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TRILOBITES, BIOSTRATIGRAPHY, AND LITHOSTRATIGRAPHY OF THE MC KENZIE HILL LIMESTONE (LOWER ORDOVICIAN), WICHITA AND ARBUCKLE MOUNTAINS, OKLAHOMA

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Title Page Illustration

Stereo pair of unexfoliated pygidium (latex cast) of *Hystricurus hillyardensis* Stitt, n. sp., ×5½. This paratype specimen was collected from the lower lime-mudstone member of the McKenzie Hill Limestone along the Chandler Creek section, on the north flank of the Wichita Mountains. (See pl. 4, fig. 6.)

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TRILOBITES OF THE MC KENZIE HILL LIMESTONE

TRILOBITES, BIOSTRATIGRAPHY, AND LITHOSTRATIGRAPHY OF THE MC KENZIE HILL LIMESTONE (LOWER ORDOVICIAN), WICHITA AND ARBUCKLE MOUNTAINS, OKLAHOMA

JAMES H. STITT[1]

Abstract—The McKenzie Hill Limestone crops out in the Blue Creek Canyon Anticline, directly north of the Wichita Mountains in southwestern Oklahoma, and in the Arbuckle Mountains in south-central Oklahoma. Trilobites were collected from every fossiliferous bed in two measured sections traversing the McKenzie Hill, which is moderately fossiliferous in the lower half and increasingly less fossiliferous toward the top. From slightly more than 900 cleaned and prepared specimens (mostly from the Chandler Creek section in the Wichita Mountains area), 17 species are identified and assigned to 10 genera, including one new genus and four new species. In addition, two taxa are generically identified but not assigned to any species, and one taxon is left in open nomenclature.

The oldest trilobites in the McKenzie Hill Limestone are assigned to the *Symphysurina bulbosa* Subzone of the *Symphysurina* Zone, which begins in the underlying Signal Mountain Limestone (Stitt, 1977). The *S. bulbosa* Subzone assemblage is succeeded upsection by a trilobite assemblage assigned to the *Symphysurina woosteri* Subzone, the highest subzone of the *Symphysurina* Zone.

The middle half of the McKenzie Hill Limestone is characterized by trilobites assigned to the *Bellefontia–Xenostegium* Zone. Partly overlapping trilobite ranges allow the recognition of three subzones in this zone: a lower *Xenostegium franklinense* Subzone, a middle *Bellefontia collieana* Subzone, the thickest of the three subzones, and an upper *Bellefontia chamberlaini* Subzone. The *Bellefontia–Xenostegium* Zone is succeeded in the Chandler Creek section by the *Paraplethopeltis* Zone, the diagnostic trilobites of which were not recovered from the U.S. 77 section in the Arbuckle Mountains. The uppermost part of the McKenzie Hill yielded no identifiable trilobites, but conodonts recovered from small hand samples in this interval suggest that the *Paraplethopeltis* Zone probably extends to the top of the formation. The trilobites recovered from the McKenzie Hill enable this formation to be correlated with equivalent strata in various parts of the Appalachian Mountains, the Upper Mississippi Valley, Missouri, Texas, the Great Basin, and the central Rocky Mountains.

The lower part of the McKenzie Hill contains almost no chert, but the rest of the formation contains abundant, mostly dark chert. The lower half of the McKenzie Hill is predominantly lime mudstone and trilobite lime wackestone, which probably accumulated below wave base on a broad cratonic shelf and which contains most of the fossils in the formation. The upper half of the formation is predominantly lime grainstone, which accumulated in much shallower water and which is only sparsely fossiliferous.

The Symphysurinid Biomere is proposed for the biostratigraphic interval of the *Missisquoia*, *Symphysurina*, *Bellefontia–Xenostegium*, and *Paraplethopeltis* Zones. This biomere is bounded below by the extinction of the *Saukia* Zone fauna and bounded above by the extinction of all of the abundant families, subfamilies, and genera of the biomere, except for *Hystricurus*.

INTRODUCTION

The strata preserved in the Southern Oklahoma Aulacogen (Ham and others, 1964; Wickham and Denison, 1978) provide the best opportunity in the midcontinental and eastern United States to collect and study the faunas and depositional environments of the Lower Ordovician. Perhaps because subsidence was continuous and rapid in the aulacogen, the limestone deposited there during the Early Ordovician was not dolomitized, as were equivalent strata in Texas, Missouri, the Upper Mississippi Valley, and most of the Appalachian Mountains. Dolomitization destroys most nonsilicified fossils, leaving behind only occasional molds (commonly in chert) that generally occur either as float or as widely separated *in-situ* collections. Detailed biostratigraphic work is impossible in these areas, and, as a result, the trilobite studies of Ross (1951) and Hintze (1952) in the Lower Ordovician limestone sequences in the central Rocky Mountains and Great Basin have become the standard for intracontinental correlation in this interval.

Previous studies in the Arbuckle and Wichita Mountains (Stitt, 1971b, 1977) documented the Upper Cambrian and lowest Ordovician trilobite succession, from the base of the Reagan Sandstone

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to the top of the Signal Mountain Limestone, in these areas. Excellent correlations between the Oklahoma sections and other areas in North America are possible from the succession of trilobite zones established in these studies. The present project continues the trilobite studies upsection into the overlying McKenzie Hill Limestone. The McKenzie Hill had been mapped in the Arbuckle Mountains by Ham (1955) and in the Wichita Mountains area by Brookby (1969), both of whom measured McKenzie Hill sections that I have remeasured and collected to provide samples for this study. The brachiopods and molluscs collected with the trilobites will be described later.

