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LATE ORDOVICIAN THROUGH EARLY DEVONIAN ANNOTATED CORRELATION CHART AND BRACHIOPOD RANGE CHARTS FOR THE SOUTHERN MIDCONTINENT REGION, U.S.A., WITH A DISCUSSION OF SILURIAN AND DEVONIAN CONODONT FAUNAS

THOMAS W. AMSDEN AND JAMES E. BARRICK

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Title-Page Illustration

Kirkidium pingue pingue (Amsden).

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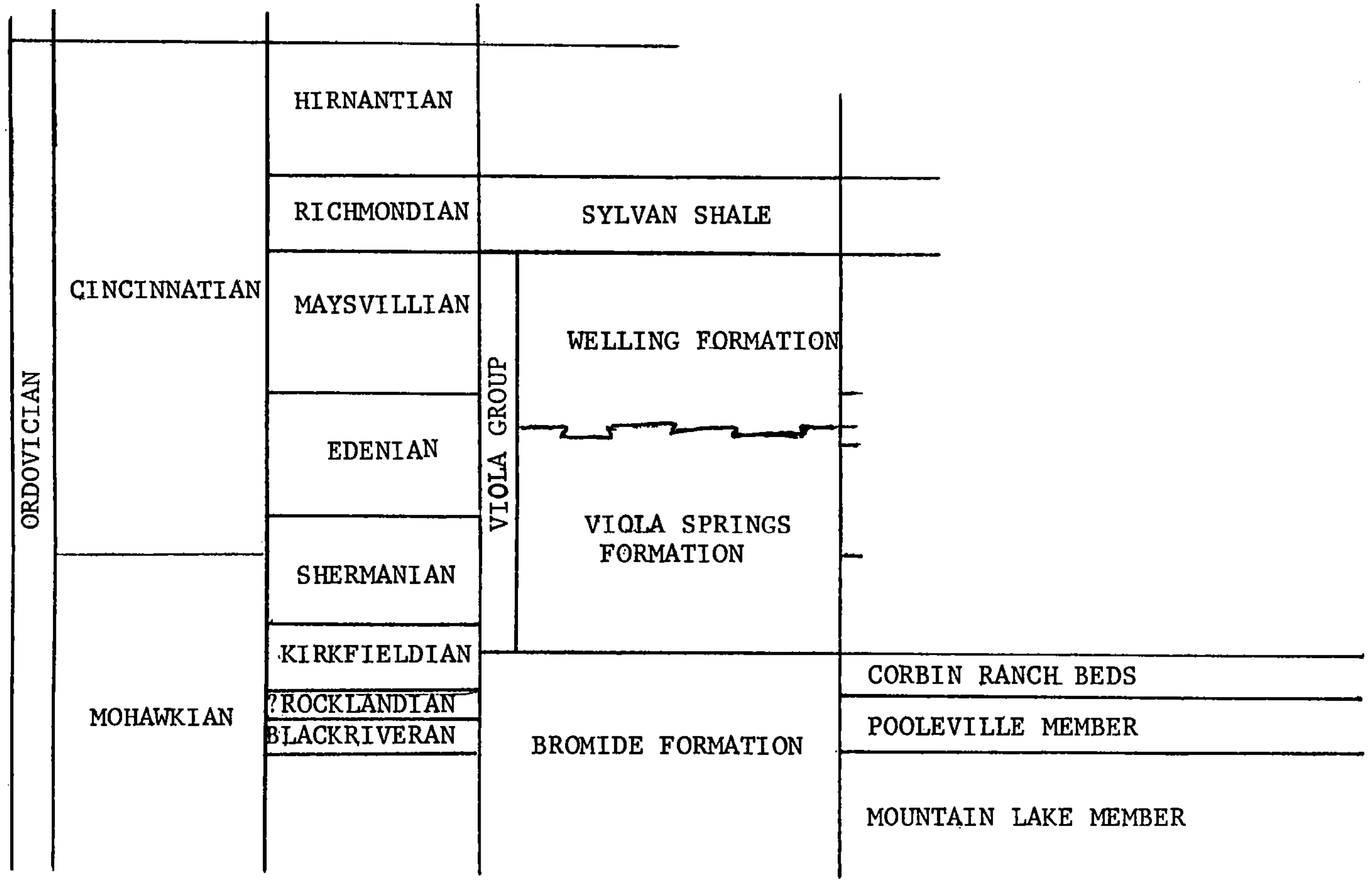
ERRATA

OGS Bulletin 143

The age assignments for the Viola Springs and Bromide Formations are incorrectly shown on Plates 1-4. The corrected assignments are shown below:



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PREFACE

This report comprises two papers on the stratigraphic sequence and faunas (conodonts and brachiopods) from middle Paleozoic strata in the region extending from the Texas Panhandle across Oklahoma to the Mississippi River.

The first paper (by Amsden) presents a stratigraphic correlation chart covering strata from the Middle–Late Ordovician Viola Group to the late Early Devonian (Sawkillian) Sallisaw Formation. The chart is annotated to provide information on the various stratigraphic units recognized. Generic and specific articulate brachiopod range charts show the known stratigraphic distribution of the various taxa recognized. The accompanying text discusses the paleoenvironmental factors believed to affect brachiopod distribution, and concludes with an analysis of Silurian–Devonian brachiopod phylogeny.

The second paper (by Barrick) discusses the stratigraphic distribution of conodont faunas in the Silurian–Devonian portion of the Hunton Group of Oklahoma, based in part on heretofore unpublished information. These conodonts are compared with those from other areas, including species from the Silurian–Devonian stratotype sequence in Czechoslovakia.

PART I

LATE ORDOVICIAN THROUGH EARLY DEVONIAN ANNOTATED CORRELATION CHART AND BRACHIOPOD RANGE CHARTS FOR THE SOUTHERN MIDCONTINENT REGION, U.S.A.

THOMAS W. AMSDEN[1]

Abstract—This report presents a stratigraphic correlation chart and three articulate-brachiopod range charts for the Upper Ordovician (Viola Group, Cincinnatian Series) through the Lower Devonian (Texas Panhandle, Oklahoma, Arkansas, eastern Missouri, and southwestern Illinois). The correlation chart is annotated to provide supplementary data on the lithostratigraphic-biostratigraphic succession, including references to major publications on various aspects of these strata. The distribution of articulate brachiopods is shown in three charts—one for species arranged stratigraphically, a second for genera arranged stratigraphically, and a third for genera arranged taxonomically. Deposition in the region under study took place mainly in tropical to subtropical, shallow-water carbonate seas occupied by a diverse benthic fauna. The paleoenvironment was affected by the introduction of fine terrigenous detritus, which in areas of greatest concentration sharply reduced the shelly biomass and faunal diversity. Deposition was interrupted by periods of uplift and subaerial erosion, and these episodes are preserved in the stratigraphic record by unconformable seams. The articulate brachiopods exhibit substantial phylogenetic change during Late Ordovician through Early Devonian time; however, much of the fossil-stratigraphic record is lost in the unconformities. It is herein suggested that the observed distribution of brachiopod taxa in this succession is best explained by an episodic evolution, with periods of stasis alternating with periods of accelerated phylogeny.

Four new genera and two new species are described in Appendix 1. The new genera are *Linterella*, *Luterella*, and *Undulorhyncha* from Late Silurian strata in Oklahoma and Tennessee, and *Tonsella* from Late Ordovician (Hirnantian) strata in Arkansas, Oklahoma, and Missouri.

INTRODUCTION

This study analyzes the biostratigraphic distribution of articulate brachiopods in Late Ordovician (Cincinnatian), Silurian, and Early Devonian strata from the southern Midcontinent region (see Pl. 1). It is based largely on biostratigraphic, biofacies, and taxonomic studies of brachiopods I collected from subsurface cores and surface outcrops. The only exceptions are the Welling brachiopods (Cincinnatian), whose ranges were obtained from Alberstadt (1973; see Amsden, *in* Amsden and Sweet, 1983), and a small collection of Clifty brachiopods supplied by Charles A. Renfroe. The total brachiopod fauna comprises 276 species, referred to 167 genera, from the Anadarko basin (subsurface) of central and western Oklahoma and the Texas Panhandle; outcrop areas in the Arbuckle Mountains and Criner Hills of south-central Oklahoma; the Arkoma basin (subsurface) and surface outcrops of eastern Oklahoma; outcrops in the Batesville district, north-central Arkansas; outcrops in Cape Girardeau County, southeastern Missouri, and Alexander County, southwestern Illinois; and outcrops in Pike County, northeastern Missouri, and Calhoun County, western Illinois (Text-fig. 1).

The stratigraphic distribution of the genera and species is analyzed with particular attention to the relationship between paleoenvironment, unconformities, and brachiopod phylogeny.

Four new rhynchonellacean genera are proposed (see Appendix 1)—*Linterella*, type species *Camarotoechia perryvillensis* Amsden, Brownsport Formation, western Tennessee; *Luterella*, type species *Camaroteochia altisulcata* Amsden, Henryhouse Formation, Arbuckle Mountains, Oklahoma; *Undulorhyncha*, type species *Camarotoechia hollandi* Amsden, Brownsport Formation, western Tennessee; and *Tonsella*, type species *T. parva* Amsden, new species, Cason oolite, north-central Arkansas and Keel Formation, Arbuckle Mountains, Oklahoma. This report also includes new morphologic data for several previously described species (see Appendix 1).

Acknowledgments

I wish to express my indebtedness to the following individuals, who reviewed this study: Dr. J. E. Barrick, Texas Tech University; Dr. A. J. Boucot, Oregon State University; Dr. J. Thomas Dutro, Jr., U.S. Geological Survey; Dr. J. G. Johnson, Oregon State University; Dr. M. E. Johnson, Williams College; Dr. Gilbert Klapper, University of Iowa; Dr. R. B. Neuman, U.S. Geological Survey; Dr. R. J. Ross, Jr., Colorado School of Mines; Dr.

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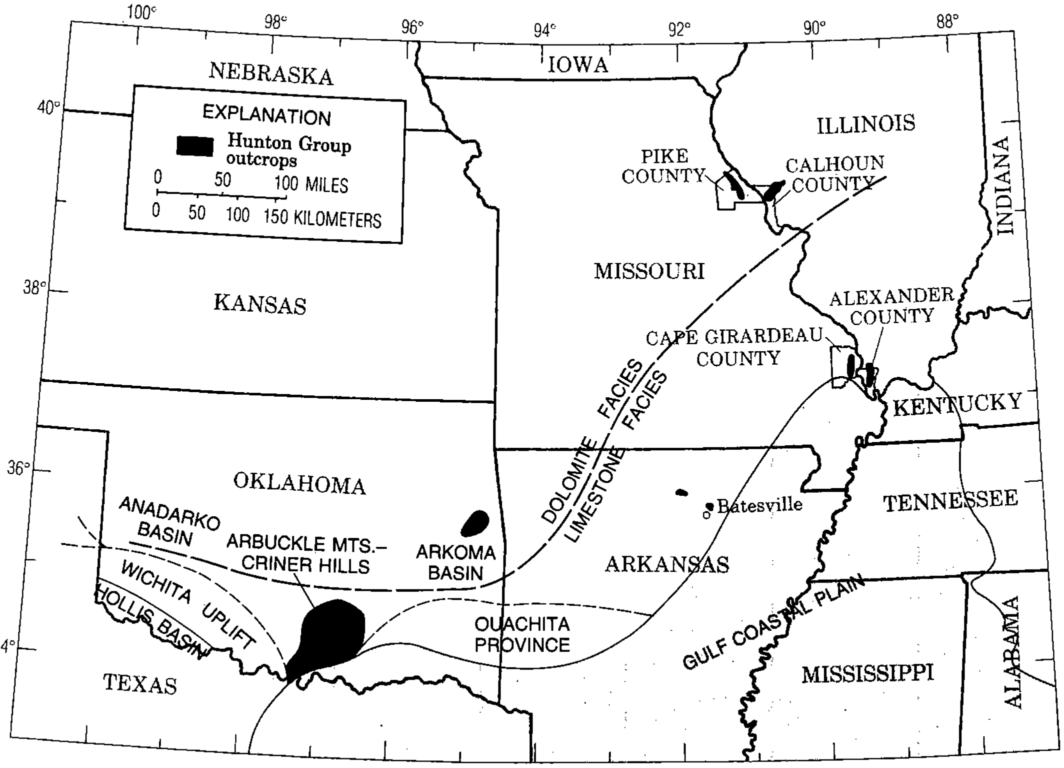


Text-figure 1. Map showing major Upper Ordovician, Silurian, and Devonian outcrops discussed in this report. Upper Ordovician (Hirnantian) through Lower Devonian (Helderbergian) strata north and west of the dolomite-limestone boundary are moderately to heavily dolomitized.

T. L. Thompson, Missouri Department of Natural Resources.

In a study such as this I would be remiss not to acknowledge a special obligation to Drs. A. J. Boucot and J. G. Johnson for their research on Silurian–Devonian brachiopod faunas and correlation.

CORRELATION CHART

The primary purpose of the correlation chart (Pl. 1) is to show the inferred age and correlatives of the various groups, formations, and members from which brachiopods were obtained for this study. Although some zones and biozones are identified, the divisions recognized are primarily lithostratigraphic. The chart is focused on the interval extending from the Welling ("Fernvale") Formation through the Early Devonian. Locally, in the region extending from the eastern Arbuckle Mountains outcrops across the Arkoma basin, it is extended back to the Corbin Ranch Beds (Pooleville Member, Bromide Formation) and the Fite Formation of Middle Ordovician (Mohawkian) age. The chart includes the Woodford–Chattanooga Shale of Late Devonian–Early Mississippian age; however, the shelly faunas studied are confined to the Lower Devonian and older strata with the sole exception of the Middle Devonian Clifty Formation locally present in western Arkansas (see Appendix 2).

Each column on the correlation chart represents either a single stratigraphic section (infrequent) or, more commonly, a small geographic area encompassing rocks of similar stratigraphic relationships. Both surface and subsurface data are incorporated in the chart. Subsurface biostratigraphic data are derived exclusively from cores; however, well samples (studied by means of thin sections) were used to provide additional lithostratigraphic, lithofacies, and biofacies information.

The principal biostratigraphic control is derived from my own brachiopod studies, although I have tried to incorporate brachiopod data from all published sources. In addition, I have incorporated information from other faunal groups including trilobites, corals, ostracodes, conodonts, chitinozoans, palinomorphs, and graptolites.

Annotations to the correlation chart are provided in Appendix 2. These include a discussion of various lithostratigraphic, biostratigraphic, and paleoenvironmental problems, as well as some morphologic details on key brachiopod species and citations of major bibliographic references.

Zones, Biozones, Beds, and Biofacies

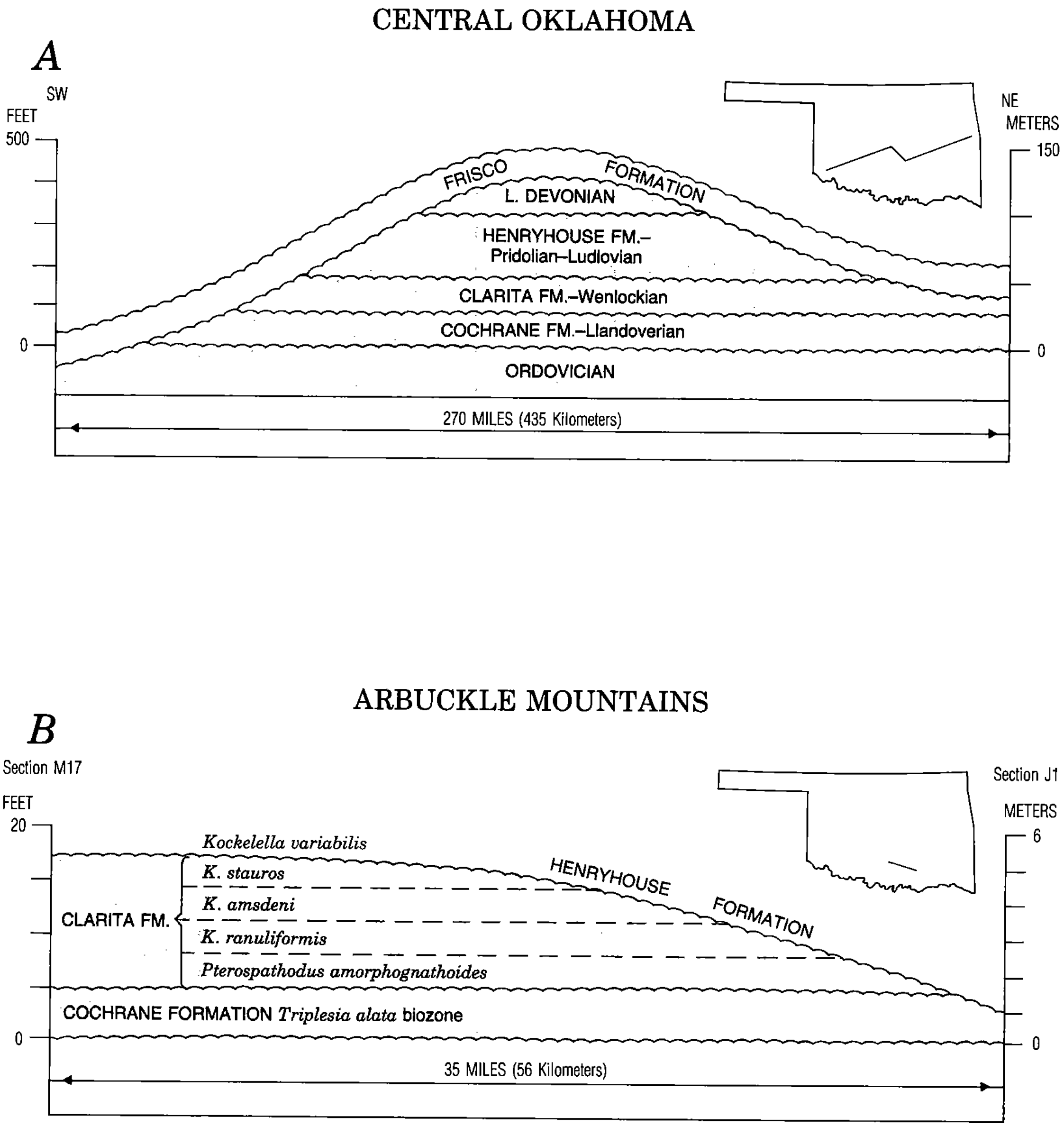
As used on the correlation chart, the term *zone* is confined to conodont and graptolite zones, all of which are taken from published sources—e.g., *Pterospathodus amorphognathoides* Zone (Barrick and Klapper, 1976, p. 66). *Biozone* is used for the restricted biostratigraphic range of a taxon in the region under study, but whose ultimate upper and lower ranges have not been clearly defined—e.g., *Amphigenia* biozone; *Lepidocyclus oblongus* biozone (see Appendix 2, this report, and Amsden, *in* Amsden and Sweet, 1983, p. 40–43). The term *beds* is applied to localized biostratigraphic divisions—e.g., *Placotriplesia* beds (Amsden, 1968, p. 17–18); note that *Bed* is also used for a lithostratigraphic division smaller than a member—e.g., Corbin Ranch Beds. The term *biofacies* is applied to a regional faunal assemblage that is confined to a circumscribed paleoenvironment during a restricted time interval—e.g., Henryhouse Formation–*Kirkidium* biofacies, a particular environment restricted to Ludlovian–Pridolian time (see Correlation Chart and Appendix 2).

Unconformities

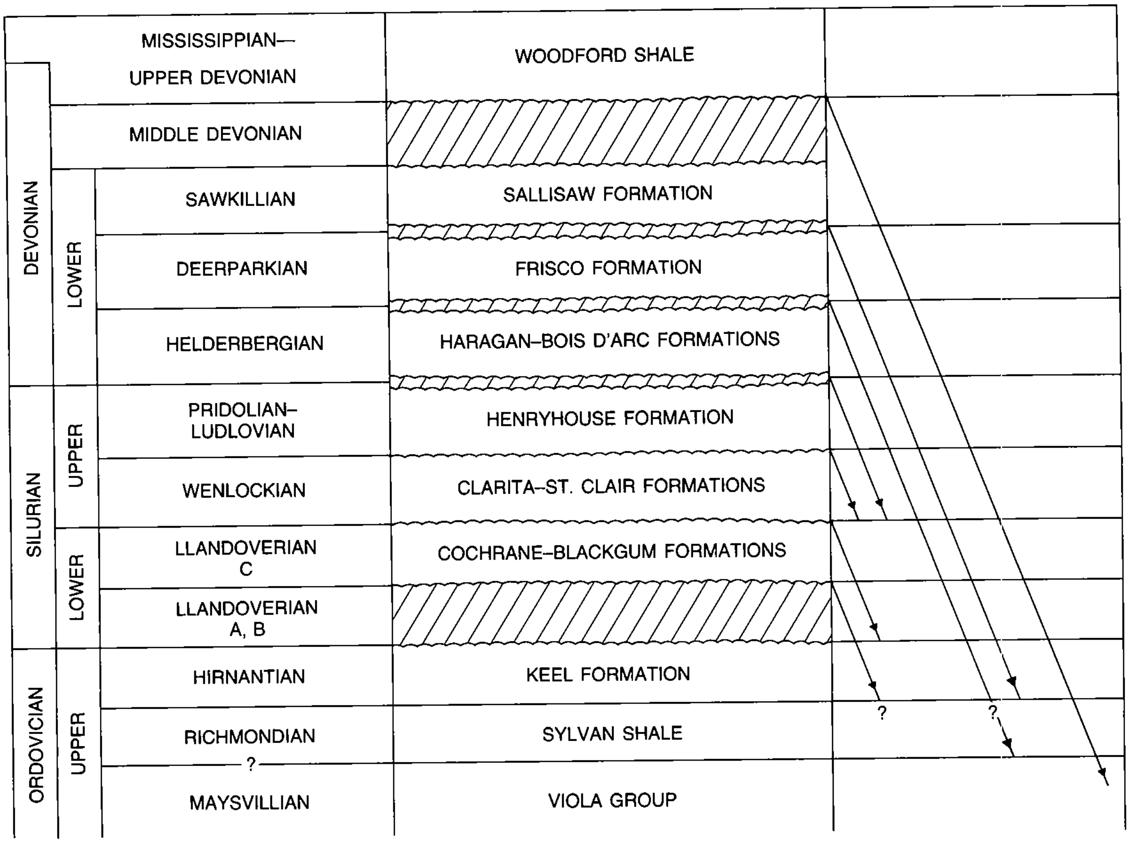
The lithostratigraphic and biostratigraphic sequence throughout this region is interrupted by unconformities. Much confusion is associated with the term *unconformity* because this relationship has been defined in different ways. I define an unconformable contact as one for which there is local and/or regional lithostratigraphic and biostratigraphic evidence for truncation of an underlying stratigraphic unit by an overlying stratigraphic unit. According to my definition, the uppermost beds of the unit underlying the surface of unconformity will be diachronous (the base of the unit overlying the surface of unconformity *may* also be diachronous). Thus the magnitude of the missing chronostratigraphic interval represented by the unconformable surface may differ widely from place to place. A good example is the pre-Frisco (Deerparkian Stage) unconformity shown in Text-figure 2A. The Frisco Formation crops out over a distance of ~20 mi in the northeastern part of the Arbuckle Mountains (Amsden, 1961, p. 28) where it rests directly on the Lower Devonian Haragan–Bois d'Arc Formation. There is no physical evidence of truncation at the contact. There is, however, a sharp lithostratigraphic contact (hardground) separating the two stratigraphic units and a well-defined taxonomic separation of the brachiopod faunas. The Haragan–Bois d'Arc brachiopod fauna is assigned to the Helderbergian Stage (Amsden, 1958a,b) and the Frisco brachiopod fauna to the superjacent Deerparkian Stage (Amsden and Ventress, 1963). (See Brachiopod Range Charts, Pls. 2–4.) In the eastern Oklahoma outcrop area the Frisco rests directly on the early Upper Silurian (Wenlockian) Quarry Mountain Formation (Amsden, 1961, p. 37–42, pls. 4,5; Amsden, 1978). In the subsurface of central Oklahoma, the Frisco directly overlies the Upper Silurian (Pridolian–Ludlovian) Henryhouse Formation–*Kirkidium* biofacies (Amsden, 1975, p. 69–74, pl. 15); in the subsurface of the Hollis basin in southwestern Oklahoma, the Frisco rests on the Late Ordovician Viola Group (Amsden, 1975, p. 92).

Another excellent example is the unconformable relationship between the Henryhouse Formation and the Clarita Formation in the Arbuckle Mountains outcrop area. The stratigraphic section illustrated in Text-figure 2B extends from the outcrops on U.S. Highway 77 near Interstate 35 (stratigraphic section M17, Amsden, 1960, p. 256; Amsden, *in* Ham, 1969, p. 39–42) to the outcrops south of Wapanucka (stratigraphic section J1, Amsden, 1960, p. 61,215; see also Amsden, 1968, p. 14–18). At M17 on U.S. Highway 77 Barrick and Klapper (1976, p. 61–63) described five conodont zones beginning with the *Pterospathodus amorphognathoides* Zone of latest Llandoverian–earliest Wenlockian age (Prices Falls Member) and extending up to the *Kockelella variabilis* Zone of probable earliest Ludlovian age in the basal Henryhouse Formation. The Henryhouse–Clarita contact at the M17 outcrop is a sharply defined surface (hardground; Amsden, 1975, p. 25, pl. 8, figs. 4a,b), although there is no unequivocal evidence for truncation in this area. According to Barrick and Klapper (1976, p. 61) the basal Clarita to basal Henryhouse conodont sequence is complete, and the Clarita–Henryhouse contact represents a hiatus of intrazonal duration. In the southwestern part of the Arbuckle Mountains the Henryhouse Formation truncates the Clarita, coming to rest on the *K. amsdeni* Zone at stratigraphic section J5 near Wapanucka (Barrick and Klapper, 1976, p. 61; Amsden, 1960, p. 214,218). At stratigraphic section J1, about half a mile southeast of J5, the Henryhouse rests directly on the Late Llandoverian Cochrane Formation (Amsden, 1960, p. 215). According to the conodont biostratigraphy of Barrick and Klapper (1976, p. 61), the base of the Henryhouse is also diachronous (see section on Paleoenvironments, Wapanucka Uplift; see also Part II).

Clarita strata in the vicinity of stratigraphic section M17 (Text-fig. 2B) include few brachiopods (ostracodal marlstone facies; Amsden and others, 1980, text-fig. 4); however, there is close biostratigraphic brachiopod control for the Henryhouse–Clarita boundary on the Lawrence uplift



Text-figure 2. A—Stratigraphic section showing the unconformable relationship between the Frisco Formation and the underlying Devonian and Silurian strata. This section extends from the outcrop area of eastern Oklahoma, to the Arbuckle Mountains in central Oklahoma, to the Hollis basin (core) in southeastern Oklahoma. Silurian strata in the Arbuckle Mountains have a maximum thickness of ~300 ft. B—Stratigraphic section showing the unconformable relationship between the Henryhouse Formation (Late Silurian; Ludlovian–Pridolian) and the underlying Clarita Formation (Wenlockian). This section extends from the central part of the Arbuckle Mountains (south of Davis) to the southeastern part of the Arbuckle Mountains (near Wapanucka). Note that in the sections shown the effects of erosion other than pre-Frisco (A) or pre-Henryhouse (B) have been deleted. (After Amsden, 1960, p. 214–216; Barrick and Klapper, 1976, p. 61–62. M17 and J1 are stratigraphic sections described in the Appendix, Amsden, 1960.)



Text-figure 3. Chart showing stratigraphic divisions recognized in Oklahoma and adjacent areas. Arrows indicate the known point of maximum truncation.

(stratigraphic section P1, Amsden, 1960, p. 262) some 30 mi to the northeast. Here Wenlockian age brachiopods of the *Placotriplesia* beds (see Appendix 2) are found within a few feet of the Ludlovian brachiopod fauna of the Henryhouse Formation. The two uppermost conodont zones, *K. stauros* and *K. variabilis*, have not been found in the crinoid sparite facies of this northeastern Arbuckle region (Amsden and others, 1980, p. 5) and the upper Clarita strata have probably been truncated to some extent toward the northeast as well as the southwest (see Part II).

The pre-Frisco and Henryhouse–Clarita unconformities (Text-fig. 2A,B) show a similar diachronous relationship, ranging from a minimal time break (intrastage, intrazone) to a significant and biostratigraphically well-defined time gap. The chart in Text-figure 3 shows the time-stratigraphic units recognized, with arrows indicating the point of maximum truncation identified in the region under study. At maximum biostratigraphic representation all contacts are intrastage boundaries except the Cochrane–Keel, at which the Lower (A) and Middle (B) Llandoverian Stages are missing. Only Late Llandoverian (C) age brachiopods have been identified in the Cochrane, Blackgum, Cason "Brassfield," and Sexton Creek Formations. However, these strata are not abundantly fossiliferous, and in a region where diachroneity is common, some part of the Llandoverian A or B units may be represented. For a discussion on the conodont biostratigraphy associated with the Ordovician–Silurian boundary in this area, see Barrick (*in* Amsden and Barrick, 1986) and Part II, this report. Brachiopod defined stage divisions within the Wenlockian Series are not identified in this report, and the Ludlovian–Pridolian stages recognized in this report are based on graptolites (H. Jaeger; Amsden, 1980, p. 43) and conodonts (Part II, this report). At the localities with maximum biostratigraphic representation, no stages are known to be missing in the Late Llandoverian through Early Devonian sequence; however, some intrastage biostratigraphic units could be absent (see section on Brachiopod Phylogeny). All evidence indicates that the post-Early Llandoverian (A,B) missing time intervals at the seams shown in Text-figure 3 were of relatively short duration.

Evidence of dissolution is present in the carbonate strata immediately underlying many of the seams (Amsden, 1961, p. 56, 64–66; 1962, p. 1511) and is here interpreted as indicating subaerial exposure. An especially good exposure of the Frisco–Quarry Mountain contact (Deerparkian–Wenlockian) is present in the old limestone mine of the St. Clair Lime Company (sec. 14, T13N, R23S, Sequoyah County, Oklahoma; Amsden, 1961, p. 38, text-fig. 13).

Dolomitization

Upper Ordovician (Hirnantian) through Lower Devonian (Helderbergian) strata can be separated into a well-defined limestone facies (south and east) and dolomite facies (north and west) as shown in Text-figure 1 and the correlation chart (Pl. 1). This is a part of the Silurian dolomite province occupying much of central North America (Berry and Boucot, 1970, pl. 1; Amsden, 1955, p. 60–74; 1975, p. 43–56; 1980, p. 51–57).

BRACHIOPOD RANGE CHARTS

The Brachiopod Range Charts (Pls. 1–4) show the distribution of articulate brachiopods through Upper Orodovician–Silurian–Lower Devonian strata in the southern Midcontinent. Three charts are used—a Species Range Chart based on 276 species, stratigraphically arranged (Pl. 2); and two Generic Range Charts (167 genera), one arranged stratigraphically (Pl. 3) and one arranged taxonomically (Pl. 4). The stratigraphic divisions and time classification used for the range charts correspond to that on the Correlation Chart (Pl. 1).

For the most part these are composite range charts—for example, the brachiopod ranges recorded for the Wenlockian Fitzhugh Member, Quarry Mountain Formation, and St. Clair Formation are derived by combining data on species collected from the Fitzhugh Member in the Arbuckle Mountains, the Quarry Mountain Formation of eastern Oklahoma, and the St. Clair Formation of north-central Arkansas. Thus the range shown for a particular species is derived by combining its observed range in the Fitzhugh with its range observed in the other two units, if it is present. The principal departures from this method are ranges shown for the Welling Formation, which were taken from Alberstadt's published ranges in the Arbuckle Mountains region (1973) and the Henryhouse and Haragan–Bois d'Arc ranges, which were derived exclusively from the Arbuckle Mountains–Criner Hills area. I omitted data from some fossiliferous units such as the Moccasin Springs and Bailey Formations of Missouri because no reliable biostratigraphic control is available. Caution must be exercised in determining the precise range of a species in a particular formation because of the diachroneity which may affect both the upper and lower surfaces. Thus species A may range throughout a formation at one locality and not at another.

Recently Schopf (1981) discussed some of the problems in determining the range of species, including inadequacy of the fossil record, tendency to concentrate all morphologic variation in existing species, and tendency for the known range of a species to be expanded to occupy the entire range of the interval being analyzed. Other problems are (1) finding and extracting reasonably well-preserved specimens, especially in critical parts of a sequence; (2) determining ranges in a sequence interrupted by unconformities; and (3) the ever-present difficulty of distinguishing between change that is the result of time (phylogeny) and change that is the result of environmental shifts. No methodology will solve all these problems. However, I have tried to develop a data base which provides maximum information on the areas of greatest uncertainty by (1) determining the stratigraphic and geographic position of all specimens collected; (2) determining the lithofacies-biofacies characteristics of the enclosing sediments; (3) determining the local and regional lithostratigraphic-biostratigraphic relationships of the faunas; and (4) providing a description and illustrations of the species collected, including a comparison with related species and a summary of the morphologic variations encompassed in the species paradigm.

