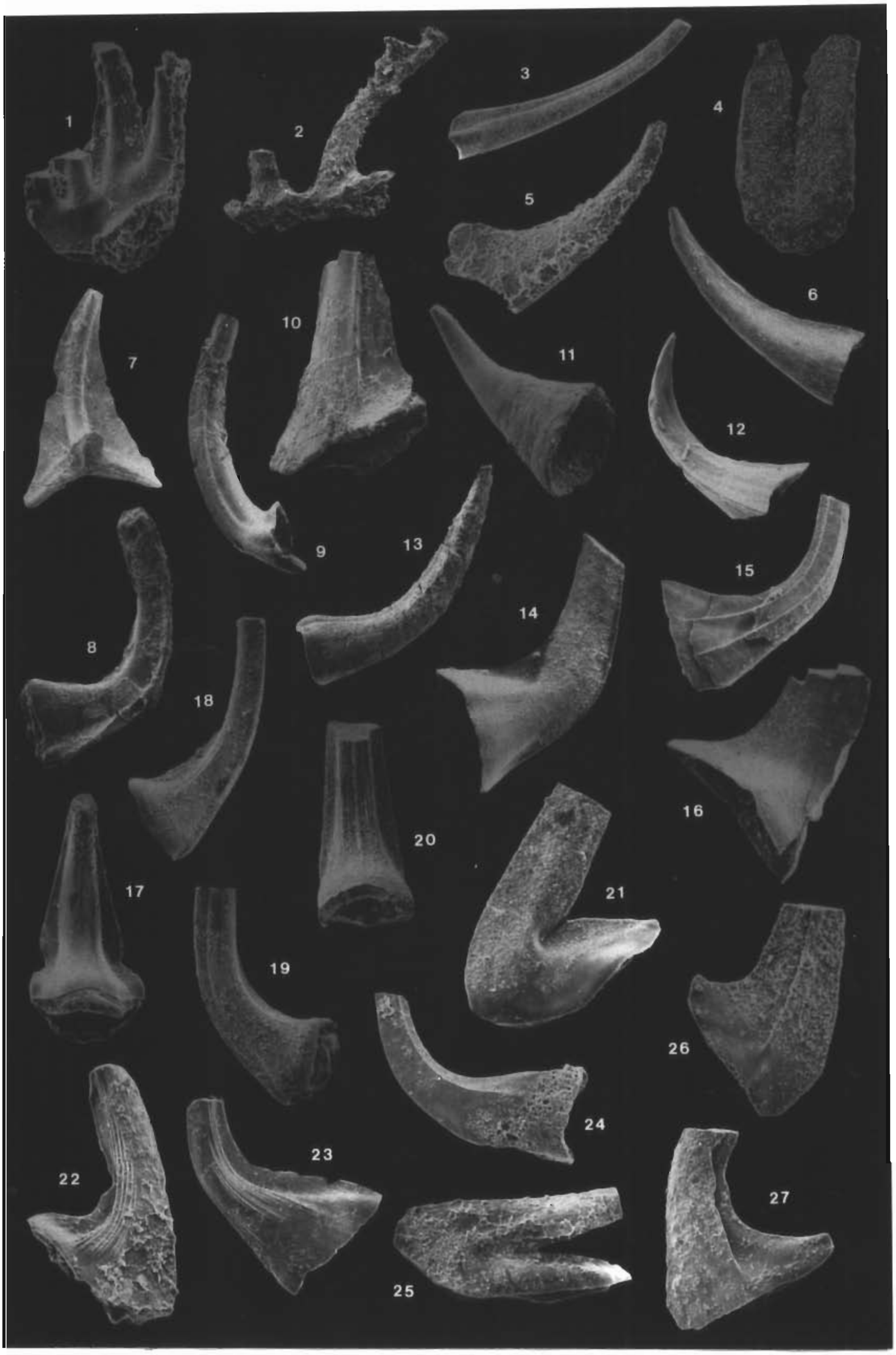
25. "*Oistodus*" sp. cf. "*O.*" *venustus* Stauffer, 1935a. Lateral view, X82. Little Oak Limestone at Pelham (80MS7-25). OSU 36310.