Previous reports of fossils from the McKenzie Hill Limestone were always part of larger reconnaissance studies of the fauna of the entire Arbuckle Group (see, for example, Bridge, 1936; Decker, 1939a, 1939b; Frederickson, 1941; Cooper, 1952). The few collections reported from the McKenzie Hill were usually many feet apart and of limited biostratigraphic value. The McKenzie Hill Limestone is not nearly as fossiliferous as the underlying Signal Mountain Limestone; a person walking through the section and sampling only occasionally might conclude that the formation is nearly unfossiliferous. Only by sampling every exposed bed and splitting a large volume of limestone was I able to recover the trilobites that are described in this paper. Many of the collections came from very thin seams of limestone, discovered only by a lucky blow of the hammer. Even with this detailed sampling effort, fossils became progressively harder to find in the upper half of the McKenzie Hill, and the upper 100–150 feet of the formation yielded practically nothing. The fossils that were collected were wrapped and bagged, and labeled with the footage above the base of the section. They were cleaned and identified in succeeding summers at the University of Missouri–Columbia. The rest of the project was completed during my sabbatical leave in 1981–82.

Acknowledgments

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The ranchers in the areas where the measured sections are located are thanked for their cooperation in allowing me access to the outcrops.

Sandee White, Lindy Eime, Beverly Sapp, and Rebecca Stoker typed the original and revised manuscripts, and they are thanked for their careful work.

LITHOSTRATIGRAPHY

Introduction

The type section of the McKenzie Hill Limestone, Arbuckle Group, is on McKenzie Hill (Decker, 1939a, p. 1318–1319), in the western part of Fort Sill Military Reservation. Only 223 feet of limestone is assigned to the formation at the type section, which is less than one-fourth of the usual thickness in exposures to the north, suggesting that the entire formation is not exposed at the type section. Complete sections and more continuous exposures of the McKenzie Hill occur in northwest-trending outcrops of the Arbuckle Group along the northeast side of the Wichita Mountains (figs. 1, 4). Similar thick, well-exposed sections of the Arbuckle Group, including the McKenzie Hill, occur throughout the western Arbuckle Mountains (Ham, 1955, fig. 1; also see map in pocket).

Two sections were chosen for detailed examination of the McKenzie Hill, each with excellent exposures and good access. In the Wichita Mountains area, the Chandler Creek section (fig. 4; Brookby, 1969) had already been examined in detail during a study of the underlying formations (Stitt, 1977), and this section was extended through the McKenzie Hill and collected in detail. In the Arbuckle Mountains, the U.S. 77 section (fig. 6; Ham, 1955, figs. 1, 2) had similarly been studied in detail, from the Reagan Sandstone to the Butterly Dolomite (Stitt, 1971b). This section was offset to the southeast along the top of the Butterly to an area of good exposures, extended through the McKenzie Hill, and collected in detail.

The regional setting of the Southern Oklahoma Aulacogen and its influence on the deposition of the Arbuckle Group was first documented by Ham and others (1964) and recently updated by Wickham and Denison (1978). The continued subsidence along the aulacogen, combined with the steady production of carbonate sediment, resulted

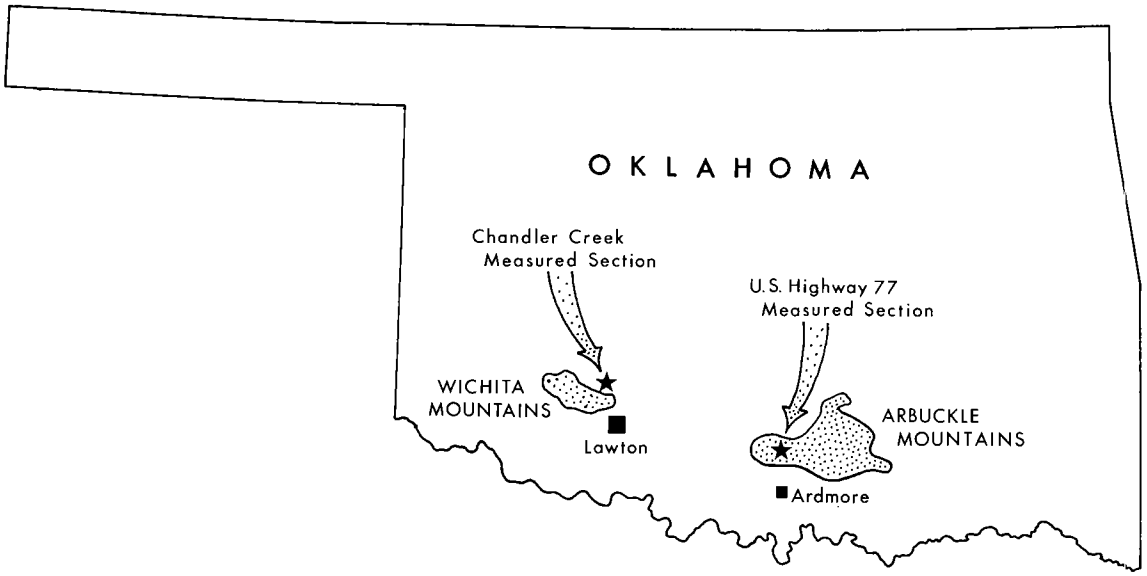

Figure 1. Index map showing outlines of Wichita and Arbuckle Mountains and general locations of measured sections.

in a much thicker accumulation of Upper Cambrian and Lower Ordovician limestones and dolomites in southern Oklahoma than in adjacent areas (Ham, 1969, fig. 3). The limestones contain the depositional features and varied fauna indicative of accumulation in shallow water of normal marine salinity (Ham, 1969, p. 8; Stitt, 1971b, p. 5–7; 1977, p. 4–10), suggesting that the sea floor in the aulacogen was not significantly deeper than the sea floor in adjacent areas. The description of the McKenzie Hill Limestone and its probable depositional history, presented below, provide additional support for these interpretations.