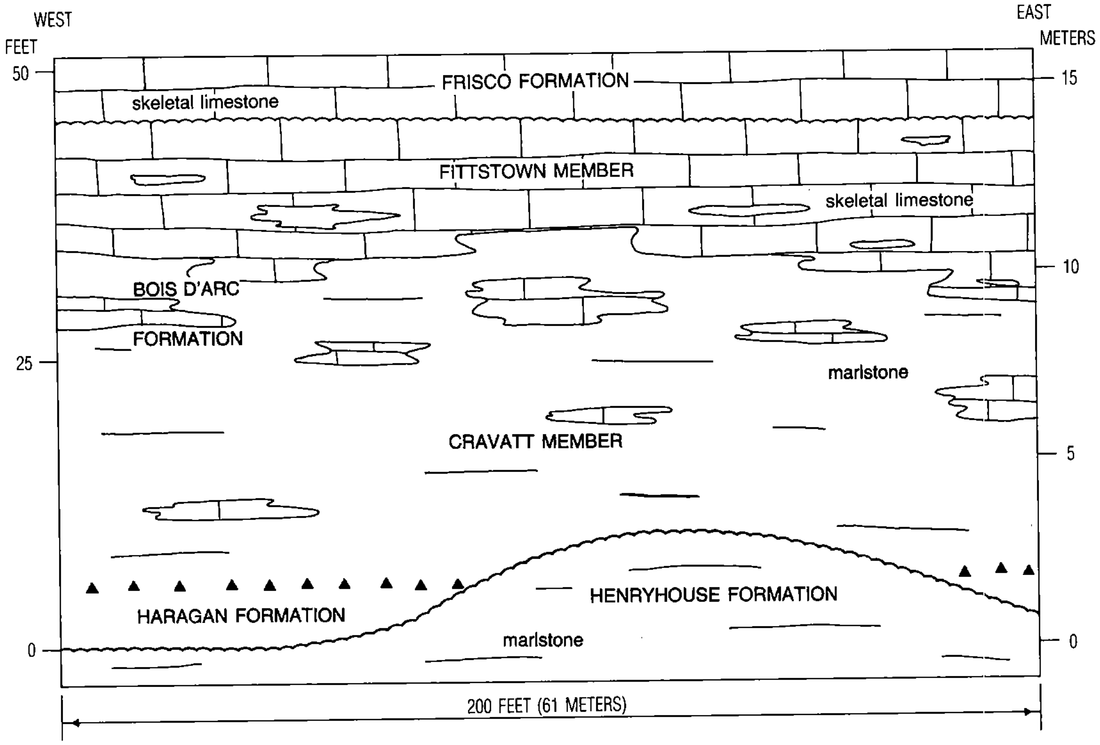
PALEOENVIRONMENTS

Paleoenvironments are similar throughout the southern Midcontinent region. The present discussion concentrates on selected examples from the Arbuckle Mountains–Criner Hills outcrop region only because it has the most complete and best-exposed stratigraphic sequence.

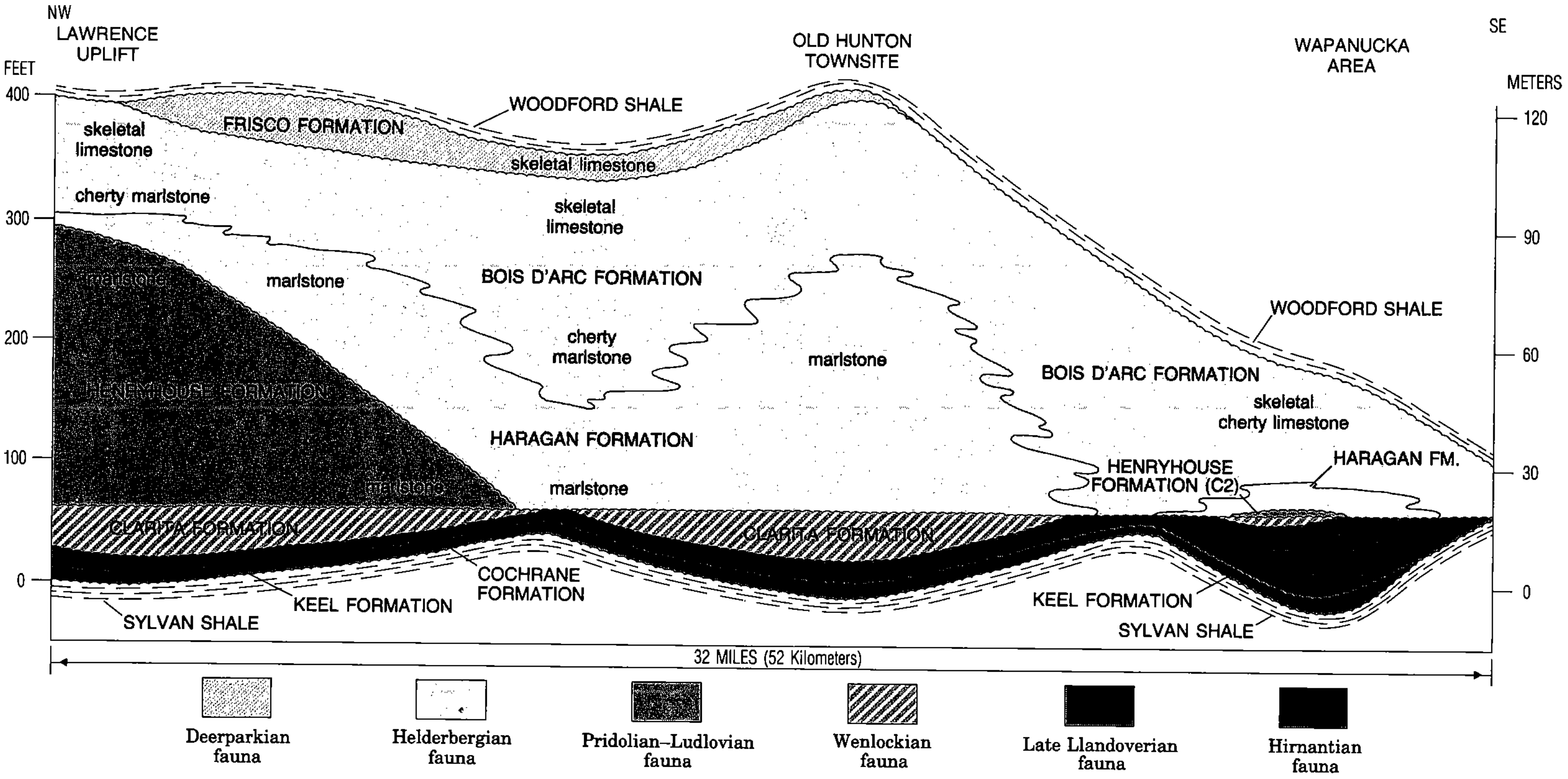
Upper Ordovician through Lower Devonian strata are represented largely by carbonate strata deposited in warm, subtidal, shallow water reflecting generally similar environments. However, excluding the Henryhouse–Haragan boundary (see Appendix 2, Henryhouse Formation), all contacts involve lithofacies-biofacies changes representing at least minor shifts in environments which *could* have affected the brachiopod faunas.

The Fitzhugh Member (Clarita Formation)–Henryhouse contact is well exposed on Chimneyhill Creek at the north end of the Arbuckle Mountains outcrop area (stratigraphic section P1, Amsden, 1960, p. 268; Amsden, 1968, p. 18–20, pl. 20, fig. 3c; Amsden and others, 1980, p. 8, text-fig. 9). The upper 2 ft of the Fitzhugh, comprising the *Placotriplesia* beds, is skeletal micrite (23% matrix) with about 4% terrestrial detritus and a diverse shelly fauna. This unit has a Wenlockian brachiopod fauna of 14 species, eight of which are also present in the St. Clair Formation of Arkansas. The basal beds of the overlying Henryhouse Formation are mud-supported marlstones (56% matrix) with 14% fine detritus. These strata have a moderately diverse benthic fauna, although the volume of shelly material is substantially less than that in the *Placotriplesia* beds. All 10 brachiopod species in the basal Henryhouse beds are typical Henryhouse species (Ludlovian–Pridolian), present elsewhere in this formation. Lateral lithofacies changes in both formations affect the biofacies, including the brachiopod faunas. The volume of fine detritus in the Fitzhugh Member increases toward the south and is accompanied by a reduction in the volume and diversity of the benthic fauna, including the brachiopods (Amsden and others, 1980, p. 9, fig. 7; Part II, this report). Although these facies changes produce a marlstone texture similar to that of the overlying Henryhouse Formation, they are not accompanied by taxonomic drift toward Henryhouse-type brachiopods; all Fitzhugh brachiopods are taxonomically distinct from Henryhouse species (Amsden, 1968). Toward the north and west, Henryhouse marlstones grade into skeletal limestones of the *Kirkidium* biofacies (Amsden, 1981), which represent a biofacies similar to the skeletal limestones of the Fitzhugh and St. Clair. These lithofacies-biofacies changes are also accompanied by faunal changes, the most notable being the strong influx of the large pentamerid brachiopod *Kirkidium*. Again there is no taxonomic drift toward a brachiopod fauna resembling that of the Fitzhugh–St. Clair.

The Upper Silurian Henryhouse Formation (Ludlovian–Pridolian; see Part II) in most places is remarkably similar in lithofacies-biofacies characteristics to the overlying Lower Devonian Haragan Formation (Helderbergian), and the boundary between these units is based almost entirely on the faunas. The Henryhouse–Haragan relationship is thus enigmatic in the sense that the lithostratigraphic boundary is generally obscure, whereas the biostratigraphic boundary as defined by sessile and vagrant shelly faunas is well marked and easily traced. Both formations are marlstones so similar in texture and composition that it is difficult to separate them lithologically, even in areas of complete exposure. A notable exception is the exposure on Bois d'Arc Creek, Pontotoc County, Oklahoma (Amsden, 1957, p. 30–31; 1960, p. 277) where there is a clearly marked discordance between upper Henryhouse and lower Haragan strata (Text-fig. 4). The



Text-figure 4. Stratigraphic diagram showing Henryhouse–Haragan–Bois d'Arc–Frisco Formations at stratigraphic section P8, north side of Bois d'Arc Creek, Pontotoc County, Oklahoma (Amsden, 1957, p. 30–31, text-fig. 6, pl. 2; Amsden, 1962, p. 1512).



Text-figure 5. Northwest–southeast stratigraphic section extending along the northeastern margin of the Arbuckle Mountains from the Lawrence uplift, Pontotoc County, to the Wapanucka area in Johnston County, Oklahoma. This shows the formations recognized and the distribution of major brachiopod faunas. (From Amsden, 1957, fig. 4; see also Amsden, 1960, panel 3, pl. C.)

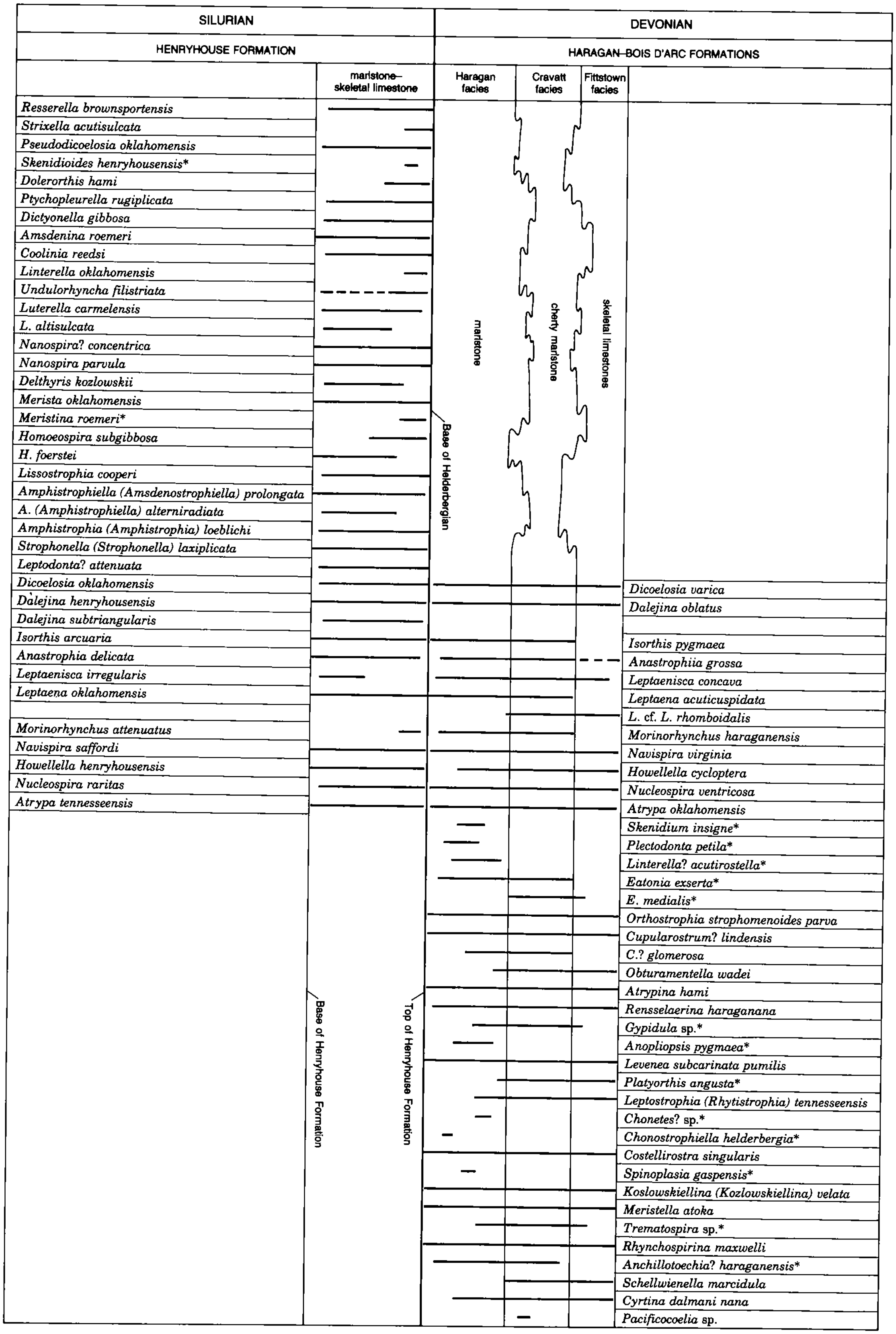
Henryhouse and Haragan Formations can, however, be readily distinguished throughout the outcrop area on the basis of their shelly faunas, and a brief summary of past investigations will be useful in demonstrating the near unanimity of biostratigraphers working with megafossils in positioning this boundary.

Chester Reeds (1911) named the Henryhouse–Haragan Formations and provided faunal lists which today can be equated with recent taxonomic studies. Maxwell (1936) in a detailed lithostratigraphic-biostratigraphic study of Hunton strata, provided much additional biostratigraphic and taxonomic data on the Henryhouse–Haragan contact and, of special note, demonstrated the regional distribution of Henryhouse strata in the Arbuckle Mountains–Criner Hills outcrop area. His investigation showed that the Haragan Formation truncated the Henryhouse beds, thus bringing the Early Devonian Haragan and Bois d'Arc strata into direct contact with Clarita (Wenlockian) and Cochrane (late Llandoverian) strata over a large area in the southeastern part of the Arbuckle Mountains outcrop area (see Wapanucka Uplift). In a series of bulletins and articles Amsden (1951,1958a,b,1960,1975,1980; Amsden and Ventress, 1963) provided detailed information on the lithostratigraphic, lithofacies, and biofacies characteristics of Henryhouse, Haragan, and Bois d'Arc strata, including taxonomic studies of the brachiopods. These descriptions were based on specimens collected from measured stratigraphic sections which repeatedly cross the Henryhouse–Haragan boundary in all parts of the Arbuckle Mountains and Criner Hills. This study demonstrated a well-defined taxonomic and phylogenetic separation of Henryhouse and Haragan brachiopods, and the local and regional truncation of Henryhouse strata by the overlying Haragan strata (Text-fig. 5). The brachiopod faunal changes at this boundary are illustrated in the brachiopod range charts (Pls. 2–4) and are shown in greater detail in Text-figure 6 which isolates the Henryhouse and Haragan species from the other brachiopod taxa.

Sutherland (1965) described the Henryhouse rugose corals, basing his study on specimens derived from measured and described stratigraphic sections. Lundin (1965,1968) in an exemplary biostratigraphic-taxonomic study, described the ostracodes, basing his study on specimens obtained by an in-depth sampling of Henryhouse–Haragan–Bois d'Arc strata throughout the Arbuckle Mountains–Criner Hills region. Of special interest was the finding of abraded Henryhouse ostracodes mixed with the basal Haragan fauna (Lundin, 1968, p. 11). Maxwell (1936) also reported abraded Henryhouse fossils mixed with the basal Haragan fauna. Campbell (1967,1977) described the Henryhouse, Haragan, Bois d'Arc, and Frisco trilobites, basing his descriptions in part on specimens collected by Amsden. All of these studies agree on the following points with respect to the Henryhouse–Haragan boundary: (1) that it is a well-defined biostratigraphic boundary; (2) the stratigraphic position of the boundary and distribution of these strata in the outcrop area; (3) that the Henryhouse is of Late Silurian (post-Wenlockian–pre-Helderbergian) age, although its precise position within this Series is indeterminate; and (4) the Haragan is of Early Devonian, Helderbergian, age. For a discussion of the Henryhouse–Haragan conodont faunas, see Part II.

I believe the lithostratigraphic and biostratigraphic data bearing on the Henryhouse–Haragan relationship indicate an unconformity between these two formations. Conodont data (Part II) also indicate that the base of the Henryhouse is diachronous; however, this kind of relationship is not unique. Basal Woodford strata which overlie a major regional unconformity are known to be diachronous (Amsden and Klapper, 1972, p. 2326–2330), and the basal strata of the Late Llandoverian Cochrane–Blackgum–Sexton Creek Formations are probably diachronous.

The Haragan (Helderbergian) marlstones grade vertically and laterally into the cherty marlstones of the Cravatt Member (Bois d'Arc Formation) and ultimately into the grain-supported, skeletal limestones of the Fittstown Member, Bois d'Arc Formation (Text-figs. 3–5). This facies shift primarily reflects a reduction in terrigenous detritus accompanied by an increase in energy level (Amsden, 1958b, p. 8–14; Amsden and Ventress, 1963, p. 16–22). These lithofacies-biofacies changes affect the brachiopod faunas, mainly by changes in the relative abundance of species in both faunas rather than by the introduction of new species (Amsden, 1958b; Text-fig. 7, this report). I detected no viable zonation within the Haragan–Bois d'Arc brachiopod faunas, but Campbell (1977, p. 4) in his study of the trilobites notes that the "... Fittstown Member and the upper part of the Cravatt Member are younger than most of the Haragan, though the age difference is slight." Boucot and Johnson (1967, p. 46) express a similar opinion stating that "... the difficulty observed in the present study of distinguishing New Scotland from younger Helderbergian faunas suggests caution before firm assignment of the Haragan and Bailey faunas to the New Scotland only. The presence of *Leptocoelia* (= *Pacificoelia* sp.; see Appendix 1) in New Scotland equivalents is not yet authenticated so its presence in the Bois d'Arc of Oklahoma (Amsden, 1963) suggests the possibility that the formation ranges above the New Scotland." These are pertinent observations and I agree that some phylogenetic change is to be expected and does occur in the Haragan–Bois d'Arc sequence. However, the observation which I have expressed elsewhere, and would here re-


SILURIAN
HENRYHOUSE FORMATION
marlstone–skeletal limestone
DEVONIAN
HARAGAN–BOIS D'ARC FORMATIONS
Haragan facies
Cravatt facies
Fittstown facies
marlstone
cherty marlstone
skeletal limestones
Base of Helderbergian
Base of Henryhouse Formation
Top of Henryhouse Formation
Resserella brownsportensis
Strixella acutisulcata
Pseudodicoelosia oklahomensis
Skenidioides henryhousensis*
Dolerorthis hami
Ptychopleurella rugiplicata
Dictyonella gibbosa
Amsdenina roemeri
Coolinia reedsi
Linterella oklahomensis
Undulorhyncha filistriata
Luterella carmelensis
L. altisulcata
Nanospira? concentrica
Nanospira parvula
Delthyris kozlowskii
Merista oklahomensis
Meristina roemeri*
Homoeospira subgibbosa
H. foerstei
Lissostrophia cooperi
Amphistrophiella (Amsdenostrophiella) prolongata
A. (Amphistrophiella) alterniradiata
Amphistrophia (Amphistrophia) loeblichi
Strophonella (Strophonella) laxiplicata
Leptodonta? attenuata
Dicoelosia oklahomensis
Dalejina henryhousensis
Dalejina subtriangularis
Isorthis arcuaria
Anastrophia delicata
Leptaenisca irregularis
Leptaena oklahomensis
Morinorhynchus attenuatus
Navispira saffordi
Howellella henryhousensis
Nucleospira raritas
Atrypa tennesseensis
Dicoelosia varica
Dalejina oblatus
Isorthis pygmaea
Anastrophiia grossa
Leptaenisca concava
Leptaena acuticuspidata
L. cf. L. rhomboidalis
Morinorhynchus haraganensis
Navispira virginia
Howellella cycloptera
Nucleospira ventricosa
Atrypa oklahomensis
Skenidium insigne*
Plectodonta petila*
Linterella? acutirostella*
Eatonia exserta*
E. medialis*
Orthostrophia strophomenoides parva
Cupularostrum? lindensis
C.? glomerosa
Obturamentella wadei
Atrypina hami
Rensselaerina haraganana
Gypidula sp.*
Anopliopsis pygmaea*
Levenea subcarinata pumilis
Platyorthis angusta*
Leptostrophia (Rhytistrophia) tennesseensis
Chonetes? sp.*
Chonostrophiella helderbergia*
Costellirostra singularis
Spinoplasia gaspensis*
Koslowskiellina (Kozlowskiellina) velata
Meristella atoka
Trematospira sp.*
Rhynchospirina maxwelli
Anchillotoechia? haraganensis*
Schellwienella marcidula
Cyrtina dalmani nana
Pacificocoelia sp.

emphasize, is that the brachiopod faunas of the Cravatt and Fittstown Members are taxonomically closely allied to the fauna of the Haragan (all of the brachiopod species associated with *Pacificoelia* are either positively or provisionally identified as Haragan species). The significant taxonomic and phylogenetic change that occurs in the Haragan–Bois d'Arc–Frisco sequence is sharply localized at the base of the Frisco Formation (Range Charts, Pls. 2–4), and this relationship is in accord with the trilobite succession as defined by Campbell (1977, p. 5). The lithofacies-biofacies composition of the Fittstown Member is closely related to that of the overlying Frisco, but its articulate brachiopod fauna is closely related to that of the Haragan.

Lundin (1968, p. 17) identified 20 species of Cravatt ostracodes, seven of which are also present in the Fittstown Member and the Haragan Formation; however, he considers the Bois d' Arc samples too limited to be representative of the formation.

Terrigenous Detritus in Oklahoma and the Texas Panhandle

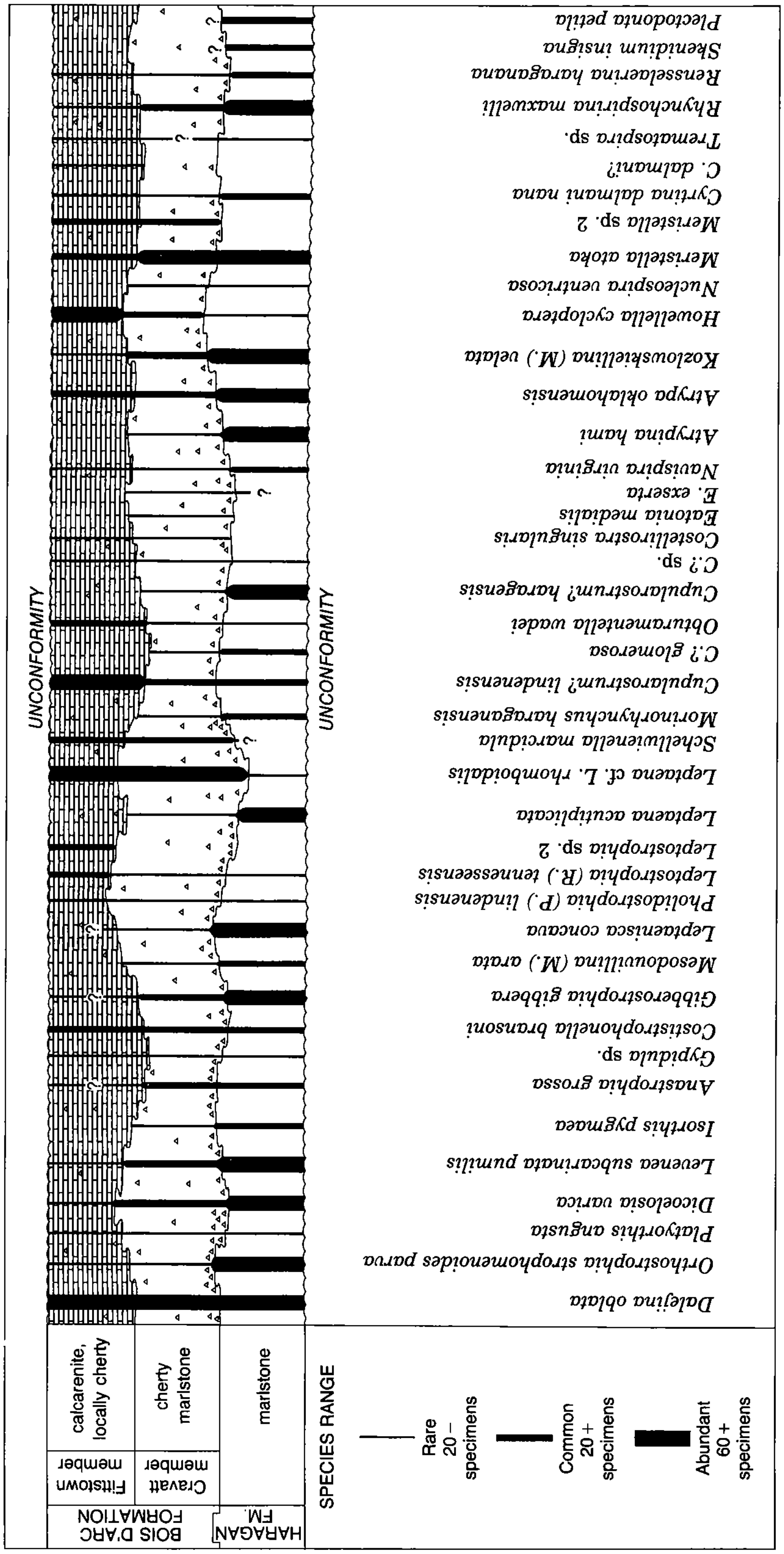
The carbonate seas of the Late Ordovician (Welling Formation) received very little extrabasinal, terrigenous detritus. This was followed in Richmondian time by a strong influx of fine (mostly clay-size) terrigenous clastics (Sylvan Shale) which extended westward across the ancestral Anadarko basin, grading into carbonates only in the far western part of this basin (Amsden, 1980, p. 38–42). In latest Ordovician time (Hirnantian) the oolitic and shelly carbonates of the Keel Formation received a minimum of detritus, and this was followed by the relatively clear carbonate Llandoverian seas (Cochrane–Blackgum). Beginning in earliest Wenlockian time (Prices Falls Member, Clarita Formation), various quantities of fine silt- and clay-size terrigenous detritus was injected into the carbonate seas, continuing through the Silurian and into Early Devonian (Helderbergian) time. The geographic distribution of this detritus indicates that it was derived from the Ouachita basin (Amsden and others, 1980, p. 13; Amsden, 1981, p. 166, text-figs. 6,10). During this time the volume of terrigenous material ranged widely, with the heaviest influxes producing marlstones and calcareous shales, some of which extended as far west as the Texas Panhandle. This detritus influenced the biofacies as well as the lithofacies, with the strongest injections causing a reduction in volume of shelly material produced, and in faunal diversity (Amsden, 1981, p. 157–158, text-figs. 3–9; Amsden and others, 1980, p. 4–11,22–24,27–34). The source of terrigenous detritus was abruptly cut off at or near the close of Helderbergian time, and the Frisco (Deerparkian) carbonate seas were largely free of extrabasin detritus (Amsden, 1975, p. 69–70; 1980, p. 46).

Late Silurian Marlstone Facies in the Southern Midcontinent Region

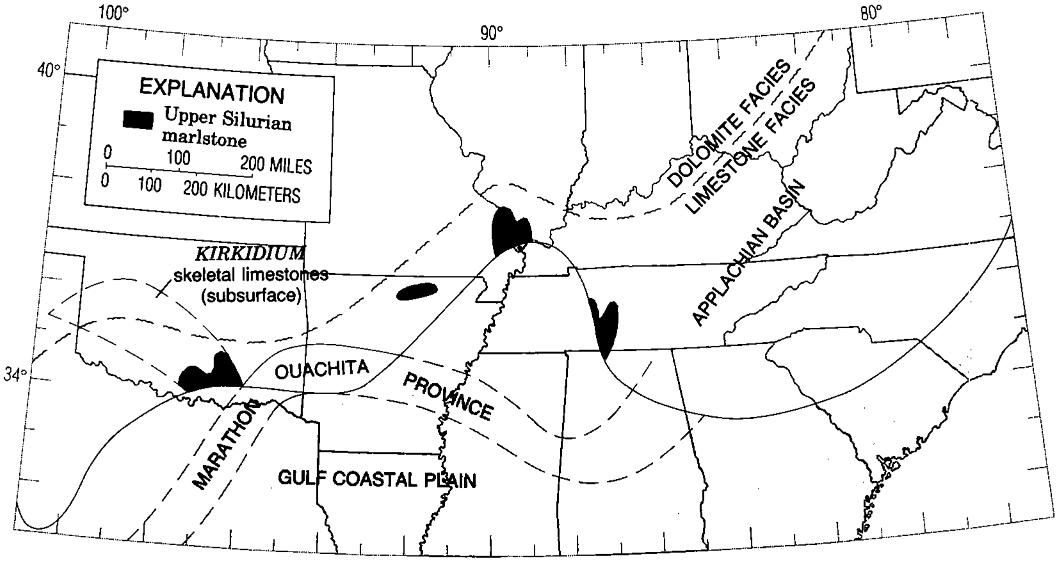
The Henryhouse Formation is correlated with the Moccasin Springs Formation (Bainbridge Group) of Missouri (Amsden, 1949, p. 33–34), the Brownsport Formation of western Tennessee (Amsden, 1951, p. 70–72), and at least the lower part of the Lafferty Limestone of north-central Arkansas (Text-fig. 8; see Berry and Boucot, 1970, correlation chart). These Upper Silurian strata are mainly marlstones with similar lithofacies-biofacies characteristics, although in places they grade into skeletal limestones such as the *Kirkidium* biofacies of western Oklahoma (see Appendix 2). A similar biofacies is present in the Brownsport Formation (Amsden, 1969, p. 968) and skeletal limestones are probably locally developed in all of these marlstones. These marlstones now comprise isolated sedimentary bodies which are draped around the Ouachita–Marathon basin (Text-fig. 8); however, they would seem to be reasonably interpreted as erosional remnants of a once continuous marlstone deposit whose detritus was derived from that basin.

These marlstones and shelly limestones have high-diversity, shelly faunas, and a number of taxonomic studies describing different groups have been published. Most investigators have assigned these faunas to the Ludlovian of Late Silurian undifferentiated (post-Wenlockian, pre-Helderbergian) age, and recognition of Pridolian age faunas in the upper part is based largely on recent conodont and graptolite studies. Barrick's

Text-figure 6 (opposite). Chart showing range of brachiopod species in the Henryhouse and Haragan–Bois d'Arc Formations, Arbuckle Mountains–Criner Hills, south-central Oklahoma. Eleven genera cross this boundary, all represented by different species. Henryhouse and Haragan species representing *Dicoelosia, Dalejina, Anastrophia, Leptaena, Navispira*, and *Atrypa* are illustrated together on plate 12, Amsden, 1958a; see also Text-figure 11, this report (after Amsden, 1962a, fig. 4, with generic emendations made since 1962). This diagram is useful to show the range of brachiopod species within the Henryhouse Formation and the relationship of this fauna to that of the overlying Haragan–Bois d'Arc. Inasmuch as the upper and lower boundaries of the Henryhouse Formation are diachronous, these ranges must be viewed with caution for the post-Wenlockian, pre-Helderbergian (Ludlovian–Pridolian) interval.



Text-figure 7. Chart showing range and relative abundance of brachiopod species in the Haragan Formation, and in the Cravatt and Fittstown Members of the Bois D'Arc Formation. This is based on a count of specimens I collected. For illustration, it was necessary to present this as three distinct lithologic types arranged in vertical sequences; actually, there is a complete gradation from marlstone to shelly limestone, and this gradation occurs laterally as well as vertically. See Text-figures 4,5 of this report, and discussion in Amsden, 1958b, p. 18–19. (After Amsden, 1958b, fig. 4, with generic emendations made since 1958).