26-27. "*Acodus*" *variabilis* (Webers, 1966).

26. Acodiform (geniculate) element. Lateral view, X125. Little Oak Limestone at Pelham (80MS7-9). OSU 36201.

27. Acontiodiform (nongeniculate) element. Lateral view, X87. Little Oak Limestone at Pelham (80MS7-7). OSU 36202.

PLATE II.



DESCRIPTION OF PLATE III.

Figure

1-2. Panderodus gracilis (Branson and Mehl, 1933).

1. Compressiform (nongeniculate, M) element. Lateral view, outer side, X65. Little Oak Limestone at Pelham (80MS7-18). OSU 36319.

2. Graciliform (nongeniculate, S) element. Lateral view, outer side, X65. Little Oak Limestone at Pelham (80MS7-18). OSU 36320.

3. Panderodus alabamensis (Sweet and Bergström, 1962). Lateral view, outer side, X65. Lenoir Limestone at Calera (80MS11-1). OSU 36317.

4. "Oistodus" sp. Lateral view, X54. Lenoir Limestone at Pratt Ferry (80MS8-26). OSU 36312.

5. "Protopanderodus" giganteus (Sweet and Bergström 1962). Lateral view, X17. Pratt Ferry Formation at Pratt Ferry (64B2-12). OSU 36376.

6. Paltodus sp. Lateral view, outer side, X55. Lenoir Limestone at Pratt Ferry (80MS8-26). OSU 36315.

7. Protopanderodus varicostatus (Sweet and Bergström, 1962). Lateral view, X82. Lenoir Limestone at Calera (80MS11-1). OSU 36377.

8. Belodina sp. cf. B. compressa (Branson and Mehl, 1933). Rastrate element. Lateral view, X82. Little Oak Limestone at Pelham (80MS7-25). OSU 36229.

9. Belodella n. sp. cf. B. devonica (Stauffer, 1940). Lateral view, X82. Little Oak Limestone at Pelham (80MS7-25). OSU 36213.

10-13. Belodella nevadensis (Ethington and Schumacher, 1969).

10. Oistodiform (geniculate, M?) element. Lateral view, X70. Chickamauga Limestone at Red Mountain (80MS10-5). OSU 36215.

Figure

11. Biconvex belodelliform (asymmetrical ramiform, Sc?) element. Lateral view, X86. Little Oak Limestone at Ragland (80MS9-3). OSU 36216.

12. Oepikodiform (nongeniculate, P?) element. Lateral view, X82. Chickamauga Limestone at Red Mountain (80MS10-5). OSU 36217.

13. Triangular biconvex (alate ramiform, sa?) element. Lateral view, X70. Chickamauga Limestone at Red Mountain (80MS10-5). OSU 36218.

14-15. Belodella sp.

14. Triangular belodelliform (alate ramiform, Sa) element. Lateral view, X55. Lenoir Limestone at Pratt Ferry (80MS8-12). OSU 36225.

15. Biconvex belodelliform (asymmetrical ramiform, Sc?) element. Lateral view, X82. Little Oak Limestone at Ragland (80MS9-2). OSU 36226.

16-18. Belodina monitorensis Ethington and Schumacher, 1969.

16. Eobelodiniform (geniculate, Sc?) element. Lateral view, outer side, X82. Chickamauga Limestone at Red Mountain (80MS10-5). OSU 36231.

17. Grandiform (rastrate, P?) element. Lateral view, outer side, X51. Chickamauga Limestone at Red Mountain (MS10-5). OSU 36232.

18. Compressiform (rastrate, P?) element. Lateral view, outer side, X51. Chickamauga Limestone at Red Mountain (80MS1-5). OSU 36233.

19. Belodella? sp. cf. B. nevadensis (Ethington and Schumacher, 1969). Lateral view, X110. Chickamauga Limestone at Red Mountain (80MS10-5). OSU 36223.

20-25. Periodon aculeatus Hadding, 1913.