Chert Members

Ham (1955, fig. 1) observed that approximately the lower one-third of the McKenzie Hill Limestone in the Arbuckle Mountains contains little or no chert, whereas the upper two-thirds of the formation commonly contains several types of chert. Brookby (1969, p. 27–29) found a similar distribution of chert in the McKenzie Hill Limestone in the Wichita Mountains area and further commented that the chert may occur as thin layers of discoidal nodules or as irregular masses. He divided the McKenzie Hill into an upper cherty member and a lower noncherty member, and mapped these members throughout his thesis area. Brookby observed also that the interval between the Cambrian–Ordovician boundary (= base of the *Missisquoia* Zone) and the base of his upper cherty member had a nearly uniform stratigraphic thickness throughout his mapping area, and he suggested that the base of the upper cherty member might be a useful time-stratigraphic horizon in the Wichita Mountains area. Within the Arbuckle Anticline, the base of the upper cherty member maintains a more or less uniform stratigraphic distance above the base of the *Apheoorthis* Zone (Ham, 1955, figs. 1, 2). However, the base of the upper cherty member crosses biostratigraphic zone boundaries between the Wichita Mountains and the Arbuckle Mountains, suggesting that this lithostratigraphic boundary is not as useful as the faunal zones in correlations between these two areas. The base of the upper cherty member occurs in the upper part of the *Xenostegium franklinense* Subzone in the Wichita Mountains but drops down into the upper part of the underlying *Symphysurina woosteri* Subzone and is about 100 feet closer to the Cambrian–Ordovician boundary in the Arbuckle Mountains (compare chert distribution on columnar sections, figs. 5, 7).

The chert is clearly a replacement of the limestone and retains the original texture of the limestone in many samples (personal observation, and also the opinion of the late W. E. Ham—see Brookby, 1969, p. 28). If the replacement is complete, smooth-weathering nodules of vitreous chert are formed. If the replacement is incomplete, porous tripolitic chert nodules are the result (Ham *in* Brookby, 1969, p. 28–29). The formation of the chert nodules was probably neither a time-dependent event nor an isochronous event, and probably occurred long after the deposition of the limestone beds that now contain them. Although the base of the upper cherty member may be a useful mapping horizon in the Wichita Mountains area and in the western Arbuckle Mountains, I believe that the biostratigraphic zones should be used to determine any chronostratigraphic relationships within the McKenzie Hill between these two areas.

The base of the upper cherty member of the

McKenzie Hill does not correspond to the major change in the lithology of the limestones that constitute the formation. The lower part of the McKenzie Hill in the Wichita Mountains consists mostly of lime mudstones and lime wackestones (Dunham, 1962), whereas the upper part consists predominantly of pelletal and intraclastic lime grainstones. A similar lithologic contrast between the lower and upper parts of the McKenzie Hill is present in the western Arbuckle Mountains. This upward change in lithology is matched by a marked decrease in the abundance of fossils. Because this change affects both the lithology and the paleontology of the McKenzie Hill, I believe this horizon to be more important than the base of the upper cherty member in terms of understanding the depositional and faunal history of the formation. For this reason, I have chosen to recognize a lower lime-mudstone member and an upper grainstone member in the McKenzie Hill, and to discuss the depositional history of the formation in terms of these members.

The McKenzie Hill consists entirely of limestone, with only a few beds of dolomite. Dunham's (1962) classification was used to describe these rocks, because it emphasizes depositional textures, simplified terminology, and widespread use by carbonate petrologists. However, Dunham made an unfortunate mistake when he chose to apply the term mudstone (p. 117) to the fine-grained limestones composed almost entirely of micrite (Folk, 1962, p. 66), because the term "mudstone" is used also for detrital sedimentary rocks composed of mixtures of quartz silt and clay minerals (illite, montmorillonite, etc.). Constantly inserting the word "lime" in front of "mudstone" to distinguish micritic limestones from detrital mudstones quickly becomes cumbersome, especially when all the rocks under discussion are limestones. The other terms in Dunham's limestone classification, such as wackestone, grainstone, etc., are not used as such in the classification of detrital sedimentary rocks, and there the word lime does not have to be prefixed to these terms to make an author's meaning clear.

Because the McKenzie Hill is composed entirely of carbonate rocks, the words mudstone, wackestone, and grainstone will be used in the sense of Dunham's classification, and refer only to limestones. The word lime will be inserted only where it is needed for clarity.

Lower Lime-Mudstone Member

The base of the McKenzie Hill Limestone in the Wichita Mountains area is placed at the base of the thick-bedded limestones overlying the thin- to medium-bedded limestones that characterize the upper part of the underlying Signal Mountain Limestone. This is a conformable contact, and the change in bedding character is not accompanied by a change in lithology. The lime mudstones, trilobite lime wackestones, and occasional lime grainstones of the upper Signal Mountain continue into the lower lime-mudstone member of the McKenzie Hill.

In the western Arbuckle Mountains, the base of the McKenzie Hill is placed at the base of the first limestone bed overlying the Butterly Dolomite. This is also a conformable contact, although it can be locally irregular along strike owing to the replacement nature of the Butterly Dolomite (see Ham, 1955, figs. 1, 2).

The lower lime-mudstone member consists predominantly of lime mudstone, trilobite lime mudstone, and trilobite lime wackestone, with lesser amounts of intraclastic lime grainstone. Minor amounts of dolomite are present, especially along stylolites and healed joints. Some beds contain fine-grained quartz sand, and the upper 40 percent of the member contains abundant dark chert.

Lime mudstone and lime wackestone constitute about 80 percent of the exposed strata of this member in the Wichita Mountains, and about 80 percent of the fossil collections in the Chandler Creek section come from this member. These percentages are somewhat lower for the lower lime-mudstone member in the U.S. 77 section, where about 45 percent of the limestones are mud supported (mudstones and wackestones); about 70 percent of the fossil collections in this section come from this member. The lower lime-mudstone member averages 11 or 12 trilobite collections per 100 feet of section in both sections, whereas this figure falls to three or four collections per 100 feet of section in the upper grainstone member. In addition, there are decidedly more trilobite specimens per collection from the lower lime-mudstone member than there are per collection from the upper grainstone member.

In the Chandler Creek section, about 80 percent of the trilobites from the lower lime-mudstone member occur in mud-supported rocks (mudstones or wackestones), and 20 percent occur in intraclastic grainstones. However, only certain mudstones are fossiliferous. Most of the thick-bedded limestones in the lower lime-mudstone member are mudstones, and these thick beds are rarely fossiliferous. Many of the trilobites occur in thin seams in the thin- to medium-bedded mudstones and wackestones. The reason for the thinner bedding in these rocks is not apparent. In a similar fashion, only certain grainstones contain trilobites. Although almost all of the intraclastic grainstones are thin to medium bedded, only those intraclastic grainstones that contain some medium to large mudstone intraclasts (clasts with diameters of 1–3 mm or more) contain trilobites. Grainstones that consist only of small mudstone intraclasts (less than 1 mm in diameter) or pellets are unfossiliferous.