Text-figure 8. Map showing distribution of Upper Silurian (post-Wenlockian, pre-Helderbergian) marlstone facies in the southern Midcontinent region.

investigation of Henryhouse conodonts indicates a range from early Ludlovian into the Pridolian (Part II). On the basis of graptolites, Berry and Satterfield (1972, p. 492–498) assign the upper beds of the Moccasin Springs Formation (Bainbridge Group) to the Pridolian Series and the lower beds to the Ludlovian Series. Rexroad (*in* Berry and Boucot, 1970, p. 129) reports *K. siluricus* (Ludlovian) from the Brownsport Formation. To my knowledge no conodonts have been reported from upper Brownsport beds; however, the overlying Decatur Formation, from which I (Amsden, 1949, p. 11) reported a small Brownsport brachiopod fauna, carries Pridolian age conodonts in the lower part and Lochkovian(?) age conodonts at the top (McComb and Broadhead, 1981, p. 39).

Most of the southern Midcontinent marlstones have diverse articulate brachiopod faunas with generic affinities to the Ludlovian faunas of Britain and Götland. This is brought out by Bassett and Cocks (1974) in their study of Götland brachiopods and is fully supported by my own collections from Britain and Götland. On the other hand, my brachiopod collections from the Kopanina and Pridolian strata of Czechoslovakia have few generic ties with brachiopods from the Late Silurian marlstones of the southern Midcontinent region, and provide no basis for the recognition of these two biostratigraphic divisions in this area. This also appears to be the case with the brachiopod faunas recently reported from Late Silurian strata in Podolia (Abushik and others, 1985, p. 127–138).

The Henryhouse, Moccasin Springs, and Brownsport Formations are overlain by the Haragan–Bois d'Arc, Bailey, and Birdsong Formations, all of the latter having substantial brachiopod faunas with distinct affinities to Helderbergian faunas (especially New Scotland brachiopods) of the Appalachian basin. In contrast, the diverse brachiopod faunas of the Late Silurian (post-Wenlockian) strata in the southern Midcontinent region appear to have little in common with most faunas in the pre-Keyser–Cobleskill, Late Silurian strata in the Appalachian basin. This lack of similarity may be closely related to differences in the lithofacies-biofacies characteristics of the two regions (Rickard, 1975).

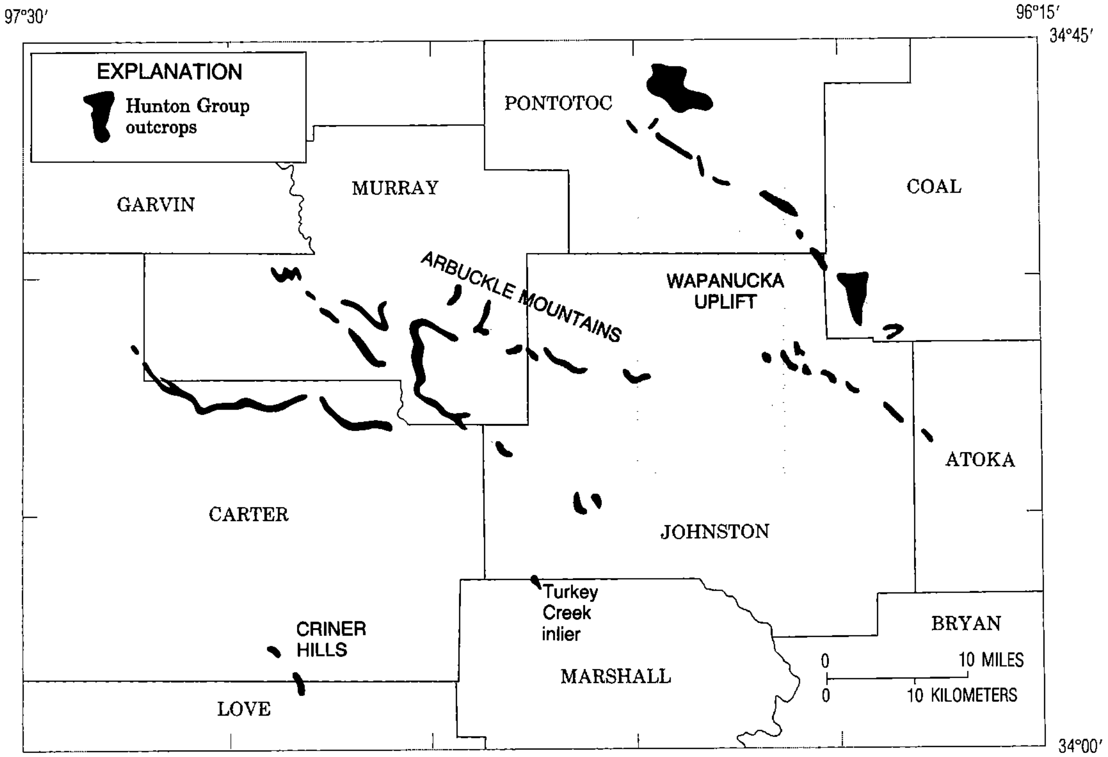
The brachiopod faunas from the Keyser Limestone of Maryland and adjacent states were described by Bowen (1967) who recognized a lower *Eccentricosta jerseyensis* Zone (see Berry and Boucot, 1970, p. 33), assigned to the Late Silurian, and an upper *Meristella praenuntia* Zone, assigned to the Early Devonian. Brachiopods from the upper zone generally resemble those from Helderbergian strata of the southern Midcontinent region, which are marked by the presence of an early terebratulid *Nanothyris* (cf. to *Rensseraerina* from the Haragan) and *Kozlowskiellina (Megakozlowskiellina), Cyrtina, Rhynchospirina,* and *Cupularostrum*; however, these genera are associated with *Merista* and *Stropohonella,* genera which are common in the Henryhouse and absent in the Haragan. Brachiopods from the lower *Eccentricosta* Zone have mixed affinities with those from the Henryhouse Formation. *Eccentricosta* is not present in the Henryhouse, nor are

Machaeraria, Cupularostrum, and *Rhynchospirina* (the last two are present in the Haragan), but *Isorthis, Dalejina, Strixella, Resserella, Strophonella,* and halysitid corals are present in the Henryhouse. Viewed in terms of the southern Midcontinent Late Silurian–Early Devonian brachiopod faunas, the Keyser brachiopod faunas would appear to be transitional between the Haragan fauna, a New Scotland correlative, and the Henryhouse fauna, here provisionally considered to be slightly older than the *Eccentricostata jerseyensis* Zone. In the Maryland stratigraphic sequence this horizon presumably falls within the Tonoloway Formation; however, in the absence of any modern biostratigraphic study of Tonoloway brachiopods, this suggested correlation cannot be evaluated.

Berdan (1972) described the brachiopods and ostracodes from the Cobleskill Formation of central New York and correlated these faunas with the *Eccentricostata jerseyensis* Zone of the Keyser Formation. Cobleskill brachiopods have little in common with the Henryhouse fauna; however, the Cobleskill ostracode *Thilipsuropsis inaequalis* (Ulrich and Bassler)(Berdan, 1972, p. 38–39, pl. 6, figs. 1–3) is present in the Henryhouse (Lundin, 1965, p. 13,78, pl. 18, figs. 1a–j).

Wapanucka Uplift

During Silurian time (late Wenlockian–Ludlovian) a large area in the southeastern part of the Arbuckle Mountains region was broadly uplifted (Text-figs. 5,9). This had a marked effect on the distribution of post-Cochrane, pre-Helderbergian strata, and throughout this region only remnants of Clarita and late Henryhouse strata are preserved (Amsden, 1960, panel 3, pls. B,C). The first phase of the uplift began in the late Wenlockian and extended into the Ludlovian, causing extensive truncation of the Clarita Formation (Text-fig. 2B; Amsden, 1960, panel 3). In late Henryhouse time (Pridolian) the area was again submerged and the Henryhouse seas transgressed the Wapanucka area. In latest Pridolian time, and probably extending into earliest Helderbergian time, the area was again uplifted, causing truncation of the Henryhouse and older strata. The Early Devonian seas then transgressed the area to deposit the Haragan and Bois d'Arc sediments. Over much of the Wapanucka uplift the Cochrane Formation and remnants of the Clarita and Henryhouse Formations are overlain by the Cravatt Member of the Bois d'Arc Formation (see Appendix 2, Henryhouse Formation).



Text-figure 9. Map showing location of the Wapanucka uplift and its relationship to Hunton outcrops in the Arbuckle Mountains–Criner Hills of south-central Oklahoma. (From Amsden, 1960, panel 3).

BRACHIOPOD VS. CONODONT ZONATION

This report is concerned primarily with brachiopod biostratigraphy, but every effort has been made to coordinate this with other megafaunal studies and with the conodont investigations of J. E. Barrick (Part II). In general, reasonably good agreement exists between brachiopods and conodonts on the faunal divisions of the Late Ordovician (Hirnantian), Early Silurian (late Llandoverian), Late Silurian (Wenlockian and Ludlovian–Pridolian undifferentiated), and Early Devonian. For parts of this sequence the conodonts provide a more precise zonation. This is true for much of the Silurian where conodonts indicate a nearly continuous late Llandoverian, Wenlockian, Ludlovian, and Pridolian zonation on a local, regional, and international scale. This contrasts with the brachiopods, which can be used to distinguish late Llandoverian, Wenlockian, and Ludlovian–Pridolian (undifferentiated) faunal divisions, but which provide no firm basis for finer zonation within these divisions. The Silurian–Devonian boundary based on brachiopods is in accord with that of the conodonts, the maximum known stratigraphic discordance being at most a foot or so. The principal difference between the two groups is that the conodont-defined boundary is based on only a few taxa; however, these are conspecific with conodonts from the stratotype section in Czechoslovakia. On the other hand, the brachiopod-defined boundary is based on substantial faunal changes (Pls. 2–4). These faunas can be traced across the southern Midcontinent region but cannot at this time be closely related taxonomically to brachiopod faunas in the Czechoslovakian sequence. (I have substantial brachiopod collections from the Kopanina, Pridoli, and Lochkov in the Barrandium, Czechoslovakia.)

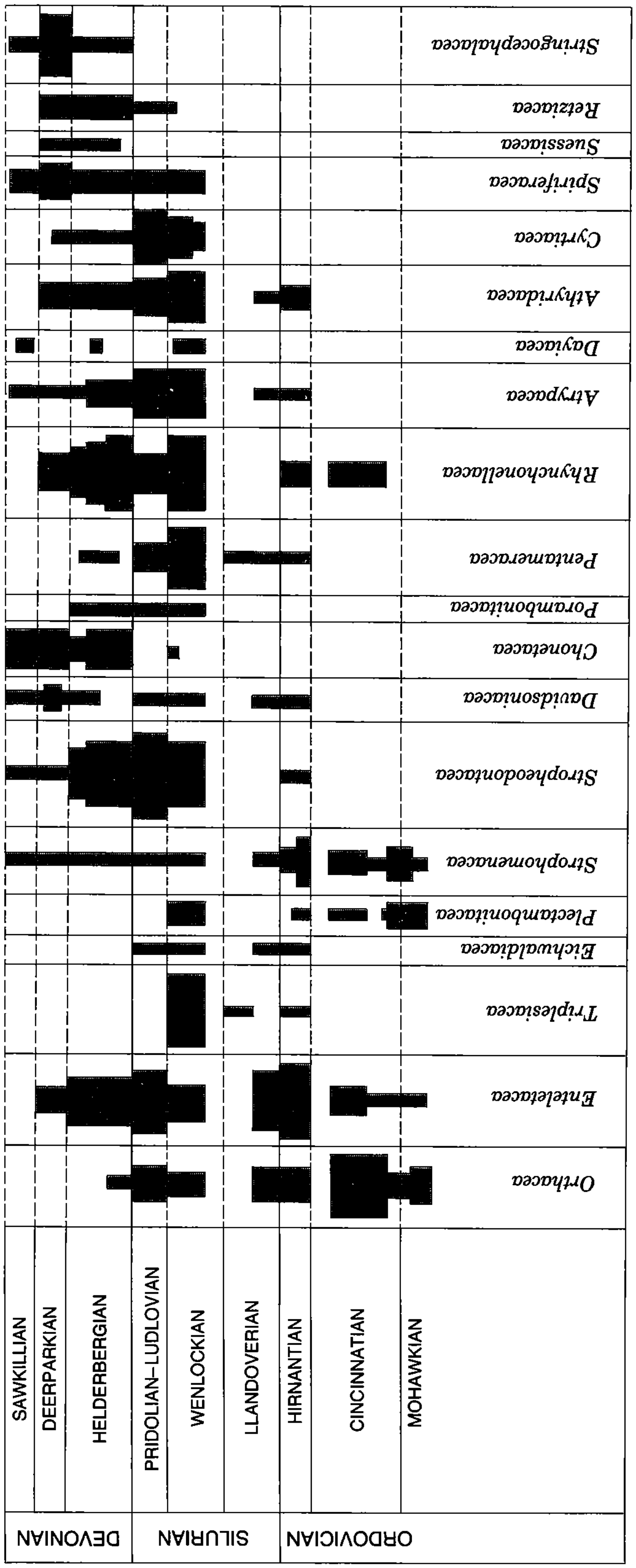
Conodont zonation is based largely on multielement platform-ramiform species comprising only a small percentage of the total recovered fauna (Amsden and others, 1980, p. 4,26–34). Paleoenvironmental factors also influence the distribution of both conodonts and brachiopods in the Late Silurian Henryhouse Formation (see section on Paleoenvironments; and Part II). Nevertheless, the conodont biostratigraphic studies summarized in Part II of the present report indicate that in the areas of maximum stratigraphic representation the Cochrane–Clarita–Henryhouse sequence represents a nearly complete late Llandoverian through Pridolian succession.

BRACHIOPOD PHYLOGENY

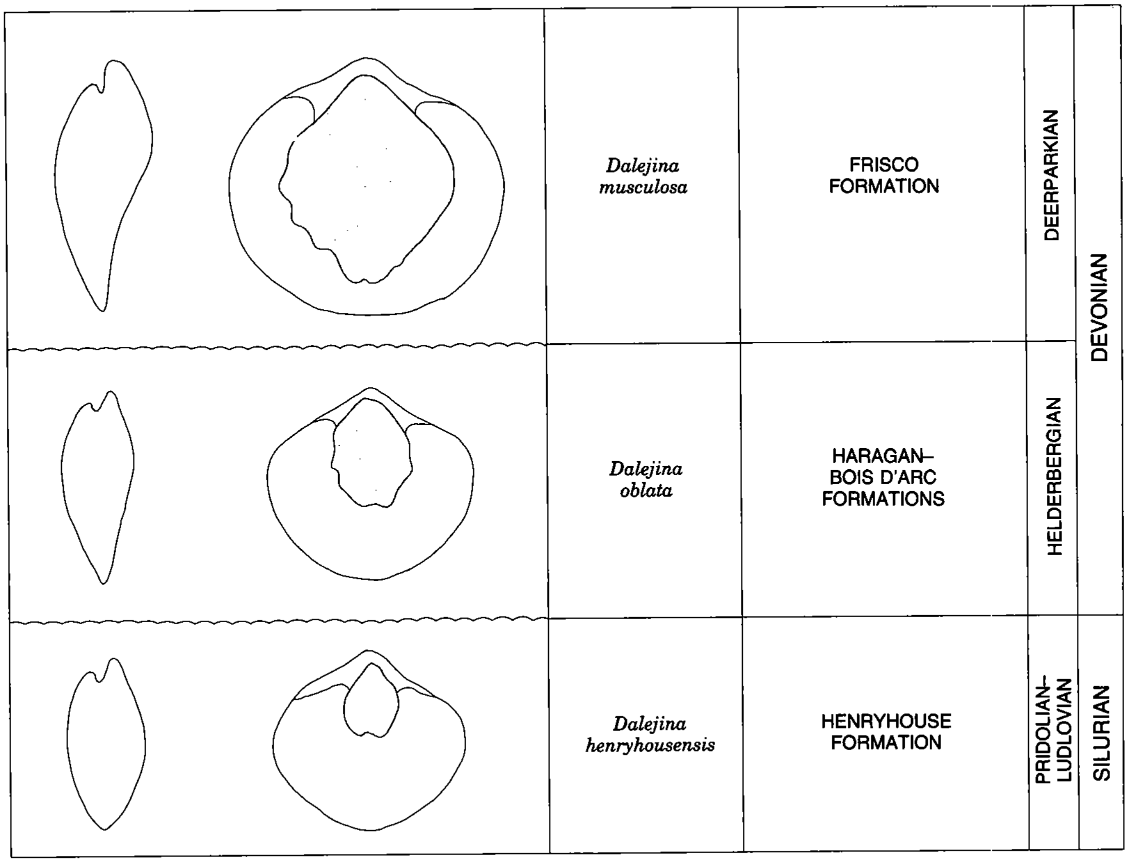
The Brachiopod Range Charts (Pl. 2–4) show substantial phylogenetic change in the articulate brachiopod faunas during Late Ordovician through Early Devonian time. This not only involved species and genera (Pl. 2–3), but also families and superfamilies (Pl. 4, Text-fig. 10). The range charts also indicate that much of this faunal change is concentrated in the seams between the formations, or, stated another way, little of the total phylogeny is preserved in the rocks. (In this report, the term *seam* is applied to the unconformable contact surface between two adjacent biostratigraphic-lithostratigraphic units. In all cases these represent chronostratigraphic gaps or hiatuses of different magnitude; see Unconformities). This does not preclude phylogenetic change within the preserved brachiopod faunas, and, in fact, some reasonably well-developed lineages have been identified. For example, a *Dalejina* sequence is present in the Late Silurian–Early Devonian strata of Oklahoma (Text-fig. 11), and portions of a *Dicoelosia* lineage are preserved in the Late Ordovician, Silurian, and Early Devonian strata of the southern Midcontinent region (Amsden, 1974, p. 42–44, text-fig. 30). Reasonably close biostratigraphic control on these lineages demonstrates that the morphologic change from one species to the next is lost in the unconformable seams. Other interesting lineages include the stricklandiids from the late Llandoverian strata (see Appendix 1, Stricklandia protriplesiana) and a pentamerid lineage (see Appendix 2, Kirkidium Biofacies, Pentamerus sp.) in the Anadarko basin; however, the available biostratigraphic control for these phylogenes is not as precise as those from the Arbuckle Mountains–Criner Hills area.

The brachiopod phylogeny probably was affected by the migration of exotic species into the Midcontinent region. I believe that, at least intermittently during Silurian time, there was a reasonably free interchange of European and Midcontinent species where the paleoenvironments were favorable (Amsden, *in* Amsden and Barrick, 1986). Present information on the stratigraphic and geographic distribution of brachiopoda taxon would suggest that this was not a major factor in the phylogenetic sequence discussed here.

Species variations can be observed within a stratigraphic unit. For example, *Dictyonella gibbosa* is a common species which ranges throughout the Henryhouse Formation. At the north end of the Arbuckle Mountains outcrop area (stratigraphic section P1, Amsden, 1960, p. 262–270) it is especially abundant in the upper part of the formation, and these specimens are about half again larger than those from the basal part of the Henryhouse. This could be the result of phylogeny, but since the upper part of the formation in this area has a reduced silt-clay content (Amsden, 1981) this change can reasonably be attributed to the effect of environment, especially since no other morphologic variations were observed. Some brachiopod species appear to have a restricted



Text-figure 10. Range chart showing distribution of articulate-brachiopod superfamilies in the region studied. Width of bar is proportional to the number of genera represented. Based on data given on the Brachiopod Generic Range Chart, Plate 3.



Text-figure 11. Lateral profile and pedicle interior views of three species of *Dalejina* from the Late Silurian–Early Devonian strata in Oklahoma. Each of these species shows little change within the formation in which it occurs; the morphologic changes are concentrated in the unconformable seams. (After Amsden and Ventress, 1963, p. 64, text-fig. 21.)

stratigraphic range. For example, *Strixella acutisulcata* has been found only in the upper part of the Henryhouse Formation (Text-fig. 6), but in the absence of any information on the antecedents of this species such biostratigraphic data must be interpreted with caution.

Faunal Sequence in the Arbuckle Mountains–Criner Hills Strata

The Welling Formation, which carries a substantial Cincinnatian (?Maysvillian–Edenian; ?Richmondian) brachiopod fauna (Alberstadt, 1973; Amsden, *in* Amsden and Sweet, 1983), is overlain by the Sylvan Shale, which yields graptolites and chitinozoans but no articulate brachiopods. The Keel Formation has a Hirnantian brachiopod fauna (Amsden, 1974; Amsden, *in* Amsden and Barrick, 1986) and is unconformably overlain by the Cochrane Formation, which bears a sparse brachiopod fauna of Late Llandoverian age. Locally, Silurian conodonts have been found in the upper few inches of the Keel (Barrick, *in* Amsden and Barrick, 1986), but these strata yield no brachiopods. Thus the sharp taxonomic breaks between the Welling–Keel and Keel–Cochrane faunas can be readily accounted for by the missing faunas of late Cincinnatian (Richmondian) and early and middle (A,B) Llandoverian age. However, the well-defined faunal breaks in the overlying strata of Late Silurian (Wenlockian) through Early Devonian (Sawkillian) age differ in that they occur in a sequence of fossiliferous carbonates whose biostratigraphic boundaries generally fall at the intrastage level in those places where biostratigraphic representation is at a maximum. In these biostratigraphic sequences, the missing faunal elements are not clearly identifiable from faunal sequences (series, stages) known from other regions. Moreover, the conodont biostratigraphy indicates that in areas of maximum stratigraphic representation the Silurian (Late Llandoverian through Pridolian) sequence is nearly complete (see section on Brachiopod Zonation vs. Conodont Zonation; and Part II).

Phylogenetic Mode

Brachiopod evolution during Late Ordovician through Early Devonian time was extensive, and even in the Silurian and Early Devonian strata where phylogenetic representation is at its maximum, most of the changes are concentrated in the seams. A strictly gradualistic evolutionary mode (Schopf, 1981, p. 158) would certainly require that the missing strata and fossils represent much greater time than that which is preserved in the rocks. Such a model would be in conflict with conodont biostratigraphy, which indicates that the missing intervals are of short duration. Moreover, the missing portions of this phylogenetic sequence should be preserved in the presumably more complete basin deposits in other parts of the world. Southern Midcontinent Late Ordovician (Hirnantian) and Silurian brachiopod faunas can be correlated with European faunas at the series level, but this is not sufficiently detailed to permit reliable comparison of the brachiopod phylogenies in the two regions. A more exact correlation (stage category) can be made with Early Devonian strata in the Appalachian basin. Stratigraphic studies in this basin by Oliver and others (1969) and Rickard (1975) record a more complete sequence of strata than is present in the region under study. Boucot (1959) and Boucot and Johnson (1968) show transitional faunal elements in the Oriskany–Esopous–Woodbury Creek brachiopod faunas (Deerparkian–Sawkillian). In a recent study, Dutro (1981, p. 67–74) summarizes the known distribution of brachiopod species in the Lower Devonian of New York, and shows the presence of additional strata and brachiopod species in the intervals between the New Scotland (= Haragan–Bois d'Arc), Oriskany (= Frisco), and Carlisle Center (= Sallisaw). Dutro's brachiopod range charts show a stairstep pattern similar to that of the present study, although the number of steps is greater and the time represented by each step is shorter than in the southern Midcontinent charts. Johnson (1982, p. 1330) believes that these Early Devonian Appalachian faunas comprise a series of assemblage zones directly related to the lithostratigraphy, and suggests ". . . the relatively provincial, shallow-water stationary brachiopods evolved when the environment changed, but not appreciably or obviously while an environment persisted." He further contrasts the brachiopods with the conodonts, interpreting the latter as pelagic organisms not confined to a particular rock unit and evolving phyletically and gradually (see Part II). Feldman (1985, p. 299–300), in a recent study of Onondaga brachiopods, reported a significant degree of stasis in the Bois Blanc–Onondaga brachiopod faunas (Sawkillian–Southwoodian), and concluded that this ". . . may support Eldredge and Gould's (1972) idea of punctuated equilibrium rather than phyletic gradualism for the species described in this report."

The present study of brachiopod biostratigraphy in the southern Midcontinent region suggests an episodic evolutionary process with relatively long periods of stasis alternating with much shorter periods of accelerated phylogeny induced by factors which are poorly understood. This is in general agreement with Johnson's model (1975, 1982; see also Johnson and Niebuhr, 1976; Feldman, 1985; Eldredge and Gould, 1972; Simpson, 1944), although the phylogenetic changes in the region under study are concentrated largely in the seams. Paleoenvironmental shifts did occur, but their principal effect was to induce changes in the relative abundance of the different filter feeders rather than in morphologic change which could be related to phylogeny.

This is not proposed as the only way in which brachiopods evolved. Well-documented examples of phyletic gradualism are known from other areas (e.g., the stricklandiid brachiopod studies of Williams, 1951, and Baarli and Johnson, 1982, and incomplete examples also are present in the Midcontinent area under study). Nevertheless, the available evidence suggests that brachiopod evolution was dominantly episodic rather than gradualistic.

PART I

APPENDIXES

APPENDIX 1
SYSTEMATIC PALEONTOLOGY*

The following new subfamily, genera, and species are described in this section: *Linterella, Luterella, Undulorhyncha,* Subfamily Undulorhynchinae, *Tonsella, Tonsella parva,* and *T. magna.* Also, new information is provided for the following taxa: *Rhynchotreta americana* (Hall), *Acutilineolus acutilineatus* (Amsden), *Myriospirifer myriofila* Havlíček, *Stricklandia, Microcardinalia,* and *Pacificoelia.*

Superfamily RHYNCHONELLACEA Gray, 1848
Family TRIGONIRHYNCHIIDAE McLaren, 1965
Subfamily TRIGONIRHYNCHIINAE McLaren, 1965
Genus **Linterella** Amsden, new genus

Type species.—Camarotoechia perryvillensis Amsden, 1949 (p. 56, pl. 6, figs. 1–8).

Diagnosis.—Small to moderate size trigonirhynchiids with a well-developed fold and sulcus. Shell costate with rounded costae; anterior commissure serrate. Pedicle interior with short but well-formed dental plates; shell wall thin, muscle scars not deeply impressed. Brachial interior with a high, thin median septum supporting an open septalium.

Discussion.—This genus is characterized externally by its subtriangular outline, erect pedicle beak, rounded costae, and biconvex shell showing no tendency toward a cuboidal shape. The fold and sulcus are in front of the beaks, becoming well marked toward the front margin. The costae are rounded and show little evidence of a split, except at the front margin of the brachial valve, where the costae are divided to produce pointed ends which mesh with the plications (costae) on the pedicle valve (serrate commissure; Amsden, 1949, pl. 6, fig. 14; Amsden, 1951, pl. 18, fig. 5). Internally the brachial valve is marked by a well-developed, unroofed septalium which is supported on a high median septum extending forward for one-third to one-half the valve length. The pedicle interior has distinct dental plates and obscure muscle scars.

This genus can be distinguished from most of the genera presently referred to the Trigonirhynchiidae (McLaren, *in* Moore, 1965) by its open septalium. *Nymphorhynchia* Rzhonsnitskaya has transverse notches on the costae, and *Lepidocycloides* Nikiforova has deeply impressed pedicle muscle scars. *Ptychomaletoechia* (Sartenaer, 1961, p. 7, pl. 1, figs. 6a–e, pl. 2, figs. E,F) has more strongly developed dental plates and angular costae, and *Luterella* Amsden, new genus, has angular costae and a strongly developed fold and sulcus.

This genus is presently known from Ludlovian–Pridolian strata in the Midcontinent area of the United States; questionably in Helderbergian-age strata in this same region.

Species assigned.—Camarotoechia perryvillensis Amsden, 1949 (p. 56, pl. 6, figs. 1–8), Brownsport Formation, western Tennessee. *Camarotoechia shannonensis* Amsden, 1949 (p. 56–57, pl. 6, figs. 9–16), Brownsport Formation, western Tennessee; *Camarotoechia eccentrica* Amsden, 1949 (p. 57, pl. 6, figs. 17–25), Brownsport Formation, Tennessee; *Camarotoechia oklahomensis* Amsden, 1951 (p. 86–87, pl. 18, figs. 1–5), Henryhouse Formation, Arbuckle Mountains region, south-central Oklahoma.

The Early Devonian (Helderbergian) Haragan species *Trigonirhynchia acutirostella* Amsden (1958a, p. 104–105, pl. 13, figs. 1–7) is a questionable representative of this genus.

Genus **Luterella** Amsden, new genus

Type species.—Camarotoechia altisulcata Amsden, 1951 (p. 86–87, pl. 18, figs. 6–13).

Diagnosis.—Small to moderate size trigonirhynchiids with strongly developed fold and sulcus, and strong, angular costellae; commissure serrate. The pedicle interior has dental plates; the shell wall is thin, and the muscle scars are not deeply impressed. Brachial interior with a high median septum bearing an open cruralium.

Discussion.—This genus differs from *Linteretta* Amsden, new genus, in its sharply angular costae and strongly flexed fold and sulcus. Internally, these two genera are alike in all essential respects. *Ptychomaletoechia* Sartenaer (1961, p. 7) has angular costae, but lacks the broad, high fold and sulcus of *Luterella.*

Luterella is presently known only from Ludlovian–Pridolian strata in the Midcontinent region of the United States.

Species assigned.—Camarotoechia altisulcata Amsden, 1951 (p. 86, pl. 18, figs. 6–13), Henryhouse Formation, Arbuckle Mountains region, south-central United States.

Camarotoechia carmelensis Amsden, 1951, p. 85–86, pl. 18, figs. 14–18; = *Camarotoechia acutiplicata* Amsden, 1949 (p. 57–58, pl. 7, figs. 10–14, text-fig. 27; not Hall, 1859, p. 232), Brownsport Formation, western Tennessee, and Henryhouse Formation, Arbuckle Mountains region, south-central Oklahoma.

Subfamily UNDULORHYNCHINAE Amsden, new subfamily

Trigonirhynchiids lacking a well-defined septalium and with costae bearing closely and evenly spaced lirae.

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*This publication was officially released by the Oklahoma Geological Survey in 1988, which is the correct year of publication for purposes of nomenclatural priority. However, Plates 1 through 4 of this publication bear a 1987 imprint date; since this date does not correspond to the official release date and is incorrect with respect to nomenclatural priority, it has been corrected to 1988. The day and month of official release are on permanent file at the Oklahoma Geological Survey.

Genus **Undulorhyncha** Amsden, new genus

Type species.—"*Camarotoechia*" *hollandi* Amsden, 1958 (p. 153); = *Camarotoechia cedarensis* Amsden, 1949 (p. 58–59, pl. 7, figs. 1–9; not Stainbrook, 1942, p. 611–612, pl. 88, figs. 10–15, text-fig. 2).

Diagnosis.—Subtriangular trigonirhynchiids with a well-developed fold and sulcus, and costae being closely and evenly spaced concentric lirae; brachial septalium absent.

Discussion.—Internally this genus has short but well-developed dental plates, but lacks the high median septum and cruralium which characterizes the Trigonirhynchiinae. In *Undulorhyncha* the median septum is low and at its posterior end develops only a poorly defined callosity to which the crural bases are attached. Externally this genus is marked by sharply defined concentric lirae (Amsden, 1949, pl. 7, fig. 8; 1958, pl. 19, fig. 14).

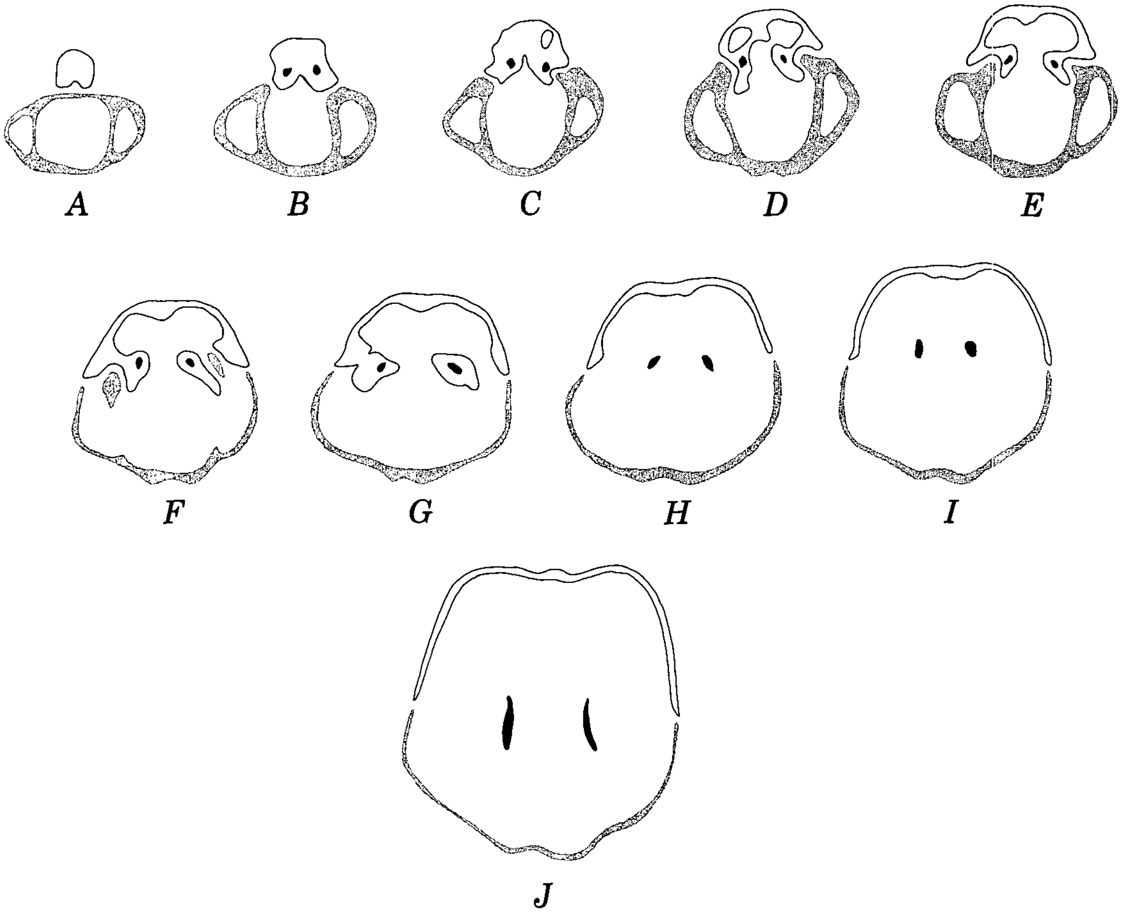
This genus is presently known only from Ludlovian–Pridolian strata in the Midcontinent area of the United States.