20. Falodiform (geniculate, M) element. Lateral view, X60. Lenoir Limestone at Calera (80MS11-3). OSU 36323.

Figure

21. Phragmodiform (bipennate, Sc?) element. Lateral view, inner side, X56. Lenoir Limestone at Calera (80MS11-1). OSU 36324.

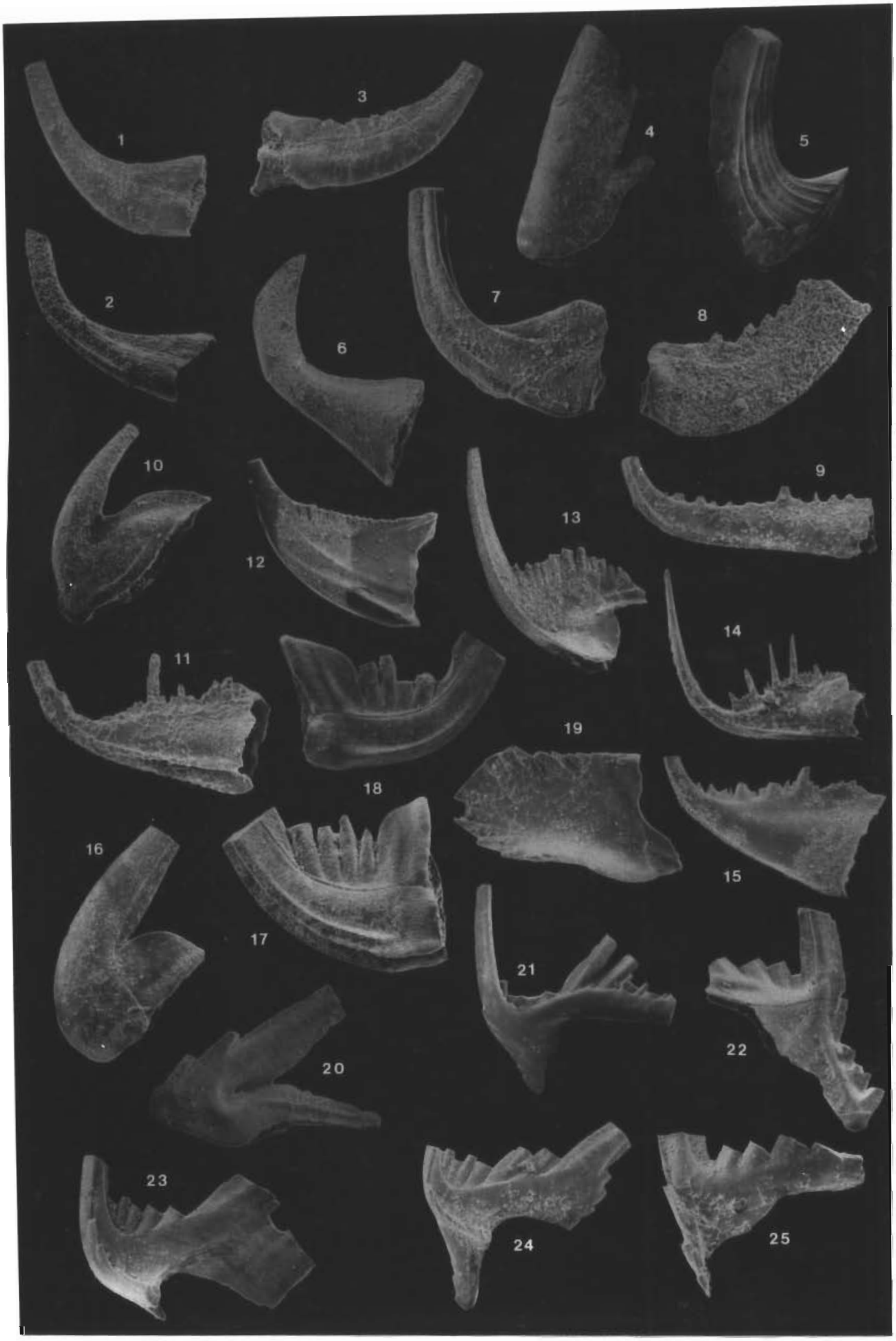
22. Prioniodiniform (digyrate, Pa?) element. Lateral view, inner side, X73. Lenoir Limestone at Calera (80MS11-1). OSU 36325.