Similar relationships between the occurrence of

fossils and the lithology of the limestones occur in the Arbuckle Mountains. Thick-bedded mudstones are usually unfossiliferous, whereas the thin- to medium-bedded mudstones and wackestones are more likely to contain trilobites. Intraclastic grainstones are much more abundant in this member in the U.S. 77 section than in the Chandler Creek section. As in the Chandler Creek section, however, the grainstones with only small mudstone intraclasts or pellets are unfossiliferous, whereas those with some medium to large mudstone intraclasts commonly contain trilobites.

Upper Grainstone Member

The base of the upper grainstone member is not marked in the field by a conspicuous change in bedding character, color, or other weathering features, and probably for this reason it has not been used by previous investigators to subdivide the McKenzie Hill into mappable units. However, the base of the upper grainstone member is the horizon (in both measured sections) above which mud-supported limestones become scarce and intraclastic and pelletal grainstones become dominant, accounting for 75 to 80 percent of the exposed limestone (see descriptions of measured sections).

The top of the upper grainstone member is the base of the overlying Cool Creek Limestone. In the Chandler Creek section, this contact is placed at the base of a distinctive 1-foot–thick bed of coarse, arenaceous oolitic grainstone. In the U.S. 77 section, the base of the Cool Creek is marked by a bed of arenaceous stromatolitic boundstone. The sudden influx of abundant quartz sand, which can easily be seen on weathered surfaces, as well as the presence of abundant stromatolites and ooliths, makes the base of the Cool Creek easy to locate in the field.

The upper grainstone member consists predominantly of intraclastic and pelletal lime grainstones, especially grainstones with small lime-mudstone intraclasts (criteria used here for distinguishing small intraclasts from pellets follow Folk, 1962, p. 63–65). In the field, many of these grainstones look like mudstones, because their dark color makes the pellets and small intraclasts very difficult to see. Lesser amounts of lime mudstone and scattered lime wackestones are present. Dark-gray to black chert nodules are common throughout the member. Minor amounts of dolomite are present, especially along stylolites. Ooliths and scattered quartz sand are also present in some beds, especially near the top of the member. The intraclasts in the grainstones in both members of the McKenzie Hill are invariably composed of lime mudstone. Wackestone or grainstone intraclasts are exceedingly scarce.

Grainstones constitute about 80 percent of the exposed beds in this member, in both the Arbuckle and the Wichita Mountains. Only 20 to 30 percent of the trilobite collections in the McKenzie Hill come from this member, and trilobites become progressively scarcer in the upper part of the member. The upper 88 feet in the Chandler Creek section yielded no trilobites, and the upper 95 feet in the U.S. 77 section yielded only a few unidentifiable trilobite fragments. The grainstone beds that did yield trilobites invariably contain some medium to large lime-mudstone intraclasts. Those grainstones composed entirely of small lime-mudstone intraclasts and pellets rarely contain trilobites.

Depositional History

The McKenzie Hill Limestone in the Arbuckle and Wichita Mountains was deposited on a shallow-marine shelf in an area of continued and rapid subsidence (the Southern Oklahoma Aulacogen). The lower lime-mudstone member of the McKenzie Hill exhibits many of the lithologic characteristics of the underlying Signal Mountain Limestone and probably formed in a similar fashion. As previously suggested (Stitt, 1977, p. 9), a delicate balance between the rate of subsidence and the rate of carbonate accumulation may account for the repeated interbedding of the generally unfossiliferous, thick-bedded lime mudstones, the trilobite lime wackestones, and the intraclastic lime grainstones, the most abundant rock types in the lower lime-mudstone member. The fauna of trilobites, brachiopods, gastropods, conodonts, a few cephalopods, and scattered sponge spicules suggest normal marine salinity during the deposition of this member.

Lime mudstone and trilobite wackestone are the most common rock types in the lower lime-mudstone member, and the fine-grained nature of these carbonates suggests that most of this member was deposited either below effective wave base or at least in areas of low wave and current energy. Occasional storm waves probably scoured the sea floor, eroding the lime mud to form the numerous lime-mudstone intraclasts that occur in the grainstone beds. Some of these grainstones have sharp lower boundaries, and in places (such as CC 2302) small channels filled with intraclastic debris clearly cut into the underlying lime mudstone. Many of the trilobites are preserved in thin beds that may represent wave or current concentrations of fossil debris. The fossils probably were not transported very far, because, although disarticulated, they are not broken or abraded.

The Chandler Creek section may have been closer to the axis of the subsiding Southern Oklahoma Aulacogen, and in slightly deeper or at least in quieter water, than was the U.S. 77 section. This would explain the greater total accumulation of lime mudstone in the lower lime-mudstone

member in the Chandler Creek section, and the higher proportion of grainstones in this member in the U.S. 77 section. The change from the lower lime-mudstone member to the upper grainstone member reflects a long-term change to dominantly shallower water conditions and the formation predominantly of grainstones for the remainder of the formation. The change occurred first in the lower part of the *Bellefontia collieana* Subzone in the U.S. 77 section and later in the upper part of that subzone in the Chandler Creek section (fig. 2), again suggesting that the U.S. 77 section was closer to shallow-water conditions along the side of the aulacogen than was the Chandler Creek section.

The grainstones in the upper grainstone member consist predominantly of pellets and small intraclasts. Fossils are progressively scarcer toward the top of the member, and beds containing fossils generally also contain coarser intraclasts, suggesting hydraulic sorting of some kind. The scarcity of fossils, including a noticeable decline in brachiopods as well as trilobites, suggests that perhaps these shallow-water grainstones accumulated in areas of slightly elevated salinity, which inhibited habitation by the diverse and more abundant marine fauna that characterized the lower lime-mudstone member. Winnowing can hardly explain the absence of fossils, because winnowing would not have carried away the much larger asaphid trilobite exoskeletons and left behind the much finer grained pellets and small intraclasts. I suspect that the water was too shallow, or the salinity too high, and that trilobites, brachiopods, and other marine organisms found most of the area unfavorable for habitation, especially toward the end of McKenzie Hill deposition.