Species assigned.—*Camarotoechia hollandi* Amsden, 1958c (p. 153) (see references cited above), Brownsport Formation, western Tennessee. *Camarotoechia filistriata* Amsden, 1951, p. 87, pl. 19, figs. 39–44; Henryhouse Formation, Arbuckle Mountains region, south-central Oklahoma.

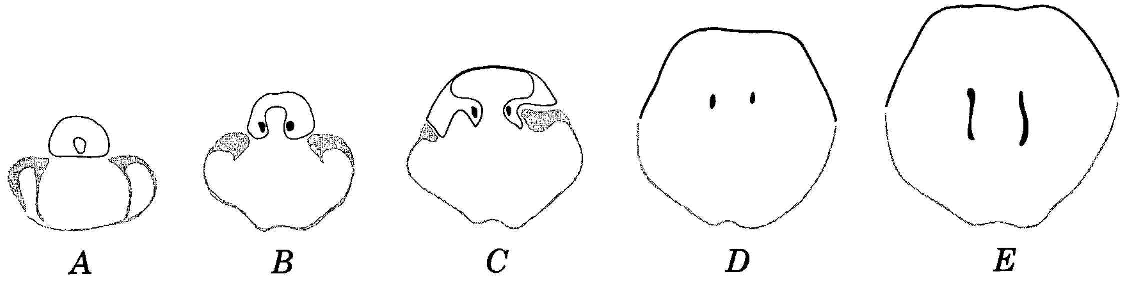
Superfamily RHYNCHONELLACEA Gray, 1848
Family OLIGORHYNCHIIDAE Cooper, 1956
Genus **Tonsella** Amsden, new genus

Type species.—*Tonsella parva* Amsden, new species.

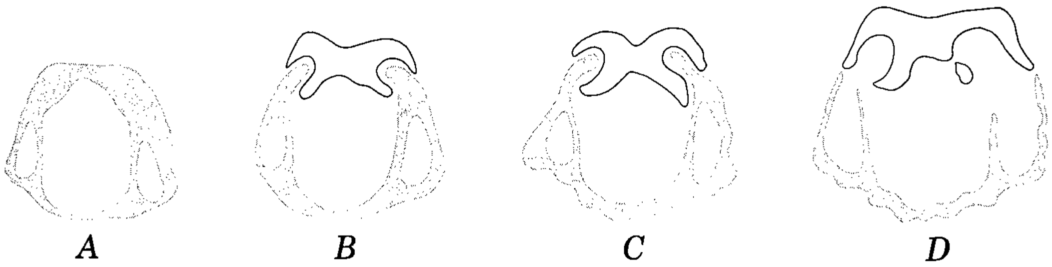
Diagnosis.—Small, relatively coarsely costellate oligorhynchids lacking a fold and sulcus (Pl. 7, Figs. 1–16). Pedicle valve with well-defined



Text-figure 12. Transverse serial sections (×9) of *Tonsella parva* Amsden; specimen sectioned is from the basal 3 ft of the Cason oolite, St. Clair Springs, SW¼SW¼ sec. 18, T14N, R5W, Independence County, Arkansas. Posterior tip of pedicle valve broken and no measurements available. (Pedicle valve stippled; crura solid.) Peels, OU 10439.



Text-figure 13. Transverse serial sections (× 9) of *Tonsella parva* Amsden, new genus and species, from the basal 3 ft of the Cason oolite, St. Clair Springs, SW¼SW¼ sec. 18, T14N, R5W, Independence County, Arkansas. Posterior tip of pedicle valve broken and no measurements available. (Pedicle valve stippled; crura solid.) Peels, OU 10449.



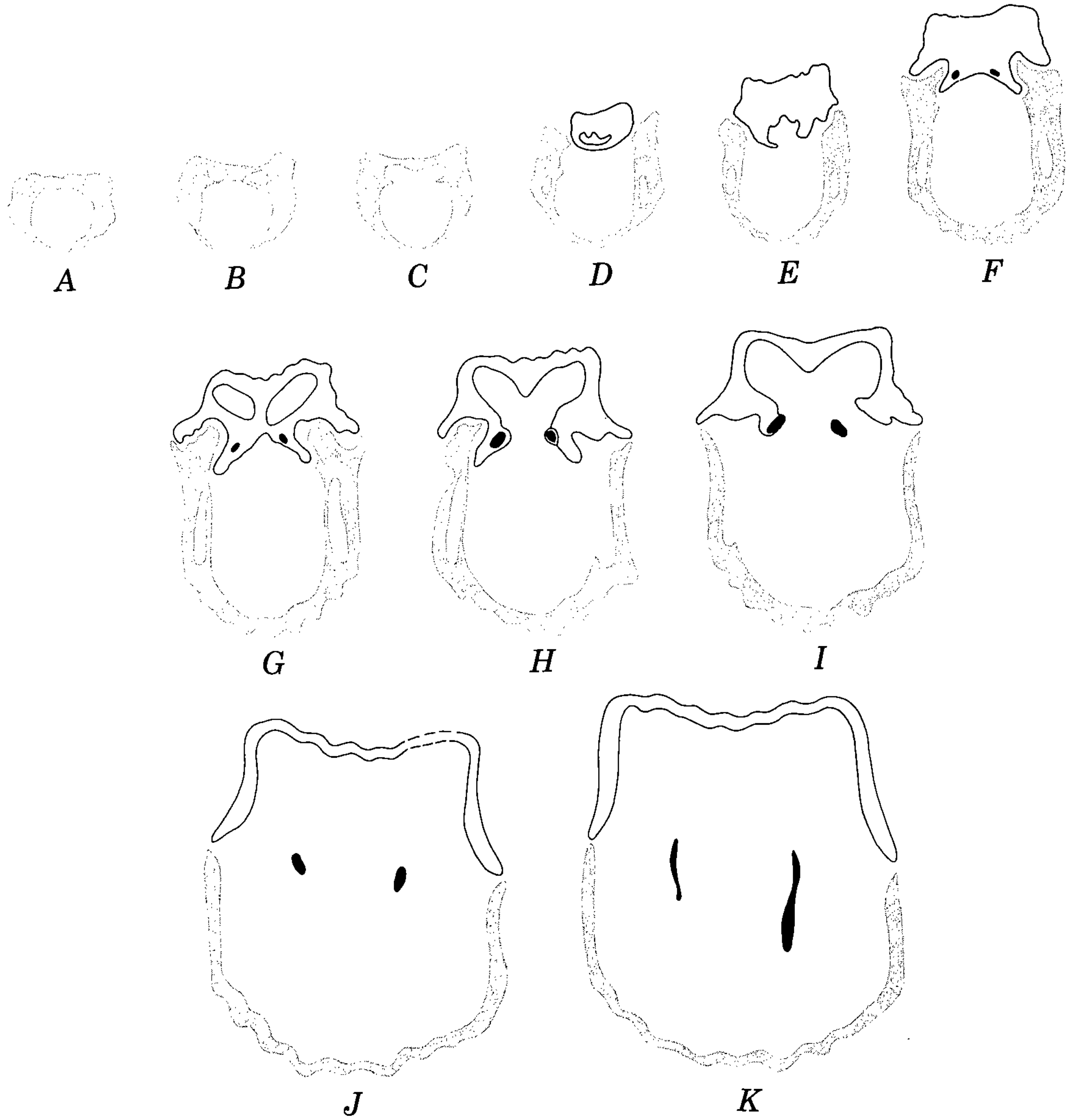
Text-figure 14. Transverse serial sections (× 15) of *Rhynchotreta* cf. *R. americana* (Hall) from the Barber Member, Quarry Mountain Formation, St. Clair Lime Company quarry, SE¼SE¼NE¼ sec. 14, T13N, R23E, Sequoyah County, Oklahoma. (Pedicle valve stippled.) This is the specimen illustrated in Amsden (1974, pl. 9, figs. 2a–c). Peels, OU 8589.

dental plates. Brachial hinge plate attached to lateral valve walls and supported at its posterior end by shell material which extends forward a very short distance as a low ridge (Text-figs. 12,13). The crura comprise two slender rods with only a slight ventral inclination; these are relatively long, extending forward about a third of the valve length, where they abruptly expand into broad, nearly flat vertical plates.

Discussion.—Tonsella appears to be closely related to *Oligorhynchia* Cooper (1935, p. 49; 1956, p. 658). Both genera have small, sharply triangular shells with erect pedicle beak, relatively coarse costellae (plicae), and generally similar internal structures. Species referred to *Oligorhynchia* are weakly biconvex with fairly strong plications, whereas *Tonsella* is more strongly biconvex with a deeper living chamber. Also *Oligorhynchia* has an interplicate anterior commissure, whereas *Tonsella* has a rectimarginate commissure if the serrations produced by the interlocking plications are excluded. Internally the two genera have similar articulation; however, the crura in *Tonsella* terminate in paddlelike expansions, whereas no similar structure is cited in Cooper's description of the various species assigned to *Oligorhynchia.*

In its erect pedicle beak and sharply triangular outline, *Tonsella* resembles *Rhynchotreta* (*R. cuneata* [Dalman] type species) from the Klinteberg Beds of Götland; however, the latter has a larger, more evenly costellate surface (Bassett and Cocks, 1974, p. 25–26, pl. 8, fig. 1; these authors note considerable variation in the degree of sulcation present on *R. cuneata* and suggest that more than one species may be present in the Klinteberg beds). Internally, *Tonsella* is also similar to *R. cuneata* (St. Joseph, 1937, p. 164–169) although the cruralium and median septum of the Götland species is better developed. The crura of *R. cuneata* are straight, slender rods which lack the distinctive paddle-shaped terminations of *Tonsella* (cf. St. Joseph, 1938, figs. 2–5 to Text-figs. 14,15 of this report).

Specimens of *Rhynchotreta americana* (Hall) from the Waldron Shale, Tennessee, are similar in outline and profile to representatives of *Tonsella*, differing mainly in the well-developed fold and sulcus present on the Waldron shells (Pl. 7, Figs. 26–29; see also Hall and Clarke, 1892, pl. 56, fig. 34; Beecher and Clarke, 1889, pl. 4, fig. 15). Serial sections prepared from a well-preserved Waldron shell (Text-fig. 15) show an internal structure



Text-figure 15. Transverse serial sections (×9) of *Rhynchotreta americana* (Hall) from the Waldron Shale, Newsom Station, Tennessee. (Pedicle valve stippled; crura solid.) Distance from posterior tip of pedicle beak (mm): A—0.5; B—0.9; C—1.1; D—1.2; E—1.6; F—1.6; G—2.3; H—2.7; I—2.9; J—4.1; K—5.3. Peels, OU 10450.

much like that of *R. cuneata* from Götland except for the paddlelike terminations on *R. americana* (cf. St. Joseph, 1937, figs. 2–5 to Text-fig. 15 of the present report; Hall and Clarke, 1894, p. 186, mention flattened terminations on *R. americana*).

Cooper (1956, p. 658–669) assigned three genera—*Oligorhynchia, Dorytreta*, and *Sphenotreta*—to the family Oligorhynchiidae. All of these are from Middle Ordovician strata in the central United States. Schmidt (*in* Moore, 1965, p. H554) provisionally included *Rhynchotreta* in this family, the uncertainty of this assignment undoubtedly being caused at least in part by the substantial time gap between the Middle Ordovician genera and the Late Silurian Rhynchotreta. The finding of Late Ordovician species having distinct morphologic affinities with both groups serves to better unite these genera into a phylogenetic unit. Further investigations of Late Ordovician–Early Silurian oligorhynchids will undoubtedly show the need for taxonomic revisions, but present information justifies the inclusion of *Oligorhynchia, Dorytreta, Sphenotreta, Tonsella*, and *Rhynchotreta* in the family Oligorhynchiidae.

Tonsella parva Amsden, new species
Pl. 7, Figs. 1–16; Text-figs. 12,13

Holotype.—Basal 3 ft of Cason oolite, St. Clair Springs, SW¼SW¼ sec. 18, T14N, R5W, Independence County, Arkansas; Pl. 7, Figs. 2–3; OU 10441.

Description.—Small, biconvex shells with a sharply triangular outline and erect pedicle beak. Surface with relatively large, rounded costellae. Anterior commissure rectimarginate, although substantial serrations are produced by the median brachial costella and matching pedicle trough; the brachial costellae split near the front margin (Pl. 7, Fig. 10), and the pedicle trough develops a small costella toward the front (Pl. 7, Fig. 11).

The pedicle interior has well-developed dental plates. In the brachial valve the crural bases are attached to the lateral walls and wrap around the pedicle teeth; at the posterior end these plates are supported by shell material which extends forward a very short distance as a low ridge. The crural plates extend forward as slender rods for about a third the valve length, rising slightly toward the ventral valve; these terminate as flattened, paddlelike structures (Text-figs. 12,13).

The holotype is 6.0 mm long, 4.2 mm wide, and 2.7 mm thick; another complete shell from the Cason oolite at St. Clair Springs measures 5.8 mm long, 4.4 mm wide, and 3.9 mm thick. Specimens from the Keel Formation (laminated limestone) at stratigraphic section P9, Coal Creek, Oklahoma (Amsden and Barrick, 1986) are slightly larger, the largest pedicle valve being 7.8 mm long and 5.5 mm wide.

Discussion.—This species is represented by about 20 well-preserved articulated shells and free valves from the lower 3 ft of the Cason oolite at St. Clair Springs, north-central Arkansas (Amsden and Barrick, 1986, p. 20,22). It is also present in the laminated limestone of the Keel Formation, Coal Creek, south-central Oklahoma, where about 30 specimens, mostly free valves, were collected (Amsden, 1960, p. 282; Amsden and Barrick, 1986).

T. parva is most similar to *T. magna* from the Edgewood Group of Missouri; for a comparison, see Discussion under *Tonsella magna* below. *T. parva* also has similarities with *Oligorhynchia subplana* Cooper and several other oligorhynchid species described by Cooper (1935, p. 49–51; 1956, p. 659–663). A comparison of *T. parva* with these species is given in the section describing the new genus *Tonsella*.

Tonsella magna Amsden, new species
Pl. 7, Figs. 17–25

Holotype.—*Stegerhynchus*? sp. (Amsden, 1974, p. 68, pl. 16, figs. 1f–j; this report, Pl. 7, Figs. 17–25 [University of Illinois RX-321]), Edgewood Group, Cyrene Formation(?), Wiggington farm, near Cyrene, sec. 12, T52N, R2W, Pike County, Missouri (see Locality N, Amsden, 1974, p. 86).

Description.—Shell triangular in outline, moderately biconvex with erect pedicle beak. Surface bears relatively coarse, rounded costellae; brachial valve with prominent median costellae which splits toward the front, and pedicle with prominent median trough which also splits toward the front. Anterior commissure rectimarginate, but with prominent serrations produced by the costellae. Pedicle and brachial interiors unknown.

The holotype measures 9 mm long, 7 mm wide, and 4 mm thick.

Discussion.—The Rowley Edgewood collections that I studied in 1974 include only three specimens of this species, all from the Edgewood Group at the Wiggington farm near Cyrene (= locality N, Amsden, 1974, p. 86). In 1974 I referred this species to the Bryant Knob Formation, but it is more reasonably assigned to the Cyrene Formation, as the type locality for that unit is at or near the Wiggington farm. (The associated brachiopod fauna is fully compatible with such a stratigraphic position; Amsden, 1974, p. 86.) For a recent discussion on the biostratigraphy of the Edgewood Group in Pike County, Missouri, see Amsden (*in* Amsden and Barrick, 1986).

T. magna is closely comparable with *T. parva* in most respects, except for size. The split in the median brachial costella and corresponding pedicle valley is more prominent on *T. magna*, but this can be at least partly related to size. The two shell features which cannot be related to size are the slightly better defined costellation and distinctly shallower convexity of *T. magna; T. parva* has a length/thickness ratio of ~1.5, and *T. magna* has a ratio of ~2.3 (cf. Pl. 7, Figs. 4,18). It should be stressed that the internal structure of *T. magna* is unknown; however, its close external resemblance to *T. parva* strongly suggests that it is an oligorhynchid closely related to *Tonsella*.

Genus **Rhynchotreta** Hall, 1879
Rhynchotreta cf. **R. americana** (Hall), 1843
Text-fig. 14

Rhynchotreta cf. *R. cuneata* (Dalman) Amsden, 1978, p. 26, pl. 9, figs. 2a–d.

Discussion.—My original description was based on specimens from the Quarry Mountain Formation (Wenlockian) of eastern Oklahoma. The internal structure of the Quarry Mountain shells was then unknown and its reference to *Rhynchotreta* was based on external features. The best-preserved specimens were small, showing only slight sulcation, and for this reason were compared with *R. cuneata* (Dalman) from the Klinteberg beds of Götland rather than with *R. americana* (Hall) from the Waldron Formation and other formations of eastern North America.

In 1984 I serially sectioned the specimen illustrated in 1978 (Amsden, 1978, pl. 9, figs. 2a–c); these sections show an internal structure (Text-fig. 14, this report) similar to that of *R. cuneata* (Dalman) (St. Joseph, 1937, p. 164–169, figs. 2–5) and *R. americana* (Hall) (Pl. 7, Figs. 26–29; Text-fig. 15, this report). Unfortunately, the terminal ends of the crura are not preserved making it impossible to determine if it had paddle-shaped crura as in *R. americana* from the Waldron Formation (Text-fig. 15, this report). Also, additional preparation of two specimens from the Quarry Mountain collections show that larger specimens have rather well-developed sulcation. Thus, the external shell morphology and costellation is similar to that of the Waldron specimens I examined (Pl. 7, Figs. 26–29), although the preservation of the Quarry Mountain shells is inadequate for precise species identification.

Superfamily CYRTIACEA Frederiks, 1919 (1924)
Family CYRTIIDAE Frederiks, 1919 (1924)
Subfamily EOSPIRIFERINAE Schuchert and LeVene, 1929
Genus **Acutilineolus** Amsden, 1978
Pl. 5, Figs. 1,2

Discussion.—In October of 1978 I proposed a new subgenus, *Eospirifer (Acutilineolus)* the type species being *Eospirifer acutilineatus acutilineatus* Amsden from the St. Clair Limestone of Arkansas. *Eospirifer (Acutilineolus)* was distinguished from *Eospirifer (Eospirifer)*, type species *E. (E.) radiatus* (J. de C. Sowerby) from the Wenlock of Great Britain, by its delicate capillae and very fine interspaces. In the British species the capillae are relatively stout and are separated by wide, U-shaped interspaces with concentric filae (Pl. 5, Figs. 4,5), whereas in *Acutilineolus* the capillae are low, very narrow, and separated by interspaces which are reduced to fine grooves (Pl. 5, Figs. 1–3). In March 1978 Havlíček (p. 105–106) proposed the new genus *Myriospirifer*, type species *M. myriofila* Havlíček from the Koneprusy Limestone, Koneprusy, Czechoslovakia, which is distinguished by broad, flat capillae separated by relatively narrow interspaces. *Myriospirifer* was distinguished from *Eospirifer* by its relatively wide capillae, which increase mostly by bifurcation; in *Eospirifer* the capillae are relatively narrow with respect to the interspaces and increase mainly by implantation (Pl. 5, Fig. 4). Included in my collections from the Koneprusy Limestone, Koneprusy, Czechoslovakia, is a specimen of *M. myriofila* with well-preserved ornamentation (Pl. 5, Figs. 6–8). This shell has broad, flat-topped capillae separated by narrow, but very deep, interspaces with fine filae. As noted by Havlíček, the capillae increase mainly by bifurcation; other than this, the two genera have essentially the same ornamentation. *Acutilineolus* differs from both genera in its delicate capillae and interspaces, which in cross section have a low amplitude of curvature, and which lack any trace of concentric filae. Because of their small size these ridges are easily broken and eroded, making it difficult to get any reliable quantitative information on their mode of origin; however, both implantation and bifurcation can be observed. The well-defined morphologic distinction between the capillation of *Acutilineolus* and both *Eospirifer* and *Myriospirifer* is taxonomically best expressed at the generic rather than the subgeneric level.

Recently Rong and others (1984) have proposed a new eospiriferid, *Baterospirifer*, characterized by an "*Eospirifer (Myriospirifer)* type micro-ornamentation, having a weak sulcus and fold only in the early growth stage, together with a rectimarginate anterior commissure." It is difficult to be certain from the illustrated material, but *Baterospirifer* probably has capillation similar to that of *Eospirifer*, from which it differs in having a rectimarginate commissure. The type species is *B. rectimarginatus* Rong, Sui, and Li, from the Late Silurian of Inner Mongolia.

Acutilineolus is presently known only from Wenlockian age strata in the Midcontinent region, being represented by *A. acutilineatus* and *A. pentagonus* in the St. Clair Limestone of Arkansas and *A. inferatus* in the Clarita Formation (Fitzhugh Member) of Oklahoma.

Superfamily PENTAMERACEA M'Coy, 1844
Family STRICKLANDIIAE Schuchert and Cooper, 1931
Genus **Stricklandia** Billings, 1859
Stricklandia protriplesiana (Amsden), 1966

Discussion.—This species is based on specimens from the Blackgum Formation of eastern Oklahoma (Amsden, 1966, p. 1010, pl. 115, figs. 1–21). The Blackgum shells were originally assigned to *Stricklandia triplesiana* Foerste, a species based on specimens from the Brassfield Limestone of Ohio; however, a later detailed study of the internal structure of the Oklahoma shells demonstrated a more primitive brachial apparatus, and they were assigned to a new species and referred to Boucot and Ehlers' genus *Microcardinalia*. The genus *Microcardinalia* was proposed by Boucot and Ehlers (type species *S. triplesiana* Foerste) and was distinguished from *Stricklandia* by its smaller brachial apparatus and by its pentagonal to pyriform shape. This distinction was questioned by Cocks and Rickard (1968, p. 221) who pointed out that the British stricklandias had small internal structures which did not differ in any significant respect from those of *Microcardinalia* (see also Johnson, 1979). In my original study I noted no significant difference in cardinalia size between the North American and Welsh shells (Amsden, 1966, pls. 115–117), but retained *Microcardinalia* because of the small, distinctive and persistent pentagonal shape of *triplesiana* and *protriplesiana*. Published illustrations of European representatives of this genus provide meager information on shell shape, especially on the differences in the various species. In 1982, with the help of Markes Johnson, I was able to collect a reasonably representative suite of *Stricklandia lens intermedia* from the Solvik Formation in the Oslo area; this collection has been supplemented by the loan of a large suite of well-preserved shells of *S. lens lens* and *S. lens intermedia* from the Paleontologisk Museum, Oslo, arranged by Dr. David Worsley. These show a wide variety of shell shapes at all growth stages, from pentagonal to elliptical to circular, and there thus appears to be no compelling morphologic grounds for separating *Microcardinalia* from *Stricklandia*. However, Arthur Boucot (letter, Dec. 28, 1984) objects to this interpretation, pointing out, quite correctly, that there is a late Llandoverian lineage of small-shelled stricklandids in North America which do not appear to be represented in the European faunas. My own first-hand experience with North American stricklandids is limited to late Llandoverian (C Stage) specimens in shelly carbonates extending from the Texas Panhandle to Ohio. Internal characteristics are the basis for referring these to two species, *S. triplesiana* (Foerste) and *S. protriplesiana* (Amsden); however, externally they comprise a morphologically compact group of small, weakly biconvex shells, mostly less than 30 mm wide (rarely up to 35 mm), having a distinct quadrate to pentagonal outline which only rarely develops very weakly rounded lateral margins. Recently, Johnson (1979, pl. 67, figs. 1–4,6–9) illustrated specimens of *S. lens progressa* Williams and *S. lens ultima* Williams from the Hopkinton Dolomite of Iowa. The specimens illustrated by Johnson and by Williams (1951, pl. 5, figs. 1–6), as well as those in my collections from the type Llandovery, are all fragmentary; however, they clearly represent a large, robust shell quite unlike *S. triplesiana* (Foerste) and *S. protriplesiana* (Amsden) from the Blackgum and Sexton Creek Formations of the southern Mid-continent region. The latter should certainly be separated at the species level, and better preserved specimens of *S. lens progressa* and *S. lens ultimata* may well show the need for a separation at the subgeneric level.

Distribution.—*S. protriplesiana* is present in the Blackgum Formation of eastern Oklahoma; in a core from the Kirkpatrick #1 Blevins Unit, depth 7,036 ft (Amsden, 1980, p. 39); in a core from the Phillips #1-D Franklin, Gray County, Texas, depth 11,930–11,932 ft (Amsden, 1975, p. 86); and in the Sexton Creek Formation, Alexander County, Illinois (Amsden, 1974, p. 24). Foerste based his description of *Stricklandia triplesiana* (Foerste) on specimens from the Brassfield Limestone, Soldiers Field Quarry, Dayton, Ohio. The holotype of this species is illustrated in Amsden, 1966, pl. 115, figs. 22–31. *S. triplesiana* (Foerste) is also present in the Sexton Creek Limestone, Calhoun County, Illinois (Amsden, 1974, p. 24).

Superfamily DAYIACEA Waagen, 1883
Family LEPTOCOELIIDAE Boucot and Gill, 1956
Genus **Pacificoelia** Boucot, 1975

Discussion.—Amsden (1962b, p. 215, fig. 4) illustrated two specimens identified as *Leptocoelia* sp. (= *Pacificoelia* sp.) from the type locality of the Cravatt Member (Bois d'Arc Formation), SW¼ sec. 2, T2S, R7E, Johnston County, Oklahoma. These specimens came from a bed 20–25 ft above the base of this member (the Cravatt directly overlies the Cochrane Formation at this locality), where they were associated with the following brachiopods: *Orthostrophia strophomenoides parva, Dalejina oblatus*?, *Costistrophonella bransoni, Leptaena acuticuspidata, Sphaerirhynchia lindenensis, Morinorhynchus* sp., *Meristella atoka*, and *Howellella cycloptera*. With the exception of *Pacificoelia* sp., all of these species are also present in the Haragan Formation. Boucot (1975, p. 212–213,361–362) proposed *Pacificoelia* for leptocoeliids with a gently convex brachial valve and the Cravatt specimens conform to this shape (the internal structure of the Oklahoma shells is unknown). Boucot and Rehmer (1977, p. 1223–1224) discuss the age of *Pacificoelia*, noting that "Helderberg leptocoeliids formerly assigned to *Leptocoelia*, known in many areas of the northern Appalachians such as the Cap Bon Ami Formations of Gaspé and the Matapedia Valley of Quebec and in Oklahoma (Amsden, 1963)[sic], prove on more careful examination to belong to *Pacificoelia*." These authors conclude that "... the stratigraphic range of *Pacificoelia* within the Eastern American Realm is Middle Gedinnian through Eifelian." (See Appendix 2, Bois d'Arc Formation.)

PLATES

PLATE 5

Acutilineolus, Eospirifer, Myriospirifer

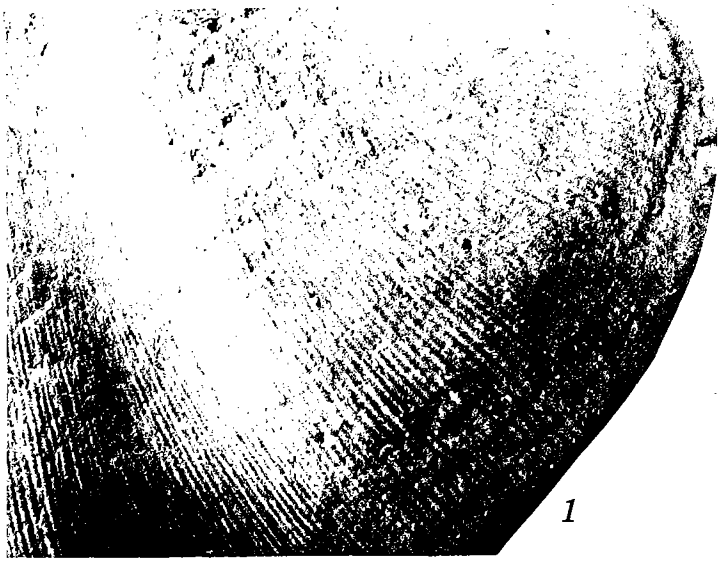
Figured specimens: USNM—United States National Museum, Washington, D.C. OU—University of Oklahoma, Norman, Oklahoma.

Figures 1,2. *Acutilineolus acutilineatus* (Amsden), St. Clair Limestone, St. Clair Springs, 5 mi northeast of Batesville, NE¼NE¼ sec. 24, T14N, R6W, Independence County, Arkansas (see Amsden, 1968, pl. 1, fig. 1r) (USNM 158054).
1, enlarged surface view (×10) of pedicle valve.
2, enlarged surface view (×5) of partly exfoliated pedicle valve.

Figure 3. *Acutilineolus pentagonus* (Amsden), St. Clair Limestone, Searcy Mine, about 6 mi north of Batesville, SE¼SW¼ sec. 10, T14N, R6W, Independence County, Arkansas (USNM 158068). (See Amsden, 1968, pl. 1, fig. 2t).
3, enlarged view (×5) of slightly weathered pedicle surface.

Figures 4,5. *Eospirifer radiatus* (Sowerby), Wenlock Limestone, west side Wren's Nest, North Dudley, England (936920 #130 Kidderminster). (See Amsden, 1978, pl. 3, figs. 2c–f); (OU 8516).
4, 5, enlarged surface views (×10, ×5) of the brachial surface showing capillae, interspaces, and concentric filae.

Figures 6–8. *Myriospirifer myriofila* Havlíček, Koneprusy Limestone, Houba Quarry, Koneprusy, Czechoslovakia (OU 10452).
6, 8, enlarged views of pedicle surface (×10, ×5) showing flat-topped capillae, narrow but deep interspaces, and concentric filae.
7, enlarged surface view (×5) of the natural mold of the specimen shown in Figures 6,8; this reverse shows clearly the considerable depth of the narrow, U-shaped interspaces.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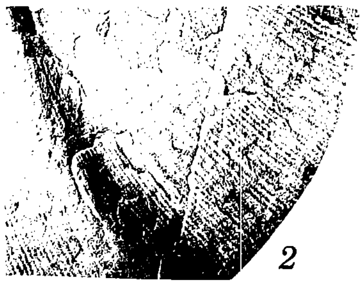
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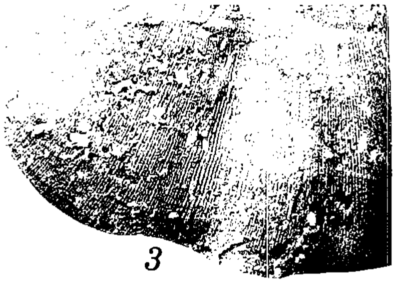
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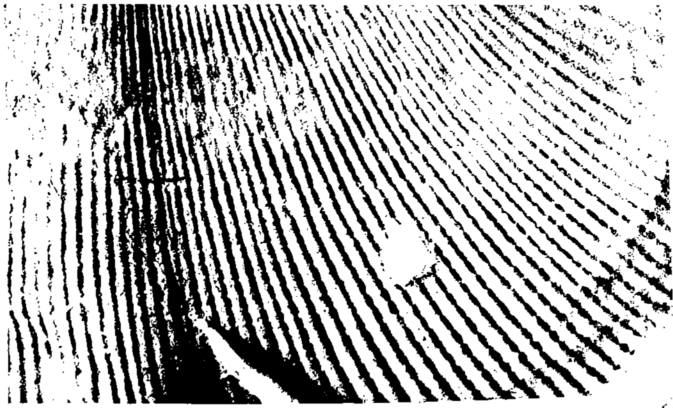
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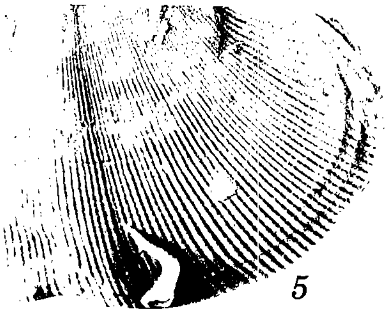
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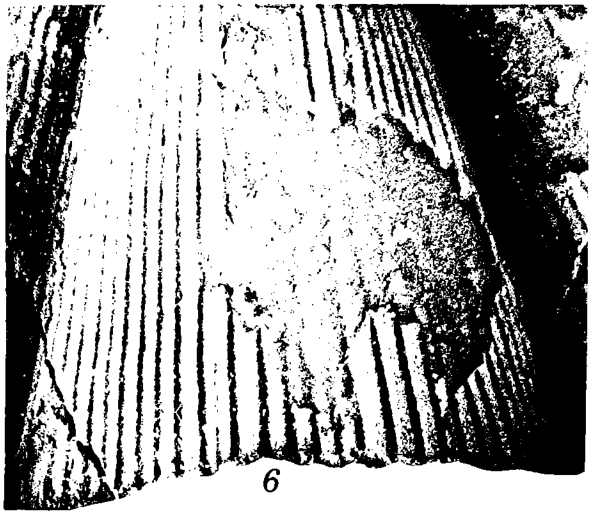
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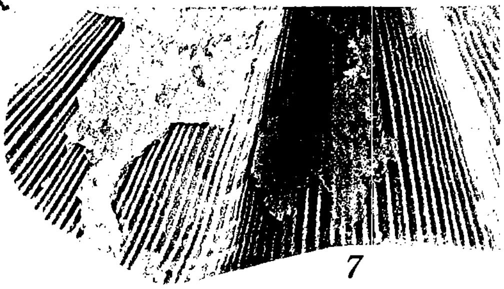
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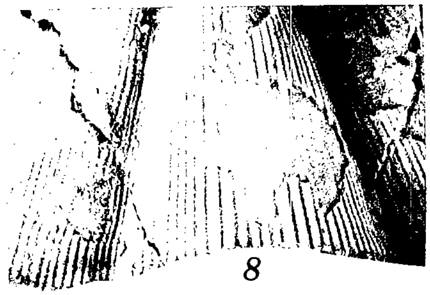
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PLATE 6

Kirkidium, Triplesia, Stricklandia

Figured specimens: USNM—United States National Museum, Washington, D.C. OU—University of Oklahoma, Norman, Oklahoma.