23. Trichonodelliform (alate, Sa?) element. Lateral view, X90. Lenoir Limestone at Calera (80MS11-2). OSU 36326.

24. Roundyaform (tertiopedate, Sb?) element. Lateral view, outer side, X82. Lenoir Limestone at Calera (80MS11-1). OSU 36327.

25. Eoligonodiniform (bipennate, PB?) element. Lateral view, inner side, X82. Lenoir Limestone at Calera (80MS11-1). OSU 36328.

PLATE III.



EXPLANATION OF PLATE IV

Figure

1. *Periodon* sp. Falodiform element. Lateral view, X62. Lenoir Limestone at Rockmart (72B18-1). OSU 36335.

2-5. *Plectodina aculeata* (Stauffer, 1930).

  2. Trichonodelliform (alate, Sa) element. Posterior view, X82. Chickamauga Limestone at Red Mountain (80MS10-3). OSU 36357.

  3. Prioniodiniform (angulascaphate, Pb) element. Lateral view, X68. Chickamauga Limestone at Red Mountain (80MS10-1). OSU 36358.

  4. Cordylodiform (bipennate, Sc) element. Lateral view, X76. Chickamauga Limestone at Red Mountain (80MS10-1). OSU 36359.

  5. Zygognathiform (tertiopedate, Sb) element. Posterior view, X65. Chickamauga Limestone at Red Mountain (80MS10-3). OSU 36360.

6. *Plectodina* sp. Cordylodiform element. Lateral view, X61. Chickamauga Limestone at Red Mountain (80MS10-3). OSU 36364.

7-11. *Phragmodus flexuosus* Moskalenko, 1973?

  7. Phragmodiform (tertiopedate, Sb) element. Lateral view, X45. Pond Spring Formation at Chickamauga (80MS1-1). OSU 36337.

  8. Subcordylodiform (bipennate, Sc) element. Lateral view, X78. Pond Spring Formation at Chickamauga (80MS1-1). OSU 36338.

  9. Cyrtoniodiform (dolabrate, M) element. Lateral view, X30. Pond Spring Formation at Chickamauga (80MS1-1). OSU 36339.

  10. Dichognathiform (pastiniplante, Pa) element. Lateral view, X82. Pond Spring Formation at Chickamauga (80MS1-1). OSU 36340.

Figure

11. Breviform (pastiniplanate, Pb) element. Lateral view, X35. Pond Spring Formation at Chickamauga (80MS1-1). OSU 36341.

12. Phragmodus? n. sp. lateral view, X76. Pond Spring Formation at Chickamauga (80MS1-1). OSU 36355.

13-16. Phragmodus inflexus Stauffer, 1935.

13. Dichognathiform (pastiniscaphate, Pa) element. Lateral view, X105. Chickamauga Limestone at Red Mountain (80MS10-5). OSU 36347.

14. Cyrtoniodiform (dolabrate, M) element. Lateral view, X82. Chickamauga Limestone at Red Mountain. (80MS10-5). OSU 36348.

15. Subcordylodiform (bipennate, Sc) element. Lateral view, X97. Chickamauga Limestone at Red Mountain (80MS10-5). OSU 36349.

16. Phragmodiform (alate, Sa) element . Lateral view, X109. Chickamauga Limestone at Red Mountain (80MS10-5). OSU 36350.

17. Genus and Species indet. G. Lateral view, X41. Lenoir Limestone at Rockmart (72B17-1). OSU 36430.

18. New Genus n. sp. Lateral view, X74. Little Oak Limestone at Pelham (80MS7-23). OSU 36306.

19-22. Appalachignathus delicatulus Bergström, Carnes, Ethington, Votaw, and Wigley, 1974.

19. Trichonodelliform (alate, Sa) element. Posterior view, X106. Chickamauga Limestone at Red Mountain (80MS10-3). OSU 36208.