The trend toward shallower water conditions that began in the upper grainstone member con-

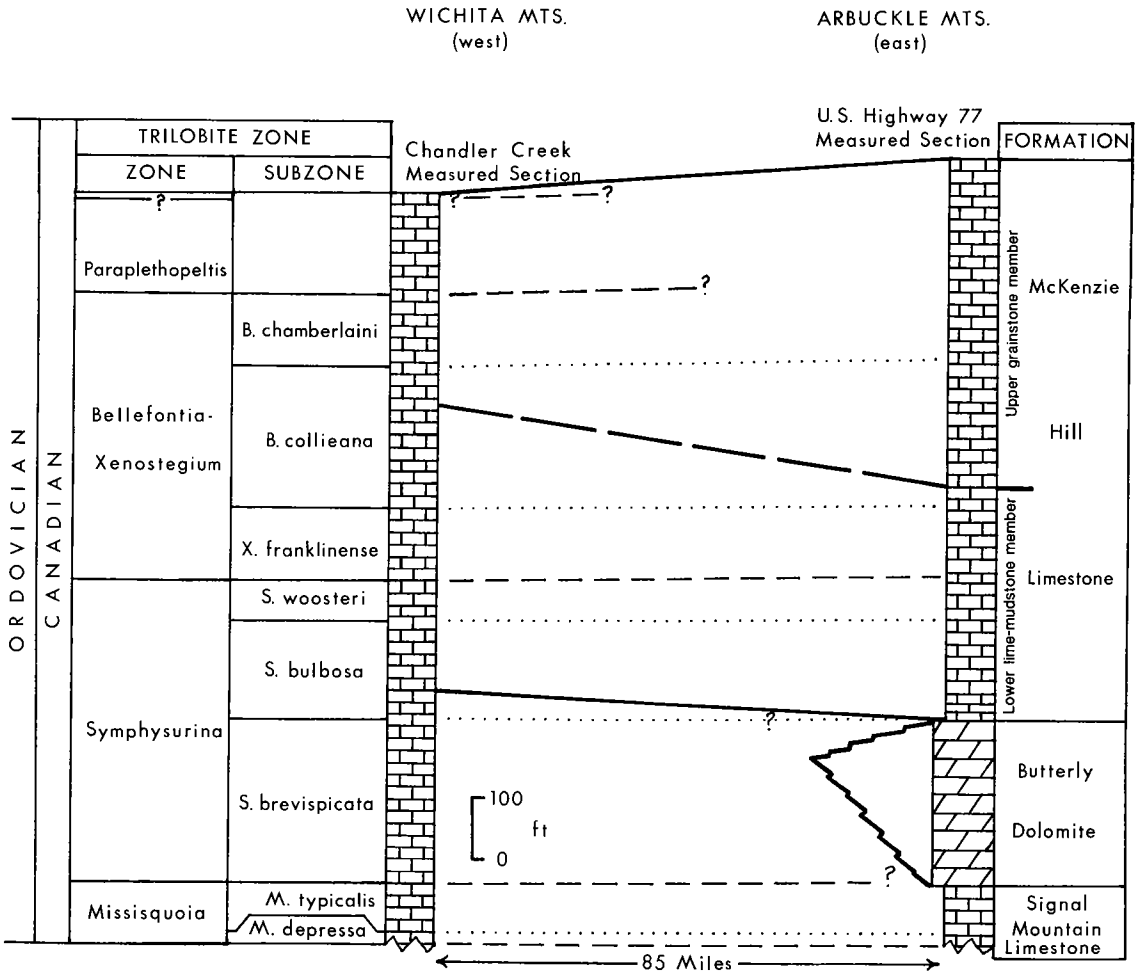

Figure 2. Diagram showing relationships between formations and trilobite zones in lowest Ordovician strata in Wichita and Arbuckle Mountains.

tinued into the overlying Cool Creek Limestone, resulting in many digitate and domal stromatolites (preserved in growth position) and oolitic limestones in the lower part of that formation.

BIOSTRATIGRAPHY

Introduction

Trilobites collected from the McKenzie Hill Limestone in the Arbuckle and Wichita Mountains are assigned to the upper third of the *Symphysurina* Zone, the *Bellefontia–Xenostegium* Zone, and the *Paraplethopeltis* Zone of the Canadian Series of the Lower Ordovician (fig. 3). Because the uppermost part of the McKenzie Hill has not yielded trilobites, I am unable to determine at present whether or not the top of the *Paraplethopeltis* Zone falls within the McKenzie Hill. The *Paraplethopeltis* Zone occupies only a thin interval in Utah and Idaho (Ross, 1951, p. 29; Hintze, 1952, p. 8), and it is possible that the base of the overlying *Leiostegium–Kainella* Zone occurs in the uppermost McKenzie Hill. A "*Leiostegium*?" was reported from the basal part of the overlying Cool Creek Limestone by Cloud and Barnes (1948, p. 372), indicating the probable presence of the *Leiostegium–Kainella* Zone in the lower Cool Creek.

In this paper, Ordovician is used in the North American sense (see Stitt, 1977, p. 25). The hierarchy of other stratigraphic terms used in the biostratigraphic discussion is shown in figure 3. The new subzones proposed here follow the guidelines and philosophy previously discussed (Stitt, 1971b, p. 7–8) and followed (Stitt, 1977, p. 10–36) for the underlying strata.