Figures 1–4. *Kirkidium pingue latum* Amsden, *Kirkidium* biofacies, Henryhouse Formation, Jones and Pellow #1 Farrell, depth 7,770–7,774 ft (Amsden, 1969, pl. 117; 1975, p. 85).
1, core showing specimens (×1); (OU 6229).
2, lateral view of an incomplete shell (×1); (OU 6228).
3, brachial valve (×1); (OU 6225).
4, brachial valve (×1); (OU 6226).

Figures 5–7. *Kirkidium pingue pingue* (Amsden), *Kirkidium* biofacies, Henryhouse Formation.
5, shell split longitudinally to show internal structures of both valves (×3), Gulf #1 Streeter, SE¼SE¼ sec. 20, T13N, R4W, Oklahoma County, Oklahoma, depth 7,060 ft (Amsden, 1969, pl. 117, fig. 2); (OU 6233).
6, pedicle valve (×1), Jones and Pellow #1 Farrell, C NE¼NE¼ sec. 14, T15N, R6W, Kingfisher County, Oklahoma (Amsden, 1969, pl. 117, fig. 8); (OU 6233).
7, core showing several specimens (×1), Jones and Pellow #1 Farrell, depth 7,801.5 ft (see Figs. 1–4 above for location); (Amsden, 1969, pl. 117, figs. 7,13); (OU 6229).

Figures 8,9. *Triplesia alata* Ulrich and Cooper.
8, brachial view (×1), Blackgum Formation, south shore Lake Tenkiller, SE¼SW¼ sec. 32, T14N, R22E, Cherokee County, Oklahoma (Amsden, 1971, pl. 1, fig. 14).
9, pedicle view (×1), Cason "Brassfield", Love Hollow Quarry, SW¼ sec. 4, T14N, R8W, Batesville district, Izard County, Arkansas (Amsden, 1971, pl. 1, fig. 19).

Figures 10–12. *Stricklandia protriplesiana* (Amsden), Blackgum Formation, SE¼SE¼NE¼ sec. 2, T14N, R21E, Cherokee County, Oklahoma (Amsden, 1966, pl. 115, figs. 2,4,5).
10, pedicle view (×1).
11, brachial view (×1).
12, pedical view (×1).

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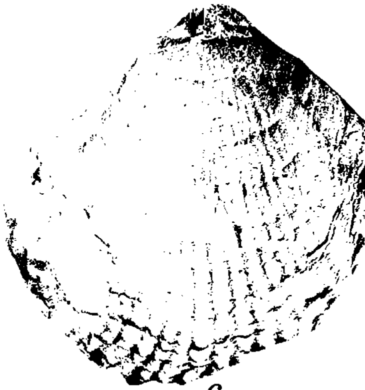

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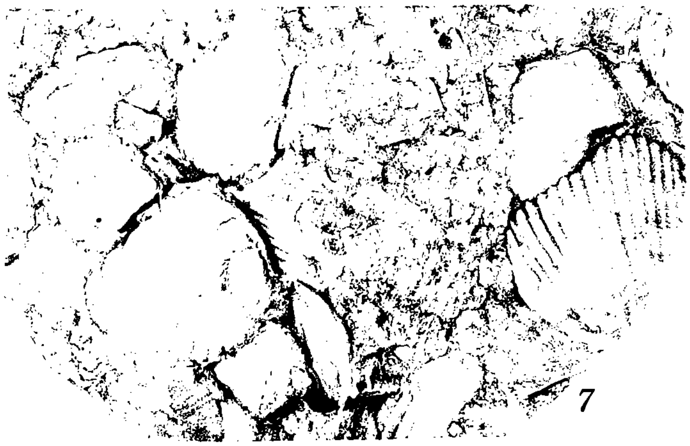

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PLATE 7

Tonsella, Rhynchotreta

Figured specimens: USNM—United States National Museum, Washington, D.C. OU—University of Oklahoma, Norman, Oklahoma.

Figures 1–12. *Tonsella parva* Amsden, new genus and new species. Cason oolite, lower 3 ft; St. Clair Springs, SW¼SW¼ sec. 18, T14N, R5W, Independence County, Arkansas.
1, pedicle valve showing thin, median rib (×5); (OU 10440).
2, 3, pedicle and lateral views of the holotype (×5); (OU 10441).
4, 5, anterior and pedicle views (×5); (OU 10442).
6, brachial view of a small shell (×5); (OU 10443).
7, 8, lateral and brachial views (×5); (OU 10444).
9, brachial view (×5); (OU 10445).
10, pedicle view showing delicate median costella (×5); (OU 10446).
11, pedicle view (×5); (OU 10447).
12, small brachial valve (×5); (OU 10448).

Figures 13–16. *Tonsella parva* Amsden, new genus and new species. Keel Formation, laminated unit, NW¼NW¼ sec. 22, T1N, R7E, Coal Creek, Pontotoc County, Oklahoma (stratigraphic section P9, Amsden, 1960, p. 382; Amsden, *in* Amsden and Barrick, 1986).
13, three brachial valves (×5); note split at anterior end of median costella; (OU 10436).
14, large pedicle valve (×5); (OU 10435).
15, pedicle valve showing small center costella (×5); (OU 10437).
16, pedicle valve (×5); note small center costella; (OU 10434).

Figures 17–25. *Tonsella magna* Amsden, new genus and new species. Edgewood Group, Cyrene Formation, Wiggington farm, near Cyrene, Pike County, Missouri; sec. 12, T52N, R2W (locality N, Amsden, 1974, p. 86). These are the specimens I described and illustrated as *Stegerhynchus*? sp. (Amsden, 1974, p. 68, pl. 16, figs. 1a–j).
17–21, lateral, anterior, posterior, brachial, and pedicle views (×3) of the specimen illustrated in 1974, pl. 16, figs. 1f–j; here designated the holotype (University of Illinois RX-321).
22–25, brachial, lateral, pedicle, and anterior views (×3) of the specimen illustrated in 1974, pl. 16, figs. 1a–e (University of Illinois RX-320).

Figures 26–29, *Rhynchotreta americana* (Hall), Waldron Formation, quarry at Newsom Station, Tennessee.
26–29, anterior (×2), pedicle beak showing foramen (×6), brachial (×2), and lateral (×2) views; (OU 10451). Serial sections prepared from a Waldron shell from this same locality illustrated in Text-figure 15.


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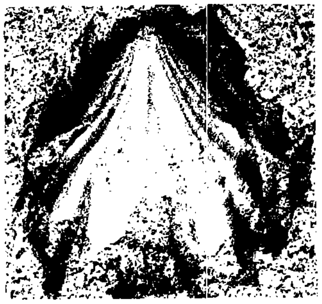
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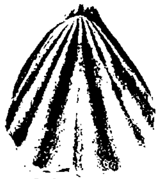
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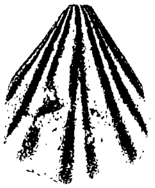
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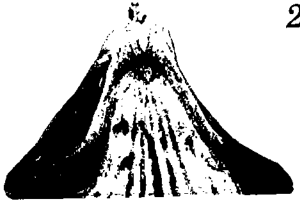
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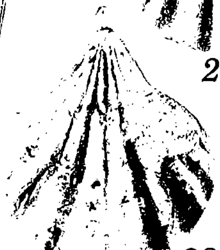
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APPENDIX 2
ANNOTATIONS

This section provides information on the stratigraphic divisions, faunal zones, and other data cited on the Correlation Chart (Pl. 1A). Data provided include location of type sections; citation of important references; discussion of various lithostratigraphic, biostratigraphic, and paleoenvironmental problems; and morphologic details for some key brachiopod species. Unless otherwise indicated, cross references at the end of each discussion refer to subjects in this Annotations section.

ACUTILINEOLUS BEDS (= EOSPIRIFER BEDS OF AMSDEN, 1968)—In 1968, I recognized two faunal divisions in the Fitzhugh Member, Clarita Formation: lower *Eospirifer* beds (= *Acutilineolus* beds) and upper *Placotriplesia* beds. The *Placotriplesia* beds, which are dominated by the triplesid brachiopod *Placotriplesia praecipta* (Ulrich and Cooper), have been identified at only a single outcrop located near the northern end of the Arbuckle Mountains (stratigraphic section P1-F, Amsden, 1960, p. 268; Amsden and others, 1980, p. 8). The *Acutilineolus* beds (= *Eospirifer* beds) comprise the lower unit; the dominant brachiopod is *A. pentagonus* (Amsden), which is relatively abundant in the crinoidal sparite facies of the Fitzhugh Member (Amsden and others, 1980, p. 4–8). This brachiopod is also abundant in the St. Clair Formation of north-central Arkansas. See Fitzhugh Member, Clarita Formation; see also Appendix 1, Genus Acutilineolus.

AMPHIGENIA BIOZONE—The terebratulid brachiopod *Amphigenia curta* (Meek and Worthen) is common in the Lower Devonian (Sawkillian) Sallisaw Formation of eastern Oklahoma and the Clear Creek Formation of southeastern Missouri and southern Illinois (Amsden, 1963, p. 187–192, pls. 14,17,20). Specimens of *Amphigenia* sp. (the core material is inadequate for a precise species identification) are present in cores from central Oklahoma (Kirkpatrick #1 Cronkite) and the Texas Panhandle (Phillips #1-C Lina, Sinclair #1 Lips; a re-examination of the specimens from the Standard of Texas #1 Wheeler, which I identified [Amsden, 1975, p. 83] as *Amphigenia* show them to be a different terebratulid, possibly *Rensselaerina*). These strata represent the erosional remnants of a widespread upper Lower Devonian carbonate unit, which is cherty and arenaceous in the east, grading into cleaner limestones in the west (Amsden, 1980, p. 50, text-fig. 19). See Sallisaw Formation, Phillips #1-C Lina, Sinclair #1 Lips, Kirkpatrick #1 Cronkite.

ARTIOTRETA PARVA BIOZONE—Toomey (*in* Amsden and others, 1980, p. 21–22, text-fig. 20) reports that this small inarticulate brachiopod ranges through a considerable part of the Fitzhugh Member, Clarita Formation, in the Arbuckle Mountains, where it is associated with a large and varied agglutinated foraminifer fauna. *A. parva* is especially abundant and widespread in the lower beds of this member. These beds are underlain by the Prices Falls Member, which contains *Pterospathodus amorphognathoides*. Satterfield and Thompson (1969, p. 1042–1044) report this brachiopod from the basal beds of the St. Clair Limestone in southeastern Missouri and southwestern Illinois; this limestone is underlain by the Seventy-Six Shale, which contains *P. amorphognathoides*.

Dr. James E. Barrick, Texas Tech University, informs me (letter, Feb. 4, 1985) that *A. parva* is widespread in early Wenlockian strata in the southern United States. It occurs in the lower Maddox Member, Wayne Formation, Tennessee, in the lower part of the Pan American #1 Droke core; and in the lower part of the Wristen Formation (Wink Member) in the Mobil Pegasus well in Midland County, Texas. He also indicated that this species is abundant in the *Kockelella ranuliformis* Zone, but is extremely rare if not absent in the underlying *Pterospathodus amorphognathoides* Zone. According to Dr. Barrick neither this species nor genus is known from similar age strata in other parts of the world. See Prices Falls Member, Fitzhugh Member, St. Clair Limestone, Seventy-Six Shale, Bainbridge Group, Pan American #1 Droke.

BAILEY LIMESTONE—The type locality for this formation is in Perry County, eastern Missouri. Tansey (1922) described and illustrated the Bailey fauna, including 39 species of articulate brachiopods. Amsden (1958a, p. 24) considered the Bailey Limestone to be essentially correlative with the Haragan and Bois d'Arc Formations of Oklahoma. See Haragan Formation.

BAINBRIDGE GROUP—The type locality is near Bainbridge, Cape Girardeau County, southeastern Missouri (Ulrich, 1904; Ball, 1939). Lowenstam (1949, p. 12–18) elevated the Bainbridge to a group consisting of a lower pinkish-gray limestone, the St. Clair Formation, and an upper marlstone, the Moccasin Springs Formation. The type locality for the Moccasin Springs Formation is near that of the Bainbridge. Satterfield and Thompson (1975, p. 112–114) added a thin, basal shale member, the Seventy-Six Shale, to the Bainbridge; the type locality is near the town of Seventy-Six, in southeastern Missouri. This shale, which is underlain by the Sexton Creek Limestone and overlain by the lower limestones of the Bainbridge (= St. Clair of Lowenstam), is widely distributed in southeastern Missouri and southwestern Illinois. Satterfield and Thompson did not follow Lowenstam's division of the overlying Bainbridge into a lower St. Clair and an upper Moccasin Springs.

Flint and Ball (1926, p. 250) recorded the following brachiopods from the mottled red and gray marlstones of the upper Bainbridge (= Moccasin Springs Formation)—*Bilobites bilobus, Strophonella dixoni, S. tenuistriata, Gypidula roemeri, Trematospira simplex, Dictyonella gibbosa, Merista tennesseensis*. These authors and later investigators commonly have correlated this fauna with that of the Brownsport Formation of western Tennessee and the Henryhouse Formation of Oklahoma (Amsden, 1949, p. 32–36; Amsden, 1951, p. 69–72).

Satterfield and Thompson (1969, p. 1042–1044) report the inarticulate brachiopod *Artiotreta parva* Ireland from the basal limestones of the Bainbridge (= St. Clair Formation of Lowenstam) at the Trail of Tears State Park, Cape Girardeau County, Missouri, and at Dongola Hollow, Alexander County, Illinois. Ireland's (1961, p. 1138–1139, pl. 137, figs. 1–12) original description of this species was based on specimens from the Chimneyhill Formation of the Arbuckle Mountains, Oklahoma (= Fitzhugh Member, Clarita Formation). Toomey (*in* Amsden and others, 1980, p. 21, fig. 20) records abundant specimens of *A. parva* from the lower Fitzhugh Member. Toomey also recovered abundant agglutinated foraminifers from formic acid residues of samples from the lower Bainbridge (= St. Clair Formation of Lowenstam) at Dongola Hollow, Alexander County, Illinois; he states that these comprise a ". . . distinctive agglutinated foram micro fauna that is very similar to that of the Clarita (Fitzhugh Member) of southern Oklahoma," and Barrick (letter, Feb. 4, 1985) states that this part of the Bainbridge ranges from the *Kockelella ranuliformis* Zone into the *K. amsdeni* Zone.

Rexroad and Craig (1971) describe and illustrate a conodont fauna from the Bainbridge near Lithium in Perry County, eastern Missouri. These conodonts were collected from a sequence of red, green, and gray argillaceous limestones which are presumably equivalent to the Moccasin Springs (the upper formation in the Bainbridge Group). This fauna includes *Polygnathoides siluricus* (G. Klapper, letter, Feb. 4, 1985), a conodont which Craig (1969, p. 1626–1627) reports from the Lafferty Limestone of north-central Arkansas, and which Klapper reports from the upper part of the Hunton Group (= *Kirkidium* biofacies, Henryhouse Formation) in the Pan American #1 Post Unit, Kingfisher County, central Oklahoma (Amsden, 1975, p. 96). Rexroad and Craig regard this fauna as representing a late middle to early late Ludlow age. Berry and Satterfield (1972, p. 492–498) report *Monograptus ulrichi* and *M. angustidens* from the "upper part of the Bainbridge Formation" in southeastern Missouri. These authors believe *M. angustidens* indicates a late Pridolian age (see also Berry and Boucot, 1970, p. 186). See Moccasin Springs Formation, Lafferty Limestone, Kirkidium Biofacies, Henryhouse Formation, St. Clair Limestone, Seventy-Six Shale.

BARBER MEMBER, QUARRY MOUNTAIN FORMATION—The type section is ~3 mi southeast of Barber, Cherokee County, Oklahoma (Amsden and Rowland, 1965, p. 43–47). The Barber is the lower dolomitic member of the Quarry Mountain Formation; the upper member is the Marble City Member. Amsden (1978, p. 11, 13–40, pls. 1–11) described and illustrated 14 species of articulate brachiopods from the upper 20 ft of this member, 12 of which also are found in the overlying Marble City Member. On the basis of this brachiopod fauna, the Marble City Member and upper part of the Barber are assigned a Wenlockian age. No diagnostic fossils have been reported from the middle and lower parts of the Barber or from the upper part of the Tenkiller Formation, which underlies the Barber. Klapper (letter, May 14, 1976) reported the late Llandoverian conodont *Ptersopathodus celloni* from a bed ~5 ft below the top of the Tenkiller, and thus the Llandoverian–Wenlockian boundary falls within the Tenkiller–Barber sequence. See Quarry Mountain Formation, Marble City Member, Tenkiller Formation, Fitzhugh Member.

BLACKGUM FORMATION—The type locality is at Blackgum Landing on the south shore of Lake Tenkiller, Cherokee County, eastern Oklahoma (Amsden and Rowland, 1965, p. 20–22). *Triplesia alata* Ulrich and Cooper is present in the upper 10 ft of the Blackgum Formation, where it is associated with *Stricklandia protriplesiana* (Amsden). On the basis of these brachiopods the Blackgum Formation is assigned a Late Llandoverian (C Stage) age. See Triplesia alata Biozone, Cochrane Formation, Sexton Creek Limestone; see also Appendix 1, Stricklandia protriplesiana.

BOIS D'ARC FORMATION—The type locality is on Bois d'Arc Creek in the northern part of the Arbuckle Mountains, Pontotoc County, Oklahoma (Amsden, 1960, p. 99–104). The formation is divided into a lower Cravatt Member composed of marlstones with various amounts of chert, and an upper Fittstown Member consisting of organodetrital sparites (Amsden, 1960, p. 105–125). There is both lateral and vertical gradation between the Cravatt and Fittstown, and between these units and the Haragan marlstones. Amsden (Amsden, 1958a, p. 11–17; Amsden, 1958b, p. 17–20; Amsden and Ventress, 1963, p. 17–20, text-fig. 5) considers the Bois d'Arc Formation to be largely a lateral facies of the Haragan Formation. Amsden (1958b) describes and illustrates 50 species of articulate brachiopods from the Bois d'Arc Formation. Lundin (1968) described the ostracodes; Campbell (1977) described the trilobites; conodonts are discussed in Part II, this report.

BOWLING GREEN DOLOMITE—The type section is in Pike County, Missouri, and the name is derived from the town of Bowling Green (Keyes, 1898, p. 59,62). Laswell (1957, p. 21) cites the Magnesium Mining Company quarry section as an exemplary outcrop (Amsden, 1974, p. 83–84). Thompson and Satterfield (1975, p. 68) and Amsden (1975, p. 3) included the Bowling Green in the Edgewood Group. Thompson and Satterfield (1975, p. 86,88,90–92) reported a substantial conodont fauna from the Bowling Green Dolomite and assigned this to the Early Silurian but did not specify what part of the Llandoverian is represented. Amsden (1975, p. 15) described and illustrated five species of articulate brachiopods from the lower Bowling Green beds at the Magnesium Mining Company quarry (Howell and others, 1961, p. 28). These strata were tentatively assigned a Late Ordovician age and are considered to be the lateral equivalent of Noix strata exposed in eastern Oklahoma. Dr. T. L. Thompson (review, January 17, 1985) indicates the presence of Cyrene Limestone in the lower wall of the Magnesium Mining Company quarry and suggests that the brachiopods I described are from this stratigraphic unit. However, when I examined this quarry in 1961, the strata exposed down to the Maquoketa Shale were composed entirely of dolomite and heavily dolomitized limestones, including the beds from which the brachiopods were collected (Amsden, 1974, pl. 25, figs. 5a–j, pl. 27, figs. 3a,b; Howell and others, 1961, fig. 17). Amsden (*in* Amsden and Barrick, 1986) presents additional evidence to show that the Bowling Green Formation is in part a dolomitic facies of the Bryant Knob Formation (Silurian) and in part a dolomitic facies of the Noix–Cyrene Formations (Ordovician; Hirnantian). See Noix Formation, Cyrene Formation, Bryant Knob Formation, Edgewood Group.

BROMIDE FORMATION—The type section is near Bromide in the southeastern part of the Arbuckle Mountains, Johnston County, Oklahoma. Cooper (1956, p. 120–123) divided the formation into an upper Pooleville Member and a lower Mountain Lake Member. Harris (1957, p. 94–103) removed the uppermost birdseye limestones and marlstones of the Pooleville, assigning them to the Corbin Ranch Formation, which he believed to be separated from the underlying strata by a significant hiatus. Amsden (*in* Amsden and Sweet, 1983, p. 11–14) assigned the Corbin Ranch to submember status, and treated it as an intertidal facies of the upper Bromide, which was only locally developed in the eastern part of the Arbuckle Mountains. Decker (1952), on the basis of graptolites, and Loeblich (1942), on the basis of bryozoans, assigned the Bromide Formation an early Trentonian age; however, Cooper (1956, p. 123–124, chart 1), in his monographic study of the brachiopods, showed this formation spanning a time interval from late Ashbyan (late Chazyan) through the Porterfieldian and into the early Wildernessian (Blackriveran). On the basis of a study of the ostracodes, Harris (1957, p. 100–103) refers his Corbin Ranch Formation to the early Trentonian and the Bromide Formation (restricted) to the Blackriveran; however, Sweet (*in* Amsden and Sweet, 1983, p. 26–32, text-fig. 2), on the basis of the conodont faunas, refers the Corbin Ranch Submember to the Kirkfieldian Stage, Champlainian Series, and tentatively correlates it with the Fite Limestone. On the Ordovician correlation chart of Ross (Ross and others, 1982, sheet 2) the Corbin Ranch is assigned a slightly older Rocklandian age. See Corbin Ranch Beds, Pooleville Member.

BRYANT KNOB FORMATION—The type section is on Missouri Highway 79, Pike County, Missouri (Thompson and Satterfield, 1975, p. 98). Thompson and Satterfield (1975, p. 86,88,90–93) regard this formation as the middle stratigraphic unit in the Edgewood Group. On the basis of its conodont fauna, they assigned the Bryant Knob to the Early Silurian. Amsden (1974, p. 14,32–78, pls. 1–26) described and illustrated 14 articulate brachiopods from the Bryant Knob Formation and tentatively assigned these to the Early Silurian. This formation is considered to be a lateral facies of the Bowling Green dolomite (see also Amsden, *in* Amsden and Barrick, 1986). See Edgewood Group, Bowling Green Dolomite.

"BUTTON" SHALE—This is an informal designation given by Craig (1969, p. 1622) to the upper Cason Shale–lower St. Clair Limestone beds bearing spherical algal(?) structures with radial and concentric banding, many being strongly impregnated with manganese (Amsden, *in* Amsden and Barrick, 1986). Craig reported *Pterospathodus amorphognathoides* and *Kockelella ranuliformis* from these beds. None of the St. Clair brachiopods described by Amsden (1968) can be attributed with certainty to these conodont-bearing beds, the brachiopods coming from St. Clair strata 2–4 ft above the Cason–St. Clair contact at the Cason Mine. Barrick and Klapper (1976, p. 63) report *P. amorphognathoides* from the Prices Falls Member (Clarita Formation) and *K. ranuliformis* from the basal beds of the Fitzhugh Member (Clarita Formation) in the central Arbuckle Mountains. See Cason Shale, St. Clair Limestone, Prices Falls Member, Fitzhugh Member, Seventy-Six Shale.

CAPE LIMESTONE—Named by Templeton and Willman (1963, p. 134–135,240) for exposures in eastern Missouri. The type locality is within the city limits of Cape Girardeau, where the Cape Limestone consists of ~8 ft of organodetrital limestones overlain by the Thebes Member, Scales Formation, and Maquoketa Group; and underlain by the Kimmswick Subgroup, Galena Group. According to Craig (1975, p. 84), conodonts from the Cape are similar to those in his fauna 2 from the lower "Fernvale" limestone of north-central Arkansas (= *Lepidocyclus oblongus* Howe brachiopod biozone). Sweet and others (1975, p. 27) tentatively assigned the conodont fauna of the Cape Limestone (type section) an early- to mid-Maysvillian age. Howe (1966, p. 261, pl. 31) described *Lepidocyclus oblongus* from the Cape Formation, and Alberstadt (1973, p. 16–56) compared the articulate brachiopods from the type Cape Limestone with those from his stratigraphic unit 3 (= Welling Formation) in the Arbuckle Mountains region, noting that *L. oblongus* Howe was present in the lower part of unit 3. On the basis of lepidocyclid zonation, Amsden (*in* Amsden and Sweet, 1983, p. 40, text-fig. 23) correlated the Cape Limestone (type section) with the lower part of the "Fernvale" limestone in the Batesville district of north-central Arkansas and with the lower part of the Welling Formation in the Arbuckle Mountains region. The Cape Limestone is also exposed in scattered outcrops along both sides of the Mississippi River in the region north of Cape Girardeau. Amsden (*in* Amsden and Sweet, 1983, p. 40–41) reported specimens of *Lepidocyclus cooperi* Howe from the Cape Limestone near Valmeyer, Illinois, and along U.S. Highway 55 in Jefferson County, Missouri, suggesting that these beds are younger than the Cape Limestone at Cape Girardeau. See Welling Formation, "Fernvale" Limestone, Lepidocyclus oblongus Biozone, Lepidocyclus cooperi Biozone.

CASON "BRASSFIELD" LIMESTONE—This is an informal stratigraphic designation for a skeletal limestone locally present in the upper part of the Cason Shale interval, Batesville district, north-central Arkansas (Amsden, 1968, 1971,1980; Amsden and Barrick, 1986). Amsden (1980) and Lemastus (1979) consider this limestone to be a lateral facies of the upper Cason Shale. Amsden (1971, p. 143–153, pls. 1,2; this report, Pl. 3) described and illustrated the triplesid brachiopod *Triplesia alata* Ulrich and Cooper and correlated this limestone with the Blackgum and Cochrane Formations of Oklahoma and the Sexton Creek Limestone of southeastern Missouri and southern Illinois. Barrick (*in* Amsden and Barrick, 1986) reported Silurian age conodonts from the Cason "Brassfield" limestone at St. Clair Springs, Batesville district, Arkansas. See Cason Shale, Cason Oolite, Triplesia alata Biozone.

CASON OOLITE—This is an informal designation applied to an oolitic limestone locally present in the lower part of the Cason Shale interval, Batesville district, north-central Arkansas. Amsden (1968,1971,1980; Amsden and Barrick, 1986) and Lemastus (1979) consider this to be a lateral facies of the lower Cason Shale interval. Craig (1969) reports Ordovician age conodonts from the Cason oolite. Barrick reports *Noixodontus girardeauensis* from the Cason oolite at St. Clair Springs, and Amsden reports a Keel–Edgewood brachiopod fauna dominated by *Cliftonia tubulistriata* from these same strata (Amsden and Barrick, 1986). See Cason Shale, Cason "Brassfield" Limestone.

CASON SHALE—The type section is near Batesville, Independence County, Arkansas (Williams, 1894, p. 325–331). For many years the age of this shale was in question, some authors assigning it to the Silurian and some to the Ordovician (Miser, 1922, p. 17). Amsden (1968, p. 6–7; 1971, p. 143–153, pls. 1,2; this report, Pl. 3, Fig. 9) reported a limestone lens within the Cason Shale, the upper beds (Cason "Brassfield") bearing the brachiopod *Triplesia alata*; this was assigned a late Llandoverian age and correlated with the Cochrane and Blackgum Formations of Oklahoma. Craig (1969, p. 1624–1627) reported *Neospathognathodus amorphognathoides* from the upper Cason limestones (= Cason "Brassfield") and Upper Ordovician conodonts from the lower oolitic beds (= Cason oolite). Craig (1969, p. 1624–1627) and Satterfield and Thompson (1975, p. 118–119) identified *Pterospathodus amorphognathoides–Kockelella ranuliformis* Zone conodonts from the upper button shale of the Cason and lowermost beds of the St. Clair. Amsden (1980, p. 34–41); Amsden and Barrick, 1986) discussed the lithostratigraphic-biostratigraphic relationships of Late Ordovician–Early Silurian strata across Oklahoma and Arkansas and presented evidence that this boundary falls within the Cason shale interval. In the Batesville district there appears to be a locally developed hiatus between the base of the Cason Shale (= Cason oolite) and the top of the "Fernvale" limestone (*L. Dicellograptus cooperi* biozone) representing the Sylvan shale (*Dicellograptus complanatus* Zone). See Cason Oolite, Cason "Brassfield" Limestone, "Button" Shale, "Fernvale" Limestone.

CHATTANOOGA SHALE—The type locality is located near Chattanooga, Tennesee. This name is used for the Upper Devonian–Lower Mississippian dark shale in Arkansas and eastern Oklahoma; approximately equivalent strata in central and western Oklahoma are designated the Woodford Shale. See Woodford Shale, Misener Sandstone, Sylamore Sandstone.

CHIMNEYHILL SUBGROUP—Lowermost stratigraphic unit in the Hunton Group. The type section is on Chimneyhill Creek at the northern end of the Arbuckle Mountains, Pontotoc County, Oklahoma (Amsden, 1960, p. 27–30). This unit was originally described as a formation; however, Amsden (1967, p. 942–945) assigned it subgroup status defined to include the Clarita, Cochrane, and Keel Formations. The Chimneyhill ranges in age from Late Ordovician (Hirnantian) into late Silurian (Wenlockian). See Clarita Formation, Cochrane Formation, Keel Formation.

CLARITA FORMATION—The type locality is west of Clarita, near old Hunton townsite, Coal County, Oklahoma (Amsden, 1960, p. 52). Originally designated as a member (pink crinoidal limestone of earlier authors) in the Chimneyhill Formation, the Clarita is now a formation in the Chimneyhill Subgroup (Amsden, 1967, p. 942–945). It is divided into two unequal members, an upper Fitzhugh Member and a lower Prices Falls Member. The latter is a thin, shaly, or marly unit rarely exceeding 2 ft in thickness, whereas the Fitzhugh represents most of the Clarita and is composed largely of organodetrital micrites and sparites. Studies of conodonts (Barrick and Klapper, 1976), brachiopods (Amsden, 1968), and trilobites (Holloway, 1980) show that the Clarita ranges in age from late Llandoverian–early Wenlockian (Prices Falls Member) through Wenlockian (Fitzhugh Member), with the uppermost strata possibly representing earliest Ludlovian. See Fitzhugh Member, Prices Falls Member, St. Clair Formation, Quarry Mountain Formation.

CLEAR CREEK FORMATION—The type locality is on Clear Creek, Union County, southwestern Illinois. Amsden (1963, p. 156–159) cited the Clear Creek brachiopod fauna described by Savage, assigned it to the Esopusian Stage (Sawkillian Stage, this report), and correlated it with the Sallisaw and Camden Formations. See Sallisaw Formation.