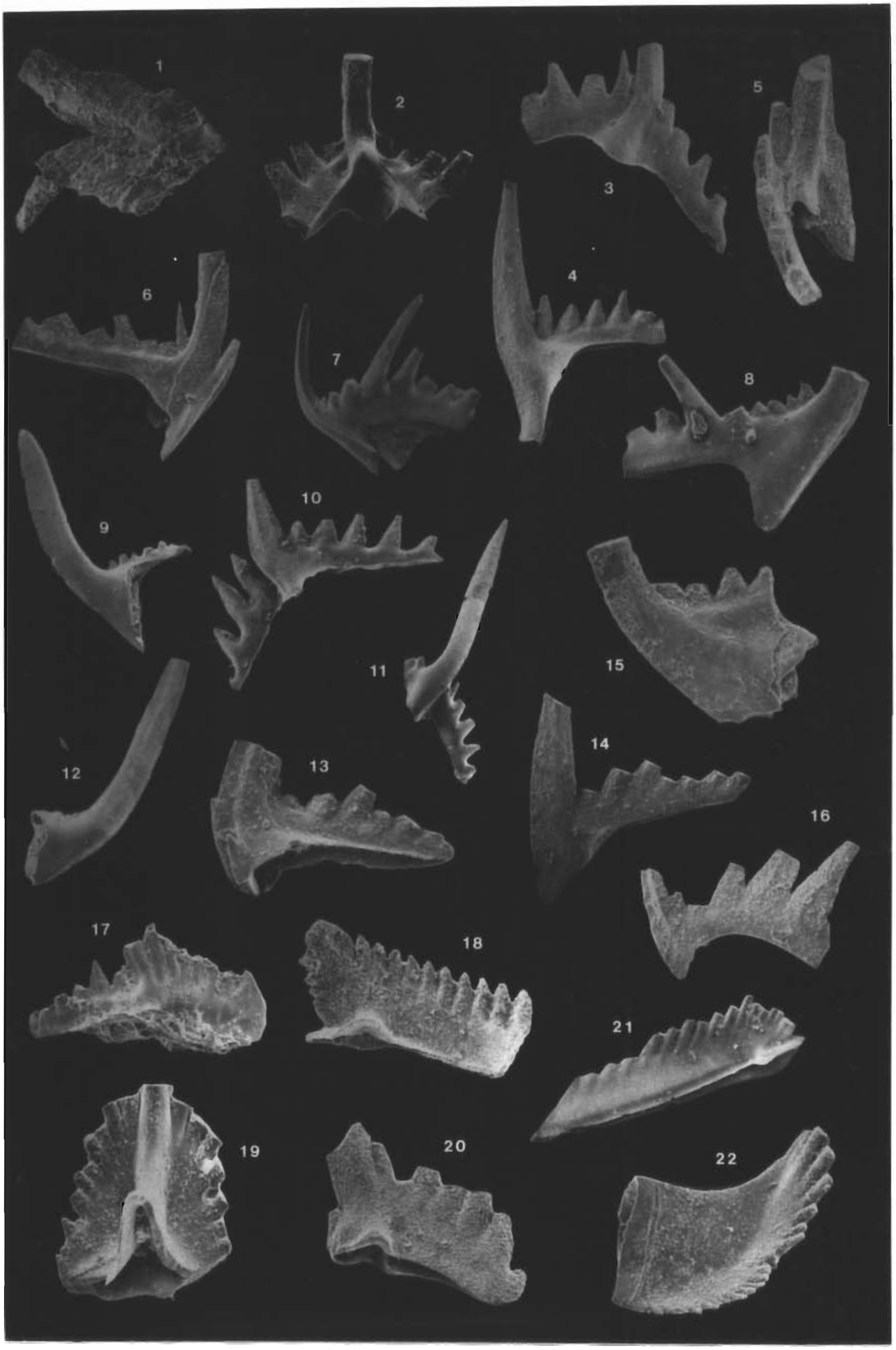
20. Ozarkodiniform (segminate, Pb) element. Lateral view, inner side, X58. Chickamauga Limestone at Red Mountain (80MS10-3). OSU 36209.

21. Spathognathodiform (segminate, Pa) element. Lateral view, inner side, X23. Chickamauga Limestone at Red Mountain (80MS10-3). OSU 36210.