The entire Lower Ordovician sequence that has been studied in detail thus far in the Wichita and Arbuckle Mountains is summarized in figure 2, which shows the relationships between the formations and the biostratigraphic zones and subzones in the Chandler Creek and U.S. 77 sections. Plate 7 (in pocket) shows the combined ranges of all of the identified trilobites for this interval. Figure 2 reveals at least three interesting aspects of the overall stratigraphy. First, the *Symphysurina woosteri*, *Xenostegium franklinense*, and *Bellefontia collieana* Subzones each occupy almost exactly the same stratigraphic thickness in each section. Second, if the Cambrian–Ordovician boundary (= base of the *Missisquoia* Zone) is drawn as a horizontal datum between these two sections, the lines connecting the bases of each of these three subzones and the bases of the *Bellefontia chamberlaini* Subzone are parallel to the boundary. Each subzonal boundary maintains a constant stratigraphic thickness above the Cambrian–Ordovician boundary. Assuming that these subzonal boundaries are the best time-stratigraphic horizons presently available for correlations between the Wichita and Arbuckle Mountains, the parallelism of the Cambrian–Ordovician boundary and these subzonal boundaries means that the rate of sediment accumulation for this interval was remarkably uniform over this large area.

A third important observation that can be made for the first time is that the Butterly Dolomite in the U.S. 77 section occupies almost exactly the interval of the *Symphysurina brevispicata* Subzone in the Chandler Creek section, as was tentatively suggested earlier (Stitt, 1977, fig. 2; p. 33). If the base of the *Symphysurina bulbosa* Subzone maintains a constant stratigraphic thickness above the Cambrian–Ordovician boundary, as do the bases of the overlying subzones (and as I have drawn it in fig. 2), then the base of the *S. bulbosa* Subzone should fall almost exactly at the base of the McKenzie Hill Limestone in the U.S. 77 section. This interpretation is explained in more detail in the discussion of the *S. bulbosa* Subzone that follows.

The thickest zone in the McKenzie Hill Limestone is the *Bellefontia–Xenostegium* Zone, which occurs in the middle half of the formation (fig. 2). This interval in the Wichita and Arbuckle Mountains contains a mixture of trilobites that were known individually from the western, midcontinental, or eastern United States, but had not been previously reported as occurring together. The joint occurrences and overlapping stratigraphic ranges of these regionally important trilobites in the Chandler Creek and U.S. 77 sections enables better correlations to be made between the predominantly dolomitic Lower Ordovician strata of the eastern and midcontinental United States and the predominantly limestone strata of the Lower Ordovician of the western United States.

Trilobite Zones

Symphysurina Zone

The *Symphysurina* Zone in Oklahoma is divided into three subzones (figs. 2, 3)—a lower *Symphysurina brevispicata* Subzone (Stitt, 1977, p. 32–33), which is the thickest of the subzones, occupying slightly more than one-half of the *Symphysurina* Zone in the Chandler Creek section; a middle *Symphysurina bulbosa* Subzone; and an upper *Symphysurina woosteri* Subzone, which is the thinnest of the subzones (pl. 7). There is no evidence that the *S. brevispicata* Subzone extends into the McKenzie Hill Limestone, and it is not discussed here.

Symphysurina bulbosa Subzone.—In the Chandler Creek section, this subzone begins in the uppermost part of the underlying Signal Mountain Limestone (Stitt, 1977, p. 32, 52; pl. 7) and continues into the lower part of the McKenzie Hill Limestone (figs. 2, 5). The entire assemblage of

SYSTEM	SERIES	ZONE	SUBZONE	BIOMERE
Ordovician	Canadian	*Leiostegium-Kainella*		
		Paraplethopeltis		Symphysurinid
		Bellefontia-Xenostegium	*Bellefontia chamberlaini*	
			Bellefontia collieana	
			Xenostegium franklinense	
		Symphysurina	*Symphysurina woosteri*	
			Symphysurina bulbosa	
			Symphysurina brevispicata	
		Missisquoia	*Missisquoia typicalis*	
			Missisquoia depressa	

Figure 3. Diagram summarizing chronostratigraphic and biostratigraphic nomenclature used in this paper.

species occurring in the subzone is listed below, and those taxa that are restricted to the subzone are indicated by an asterisk.

Clelandia texana Winston and Nicholls
Hystricurus millardensis Hintze
Hystricurus hillyardensis Stitt, n. sp.
Mannschreekia parva Stitt, n. gen. and n. sp.*
Symphysurina brevispicata Hintze
Symphysurina bulbosa Lochman
Unassigned pygidium no. 1 Stitt*
Unassigned pygidium no. 2 Stitt*

All of these taxa occur in both the Signal Mountain and the McKenzie Hill, except Unassigned pygidium no. 1, which is restricted to the Signal Mountain, and *Hystricurus hillyardensis* and *Mannschreekia parva*, which occur only in the McKenzie Hill.