CLIFTY FORMATION—The type locality is on the East Fork, Little Clifty Creek, southeastern Benton County, Arkansas. It was originally described as a limestone; however, later studies have shown it to be predominantly sandstone (Hall and Manger, 1978; Wise and Caplan, 1979, p. 7). The Clifty is unconformably overlain by the Upper Devonian Sylamore Sandstone and unconformably underlain by various formations; Hall and Manger (1978) report that the Clifty generally rests on the Ordovician Powell or Everton Formations, and Wise and Caplan (1979, p. 3) report that it is locally underlain by the Penters Chert. Ulrich (*in* Purdue and Miser, 1916, p. 9) reported Middle Devonian brachiopods from the Clifty; G. Arthur Cooper (*in* Hall and Manger, 1978) cited *Tropidoleptus carinatus* (Conrad), *Protoleptostrophia periplana* (Conrad), and *Spirifer varicosus* Hall, which he identified as a Middle Devonian Hamilton fauna. Hall and Manger (1978) reported *Icriodus alternatus* Branson and Mehl, *I. symmetricus* Branson and Mehl, and scattered fragments similar to *Polygnathus cristatus* Hinde, a conodont fauna which they thought might represent a slightly younger portion of the Middle Devonian, near the Upper Devonian boundary. I have not examined the Clifty outcrops, but in 1960 Charles A. Renfroe sent me a small collection of brachiopods from the Clifty Formation at Shady Cove, SW¼SW¼ sec. 7, T19N, R27W, Benton County, Arkansas. These are from a decalcified sandstone and include reasonably well-preserved internal and external molds of *Tropidoleptus carinatus* (Conrad) and *Brachyspirifer audaculus* (Conrad). Thus the Clifty represents an erosional remnant of Middle Devonian sandstone that is somewhat older than the *Polygnathus varcus* Zone of the Misener Sandstone in the Federal #1 Wolleson well of central Oklahoma (Amsden and Klapper, 1972). See Sylamore Sandstone, Misener Sandstone, Polygnathus varcus Zone.

COCHRANE FORMATION—The type locality is near Chimneyhill Creek at the northern end of the Arbuckle Mountains, Pontotoc County, Oklahoma (Amsden, 1960, p. 44–50; 1967, p. 942–945). The Cochrane is a skeletal limestone with a varied benthic fauna including corals, brachiopods, bryozoans, trilobites, and mollusks (Reeds, 1911; Maxwell, 1936; Amsden, 1971), although it is difficult to extract satisfactory specimens from most beds. Amsden (1971, p. 143–154, pl. 1, figs. 5–10,12; 1973, p. 264–266, figs. 6–9) described and illustrated specimens of *Triplesia alata* Ulrich and Cooper from the Cochrane, assigning this formation a Late Llandoverian age (C1-2). Barrick and Klapper (1976) reported *Pterospathodus celloni* from the uppermost Cochrane beds and assigned this conodont zone to the late Llandoverian (C5). See Blackgum Formation, Cason "Brassfield" Limestone, Sexton Creek Formation, Triplesia alata Biozone, Stricklandia protriplesiana Biozone.

CORBIN RANCH BEDS (POOLEVILLE MEMBER, BROMIDE FORMATION)—Amsden (*in* Amsden and Sweet, 1983, p. 11) assigned this stratigraphic unit submember status; however, Dr. T. L. Thompson (letter, January 22, 1985) pointed out that the North American Commission on Stratigraphic Nomenclature (1983, p. 858) recognizes *bed*(*s*) as the smallest formal lithostratigraphic division. The type section is along Oklahoma Highway 99 south of Fittstown, in the eastern part of the Arbuckle Mountains (Harris, 1957, p. 94–99). Harris treated the Corbin Ranch as a separate formation, but most later investigators have regarded it as a local facies of the upper Bromide. Amsden (*in* Amsden and Sweet, 1983, p. 11–14) redefined the Corbin Ranch and treated it as a submember of the Pooleville Member, Bromide Formation. In this study the Corbin Ranch was considered to be the western extension of the Fite birdseye limestone, having only a local development in the eastern part of the Arbuckle Mountains. Harris (1957, p. 100–103), on the basis of the ostracode faunas, assigns the Corbin Ranch to the lower Trentonian, and the underlying Bromide strata to the upper Blackriveran. Cooper (1956, p. 621–623, pl. 127H) reports the brachiopod *Ancistrorhyncha costata* Ulrich and Cooper from upper Pooleville strata along Oklahoma Highway 99, and Amsden (Amsden and Sweet, 1983, p. 13) found this species to be common in the marlstones near the top of the Corbin Ranch at this locality. On the basis of the brachiopod faunas, Cooper (1956, chart 1) assigns the upper Pooleville strata to his Wilderness Stage (upper Blackriveran); Sweet (*in* Amsden and Sweet, 1983, p. 24–35) on the basis of the conodont faunas, tentatively correlates the Corbin Ranch Submember with the Fite Limestone of eastern Oklahoma. Bauer (letter, Jan. 13, 1987) considers the Pooleville Member (minus the Corbin Ranch Beds) to be pre-Rocklandian in age, and the Corbin Ranch–Fite Beds to be of probable Kirkfieldian age.

Recently two papers have been published on the age and stratigraphic relations of the Corbin Ranch Beds. Grahn and Miller (1986) describe the chitinozoans from the Bromide Formation. None were recovered from the Corbin Ranch Beds but a substantial fauna was described from the restricted Pooleville Member (exclusive of the Corbin Ranch Beds). Following the revised conodont biostratigraphy of Sweet (1984) these authors separate the Corbin Ranch from the underlying Pooleville by a substantial hiatus, and the Corbin Ranch from the Viola by a much smaller hiatus (Grahn and Miller, 1986, fig. 2).

The second paper is by Finney (1986, p. 455) who on the basis of graptolites correlates the upper part of the Pooleville Member in the northern Criner Hills (Finney's stratigraphic section X; no Corbin Ranch identified in this area) with the lower Viola Springs Formation at the type locality of the Corbin Ranch Beds in the eastern Arbuckle Mountains region (Amsden, 1983, text-fig. 11). At the Criner Hills locality the graptolite beds are overlain by the hard ground "seam" commonly used to separate the Bromide from the Viola, and at the Arbuckle Mountains locality the graptolite beds are underlain by a hard ground "seam." (Dr. Finney and I confirmed these relations on a field trip which we both attended in 1985.) This faunal evidence appears equivocal to me in that the graptolite sequence on which it is based is very sparsely represented in the Bromide (Finney, 1986, p. 448, text-fig. 14). See Bromide Formation, Pooleville Member.

CRAVATT MEMBER (BOIS D'ARC FORMATION)—The type section is along Chimneyhill Creek near the northern end of the Arbuckle Mountains, Pontotoc County, Oklahoma (Amsden, 1960, p. 105–114; 1958b, p. 8–15; Amsden and Ventress, 1963, p. 38–41). The Cravatt, which is the lower member of the Bois d'Arc Formation, is composed mainly of marlstones and cherty marlstones. The upper member is the Fittstown Member, which is composed of organodetrital sparites. According to Amsden, the Cravatt Member is largely a lateral facies of the Fittstown Member, being the transitional lithology bridging the gap between the Haragan marlstones and the Fittstown organodetrital sparites. The age of this member is discussed under Bois d'Arc Formation; see also Fittstown Member.

CYRENE FORMATION—The type locality is near the town of Cyrene, Pike County, Missouri. Savage (1913) regarded the Cyrene as a facies of the Noix oolite and most later authors have treated the Cyrene as the skeletal limestone facies of the Noix oolite (Thompson and Satterfield, 1975, p. 68). Amsden (*in* Amsden and Barrick, 1986) noted a similar facies pattern in the Keel Formation of Oklahoma and the Cason oolite of Arkansas, where typical oolite grades into skeletal limestones having various concentrations of ooliths. These facies are intimately associated with one another and have relatively minor influence on the distribution of brachiopod taxa. On the basis of conodonts, Thompson and Satterfield (1975) assigned the Cyrene to the Late Ordovician. See Noix Formation, Keel Formation, Edgewood Group, Cason Oolite.

EDGEWOOD GROUP—The type section is ~3 mi north of Edgewood, Pike County, Missouri (Savage, 1909, p. 517–518). Although Savage proposed the Edgewood as a formation, it was later assigned group status by Thompson and Satterfield (1975, p. 68,72); Amsden (1974, p. 4–8) discussed the nomenclatural history of this stratigraphic unit. As defined in this report, the Edgewood Group in Pike County, Missouri, and Calhoun County, Illinois, includes the Noix Formation, Cyrene Formation, Bryant Knob Formation, and Bowling Green Dolomite. In Cape Girardeau County, Missouri, and Alexander County, Illinois, the Edgewood Group includes only the Leemon Formation. The Girardeau Limestone is not included in this group; however, both the brachiopods (see Girardeau Limestone) and the conodonts (see Part II, this report) suggest that this limestone is closely related to the overlying Edgewood strata. Conodonts from the Edgewood Group are described by Thompson and Satterfield

(1976), McCracken and Barnes (1982), and in Part II of the present report. The Edgewood articulate brachiopods are described by Amsden (1975). See Noix Formation, Cyrene Formation, Bryant Knob Formation, Bowling Green Dolomite, Leemon Formation, Girardeau Limestone.

EOSPIRIFER BEDS—See Acutilineolus Beds.

FEDERAL #1 WOLLESON—This well is in Noble County, Oklahoma; C NW¼NE¼ sec. 2, T21N, R2W (Amsden, 1975, p. 104). It cored the Misener Sandstone (5,083–5,106 ft), yielding specimens of the Middle Devonian conodonts *Polygnathus varcus* and *P. linguiformis linguiformis* (Klapper, *in* Amsden and Klapper, 1972, p. 2328–2330). See Misener Sandstone, Polygnathus varcus Zone.

"FERNVALE" LIMESTONE—The type locality for this formation is in Tennessee, but the name has been widely used for Late Ordovician organodetrital limestones in the Midcontinent region. Templeton and Willman (1963, p. 134) proposed to replace the "Fernvale" of southeastern Missouri with Cape Limestone, and in Oklahoma Amsden (1979) proposed Welling as a replacement for "Fernvale." The "Fernvale" limestone underlies the Cason Shale in the Batesville district of north-central Arkansas (Miser, 1922, pl. 5). In 1978, I collected brachiopods from the "Fernvale" limestone exposed a short distance east of the West Lafferty Creek bridge, SE¼SE¼SE¼ sec. 10, T14N, R8W, Independence County, Arkansas (Amsden, *in* Amsden and Sweet, 1983, p. 40); this is near Craig's (1975, p. 66) West Lafferty Creek section. The "Fernvale" is ~90 ft thick and consists of low-magnesium, low-insoluble organodetrital pelmatozoan sparite. It is unconformably overlain by the Cason Shale, the upper surface of which is marked by solution channels at least 2 ft deep, and is underlain by the thinner bedded Kimmswick Limestone. The upper 10 ft of the "Fernvale" carries a fairly substantial brachiopod fauna, including specimens of *Lepidocyclus cooperi* (Amsden, *in* Amsden and Sweet, 1983, p. 40, pl. 5, figs. 1a–g). Numerous specimens of *Lepidocyclus oblongus* were collected from the lower 3 ft of the "Fernvale," along with the sparse representation of strophomenids and orthids (Amsden, *in* Amsden and Sweet, 1983, pl. 7, figs. 1a–s). These *oblongus* beds are presumably the same as those supplying the "Fernvale" conodont fauna 2 reported by Craig (1975, p. 84) and said to be similar to that present in the Cape Limestone. See Cape Limestone, Welling Limestone, Viola Group, Lepidocyclus cooperi Biozone, Lepidocyclus oblongus Biozone.

FITTSTOWN MEMBER (BOIS D'ARC FORMATION)—The type section is along Chimneyhill Creek near the northern end of the Arbuckle Mountains, Pontotoc County, Oklahoma (Amsden, 1960, p. 115–125; 1958b, p. 8–15; Amsden and Ventress, 1963, p. 38–41; Campbell, 1977). The Fittstown is the upper member of the Bois d'Arc Formation and is composed largely of organodetrital sparites; the lower member is the Cravatt, which is composed of marlstones and cherty marlstones. According to Amsden, the Fittstown Member is largely a lateral facies of the Cravatt Member and of the Haragan Formation. For a discussion of the stratigraphic and faunal relationships of these units, see Bois d'Arc Formation.

FITZHUGH MEMBER (CLARITA FORMATION)—The type locality is along Chimneyhill Creek at the northern end of the Arbuckle Mountains, Pontotoc County, Oklahoma (Amsden, 1967, p. 944). This member consists of skeletal limestones that overlie the marly and shaly Prices Falls Member. Amsden (1968, p. 13–23) described and illustrated 17 species of brachiopods, assigned this fauna to the Wenlockian Series, and correlated it with the St. Clair Limestone of Arkansas and the Quarry Mountain Formation of eastern Oklahoma (Amsden, 1978). On the basis of brachiopods, this member was divided into two unequal faunal divisions, a lower sequence characterized by a relatively abundant representation of *Acutolineolus pentagonus* (Amsden) (= *Eospirifer acutilineatus pentagonus* Amsden), and a thin upper unit dominated by *Placotriplesia praecipta* (Ulrich and Cooper). Barrick and Klapper (1976) described the conodonts from the Clarita Formation, recognizing five conodont zones (in ascending order): *Pterospathodus amorphognathoides* in the Prices Falls and basal Fitzhugh beds; *Kockelella ranuliformis, K. amsdeni, K. stauros* in the Fitzhugh, and *K. variabilis* in the uppermost Fitzhugh beds and lowermost Henryhouse beds. Three of these zones, *P. amorphognathoides, K. ranuliformis*, and *K. amsdeni* were also identified by Barrick (1978, fig. 44) in the Pan American #1 Droke well (C NE¼NE¼ sec. 4, T18N, R9W, Kingfisher County, Oklahoma). Toomey (*in* Amsden and others, 1980) records a large fauna of agglutinated foraminifers and inarticulate brachiopods (dominantly *Artiotreta parva* Ireland) from the Fitzhugh Member. Holloway (1980) described the Fitzhugh trilobite and the St. Clair trilobite faunas. All of these authors assign the Fitzhugh Member to the Wenlockian Series, although Barrick and Klapper (1976, p. 66) provisionally refer the uppermost Fitzhugh beds (*K. variabilis* zone) to the early Ludlovian. Barrick and Klapper assign the *P. amorphognathoides* zone of the Prices Falls Member a late Llandoverian–earliest Wenlockian age. Amsden and others (1980) discuss the lithofacies, biofacies, and paleoenvironment of the Fitzhugh Member in the outcrop area of the Arbuckle Mountains–Criner

Hills, noting that these strata grade from crinoidal sparites at the northern margin through arthropodal micrites and into ostracodal silty marlstones in the central part. See Clarita Formation, Prices Falls Member, St. Clair Limestone, Quarry Mountain Formation, Placotriplesia Beds, Acutilineolus Beds.

FRISCO FORMATION—The type locality is on Bois d'Arc Creek near the northeastern end of the Arbuckle Mountains, Pontotoc County, Oklahoma (Amsden, 1960, p. 125–135; 1961, p. 23–45). Amsden and Ventress (1963, p. 41–59) described and illustrated 32 species of articulate brachiopods from the Frisco in the Arbuckle Mountains and eastern Oklahoma, assigning this fauna a middle Early Devonian age (Deerparkian; Siegenian) and correlating it with the Little Saline Limestone of southeastern Missouri, Backbone Limestone of southwestern Illinois, Harriman Formation of western Tennessee, Oriskany Sandstone of the Appalachian region, and Grande Greve Formation of Quebec. Campbell (1977, p. 5) described eight species of Frisco trilobites (none given precise species identification) and tentatively assigned them a Deerparkian age. Klapper (*in* Amsden, 1985) reported the conodont *Icriodus* from the Frisco Formation, noting that "The Frisco *Icriodus* specimens are highly fragmented but may also be referable to *I. claudiae*" (also from the Lower Devonian of Nevada). Erosional remnants of the Frisco Formation are widely distributed in the surface and subsurface of Oklahoma (Amsden, 1975, p. 69–75; 1980, p. 46–49). See Little Saline Limestone.

GETTY #1-B COFFMAN—This well is in the C SW¼NE¼ sec. 4, T22N, R24W, Ellis County, Oklahoma; cored 11,122–11,172 ft and 11,201–11,251 ft, the latter all Hunton. This core was studied by Amsden (1975, p. 82) who identified specimens of ?*Kirkidium* and *Pentameroides*. Subsequent re-examination shows no *Kirkidium*; all the pentamerids are representatives of *Pentameroides* and ?*Pentamerus*. The cored interval from 11,201–11,251 ft was assigned to the *Kirkidium* biofacies but is here transferred to the Chimneyhill Subgroup (Cochrane Formation). See Pentamerus sp., Pentameroides, Kirkidium Biofacies, Phillips #1-C Lee.

GIRARDEAU LIMESTONE—The type locality is ~2 mi north of Cape Girardeau, Cape Girardeau County, Missouri (Savage, 1913, p. 73). This formation overlies the Orchard Creek Shale and is unconformably overlain by the Leemon Formation, which locally truncates the Girardeau and rests directly on the Orchard Creek Shale (Amsden, *in* Amsden and Barrick, 1986). At Cape Girardeau, Missouri, the Girardeau Limestone is directly overlain by the Sexton Creek Limestone (Satterfield, 1971, p. 267; Thompson and Satterfield, 1975, p. 75). Savage (1909) described and illustrated several Girardeau fossils, including the following brachiopods: *Rafinesquina? delicata* Savage, *R.? mesicosta* (Shumard), *Leptaena rhomboidalis* (Wilckens), *Schuchertella missouriensis* (Shumard), *Dalmanella modesta* Savage, *Homoeospira immatura* Savage, *Protozeuga sulcocarinata* Savage, *Rhynchotrema illinoisensis* Savage, and *Camarotoechia? festinata* Savage. Two of these species, *R.? mesicosta* and *Schuchertella missouriensis* (*Coolinia? missouriensis*), were described and illustrated by Amsden (1974, p. 53,59, pl. 4, figs. 4a–d, pl. 13, figs. 3a,b). Satterfield (1971, p. 270–273) and Thompson and Satterfield (1975, p. 74–75,78) reported *Prioniodus ferrarius, P. girardeauensis* (= *Noixodontus girardeauensis*), and *Trichonodella asymmetrica* from the Girardeau Limestone, suggesting that this fauna is of Hirnantian age (see Part II). A detailed biostratigraphic and taxonomic restudy of the Girardeau brachiopods is needed to help clarify the relationship to other Late Ordovician brachiopod faunas.

GULF #1 STREETER—This well is in the SE¼SE¼ sec. 20, T13N, R4W, Oklahoma County, Oklahoma; cored 6,875–7,301 ft (Amsden, 1975, p. 100). It cored the Frisco–Henryhouse *Kirkidium* biofacies contact and provides detailed lithostratigraphic and biostratigraphic information on the Silurian–Devonian boundary in the central part of Oklahoma (Amsden, 1969, p. 965, pl. 117, fig. 11; 1975, p. 45,73, pl. 15, figs. 1,2).

HARAGAN FORMATION—The type locality is along Haragan Creek near White Mound, in the central part of the Arbuckle Mountains, Murray County, Oklahoma (Amsden, 1960, p. 86–99). This formation is composed of marlstones bearing a prolific invertebrate fauna. Amsden (1958a, p. 11–17) described and illustrated 38 species of articulate brachiopods, assigned this fauna a Helderbergian age, and correlated it with the Bailey Limestone of Missouri, the Ross–Birdsong Formations of western Tennessee, and the New Scotland Formation of New York. Fifty-four species of Haragan ostracodes were described by Lundin (1968, p. 10–17), who assigned this fauna a Helderbergian age and correlated it with the Birdsong Shale of western Tennessee and, provisionally, with the Kalkberg–New Scotland ostracode faunas of New York. Campbell described 15 species of Haragan trilobites and compared this fauna with that from the Birdsong Shale of western Tennessee and the Kalkberg–New Scotland of New York. Some differences were noted which he concluded could be the result of slight differences in time rather than in the environment. Neither Amsden, Lundin, nor Campbell detected any viable biostratigraphic zones in the

Haragan faunas they studied. The relationship between the Haragan and Bois d'Arc Formations is discussed under Bois d'Arc Formation. Loeblich and Wicander (1976) described and illustrated 31 species of organic-walled microplankton from the Haragan and Bois d'Arc Formations of Oklahoma, and assigned this fauna a Gedinnian age. See Part II for a discussion of Haragan conodonts. See Bois d'Arc Formation, Cravatt Member, Fittstown Member, Bailey Limestone.

HENRYHOUSE FORMATION—The type locality is along Henryhouse Creek in the western part of the Arbuckle Mountains (Amsden, 1960, p. 66–84). Decker (1935b, p. 434–446) described 15 species of graptolites from the lower part of the Henryhouse, assigning this fauna an early Ludlovian age; however, Jaeger (1967, p. 282; Amsden, 1975, p. 24) who has restudied Decker's graptolite collections plus recent collections made by Amsden, believes they represent a late rather than early Ludlovian age. The Henryhouse articulate brachiopods were described by Amsden (1951), the crinoids by Strimple (1963), the ostracodes by Lundin (1965), the rugose corals by Sutherland (1965), and the trilobites by Campbell (1967). All of these authors assign the Henryhouse to the Late Silurian (post-Wenlockian, pre-Helderbergian) and none were able to recognize any effective faunal zonation. However, according to the recent conodont studies of Barrick (Part II), the lower part of this formation represents the Ludlovian Series and the upper part the Pridolian Series (Part II). Within the Arbuckle Mountains–Criner Hills outcrop area, the Henryhouse is largely a marlstone with a mud-supported texture having a substantial but variable amount of silt and clay-size detritus; however, at the northern end of the Arbuckle Mountains, the formation grades into beds of grain-supported skeletal limestones; this trend continues into the subsurface of central and western Oklahoma, where the *Kirkidium* biofacies of the Henryhouse Formation is developed (Amsden, 1969; 1975, p. 29–56, panel 11; 1980, p. 22; 1981). In the outcrop area the Henryhouse ranges up to 250 ft thick, but over a large area in the southeastern part of the Arbuckle Mountains it is sharply thinned, and only a few erosional remnants are preserved between the Haragan–Bois d'Arc and the Clarita and Cochrane Formations (see Paleoenvironments, Wapanucka Uplift). One such remnant is present at stratigraphic section C2 south of old Hunton townsite, where ~10 ft of Henryhouse is preserved between the Haragan Formation and the Clarita Formation; these strata yield the brachiopods *Dictyonella* sp.; *Resserella brownsportensis, Dalejina henryhousensis, Merista* sp., *Navispira saffordi*, and *Nanospira concentrica*. At J1, southwest of Wapanucka, 3 ft of Henryhouse is present between the Haragan and the Cochrane Formations; these beds yield specimens of the brachiopod *Nanospira concentrica* and the trilobites *Ananaspis guttulus* and *Fragiscutum glebalis* (identification, Dr. K. S. W. Campbell, May 1, 1975). See Kirkidium Biofacies.

HOLLIS BASIN (PALO DURO BASIN)—This basin occupies the southwestern corner of Oklahoma and includes a thin, discontinuous sequence of middle Paleozoic strata. The only biostratigraphic control presently known is derived from the Tidewater #1 Johnson well in NE¼SE¼SE¼ sec. 19, T3N, R23W (Amsden, 1975, p. 92). A core from this well provided several Frisco brachiopods and one questionable Viola brachiopod (Jordan, 1965, p. 22; Amsden, 1975, p. 69; 1980, p. 48). Stratigraphic information for this basin in Tillman County (Correlation Chart, Pl. 1A) is derived from lithostratigraphic data obtained from well samples studied by means of thin section. See Frisco Formation.

HUNTON GROUP—The type locality is near the old Hunton townsite in sec. 8, T1S, R8E, Coal County, Oklahoma (stratigraphic section C1, Amsden, 1960, p. 182–188). As defined in this report, the Hunton Group includes the strata from the base of the Keel Formation (Late Ordovician; Hirnantian) to the top of the Sallisaw Formation (Lower Devonian; Sawkillian); the Sallisaw Formation is not present in the Arbuckle Mountains–Criner Hills of south-central Oklahoma. The name Hunton has been widely used in the subsurface to include all carbonate strata between the Sylvan Shale and the Woodford (Chattanooga) Shale.

IDEAL QUARRY MEMBER (KEEL FORMATION)—The type locality is in the Lawrence Quarry of the Ideal Cement Company, Pontotoc County, Oklahoma (Amsden, 1960, p. 30–35). It was first described as a member of the Chimneyhill Formation, which included (in ascending order) the Ideal Quarry Member, Keel Member, Cochrane Member, and Clarita Member. In 1967 (Amsden, 1967, p. 943–945; 1975, p. 24–25) the Chimneyhill was made a subgroup, and the Keel, Cochrane, and Clarita were assigned formation status; the Ideal Quarry was retained as a member in the Keel Formation. In 1975 this member was more clearly defined as the basal oolitic skeletal limestone facies of the typical Keel oolite (Amsden, *in* Amsden and Barrick, 1986). The Ideal Quarry beds are commonly partly silicified and iron stained, probably as the result of ground water moving along the Keel–Sylvan limestone-shale interface. The brachiopods from the Ideal Quarry beds are similar to those from the typical oolite facies. See Keel Formation.

KEEL FORMATION—The type locality is at the Lawrence Quarry, Ideal Cement Company, near the northern end of the Arbuckle Mountains, Pontotoc County, Oklahoma (Amsden, 1960, p. 35–44). The Keel, originally proposed as a member in the Chimneyhill Formation, is now considered to be a formation in the Chimneyhill Subgroup (Amsden, 1967, p. 943–945). The basal oolitic skeletal limestone facies is referred to the Ideal Quarry Member (Amsden, 1960, p. 30; Amsden, *in* Amsden and Barrick, 1986). Amsden described and illustrated 10 species of articulate brachiopods, correlated this fauna with the Noix and Leemon Formations of eastern Missouri and western Illinois, and assigned these units to the Late Ordovician Hirnantian Stage. Peel (1977) described a new species of monoplacophoran, and Elias (1982, p. 38) discussed the Keel–Edgewood tetracorals and tentatively assigned them to the Gamachian Stage. Barrick (*in* Amsden and Barrick, 1986) described the Keel conodonts including *Noixodontus girardeauensis*, which is also present in the Cason oolite and in the Edgewood strata of the Mississippi Valley. Locally, in the eastern Arbuckle Mountains outcrops (stratigraphic sections P9, Amsden, 1960, p. 218,279), the upper few inches of the Keel oolite contains Silurian conodonts (Barrick, *in* Amsden and Barrick, 1986, p. 57). The paleoenvironment and age of the Keel Formation was discussed by Amsden and Barrick (1986). See Ideal Quarry Member, Edgewood Group, Noix Formation, Cyrene Formation, Leemon Formation, Noixodontus girardeauensis.

KIMMSWICK LIMESTONE—The type section is at Kimmswick, Jefferson County, Missouri. I have no information on the age of the Kimmswick Limestone in the Batesville district of Arkansas.

KIRKIDIUM BIOFACIES (HENRYHOUSE FORMATION)—This unit was named by Amsden (1969) for upper Silurian (Ludlovian–Pridolian) strata which occupy much of central and western Oklahoma. In the Arbuckle Mountains–Criner Hills outcrop area the typical Henryhouse lithofacies is a mud-supported marlstone with various but substantial amounts of fine, subangular quartz detritus, averaging ~20% of the unit. In the northern part of the Arbuckle Mountains the volume of insoluble detritus is reduced, the volume of shelly material increases, and the strata locally grade into clean-washed, skeletal sparites. In the subsurface to the north and west, this facies continues to expand, and large, pentamarid brachiopods dominate the shelly faunas (Amsden, 1981). This is the *Kirkidium* biofacies, the name of which is derived from the pentamerid species, *Kirkidium pingue pingue* (Amsden) and *K. pingue latum* Amsden (Pl. 3, this report), which form a conspicuous zone of brachiopods found in many cores in central and western Oklahoma. These brachiopods are concentrated in the upper part of the Hunton Group (Amsden, 1975, p. 34–35), but in the Midwest #1 Hughes core, Major County, Oklahoma (Amsden, 1975, p. 91) specimens of *Kirkidium* sp. were collected within 69 ft of Chimneyhill beds (Clarita Formation) bearing *Acutilineolus acutilineatus* (see Acutilineolus Beds). (The contact between the Chimneyhill and Henryhouse–Kirkidium biofacies is indeterminate in this core.) *Kirkidium* brachiopods are of Ludlovian–Pridolian age, and this biofacies is assigned to the Upper Silurian.

The species *Rhipidium pingue* Amsden and *R. sewellense* Amsden (1949, p. 47–50, pl. 3, figs. 1,2, pl. 4, figs. 1–4) were based on specimens from the Brownsport Formation of western Tennessee. Almost all of the specimens came from a single locality, where they occur together in large numbers. In 1969 I (Amsden, 1969, p. 969–975, pls. 116–118) identified the species *pingue* in Upper Silurian strata of central and western Oklahoma. At that time the species *pingue* was assigned to the genus *Kirkidium*, and *sewellense* was suppressed as a synonym. The type specimens of *sewellense* have a lenticular profile with weakly developed beaks similar to that of *Rhipidium knappi* (Hall and Whitfield) (Boucot and Johnson, 1979, pl. 3, figs. 1–5), but an examination of large collections from Tennessee and Oklahoma show that this shell type is connected to the more rostrate types of *pingue* by transitional forms. This gradation is effected by acceleration of lateral (rotational) growth of the pedicle valve, whose onset may occur at different stages of development (Amsden, 1969, p. 972, text-fig. 9). On the basis of costellation differences, the Oklahoma shells were assigned to two subspecies, *K. pingue pingue* (Amsden) and *K. pingue latum* Amsden (Amsden, 1969, pl. 117; this report, Pl. 3). Boucot and Johnson (1979, p. 112–117) proposed a new subgenus, *Kirkidium (Pinguaella)*, based on *Rhipidium pingue* Amsden; this subgenus differs from *Kirkidium (Kirkidium)* in having a shorter ventral beak. Immature shells of *K. (K.) knighti* (Sowerby) from the Aymestry Limestone of Great Britain ranging up to ~30 mm in length have a lateral profile similar to that of the Brownsport–Henryhouse species; I have one shell ~50 mm long in my collections from Aymestry; its profile is similar to the specimen of *K. pingue pingue* illustrated in my 1969 study (Amsden, 1969, pl. 117, fig. 11). However, almost all specimens of *K. knighti* this size and larger have a strong rotational growth factor affecting the pedicle valve, and this produces the conspicuously hooked beak that is characteristic of this species.

The *Kirkidium* biofacies is widely distributed in the subsurface of western Oklahoma (Amsden, 1975, p. 28–38; Amsden, 1981, p. 162). Since publication in 1975 of Oklahoma Geological Survey Bulletin 121, all core data have been re-examined.

Several additional cores penetrating this biofacies have been studied and, except for the Phillips #1-C Lee and Getty #1-B Coffman cores, these additional studies confirm the conclusions of the earlier investigation. A core from the Phillips #1-C Lee (sec. 80, Blk. M-1, H&GN Survey, Wheeler County, Texas) penetrated 125 ft of organodetrital limestone bearing many fragmentary shells previously identified as *Kirkidium* sp. (Amsden, 1975, p. 93–94). These pentamerids are difficult to extract from this core, but enough have now been collected to show that these shells have a smooth exterior and an internal structure similar to that of *Pentamerus* and they are herein assigned to *Pentamerus* (Amsden, 1964, p. 221, pl. 40, figs. 5,6, pl. 42, figs. 1,12; *Pentamerus (Pentamerus)* Boucot and Johnson, 1979, p. 97–98, pl. 1,2). Corals associated with these brachiopods were examined by Dr. W. A. Oliver, Jr., U.S. Geological Survey, who provisionally assigns them a late Llandoverian–Wenlockian age. Accordingly, these strata are removed from the *Kirkidium* biofacies and assigned to the upper part of the Chimneyhill Group. This is discussed more fully under Phillips #1-C Lee; see also Pentamerus sp.

A second core requiring revision is the Getty #1-B Coffman (sec. 4, T22N, R24W, Ellis County, Oklahoma). I (Amsden, 1975, p. 83) identified questionable representatives of *Kirkidium* sp. and *Pentameroides* sp. from this core, but subsequent preparations reveal no specimens of *Kirkidium* or any costate pentamerids. There are, however, a number of smooth-shelled pentamerids in the interval from 11,211–11,250 ft, including pentamerid cross sections at 11,211, 11,225, and 11,235 ft that clearly show the distinctive brachial apparatus of *Pentameroides* (Amsden, 1964, p. 227, text-fig. 3, pl. 41, figs. 1–12). According to Amsden (Amsden, *in* Moore, 1965, p. 548) and Boucot and Johnson (1979, p. 103), the genus *Pentameroides* ranges from the Upper Llandoverian (C4) into the upper Wenlockian. This indicates a correlation with the Fitzhugh Member, Clarita Formation rather than with the *Kirkidium* biofacies, and accordingly the Getty #1-B Coffman core is assigned to the Chimneyhill Subgroup. Specimens of tetracorals from the #1-B Coffman were sent to Dr. William Oliver, Jr., U.S. Geological Survey, and samples for conodonts were sent to Dr. James Barrick, Texas Tech University, but no diagnostic fossils were recovered.