Figure

22. Eoligonodiniform (bipennate? S) element. Lateral view, inner side, X62. Chickamauga Limestone at Red Mountain (80MS10-3). OSU 36211.

PLATE IV.



EXPLANATION OF PLATE V

Figure

1. "*Ozarkodina*" sp. Lateral view, X45. Pond Spring Formation at Chickamauga (80MS4-1). OSU 36313.

2. Genus and Species indet. C. Lateral view, X53. Lenoir Limestone at Pratt Ferry (72B17-1). OSU 36424.

3. Genus and Species indet. F. Lateral view, X67. Lenoir Limestone at Pratt Ferry (80MS8-21). OSU 36428.

4. Genus and Species indet A. Lateral view, X98. Lenoir Limestone at Rockmart (72B18-1). OSU 36422.

5. "*Bryantodina*" sp. Lateral view, X49. Pond Spring Formation at Chickamauga (80MS1-1). OSU 36237.

6-9. *Eoplacognathus* sp. cf. *E*. *reclinatus* Hamar, 1964.

   6. Sinistral ambalodiform (pastiniplante, Pb) element. Anterior view, X39. Lenoir Limestone at Calera (80MS11-1). OSU 36266.

   7. Dextral ambalodiform (pastiniplante, Pb) element, immature. Anterior view, X54. Lenoir Limestone at Calera (80MS11-1). OSU 36267.

   8. Dextral ambalodiform (pastiniplante, Pb) element, mature. Anterior view, X49. Lenoir Limestone at Calera (80MS11-1). OSU 36268.

   9. Sinistral polyplacognathiform (stelliplanate, Pa) element. Anterior view, X49. Lenoir Limestone at Calera (80MS11-2). OSU 36269.

10. *Eoplacognathus* sp. Dextral polyplacognathiform (stelliplanate, Pa) element. Anterior view, X78. Lenoir Limestone at Rockmart (72B18-1). OSU 36274.

11. "*Tetraprioniodus*" *lindstroemi* Sweet and Bergström, 1962. Lateral view, X65. Lenoir Limestone at Pratt Ferry (80MS8-26). OSU 36403.

Figure

12-13. *Pygodus serra* (Hadding, 1913).

12. Pygodiform (stelliscaphate) element. Anterior view, X72. Lenoir Limestone at Calera (80MS11-1). OSU 36383.

13. Haddingodiform (tertiopedate) element. Anterior view, X72. Lenoir Limestone at Calera (80MS11-1). OSU 36384.

14. *Polyplacognathus* sp. cf. *P. sweeti* Bergström, 1971a. Ambalodiform (pastiniplanate, Pb) element. Anterior view, X74. Athens Shale at Calera (71B19-5). OSU 36371.

15. "*Roundya*" *pyramidalis* Sweet and Bergström, 1962. Posterior view, X61. Lenoir Limestone at Pratt Ferry (80MS8-26). OSU 36391.

16-17. *Pygodus anserinus* Lamont and Lindström, 1957.

16. Haddingodiform (tertiopedate) element. Lateral view, outer side, X82. Little Oak Limestone at Pelham (80MS7-28). OSU 36379.

17. Pygodiform (stelliscaphate) element. Anterior view, X82. Little Oak Limestone at Pelham (80MS7-28). OSU 36380.

18. *Polyplacognathus stelliformis* Sweet and Bergström, 1962. Anterior view, X52. Little Oak Limestone at Pelham (80MS7-23). OSU 36374.

19. *Polyplacognathus rutriformis* Sweet and Bergström, 1962. Anterior view, X40. Pratt Ferry Formation at Pratt Ferry (64B2-12). OSU 36374.

20-21. *Polyplacognathus friendsvillensis* Bergström, 1971a.

20. Ambalodiform (pastiniplanate, Pb) element. Anterior view, X21. Little Oak Limestone at Pelham (80MS7-2). OSU 36367.

21. Polyplacognathiform (stelliplanate, Pa) element. Anterior view, X45. Little Oak Limestone at Pelham (80MS7-2). OSU 36368.

PLATE V.