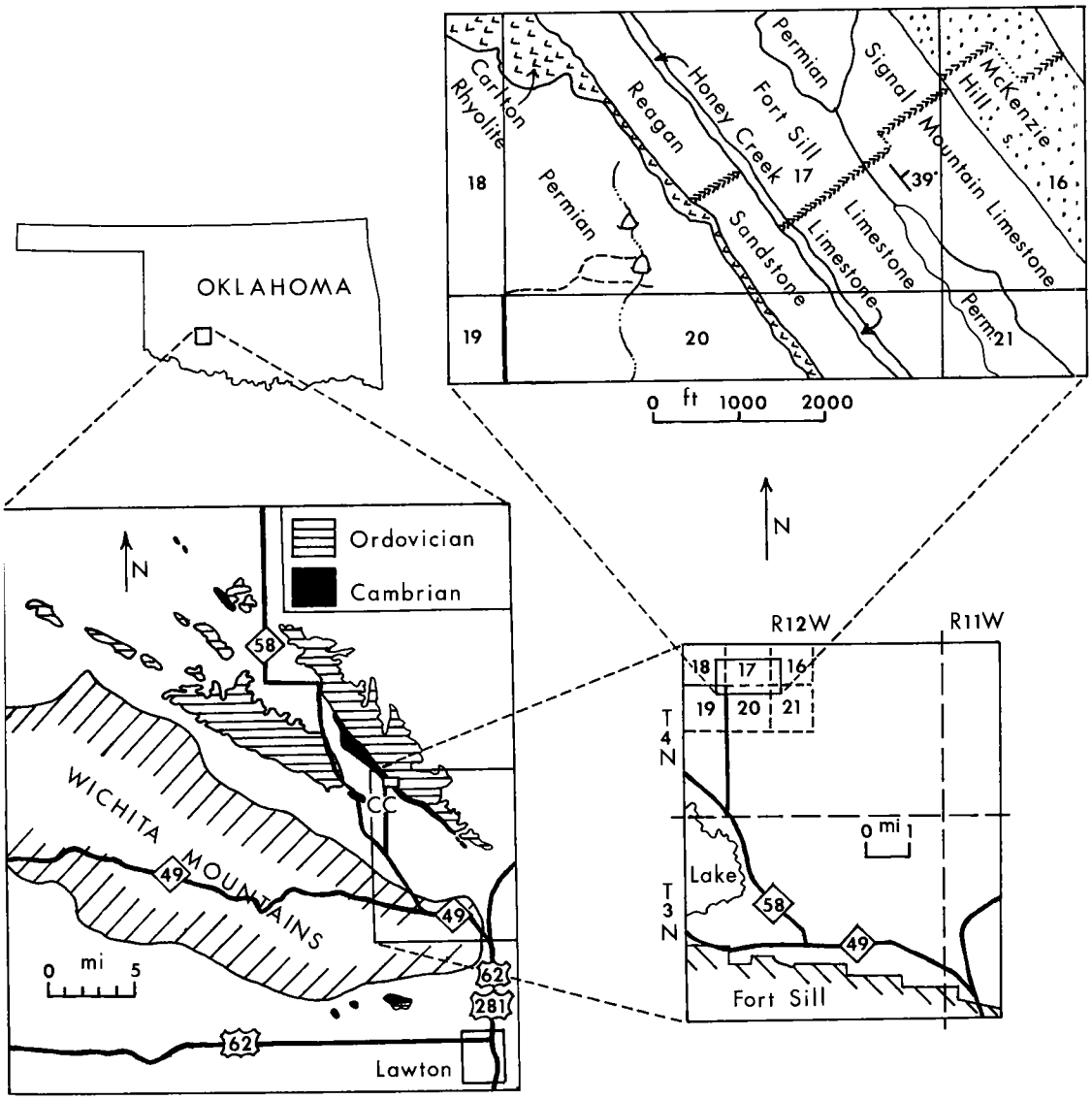

Figure 4. Maps showing regional geologic setting of Wichita Mountains, and location and geology of area surrounding Chandler Creek section (CC). Trace of section shown by chevron pattern.

The base of this subzone in the Chandler Creek section is defined by the lowest occurrence of *Symphysurina bulbosa*, which is the only abundant species to range throughout the subzone. The top of this subzone in both the Chandler Creek and the U.S. 77 sections is the base of the overlying *Symphysurina woosteri* Subzone. The base of the *S. bulbosa* Subzone in the U.S. 77 section is not as easy to resolve. As mentioned earlier, there is a strong possibility that the base of the *S. bulbosa* Subzone may occur at or near the base of the McKenzie Hill Limestone (figs. 2, 7). Unfortunately, the lowest beds of the McKenzie Hill in this section are almost unfossiliferous, consisting mostly of intraclastic lime grainstones with pellets and small mudstone intraclasts, and thick-bedded lime mudstones, the two lithologies least likely to yield fossils in this formation. The lowest occurrence of *S. bulbosa* is 93 feet above the base of the formation; only two specimens of *Hystricurus millardensis* have been collected closer to the base of the formation, and that species occurs also in the underlying *S. brevispicata* Subzone. I suspect, although I cannot prove, that if the beds at the base of the McKenzie Hill in the U.S. 77 section were fossiliferous, they would contain specimens of *S. bulbosa*. From the correlation in the Wichita Mountains, shown in figure 2, I interpret that the base of the *S. bulbosa* Subzone probably occurs very close to the base of the McKenzie Hill Limestone, and that those strata from the base of the formation to the base of the *S. woosteri* Subzone