The geographic area occupied by the *Kirkidium* biofacies lies within the region affected by Silurian dolomitization. These strata range from weakly dolomitized limestones into intensely dolomitized strata where the skeletal material has been partly to completely obliterated (Amsden, 1975, p. 43–75; 1980, p. 22, text-fig. 7). Many of the heavily dolomitized beds have excellent porosity and yield substantial gas. See Henryhouse Formation, Pentamerus sp., Phillips #1-C Lee, Getty #1-B Coffman.

KIRKPATRICK #1 BLEVINS UNIT—C NE¼SW¼ sec. 7, T17N, R2W, Logan County, Oklahoma. This well cored 46 ft of Chimneyhill Limestone with Wenlockian trilobites (identification by Dr. K. S. W. Campbell, Australian National University, Canberra, Australia) in the upper beds and *Stricklandia protriplesiana* in the basal few feet (Amsden, 1975, p. 80–81; 1980, p. 38–39). See Stricklandia protriplesiana Biozone.

KIRKPATRICK #1 CRONKITE—Kingfisher County, Oklahoma; C NE¼NW¼ sec. 14, T15N, R5W. This well cored the Hunton from 7,098–7,136 ft; beds from 7,098–7,120 ft included specimens of *Amphigenia* sp., *Leptocoelia*? sp. (preservation insufficient to distinguish from *Pacificoelia*), *Eodevonaria* sp., *Protoleptostrophia*? cf. *P. blainvillei*, *Anoplia* cf. *A. nucleata*, *Schellwienella*? sp., and *Atrypa* sp. On the basis of this fauna, these strata are correlated with the Sallisaw Formation. See Amphigenia Biozone, Sallisaw Formation, Phillips #1-C Lina, Sinclair #1 Lips.

LAFFERTY LIMESTONE—The type section is at Tate Spring on a hill west of Lafferty Creek, Izard County, Arkansas (Miser, 1922, p. 31–32). Berry and Boucot (1970, p. 173) quote Lowenstam (1961) as reporting pre-Ludlow age pisocrinids from the Lafferty Limestone; Craig (1969, p. 1626–1627) reported conodonts including *Kockelella variabilis* and a single specimen of *Polygnathoides siluricus* from the Lafferty Limestone (just below the Penters Chert) at the Batesville Stone quarry just east of the Cason Mine (from strata which Miser (1922) and Amsden (1968) assigned to the upper St. Clair). Amsden records typical St. Clair brachiopod fauna from a St. Clair bed 9 ft below the Penters Chert at the St. Clair Lime quarry west of the Cason Mine. It should, however, be noted that the Penters Chert is separated from the underlying beds by an unconformity, making a comparison of stratigraphic horizons located with respect to this contact unreliable (see St. Clair Limestone). Barrick and Klapper (1976, p. 62–67) report *Kockelella variabilis* from the uppermost beds of the Fitzhugh Member and lowermost beds of the Henryhouse Formation, a zone which they provisionally assigned to the earliest Ludlovian (see Part II, this report). Klapper reported *Polygnathoides siluricus* in a core from the Pan American #1 Post Unit in Kingfisher County, Oklahoma (Amsden, 1975, p. 96; see Part II, this report). This came from a Hunton bed 229 ft above the Sylvan–Hunton contact, from strata which Amsden correlates with the Late Silurian (Ludlovian–Pridolian) Henryhouse *Kirkidium* biofacies. There is some question concerning the distribution of the Lafferty Limestone in north-central Arkansas. In its type area this formation consists of fossiliferous marlstones with a mud-supported texture and sparse quartz detritus, whereas the St. Clair Limestone at St. Clair Springs and elsewhere is a skeletal pelmatozoan micrite and sparite with a grain-supported texture (Amsden, 1978, p. 6). Neither Miser (1922) nor Amsden (1968) report any Lafferty in the eastern outcrops near Batesville and St. Clair Springs. However, Straczek and Kinney (1950) and Craig (1969) record Lafferty from this region, and Craig suggests that the western Lafferty marlstones may be a lateral facies of the St. Clair skeletal limestones. I have no faunal data bearing on the age of the Lafferty marlstones or their relationship to the St. Clair organodetrital limestones; however, in my opinion, the St. Clair brachiopod fauna, which at the Cason Mine ranges from ~2 ft above the Cason Shale to as much as 9 ft below the Penters Chert, is Wenlockian in age; this is also the conclusion of Holloway (1980, p. 6) with respect to the St. Clair trilobites. See Bainbridge Group, Moccasin Springs Formation.

LEEMON FORMATION—The type locality is near the town of Leemon, Cape Girardeau County, Missouri (Thompson and Satterfield, 1975, p. 77). These are the strata that Savage (1909, p. 515) referred to the Edgewood Formation. In this report the Edgewood is assigned group rank and in southeastern Missouri–southwestern Illinois it includes the Leemon Formation. Thompson and Satterfield report eight species of conodonts from the Leemon Formation, assigning this fauna an Ordovician age. Amsden (1974, p. 19,21,85–86) described the stratigraphic section at the type locality, and described and illustrated eight species of articulate brachiopods. This fauna was correlated with one from the basal Leemon beds exposed near New Wells in northern Pike County, Missouri, and near Thebes in Alexander County, Illinois (Amsden, 1974, p. 22–24,86–87). Amsden (1974, p. 29; Amsden and Barrick, 1986) correlated the Leemon Formation with the Noix and Cyrene Formations of Pike County in northeastern Missouri and Calhoun County in western Illinois, and the Keel Formation of Oklahoma, assigning these strata to the latest Ordovician (Hirnantian Stage). See Edgewood Group, Keel Formation, Noix Formation, Cyrene Formation.

LEPIDOCYCLUS COOPERI BIOZONE—This rhynchonellid species occurs in the upper 30 ft of the Welling Formation (= "Fernvale" limestone) in the Arbuckle Mountains where it is associated with *Hiscobeccus capax* (Conrad) (Howe, 1966, p. 259–261, pl. 31, figs. 1–6; Alberstadt, 1973, p. 12–15, pl. 6, figs. 1–9; Amsden, *in* Amsden and Sweet, 1983, p. 40–42). In the Arbuckle Mountains region the lower part of the Welling and the upper part of the Viola Springs Formations yield specimens of *Lepidocyclus oblongus* Howe, here designated the *Lepidocyclus oblongus* biozone. Only the upper zone is present in the Welling Formation of eastern Oklahoma, where *L. cooperi* and *H. capax* range throughout the formation. Amsden (*in* Amsden and Sweet, 1983, p. 38–39, pls. 5,7) reports *L. cooperi* and *H. capax* from the upper part and *L. oblongus* from the lower part of the "Fernvale" limestone in north-central Arkansas. Specimens of *L. oblongus* are common in the Cape Limestone at Cape Girardeau (Amsden, *in* Amsden and Sweet, 1983, pl. 6), but neither *L. cooperi* or *H. capax* have been reported from this formation, although *L. cooperi* is common in the Cape Limestone farther north (Amsden, *in* Amsden and Sweet, 1983, p. 41, pl. 6). Alberstadt (1973, p. 12–15; see also Amsden, *in* Amsden and Sweet, 1983, p. 42) assigned the upper part of the Welling Formation (upper part of his stratigraphic unit 3) to the early Richmondian Stage, but Sweet (*in* Amsden and Sweet, 1982, p. 26–34) assigned these strata a Maysvillian age on the basis of the conodont faunas. See Lepidocyclus oblongus Biozone, Welling Formation, "Fernvale" Limestone, Cape Limestone, Viola Springs Formation.

LEPIDOCYCLUS OBLONGUS BIOZONE—This rhynchonellid species is present in the lower part of the Welling Formation and the upper part of the Viola Springs Formation in the Arbuckle Mountains. It is absent in the eastern Oklahoma exposures of the Welling Formation, but is again present in the lower part of the "Fernvale" limestone in north-central Arkansas, and in the Cape Limestone at Cape Girardeau in eastern Missouri (Howe, 1966, p. 261, pl. 31, figs. 11–14; Alberstadt, 1973, p. 54, pl. 7, figs. 1–3; Amsden, *in* Amsden and Sweet, 1983, p. 36–40, pls. 6,7). Alberstadt (1973, p. 13–15) tentatively assigned the *L. oblongus*-bearing strata in the Arbuckle Mountains an Edenian–Maysvillian age, but Sweet (*in* Amsden and Sweet, 1983, p. 38–40), on the basis of the conodont faunas, believes these strata are restricted to the Edenian Stage (see also Amsden, *in* Amsden and Sweet, 1983, p. 42). Biostratigraphic distribution of Late Ordovician brachiopod faunas in the Midcontinent region is presently too poorly understood to provide a satisfactory basis for a more precise age assignment. See Lepidocyclus cooperi Biozone, Welling Formation, Viola Springs Formation, "Fernvale" Limestone.

LITTLE SALINE LIMESTONE—The type locality is near Little Saline Creek, Ste. Genevieve County, southeastern Missouri. This formation is generally considered correlative with the Backbone Limestone of southwestern Illinois. Stewart (1922) described a large brachiopod fauna from the Little Saline Limestone. Amsden and Ventress (1963, p. 49–53) reported 15 brachiopod species from this formation, assigned it a Deerparkian age, and correlated it with the Oriskany Sandstone and the Frisco Formation. See Frisco Formation.

LONE STAR #1 HANAN—C NE¼ sec. 6, T19N, R24W, Ellis County, Oklahoma. This well cored the Woodford and Hunton strata at 14,322–14,344 ft (Amsden, 1975, p. 87). The area is of interest because the Sylvan grades into cherty, dolomitic shales and argillaceous dolomites (Amsden, 1980, p. 38–41, text-figs. 14,15). See Kirkpatrick #1 Blevins Unit, Mackellar #1 Ferguson.

MACKELLAR #1 FERGUSON—C SW¼NE¼ sec. 35, T24N, R21W, Woodward County, Oklahoma (Amsden, 1980, p. 82). This well cored the Chimneyhill–Sylvan–Viola interval (7,738–9,844 ft). The Chimneyhill part of the core provides early Clarita conodonts (Prices Falls–basal Fitzhugh), and the Sylvan Shale is an argillaceous dolomite with HCl insoluble residues ranging from 25% to 34% (Amsden, 1980, p. 38–41, text-fig. 15). See Lone Star #1 Hanan, Sylvan Shale.

MAQUOKETA SHALE (GROUP)—The type section is in Dubuque County, northeastern Iowa. This name has been variously applied to a shale (Maquoketa Shale) or to a sequence of limestones and shales (Maquoketa Group) of Cincinnatian age. In the area covered by the present report the shale underlying the Edgewood Group in northeastern Missouri and western Illinois is referred to the Maquoketa Shale. In southern Illinois the Maquoketa Group has been used to include the Girardeau Limestone, Orchard Creek Shale, and Thebes Sandstone sequence by some authors, and has been restricted by others to the Orchard Creek Shale and Thebes Sandstone. To my knowledge there are no recent biostratigraphic studies bearing on the precise age of these strata in the area covered in this report. See Girardeau Limestone.

MARBLE CITY MEMBER (QUARRY MOUNTAIN FORMATION)—The type section is about a mile and a half north of Marble City, Sequoyah County, Oklahoma (Amsden and Rowland, 1965, p. 47–52). This is the upper limestone member of the Quarry Mountain Formation; the lower member is the Barber Member. Amsden (1978, p. 11–40, pls. 1–11) described and illustrated 23 species of articulate brachiopods from the Marble City Member, 12 of which are also found in the upper part of the underlying Barber Member. On the basis of this brachiopod fauna, the Marble City and upper part of the Barber are assigned a Wenlockian age. See Quarry Mountain Formation, Barber Member, Fitzhugh Member, St. Clair Limestone.

MICROCARDINALIA—See Stricklandia protriplesiana Biozone.

MISENER SANDSTONE—The Misener Sandstone was named after Fred D. Misener for a sandstone found at a depth of 3,009–3,054 ft in the #1 McWilliams well, sec. 23, T15N, R10W, Creek County, Oklahoma. Amsden and Klapper (1972; Amsden, 1975, p. 11–12, panel 11; Amsden, 1980, p. 11–14, panel 4) considered this sandstone to be a basal facies of the Woodford–Chattanooga Shale, derived mainly from insoluble debris that weathered out of the underlying surface during pre-Woodford erosion. The Misener Sandstone is widely, although somewhat discontinuously, present in an area extending from the outcrop belt in eastern Oklahoma and Arkansas (Sylamore Sandstone) westward into central Oklahoma. Several Misener cores have been investigated in Grant, Noble, Canadian, Oklahoma, and Lincoln Counties of north-central Oklahoma; six of these yield conodonts of late Middle to late Devonian age (Amsden and Klapper, 1972, p. 2326–2331; Amsden, 1980, p. 72,92–93). The base of the Misener is diachronous and generally of Late Devonian age, but locally it is known to include strata of late Middle Devonian age (*Polygnathus varcus* zone; Amsden and Klapper, 1972, p. 2328). Conodonts are also present in the correlative Sylamore Sandstone of eastern Oklahoma and western Arkansas (Amsden, 1961, p. 61–68; Freeman and Schumacher, 1969), showing that conodonts are widely represented in the Misener–Sylamore Sandstone throughout western Arkansas and central and eastern Oklahoma. See Sylamore Sandstone, Polygnathus varcus Zone.

MOBIL #1 HORTON—C SE¼NW¼ sec. 14, T15N, R15W, Custer County, Oklahoma (Amsden, 1975, p. 90). This well cored parts of Hunton strata from 14,262–14,753 ft; the upper 100 ft yielded numerous specimens of *Kirkidium*. This and other wells in northeastern Custer County provide information on the *Kirkidium* biofacies (Amsden, 1975, panel 1, map A, p. 28–43,98; text-fig. 8). See Kirkidium Biofacies.

MOCCASIN SPRINGS FORMATION—The type locality is in a railroad cut 1 mi south of Moccasin Springs, Cape Girardeau County, southeastern Missouri (this is also the type locality for the Bainbridge Formation) (Lowenstam, 1949, p. 16–18). Lowenstam divided the Bainbridge Group into an upper marlstone, the Moccasin Springs Formation, and a lower limestone, the St. Clair Formation. The brachiopod fauna from the Moccasin Springs Formation is similar to that of the Brownsport Formation of western Tennessee and the Henryhouse Formation of Oklahoma. Ross (1962) described and illustrated six species of *Monograptus* from the Moccasin Springs Formation in southern Illinois and southeastern Missouri. These were assigned a Ludlovian age and correlated with various formations, including the Henryhouse Formation. See Bainbridge Group.

NOIX FORMATION—The type section is in Pike County, northeastern Missouri; the name is taken from Noix Creek near Louisiana, Missouri, and with the type section is generally placed at Clinton Springs on the south edge of Louisiana (Thompson and Satterfield, 1975, p. 90; Amsden, 1974, p. 83). Thompson and Satterfield and Amsden include the Noix as the oldest formation in the Edgewood Group of Pike County. Thompson and Satterfield (1975, p. 86,90–92) listed a conodont fauna from the Noix which they correlated with the Leemon Formation of southeastern Missouri, and to which they assigned a Late Ordovician age. Amsden (1974, p. 13,32–78, pls. 1–26) described and illustrated 15 articulate brachiopod species from the Noix Limestone of Pike County, Missouri, and Calhoun County, Illinois, correlating this fauna with that from the Leemon strata of southeastern Missouri and southwestern Illinois, and the Keel Formation of Oklahoma. These strata were assigned to the Late Ordovician (Hirnantian Stage) by Amsden (1974, p. 26–29). McCracken and Barnes (1981, p. 1474–1477) described the conodonts from the Noix Formation at its type locality, assigning this assemblage to conodont fauna 13 of Richmondian age. Amsden (*in* Amsden and Barrick, 1986) objected to this age assignment, stating that the Noix brachiopods indicated a Hirnantian rather than Richmondian age. See Edgewood Group, Cyrene Formation, Leemon Formation, Keel Formation.

NOIXONDONTUS GIRARDEAUENSIS—The conodont *Prioniodus girardeauensis* was described by Satterfield (1971, p. 271, pl. 34, figs. 1,6,15,18,19) from the Girardeau Limestone at Cape Girardeau, Missouri, and was later reported by Thompson and Satterfield (1975) from the Noix, Cyrene, and Leemon Formations (Edgewood Group) at a number of localities along the Mississippi Valley. McCracken and Barnes (1982), in a study of the conodonts from the Noix Formation (Edgewood Group) at Clarkesville, Pike County, Missouri, assigned *girardeauensis* to a new genus, *Noixodontus*, tentatively referring this fauna to the Richmondian Stage. Amsden (*in* Amsden and Barrick, 1986) objected to this age assignment, reaffirming his earlier expressed opinion that the Noix–Cyrene–Leemon–Keel brachiopods represent an Hirnantian-age fauna. Barrick (*in* Amsden and Barrick, 1986) described and illustrated specimens of *N. girardeauensis* from the Keel Formation of Oklahoma and the Cason oolite of north-central Arkansas and discussed the age and occurrence of this species elsewhere. See Keel Formation, Edgewood Group, Noix Formation, Cyrene Formation, Leemon Formation, Cason Oolite.

PAN AMERICAN #1 DROKE—This well is in C NE¼NE¼ sec. 4, T18N, R9W, Kingfisher County, Oklahoma. The entire Hunton interval was cored, starting in the basal Woodford Shale and ending in the upper Sylvan Shale; a number of important conodont and brachiopod biostratigraphic horizons can be identified, including the *Kirkidium* biofacies (Amsden, 1975, p. 84). See Pterospathodus amorphognathoides Zone.

PENTAMEROIDES SP.—This pentamerid brachiopod is present in upper Hunton strata (Chimneyhill Subgroup) in the Getty #1-B Coffman well, Ellis County, Oklahoma (Amsden, 1975, p. 82). These strata are referred to the Chimneyhill Subgroup and provisionally assigned a late Llandoverian age (Cochrane Formation) (Johnson, 1979, p. 550,564). No representatives of the genus *Pentameroides*, or of the Pentamerinae, have been reported from Silurian strata in the outcrop areas of Oklahoma or Arkansas. See Pentamerus sp., Kirkidium Biofacies, Getty #1-B Coffman, Phillips #1-C Lee.

PENTAMERUS SP.—The pentamerid brachiopod *Pentamerus (Pentamerus)* is present in upper Hunton strata (Chimneyhill Subgroup) in the Phillips #1-C Lee, Wheeler County, Texas, and possibly in the upper Hunton strata (Chimneyhill Subgroup) in the Getty #1-B Coffman well, Ellis County, Oklahoma, where they are associated with *Pentameroides* sp. (see discussion, Phillips #1-C Lee). Strata bearing *Pentamerus (Pentamerus)* sp. are referred to the Chimneyhill Subgroup (Cochrane Formation) and are provisionally assigned a late Llandoverian age (Johnson, 1979, p. 550,564, and letter, January 4, 1985). No representatives of *Pentamerus* or *Pentameroides* have been reported from Silurian strata in the outcrop areas of Oklahoma or Arkansas. Almost all the brachiopods in the Phillips #1-C Lee are pentamerids. This biofacies is represented by a low-diversity brachiopod fauna, which is, however, associated with a high-diversity benthic fauna. Point counting of thin sections showed skeletal material averaging ~68% of the total rock volume. Pelmatozoan plates and pentamerid brachiopods dominate the skeletal material along with ostracodes, bryozoans, and corals (the corals include at least six species; see Phillips #1-C Lee). The general composition of the *Pentamerus* biofacies is similar to that of the *Kirkidium* biofacies, which also has a relatively low-diversity brachiopod fauna associated with a high-diversity benthic fauna (Amsden, 1981). See Kirkidium Biofacies, Phillips #1-C Lee, Getty #1-B Coffman.

PENTERS CHERT—The type locality is at Penters Bluff Station, Izard County, north-central Arkansas. Dr. G. A. Cooper, U.S. National Museum (*in* Kinney, 1946, p. 611–612) reports a small fauna from the base of the Penters which has some affinities with the faunas from the Sallisaw, Clear Creek, and Camden Formations (Amsden, 1963, p. 161).

PETTIT OOLITE—The type section is ~3 mi southwest of Pettit, Cherokee County, Oklahoma (Amsden and Rowland, 1965, p. 22–27). The Pettit was originally described as a lower member in the Blackgum Formation, although the two units are separated by an erosional unconformity. It is here assigned formation status and is correlated with the Keel Formation in the Arbuckle Mountains. This correlation is based entirely on lithologic similarity and stratigraphic position, as no diagnostic fossils have been recovered from the Pettit. Amsden (1980, p. 34–41; Amsden and Barrick, 1986) discussed the distribution of this oolitic horizon in Oklahoma and Arkansas. See Keel Formation, Cason Shale.

PHILLIPS #1-C LEE—This well is in Wheeler County, Texas (1,980 ft FSL & FEL, sec. 80, Blk. M-1, H&GN Survey); cored Hunton strata from 14,980–15,100 ft) and is described in Amsden (1975, p. 93–94). The brachiopods are mainly large pentamerids; they were identified by me (Amsden, 1975, pl. 9, figs. 1a,b) as *Kirkidium* sp. and were assigned to the Henryhouse *Kirkidium* biofacies (Ludlovian–Pridolian). A restudy of the #1-C Lee core shows that these pentamerids have smooth shells with the internal and external characteristics of the genus *Pentamerus*. Although the shells are considerably fragmented, the preservation is adequate to show that they are representatives of *Pentamerus (Pentamerus)*, lacking the prominent fold of *Pentamerus (Supertrilobus)* (Boucot and Johnson, 1979, p. 100, pl. 2). According to Boucot and Johnson (1979, p. 98) the subgenus *Pentamerus (Pentamerus)* is confined to Late Llandoverian to upper Wenlockian age strata; these beds would thus be correlative with either the Cochrane Formation or the Clarita Formation, rather than with the Ludlovian–Pridolian Henryhouse Formation. Additional information is provided by a recent examination of corals associated with the pentamerid brachiopods in this core by Dr. W. A. Oliver, Jr., of the U.S. Geological Survey (letter, June 6, 1981). These corals, many of which are fragmented, include specimens tentatively identified as *Cladopore* sp., *Favosites* sp., *Pychactis*? sp., cf. *Rhegmaphyllum* sp., *Paliphyllum* sp., cf. *P.* sp. of Laub, and an undetermined rugose coral similar to *Brachyelasma* sp. Dr. Oliver notes that this fauna as identified cannot be precisely dated, but its similarities to the Brassfield corals described by Johnson (1982) suggest that it is of late Llandoverian age. This age assignment would be in accord with a recent study of Johnson (1979, p. 550,564; Johnson and Valerie, 1982, p. 43) on the *Pentamerus-Pentameroides* lineage in Iowa and the Great Lakes region; he reports that *Pentamerus oblongus* ranges up into the C5 Stage, and that *Pentameroides suberectus* appears in the late C5 and C6 Stages. Accordingly, the *Pentamerus* beds of the #1-C Lee are reassigned to the Chimneyhill Group and are provisionally dated as late Llandoverian (Cochrane Formation). This indicates a considerable thickening of the Chimneyhill Subgroup in western Oklahoma and the eastern Texas Panhandle. See Getty #1-B Coffman, Pentamerus sp., Pentameroides sp., Phillips #1-D Franklin.

PHILLIPS #1-C LINA—Ochiltree County, Texas; sec. 570, Blk. 43, H&TC Survey. This well cored Hunton at 11,010–11,078 ft (Amsden, 1975, p. 94). Several brachiopods were recovered, including specimens of *Amphigenia* sp., *Eodevonaria*? sp., *Acrospirifer* cf. *A. worthenanus*, and *Leptocoelia*? sp. On the basis of this fauna, these beds are correlated with the Sallisaw Formation of eastern Oklahoma and the Clear Creek Formation of Illinois and Missouri (Amsden, 1975, p. 75–76). See Amphigenia Beds, Sallisaw Formation, Sinclair #1 Lips.

PHILLIPS #1-D FRANKLIN—1,050 ft FSL and 1,000 ft FWL sec. 53, Blk. A-6, H&GN Survey, Gray County, Texas. A core from this well provided well-preserved specimens of *Stricklandia protriplesiana* 180 ft above the Sylvan–Hunton contact (Amsden, 1975, p. 86). See Stricklandia protriplesiana Biozone, Blackgum Formation.

PINETOP CHERT—The type locality and only known exposure is located in the northwestern part of the Ouachita Province, ~20 mi south of McAlester, in southern Pittsburgh County, Oklahoma. It consists of ~75 ft of bedded chert, calcareous chert, and siliceous limestone. These strata have the brachiopod *Coelospira concava* (Hall) (Amsden, 1983, p. 1258, figs. 7A–M; 8A,B; 9A–J) and five species of ostracodes (Lundin, *in* Amsden, 1983, p. 1248). On the basis of this fauna, the Pinetop is assigned a Helderbergian age and is correlated with the Haragan–Bois d'Arc Formations in the Arbuckle Mountains–Criner Hills of south-central Oklahoma, and Helderbergian strata in the Appalachian basin. See Haragan Formation, Bois d'Arc Formation.

PLACOTRIPLESIA BEDS—In 1968, I recognized two faunal divisions in the Fitzhugh Member, Clarita Formation, at the north end of the Arbuckle Mountains outcrop area (stratigraphic section P1, Amsden, 1960, p. 268–269). The lower unit, which represents most of the Fitzhugh Member, was designated the *Eospirifer* beds (now *Acutilineolus* beds); and the upper unit, which is confined to the upper 2 ft, was designated the *Placotriplesia* beds. Fourteen species were recorded from the *Placotriplesia* beds (Amsden, 1968, p. 20), the most common of which is *Placotriplesia praecipta* (Ulrich and Cooper) (Amsden, 1968, p. 40–42, pl. 12, figs. 1a–m; pl. 17, figs. 3a–q; pl. 18, figs. 3a–p; 1973, p. 253–274). *P. praecipta* is common in the St. Clair Limestone of Arkansas, where it ranges throughout most, if not all of this formation. In North America the genus *Placotriplesia* is presently known only from strata of Wenlockian age, and this may also be true in Great Britain (Bassett, 1972, p. 73). See Acutilineolus Beds, Fitzhugh Member.

POLYGNATHUS VARCUS ZONE—This late Middle Devonian conodont zone is present in the Misener Sandstone, Federal #1 Wolleson core, Noble County, Oklahoma (Klapper, *in* Amsden and Klapper, 1972, p. 2328–2330) and in the Sylamore Sandstone of northern Arkansas (Freeman and Schumacher, 1969, p. 2333). See Misener Sandstone, Woodford Shale, Chattanooga Shale.

POOLEVILLE MEMBER (BROMIDE FORMATION)—The type section is located on Spring Creek in the western part of the Arbuckle Mountains, Murray County, Oklahoma (Cooper, 1956, p. 121–123). This unit is the upper member of the Bromide Formation; the lower member is the Mountain Lake. Cooper (1956, p. 122–123, chart 1) described and illustrated 55 species of inarticulate and articulate brachiopods from the Pooleville and assigned it to the late Porterfieldian–early Wildernessian Stages (Blackriveran). Harris (1957, p. 94–99) removed the uppermost strata from the Pooleville and placed them in his Corbin Ranch Formation. Amsden (Amsden and Sweet, 1983) designated this the Corbin Ranch Submember (now Corbin Ranch Beds) and regards it as a local intertidal facies of the Pooleville Member. On the basis of the conodont faunas, Sweet (*in* Amsden and Sweet, 1983, p. 3,23–26) assigned the Pooleville to the Champlainian Series. See Bromide Formation, Pooleville Member.

PRICES FALLS MEMBER (CLARITA FORMATION)—The type section is at Prices Falls in the central Arbuckle Mountains, Murray County, Oklahoma (Amsden, 1967, p. 943). The Prices Falls, which consists of ~2 ft of shale grading into marlstone, is the basal member of the Clarita Formation. No megafossils have been reported from this member, but Barrick and Klapper (1976, p. 63,66) report *Pterospathodus amorphognathoides* which they assign a late Llandoverian–early Wenlockian age. This supports a correlation with the Cason "button" shale of north-central Arkansas, and the Seventy-Six Shale of southeastern Missouri and southwestern Illinois. Satterfield and Thompson (1975, p. 118) report *Neospathognathodus celloni* from the Prices Falls Member at its type locality and from the "button" shale of north-central Arkansas. (See Barrick and Klapper, 1976, p. 66, for a discussion of the *celloni* zone.) See Seventy-Six Shale, "Button" Shale, Pterospathodus celloni Zone, Pterospathodus amorphognathoides Zone.

PTEROSPATHODUS AMORPHOGNATHOIDES ZONE—This conodont zone of latest Llandoverian (C6)–earliest Wenlockian age is present in the Prices Falls Member and basal Fitzhugh Member of the Clarita Formation (Barrick and Klapper, 1976, p. 66). It has also been recovered from a core from the Pan American #1 Droke in Kingfisher County, central Oklahoma (Klapper, manuscript, 1964), the upper Cason Shale ("Button" bed) and lowermost St. Clair Limestone of the Batesville district, north-central Arkansas (Craig, 1969, p. 1622), and the Seventy-Six Shale of southeastern Missouri and southwestern Illinois.

PTEROSPATHODUS CELLONI ZONE—This late Llandoverian conodont zone (C5) is present in the upper Cochrane Formation (Barrick and Klapper, 1976, p. 66), in the Tenkiller Formation (Klapper, *in* Amsden, 1980, p. 25), in the Cason "Brassfield" limestone of north-central Arkansas (? = pelmatozoan limestone, Craig, 1969, p. 1622), and in the Seventy-Six Shale of southeastern Missouri–southwestern Illinois (Satterfield and Thompson, 1975, p. 118; see Barrick and Klapper, 1976, p. 66 for a discussion of this zone). See Cochrane Formation, Prices Falls Member, Tenkiller Formation, Cason "Brassfield" Limestone, Seventy-Six Shale.

QUARRY MOUNTAIN FORMATION—The type section is located on Quarry Mountain, about a mile north of Marble City, Sequoyah County, eastern Oklahoma (Amsden and Rowland, 1965, p. 42–43). The Quarry Mountain is divided into lower and upper members—the Barber Member and the Marble City Member, respectively—and the boundary between the two is gradational. The Barber Member is predominantly dolomite and the Marble City Member is predominantly low-magnesium limestone. These member divisions are useful local lithostratigraphic divisions, but cannot be traced for any appreciable distance away from the outcrop area (Amsden, 1980, p. 28). Amsden (1978) described a substantial Wenlockian articulate brachiopod fauna from the Marble City Member and the upper part of the Barber Member. See Barber Member, Marble City Member.

ST. CLAIR LIMESTONE—The type locality is at St. Clair Springs, northeast of Batesville, Independence County, Arkansas (Penrose, 1981, p. 102–103,112–114,124–128,166–174). Amsden (1968, p. 3–4) summarized the nomenclatural history of the St. Clair and described its articulate brachiopod fauna, assigned it a Wenlockian age, and correlated it with the Fitzhugh Member (Clarita Formation) and with the Quarry Mountain Formation of Oklahoma. In the 1968 publication, Amsden noted that most of the brachiopod fauna ranges through the entire formation. This stratigraphic distribution was further refined by the following collections made after publication of the 1968 monograph: Cason Mine, lower St. Clair Limestone, 2–4 ft above the Cason Shale (Amsden, 1968, locality 4, p. 102, text-fig. 3)—*Antirhynchonella thomasi, Brachymimulus americanus, Nanothyris clairensis, Leangella (O.) dissiticostella, Dicamaropsis parva, Orthostrophella clairensis*; St. Clair Lime quarry (= Cut Stone quarry), 9 ft below the Penters Chert (Amsden, 1968, locality 5, p. 102, text-fig. 3)—*Meristina clairensis, Parastrophonella lepida, Placotriplesia praecipta, Brachymimulus americanus, Kozlowskiellina* sp., *Virginiata arkansana, Orthostrophella clairensis, Acutilineolus acutolineatus, Strophodonta* sp. Holloway (1980) described the St. Clair trilobites, assigning them a Wenlockian age. Craig (1969, p. 1622) reported the *Pterospathodus amorphognathoides–Spathognathodus ranuliformis* conodont zones from the upper Cason "Button" shale and the lower St. Clair Limestone, the *sagitta* zone through the remainder of the St. Clair Limestone, and the *siluricus* zone from the Lafferty Limestone (see Barrick and Klapper, 1976, for a discussion of Wenlockian conodont zonation in the Arbuckle Mountains area). Lowenstam (1949, p. 12–18) extended the St. Clair Limestone into southeastern Missouri and southwestern Illinois, treating it as the basal formation of the Bainbridge Group. Satterfield and Thompson (1969, p. 1042–1044) reported the inarticulate brachiopod *Artiotreta parva* Ireland from the basal beds of the St. Clair Limestone in Missouri and Illinois, and Toomey (Amsden and others, 1980, p. 21,24, text-fig. 20) found this brachiopod to be abundant and widespread in the lower Fitzhugh Member, Clarita Formation, Arbuckle Mountains, Oklahoma. See Cason Shale, "Button" Shale, Lafferty Limestone, Fitzhugh Member, Prices Falls Member, Seventy-Six Shale.

SALLISAW FORMATION—The type locality is on Sallisaw Creek in Sequoyah County, eastern Oklahoma (Amsden, 1961, p. 45–59). Amsden (1963, p. 141–192) described and illustrated 11 species of articulate brachiopods from the Sallisaw Formation. This fauna was considered correlative with that of the Woodbury Creek Member of the Esopus Formation, a stratigraphic unit which Boucot (1959, p. 727–738) assigned to the Esopusian Stage. In 1975 Rickard replaced Esopusian Stage with Sawkillian Stage, defined to extend from the base of the Esopus Shale to the base of the Edgecliff Limestone, and characterized by the faunas of the Esopus and Schoharie Formations, including the Woodbury Creek Sandstone (Oliver and others, 1969, chart OC-64, col. 7). The Sallisaw Formation is correlated with the Penters Chert of Arkansas, the Camden Chert of western Tennessee, and the Clear Creek Formation of southwestern Illnois (Amsden, 1980, p. 50, text-fig. 19). One of the more distinctive brachiopods is *Amphigenia curta* (Amsden, 1963, p. 187–192, pls. 14,17,20), which has been identified in cores (*Amphigenia* biozone) in the central part of Oklahoma (Kirkpatrick #1 Cronkite, Amsden, 1975, p. 83), and in the Texas Panhandle (Mobil #1 Walker and Phillips #1-C Lina, Amsden, 1975, p. 94,102; also in the Sinclair #1 Lips, sec. 135, Blk. C, G&M Survey, Roberts County, Texas—the core of this well at 9,717 ft yields brachiopods provisionally identified as *Amphigenia* cf. *A. curta* and *Hysterolites [Acrospirifer] worthenanus*?). See Amphigenia Biozone, Sinclair #1 Lips, Phillips #1-C Lina.

SAWKILLIAN STAGE (EARLY DEVONIAN)—This stage was defined by Rickard (1964), who extended it from the base of the Esopus Formation to the base of the Edgecliff Formation. It replaces the Esopusian Stage of Boucot (1959) and is now rather widely recognized by biostratigraphers (Boucot and Johnson, 1968; Rickard, 1975; Dutro, 1981). In the Midcontinent region it includes the Camden, Clear Creek, Penters, Sallisaw, and several unnamed limestone units (*Amphigenia* biozone) in central and western Oklahoma and the Texas Panhandle. Boucot and Johnson's distribution map (1968, p. B6, fig. 2) should be emended to show a central and eastern chert facies and a western limestone facies (*Amphigenia* biozone), the latter extending at least as far as the Texas Panhandle (Amsden, 1980, p. 50, text-fig. 19). See Sallisaw Formation, Amphigenia Biozone.

SEVENTY-SIX SHALE (BAINBRIDGE GROUP)—The type locality is near the village of Seventy-Six, Perry County, southeastern Missouri (Satterfield and Thompson, 1975, p. 114). Satterfield and Thompson treat this shale as the basal member of the Bainbridge Formation; in the present report, the basal formation is of the Bainbridge Group. These authors report a small conodont fauna from this shale, including *Neospathognathoides celloni* and *Pterospathodus amorphognathoides*; on the basis of this fauna, they correlate the Seventy-Six with the Prices Falls Member, Clarita Formation, of Oklahoma and the upper Cason Shale beds ("Button" Shale; Craig, 1969, p. 1622) of Arkansas (see also Barrick and Klapper, 1976, p. 66, for a discussion of the *Pterospathodus celloni* Zone). See Prices Falls Member, Cason Shale.

SEXTON CREEK LIMESTONE—The type locality is on Sexton Creek, Alexander County, Illinois (Savage, 1909, p. 518). Amsden (1974, p. 18,24) reported the stricklandiid brachiopod *Stricklandia protriplesiana* (Amsden) from the Sexton Creek in Alexander County, Illinois, and assigned this formation to the early part of the Upper Llandoverian (C1–2). Farther north, in Calhoun County, Illinois, strata variously called the Sexton Creek, *Kankakee*, and Brassfield yield *Stricklandia*, cf. *S. lens ultima* Williams, which indicates a late Llandoverian (C4–5) age and suggests that the Sexton Creek strata are slightly diachronous from south to north. Amsden (1974, p. 3) correlated the Sexton Creek Limestone with the Blackgum Formation of eastern Oklahoma and the Cochrane Formation of the Arbuckle Mountains region. Thompson and Satterfield (1975, p. 70) reported a small conodont fauna from the Sexton Creek, which they assigned to the *Icriodina irregularis* Assemblage Zone of Nicol and Rexroad. According to Satterfield and Thompson (1975, p. 118), in Cape Girardeau County, Missouri, the Sexton Creek Limestone is overlain by the Seventy-Six Shale which bears the *N. celloni–P. amorphognathoides* conodont fauna. See Blackgum Formation, Cochrane Formation.

SINCLAIR #1 LIPS—Roberts County, Texas; sec. 135, Blk. C, G&M Survey. This well cored Hunton strata at 9,686–9,725 ft; core is stored at the Texas Bureau of Economic Geology, Austin, Texas. Brachiopods from a depth of 9,719 ft include *Amphigenia* sp. (brachial interior similar to that of *A. curta* from the Sallisaw and Clear Creek Formations) and *Acrospirifer worthenanus*?, indicating a correlation with the Sallisaw and Clear Creek Formations. See Amphigenia Beds, Sallisaw Formation, Phillips #1-C Lina.

STRICKLANDIA PROTRIPLESIANA BIOZONE—This species is based on specimens from the Blackgum Formation of eastern Oklahoma, where it is associated with *Triplesia alata* (Amsden, 1966, p. 1010, pl. 115, figs. 1–21; Amsden, 1971, p. 143–146). *S. protriplesiana* is also present in the Phillips #1-D Franklin, Gray County, Texas (Amsden, 1975, p. 86); in the Kirkpatrick #1 Blevins Unit, Logan County, Oklahoma (Amsden, 1980, p. 39); and in the Sexton Creek Formation, Alexander County, Illinois. See Blackgum Formation, Sexton Creek Formation, Triplesia alata Biozone; see also Appendix 1, Stricklandia protriplesiana.

SYLAMORE SANDSTONE—The type locality is on Sylamore Creek, Stone County, north-central Arkansas. It is a basal sandstone–conglomeratic sandstone facies of the Chattanooga (Woodford) Shale, which crops out in northwest Arkansas, southwestern Missouri, and eastern Oklahoma (Amsden, 1961, p. 61–68). Conodonts are common, and studies based on collections from north-central Arkansas show that the Sylamore ranges from Middle Devonian to Early Mississippian in age (Freeman and Schumacher, 1969, p. 2329). This basal sandstone facies continues westward into the subsurface, where it is called the Misener Sandstone. In both Arkansas and Oklahoma it is diachronous (Freeman and Schumacher, 1969; Amsden and Klapper, 1972). See Misener Sandstone.

SYLVAN SHALE—The type section is near Sylvan, Johnston County, Oklahoma (Taff, 1902). The Sylvan Shale commonly consists of an upper greenish-gray, dolomitic shale, locally grading into an argillaceous dolomite, and a lower dark-gray, noncalcareous shale. The Sylvan seas supported almost no sessile or vagrant benthic shelly fauna, and only one inarticulate brachiopod has been described from the lower 40 ft of the formation (Cooper, 1956, p. 244–245, pl. 23D). The lower dark shales yield a *Dicellograptus complanatus* graptolite fauna; these strata are assigned a late Richmondian age and are correlated with the Maquoketa of the upper Mississippi Valley, the Maravillas Chert of west Texas, and the Polk Creek Shale of the Ouachita Mountains of eastern Oklahoma and western Arkansas (Decker, 1935a, p. 697–798; Decker, 1936, p. 1256–1257; Berry, 1960, p. 31, table 1; Ross and others, 1982, sheet 2). Jenkins (1970, p. 261–265,280–285) described and illustrated 12 chitinozoan species in the entire Sylvan interval, including the upper green, dolomitic shale. This author assigned the Sylvan to the Ashgillian Series, noting that the chitinozoan zonation indicated that the uppermost Sylvan beds were of latest Ordovician age. Ham and Wilson (1967, p. 352) and Jenkins (1970, p. 264) cite physical evidence for an unconformity between the Viola and Sylvan; however, there is no clear physical evidence for any pre-Sylvan truncation in the eastern half of Oklahoma (Amsden, 1980, p. 11, panel 4, stratigraphic section A–A′, B–B′). Locally, in the western part of the state, the Sylvan grades into strongly calcareous shales and limestones, and the entire Viola–Sylvan–Hunton interval is represented by carbonates and argillaceous carbonates (Amsden, 1980, p. 38–41). The Sylvan Shale has been correlated with the Cason Shale of north-central Arkansas, but the lithostratigraphic and biostratigraphic relationships suggest a local hiatus representing Sylvan time (Amsden and Barrick, 1986). See Mackellar #1 Ferguson, Lone Star #1 Hanan.

TENKILLER FORMATION—The type locality is at Blackgum Landing on the south shore of Lake Tenkiller, Cherokee County, eastern Oklahoma (Amsden and Rowland, 1965, p. 32–41). Gilbert Klapper of the University of Iowa (letter, May 14, 1976) reports the conodont *Pterospathodus celloni* from a bed 14.9–15.7 ft above the base of the Tenkiller at the type locality, and Barrick and Klapper (1976, p. 66) report *P. celloni* from the uppermost Cochrane Formation in the Arbuckle Mountains. The contact of the Tenkiller with the underlying Blackgum Formation is sharply defined, but the contact with the overlying Barber Member of the Quarry Mountain Formation appears to be gradational. See Blackgum Formation, Barber Member, Cochrane Formation.

TENNECO 1-5 BILLER—This well is in the C SE¼ sec. 5, T13N, R6W, Canadian County, Oklahoma. This well cored 86 ft of basal Woodford and upper Hunton (Frisco–Henryhouse–*Kirkidium* biofacies) (Amsden, 1980, p. 71–72).

TRIPLESIA ALATA BIOZONE—This brachiopod is present in the Cochrane Formation of south-central Oklahoma, the Blackgum Formation of eastern Oklahoma, and the Cason "Brassfield" limestone of north-central Arkansas (Amsden, 1971, p. 143–146; this report, Pl. 2, Figs. 8,9). In the Blackgum Formation it is associated with *Stricklandia protriplesiana* (Amsden), a species that is assigned a late Llandoverian (C1–2) age (Amsden, 1966, p. 1014–1015). Barrick and Klapper (1976, p. 66) identified *Pterospathodus celloni* from the upper 1 ft of exposed Cochrane Formation at my locality C1 in the Arbuckle Mountains (Amsden, 1960, p. 188), a bed which is overlain by the Prices Falls Member of the Clarita Formation (Amsden, 1967, p. 942). Barrick and Klapper assign *P. celloni* a late Llandoverian (C5) age. To my knowledge *P. celloni* has not been found in direct association with either *S. protriplesiana* or *T. alata.* In the present report the Cochrane–Blackgum–Sexton Creek Formations are interpreted as spanning the entire late Llandoverian, C Stage, but it should be noted that the stratigraphic relationships strongly indicate that both upper and lower boundaries of these units are diachronous (see Appendix 1, Stricklandia protriplesiana). In 1971 I pointed out that in North America the genus *Triplesia* s.s. is not known in strata younger than Llandoverian, and the Wenlockian age species formerly referred to *Triplesia* were assigned to *Placotriplesia* (Amsden, 1968, p. 40; 1971, p. 146–150; 1973, p. 255–271). See Stricklandia protriplesiana Biozone, Placotriplesia Beds, Cochrane Formation, Blackgum Formation, Cason "Brassfield" Limestone.

TURKEY CREEK LIMESTONE—Turkey Creek Limestone is an informal name given to a Lower Devonian limestone exposed in a small outcrop along Turkey Creek in Marshall County, Oklahoma (Amsden and others, 1968; Amsden, 1985). On the basis of the conodont studies of Klapper (Klapper and Ziegler, 1967), and the trilobite studies of Ormiston (1968), the Turkey Creek fossils were considered to be a middle Lower Devonian fauna intermediate in age between the Frisco (Deerparkian) and Sallisaw (Sawkillian) Formations, and with distinct Bohemian affinities. A subsequent re-examination of the conodonts (Klapper, *in* Amsden, 1985) and the trilobites (Campbell, 1977, p. 10) suggests that the Turkey Creek is a Deerparkian age fauna with North American affinities. Klapper (*in* Amsden, 1985, p. 1–2) reports the conodont *Icriodus claudia*?; Ormiston (1968) described and illustrated eight species of trilobites; Amsden (1985) described and illustrated eight brachiopod species.

VIOLA GROUP—The type section is near Bromide, Johnston County, Oklahoma, in the eastern part of the Arbuckle Mountains. Some authors have defined the Viola to include the Welling Formation (= "Fernvale" limestone) and some have excluded the Welling. Amsden (*in* Amsden and Sweet, 1983, p. 3–4) elevated the Viola to a Group, which included the Welling Formation (above) and the Viola Springs Formation (below). On the basis of conodonts, Sweet (*in* Amsden and Sweet, 1983, p. 29) assigned the Welling Formation to the early Maysvillian–late Edenian Stages, the upper Viola Springs to the Edenian Stage, and the lower Viola to the Kirkfieldian–Shermanian Stages. See Viola Springs Formation, Welling Formation, Lepidocyclus cooperi Biozone, Lepidocyclus oblongus Biozone.

VIOLA SPRINGS FORMATION (VIOLA GROUP)—The type section is about a mile southeast of Viola Springs, Arbuckle Mountains region, Johnston County, Oklahoma (Amsden, *in* Amsden and Sweet, 1982, p. 3–4). This limestone, which represents the pre-Welling (pre-"Fernvale") Viola strata, consists of beds which Alberstadt (1973, p. 3,5–6) referred to stratigraphic units 1 and 2 of the Viola Formation. In this report, the Viola Springs and the Welling Formations make up the Viola Group. Alberstadt described 19 species of brachiopods from the Viola Springs Formation (stratigraphic units 1 and 2), although most of these were represented by only a few specimens, and only six were given unambiguous species identifications. *Lepidocyclus oblongus* is present in the upper part of the Viola Springs Formation and in the lower part of the Welling Formation in the Arbuckle Mountains area. This brachiopod is also present in the lower "Fernvale" strata of north-central Arkansas and in the Cape Limestone of southeastern Missouri. The Viola Springs

Formation is absent in eastern Oklahoma, and its position is marked by a hiatus (Amsden, *in* Amsden and Sweet, text-fig. 16). According to Alberstadt (1973, p. 15, text-fig. 7) his stratigraphic units 1 and 2 (= Viola Springs Formation) range in age from upper Trentonian through Edenian and into Maysvillian, and his stratigraphic unit 1 (= Welling Formation) ranges from Maysvillian into Richmondian. However, Sweet (*in* Amsden and Sweet, 1983, p. 3, text-fig. 2), on the basis of the conodont faunas, assigned the Viola Springs Formation to the Kirkfieldian, Shermanian, and lower Edenian Stages, and the Welling Formation to the late Edenian and early Maysvillian Stages. Amsden (*in* Amsden and Sweet, 1983, p. 42) points out that lepidocyclid brachiopods, including *Hiscobeccus capax*, are common in the U.S. National Museum Collections from Richmondian strata in the Cincinnati region. This formation has a large graptolite fauna (Finney and others, 1984, p. 116–120). See Welling Formation, "Fernvale" Limestone, Cape Limestone, Lepidocyclus cooperi Biozone, Lepidocyclus oblongus Biozone.

WELLING FORMATION—The type section is on the west bluff of the Illinois River, Cherokee County, eastern Oklahoma (Amsden, 1979, p. 1135; Amdsen, *in* Amsden and Sweet, 1983, p. 4–6,42). This name was proposed to replace the "Fernvale" of earlier Oklahoma usage. In the Arbuckle Mountains region, the Welling represents the upper formation in the Viola Group (Amsden, *in* Amsden and Sweet, 1983, p. 4–6); these are the beds that Alberstadt (1973, p. 3,5–6) designated as stratigraphic unit 3 in the Viola Formation. Alberstadt described 16 species of articulate brachiopods from the Welling Formation (stratigraphic unit 3) in the Arbuckle Mountains area, and 13 of these are also reported in the Welling of eastern Oklahoma. Alberstadt described specimens of *Lepidocyclus cooperi* and *L. capax* (= *Hiscobeccus capax*) from the upper Welling beds, and *L. oblongus* from the lower part of this formation and the upper part of his stratigraphic unit 2 (= upper Viola Springs Formation of this report); however, only *L. cooperi* and *L. capax* were reported from the Welling of eastern Oklahoma. Amsden (*in* Amsden and Sweet, 1983, p. 37) assigned *capax* to a new genus, *Hiscobeccus*, and further elaborated on the *cooperi-capax* and *oblongus* brachiopod zones. According to this zonation, the lower *oblongus*-bearing beds in the Arbuckle Mountains are absent in the eastern outcrops, their position being marked by a hiatus, but they are represented in the lower part of the "Fernvale" limestone of Arkansas and in the Cape Limestone of southeastern Missouri. Alberstadt (1973, p. 13–15), in his study of the Viola Group brachiopods from the Arbuckle Mountains, tentatively assigns the upper part of the Viola Springs and lower part of the Welling (= upper stratigraphic unit 2 and lower part of unit 3; *Lepidocyclus oblongus* biozone) to an Edenian–Maysvillian age, and the upper part of the Welling (upper unit 3; *L. cooperi* biozone) an early Richmondian age, with the Sylvan Shale representing most of the Richmondian Stage. Sweet (*in* Amsden and Sweet, 1983, p. 26–32), in his study of the conodonts, assigns these strata a slightly older age; the upper Welling is referred to the Maysvillian, and the lower Welling–upper Viola Springs to the upper Edenian. This report follows Sweet's age assignment for the Welling Formation; however, present information indicates that in the type Cincinnati area *L. capax* is confined to Richmondian strata (Amsden and Sweet, 1983, p. 42). See Lepidocyclus cooperi Biozone, Lepidocyclus oblongus Biozone, Viola Formation, Viola Springs Formation, "Fernvale" Limestone, Cape Limestone.

WOODFORD SHALE—This shale was named for exposures near Woodford, Carter County, south-central Oklahoma. The Woodford is a dark, silty shale that contains considerable bedded chert in places. It carries spores and conodonts, the latter indicating a time span from early Late Devonian into Early Mississippian. The Woodford blankets the entire state except for those areas where it has been removed by pre-Pennsylvanian erosion (Amsden, 1975, panels 3,4; 1980, panel 3). The name Woodford is used in central and western Oklahoma, but in the eastern part of the state this shale is commonly referred to the Chattanooga. A basal sandstone facies is generally present in the north-central and northeastern part of the state; this is called the Misener Sandstone in the subsurface and the Sylamore Sandstone in the eastern outcrop area. Conodonts show that this sandstone ranges in age from late Middle into Upper Devonian. See Chattanooga Shale, Misener Sandstone, Sylamore Sandstone, Polygnathus varcus Zone.

PART II

SILURIAN–EARLY DEVONIAN CONODONT SUCCESSION IN THE HUNTON GROUP, SOUTHERN OKLAHOMA

JAMES E. BARRICK[1]

Abstract—A nearly continuous chronologic sequence of conodont faunas extending from the late Llandoverian (C_5) to the early Lochkovian is present in the Hunton Group. Significant local faunal changes correspond to faunal turnovers recognized elsewhere, and occur within Hunton lithostratigraphic units. In contrast, distinct local faunal breaks occur at the contacts between succeeding Lower to Middle(?) Devonian units.

INTRODUCTION

Conodont faunas from Silurian through Lower Devonian strata comprise a series of intergrading assemblages that show relatively few abrupt changes in overall taxonomic composition. Typically, the stratigraphic distribution of species and genera displays a staggered pattern of appearance and extinction. This pattern can be interrupted in local stratigraphic successions by abrupt shifts in environmental conditions or, more commonly, where an unconformity exists within the stratigraphic succession and a significant hiatus is present.

Only two significant faunal turnovers occur during the Silurian (Cooper, 1980). A few genera and species that characterize Llandoverian strata disappear in the earliest Wenlockian. The second turnover marks the disappearance of the Wenlockian–early Ludlovian *Kockelella* group within the Ludlovian. The conodont fauna of the earliest Devonian (early Lochkovian) differs little from that of the latest Silurian (Pridolian). Species of *Icriodus* gradually appear and the *Ozarkodina remscheidensis-steinhornensis* group develops new morphotypes. Later, during the late Lochkovian through the Pragian, conodonts radiate into a number of new genera and species (Murphy and Matti, 1982).

Conodont faunas from the Hunton Group of southern Oklahoma follow the general sequence of Silurian–Early Devonian change outlined above. No significant break in the conodont sequence can be identified through the Cochrane–Clarita–Henryhouse–Haragan/Bois d'Arc Formations, at least in the Arbuckle Mountains outcrop area. Although diagnostic conodont elements are uncommon, the boundaries between the Bois d'Arc, Frisco, and Sallisaw Formations represent distinct breaks in the general conodont succession.

SUMMARY OF CONODONT FAUNAS

A summary of the conodont faunas of the Silurian through Lower Devonian strata of the Hunton Group is given below. This information is derived from a large number of incompletely analyzed samples collected by G. Klapper, University of Iowa, and me over a number of years. Hence, some of the information is subject to revision as the faunas are better studied.

Cochrane Formation

Elements of two simple-cone species, *Panderodus unicostatus* (Branson and Mehl) and *Walliserodus sancticlairi* Cooper, dominate the conodont fauna of the Cochrane Formation. Other simple-cone species are less abundant—*Decoriconus fragilis* (Branson and Mehl), *Dapsilodus praecipuus* Barrick, and *Panderodus* n. sp. aff. *P. recurvatus* (Rhodes). *Distomodus staurognathoides* (Walliser) is the most common platform-ramiform species; *Oulodus* elements occur sporadically. *Pterospathodus celloni* (Walliser) and *P. pennatus angulatus* (Walliser) are present in the upper beds of the Cochrane at some localities. These species make it possible to assign at least the upper part of the Cochrane to the *celloni* Zone (late Llandoverian, C_5).

No obvious succession of conodont species can be recognized within the Cochrane. With the possible exception of one undescribed species, *Panderodus* n. sp. aff. *P. recurvatus*, all Cochrane forms range into the overlying Clarita Formation.

Clarita Formation

Two major successive conodont faunas are found within the Clarita Formation (Barrick and Klapper, 1976; Barrick, 1977). The distinctive fauna of the *Pterospathodus amorphognathoides* Zone (late Llandoverian, C_6 to early Wenlockian) character-

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izes the Prices Falls Member at some localities. Elements of simple-cone species dominate the fauna—*Panderodus unicostatus, Walliserodus sancticlairi, Dapsilodus praecipuus*, and *Decoriconus fragilis*. A few less common simple-cone species—*Pseudooneotodus tricornus* Drygant, *Panderodus langkawiensis* (Igo and Koike), and *P.* sp. cf. *P. recurvatus* (Barrick, 1983, p. 239)—appear at the base of the Clarita in the *amorphognathoides* Zone.

Pterospathodus celloni occurs in only a few samples of the Prices Falls Shale. *Distomodus staurognathoides* ranges up from the Cochrane and through the *amorphognathoides* Zone. Several platform-ramiform species appear at the base of the Clarita—*Pterospathodus amorphognathoides* Walliser, *P. pennatus procerus* (Walliser), *Carniodus carnulus* Walliser, *Kockelella ranuliformis* (Walliser), *Ozarkodina hadra* (Nicoll and Rexroad), *O. polinclinata* (Nicoll and Rexroad), and *Oulodus petila* (Nicoll and Rexroad). At least two of these species, *O. polinclinata* and *K. ranuliformis*, have not been recovered from the Cochrane but are known to range into Llandoverian (C_5) age strata elsewhere.

The top of the *amorphognathoides* Zone in the Clarita is marked by the extinction of three conodont genera characteristic of the Late Llandovery—*Carniodus, Distomodus*, and *Pterospathodus*. At this level, six Llandoverian species of longer-ranging genera also disappear (Barrick and Klapper, 1976, fig. 3; Barrick, 1977, fig. 1). This distinctive faunal change occurs either at the boundary between the Prices Falls Member and the Fitzhugh Member or within the lower beds of the Fitzhugh Member.

The base of the overlying *Kockelella ranuliformis* Zone (Barrick and Klapper, 1976) is characterized by the appearance of species absent in the *amorphognathoides* Zone in Oklahoma, but known to range into that zone in other areas (Mabillard and Aldridge, 1985). *Dapsilodus obliquicostatus* (Branson and Mehl) becomes the most abundant species of the Fitzhugh Member; *Pseudooneotodus bicornis* Drygant and *Ozarkodina excavata excavata* (Branson and Mehl) are characteristic species. *Kockelella ranuliformis* is the only platform-ramiform species that persists from the *amorphognathoides* Zone, although several common simple-cone species range into the *ranuliformis* Zone and through at least part of the Fitzhugh Member.

The diversification of species of *Kockelella* during the Wenlockian is recorded within the Fitzhugh Member. At least six new species appear, three of which Barrick and Klapper (1976) used to erect a series of zones for the Wenlockian. The *Ozarkodina sagitta* lineage appears, which is represented by *O. bohemica* (Walliser) in the upper Fitzhugh. Within the upper part of the Fitzhugh, the simple-cone genus *Belodella* appears, and some minor changes occur among other simple-cone species (Barrick, 1977). "*Ozarkodina*" *crassa* Walliser, a Pb element that probably belongs to a species of *Ancoradella*, appears at the top of the Fitzhugh.

Henryhouse Formation

Conodonts of the Henryhouse Formation comprise three distinct successive faunas. In Arbuckle Mountains sections (Ca2, M17) the conodont fauna of the basal beds of the Henryhouse is identical with that of the top of the underlying Clarita Formation. Species of *Kockelella, K. variabilis* (Walliser) and *K. absidata* Barrick and Klapper, and *Ozarkodina excavata excavata* are characteristic forms. Simple-cone elements continue to dominate the conodont faunas. *Dapsilodus obliquicostatus* is the most abundant species and *Panderodus unicostatus, Decoriconus fragilis*, and *P. recurvatus* (Rhodes) are usually present. At only one section, M17, does *Polygnathoides siluricus* Branson and Mehl join the *Kockelella* fauna a few meters above the base of the Henryhouse.

The *Kockelella* fauna disappears slightly higher in the Henryhouse in the Arbuckle Mountains region and is replaced by an *Ozarkodina–Dapsilodus* fauna. In this second Henryhouse fauna, *Ozarkodina snajdri* (Walliser), *O.* n. sp. of Schönlaub (*in* Chlupác and others, 1980, p. 157, pl. 17, figs. 6–8), and extremely rare *Pedavis latialata* (Walliser) appear. Elements of *O. excavata excavata* and *Dapsilodus obliquicostatus* dominate the fauna and elements of *Decoriconus fragilis* and *Panderodus unicostatus* are less common. This conodont association corresponds to the Late Ludlovian *snajdri* Zone as recognized by Schönlaub (*in* Chlupác and others, 1980, p. 175–177) in the Barrandian area of Czechoslovakia.

The *Ozarkodina snajdri* fauna occurs near the base of the Henryhouse in sections on the Lawrence uplift, and the early Ludlovian *Kockelella* fauna appears to be absent. In this area a hiatus involving the latter part of the Wenlockian and the early Ludlovian is present, in contrast to the apparently continuous stratigraphic record that characterizes the Clarita–Henryhouse contact at sections Ca2 and M17 in the core of the Arbuckle Mountains.

In the upper part of all Henryhouse sections the *Ozarkodina snajdri* fauna disappears and is replaced by a different conodont association. Through a short stratigraphic interval *Oulodus elegans* (Walliser), *Ozarkodina remscheidensis eosteinhornensis* (Walliser), the simple-cone genus *Dvorakia*, and species of *Belodella* with extremely broad bases appear. *Belodella* elements dominate the fauna. *Dapsilodus obliquicostatus*, the most abundant species in Wenlockian and Ludlovian strata, is rare or absent. *Decoriconus fragilis, Pseudooneotodus beckmanni* (Bischoff and Sannemann), and *Panderodus unicostatus* persist from the lower faunas. The presence of *O. remscheidensis eosteinhornensis* allows this fauna to be assigned to the *eosteinhornensis* Zone in the expanded sense of Schönlaub (*in* Chlupác and others, 1980, p. 157). The *eosteinhornensis* Zone ranges from latest Ludlovian (Kopanina Formation) through the Pridolian (Pridoli Formation) in the Barrandian (Schönlaub, *in* Chlupác and others, 1980, p. 155–157).

Haragan Formation

The base of the Haragan Formation cannot be readily identified on the basis of lithology, although it can be distinguished by the appearance of its distinctive Early Devonian brachiopod fauna (Amsden, 1960). However, Henryhouse–Haragan sections do not always yield sufficient shelly fossils to permit precise placement of the boundary. Where the first Haragan brachiopods appear in these sections, they are associated with the following three changes in the conodont fauna—(1) *Oulodus elegans* disappears; (2) forms transitional from *Ozarkodina remscheidensis eosteinhornensis* to *O. r. remscheidensis* appear; (3) species of *Icriodus* appear.

It is uncertain whether *Oulodus elegans* is restricted to the Late Silurian as Walliser (1964) recorded at Cellon, or if the species ranges into the Early Devonian (Jeppsson, 1974). The morphologic transition from *Ozarkodina remscheidensis eosteinhornensis* to *O. r. remscheidensis* may be controlled in part by ecologic factors (Denkler and others, 1983), but it occurs near the Silurian–Devonian boundary at a number of sections in the Barrandian (Schönlaub, *in* Chlupác and others, 1980), the Carnic Alps (Walliser, 1964), and Nevada (Murphy and Edwards, 1977). The morphology of the I elements of *Icriodus* that appear near the base of the Haragan is variable, but most elements conform to the characteristics of *I. postwoschmidti* Mashkova. *Icriodus postwoschmidti* occurs in early Lochkovian strata in the Barrandian (Schönlaub, *in* Chlupác and others, 1980).

It is difficult to measure the magnitude of the hiatus separating the Henryhouse and Haragan Formations, or even to demonstrate that a hiatus exists on the basis of the conodont faunas. The uppermost Henryhouse is certainly Pridolian in age, but there are no reliable biostratigraphic markers among conodonts that permit subdivision of the Pridolian. One cannot ascertain if any Pridolian age strata are missing from the top of the Henryhouse. Only the basal Lochkovian *Icriodus woschmidti woschmidti* Zone is absent from the base of the Haragan, but the zone apparently represents only a brief interval.

Bois d'Arc Formation

The Bois d'Arc Formation is partly a lateral facies equivalent of the Haragan and also overlies the Haragan at most sections (Amsden, 1958b). Conodonts are relatively scarce in Bois d'Arc strata, making it difficult to determine biostratigraphic relationships. The lower member, the Cravatt Member, consists of cherty argillaceous calcilutites, and conodont elements are concentrated in thin, skeletal lag beds. Elements of *Belodella* and *Dvorakia* species that also occur in the Haragan are present. *Ozarkodina excavata wurmi* (Bischoff and Sanneman) and *O. remscheidensis remscheidensis* occur in a few samples. Near the top of the Cravatt Member, *Icriodus* elements occur that are questionably referred to *I. postwoschmidti.*

Fewer conodont elements occur in the coarse calcarenites of the Fittstown Member, the upper member of the Bois d'Arc. Most are elements of *Belodella* and *Dvorakia* species. A few elements of *O. r. remscheidensis* are present. From a few samples in the middle of the Fittstown, elements of *Ancryodelloides transitans* (Bischoff and Sannemann) have been recovered. This form is characteristic of the late Lochkovian in Europe (Schönlaub, *in* Chlupác and others, 1980) and occurs in the *delta* zone of the Cordilleran conodont zonation (Klapper and Murphy, 1980).

At least the Fittstown Member of the Bois d'Arc Formation appears to be slightly younger than the Haragan Formation. However, it should be noted that most of the diagnostic Haragan conodonts were obtained from near the base of the Haragan. Beds higher in the Haragan, especially those at the important shelly fossil locality, White Mound, yield only a few undiagnostic conodont elements.

Frisco Formation

Conodont elements from the coarse calcarenites of the Frisco are abundant but badly fragmented. Pieces of elements of *Icriodus* and *Dvorakia* are found in most samples. Klapper (*in* Amsden, 1985, p. 2) tentatively refers some *Icriodus* elements to *I. claudiae* Klapper. *Icriodus claudiae* appears in the *sulcatus* Zone and ranges into the *kindlei* Zone in Nevada (Murphy and Matti, 1982). These zones are considered to correlate with the Pragian of the Barrandian area (Klapper and others, 1978).

Sallisaw Formation

Klapper (*in* Amsden, 1985, p. 2) reports *Icriodus latericrescens robustus* Orr from the Sallisaw Formation. This form ranges from the *serotinous* to the *australis* Zones and is Delejan to Eifelian in age (Klapper and Johnson, 1980).

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[1] In 1917 this paper was reprinted from the original plates in Illinois Geological Survey Bulletin 23, p. 67–160, pls. 3–9; p. 95–160 and pls. 3–9 do not appear in the Geological Society of America Bulletin, but according to Savage (1917, p. 67) were sent out with the "extract that was distributed in November 1913." Therefore, the date of Savage's fossil descriptions is cited as 1913, although the pagination and plate numbers are from the 1917 publication.

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