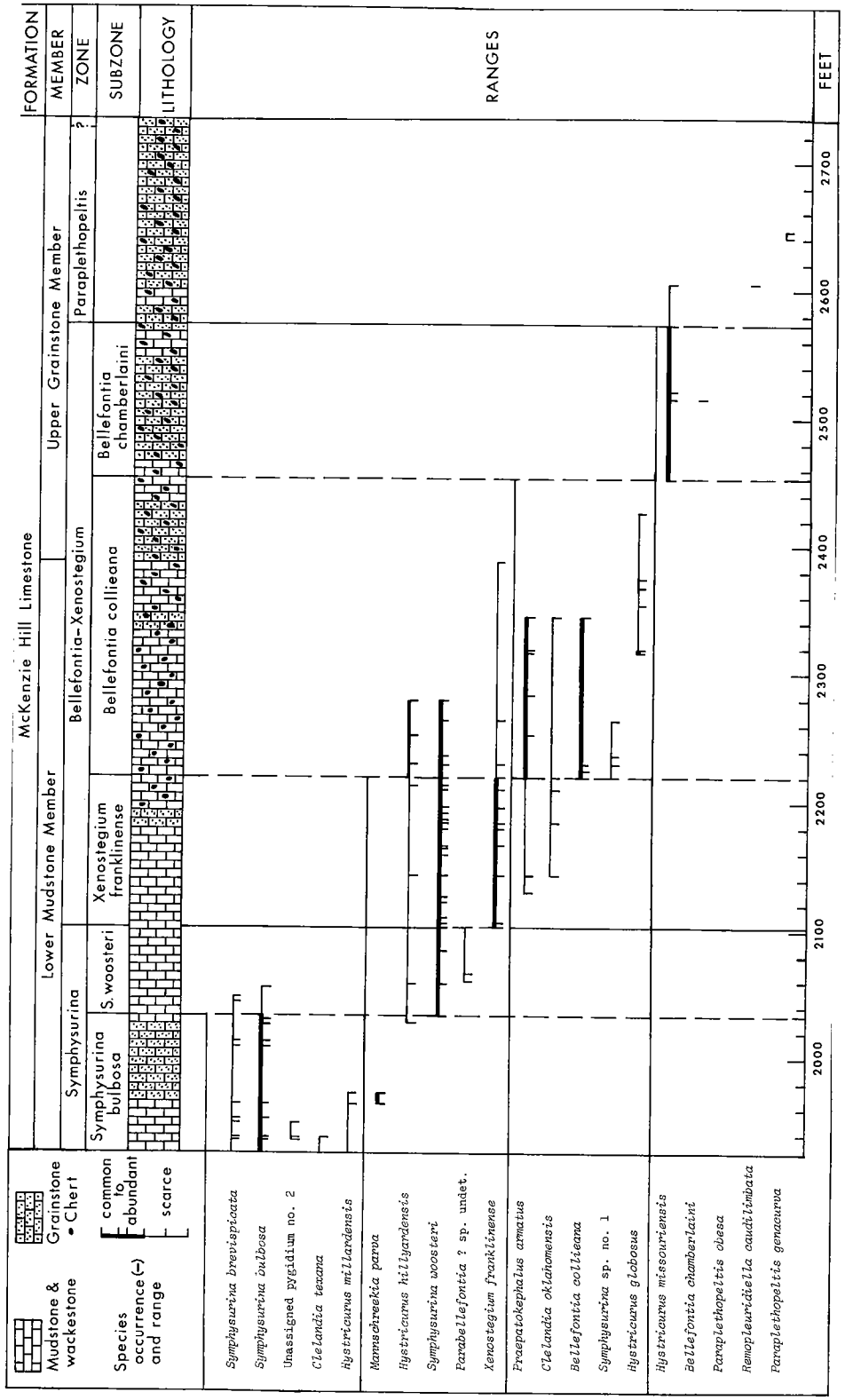

Figure 5. Diagram showing stratigraphic occurrences and ranges of identified trilobites, Chandler Creek section (CC).

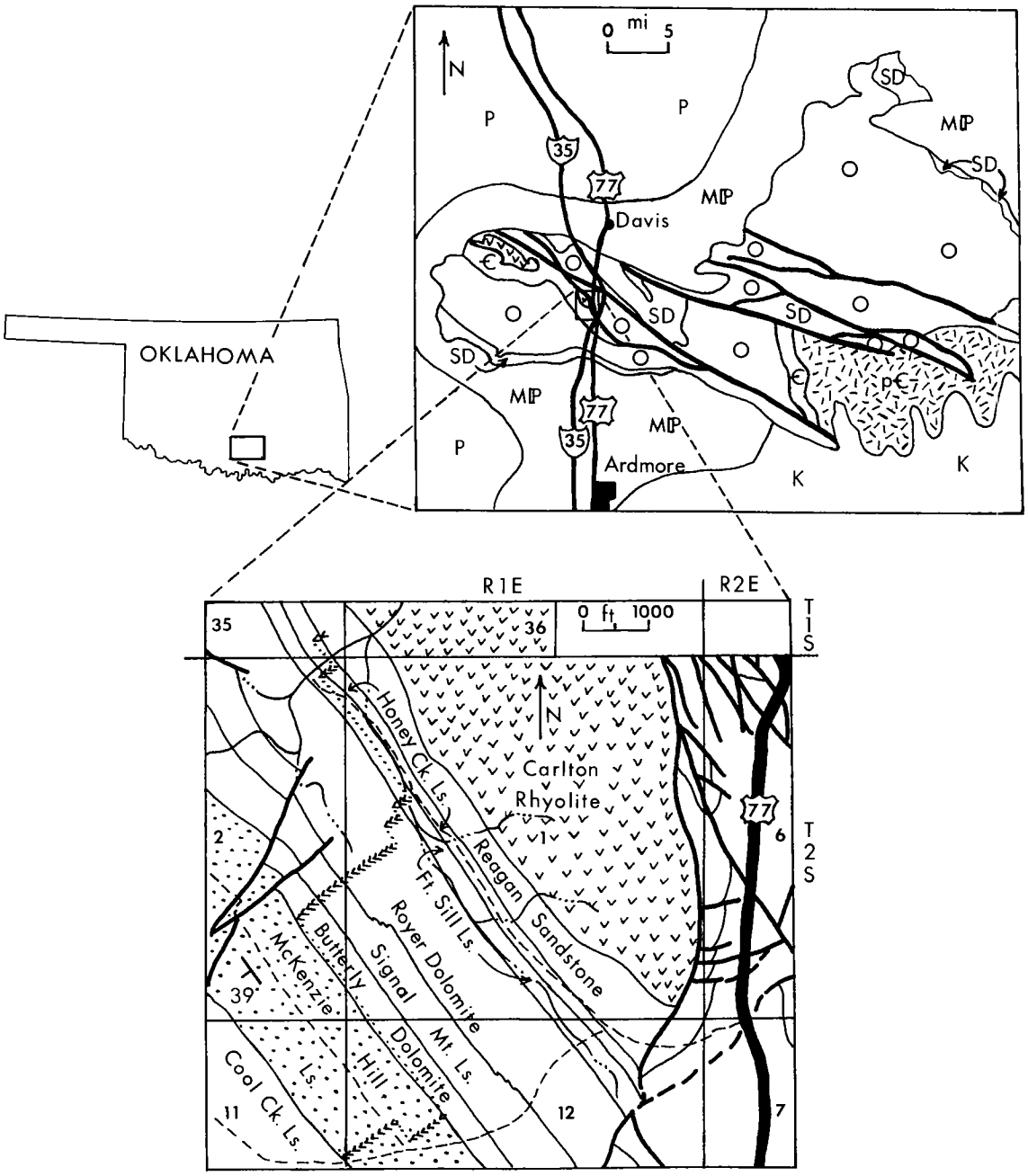

Figure 6. Maps showing regional geologic setting of Arbuckle Mountains, and location and geology of area surrounding U.S. Highway 77 section (HS). Trace of section shown by chevron pattern.

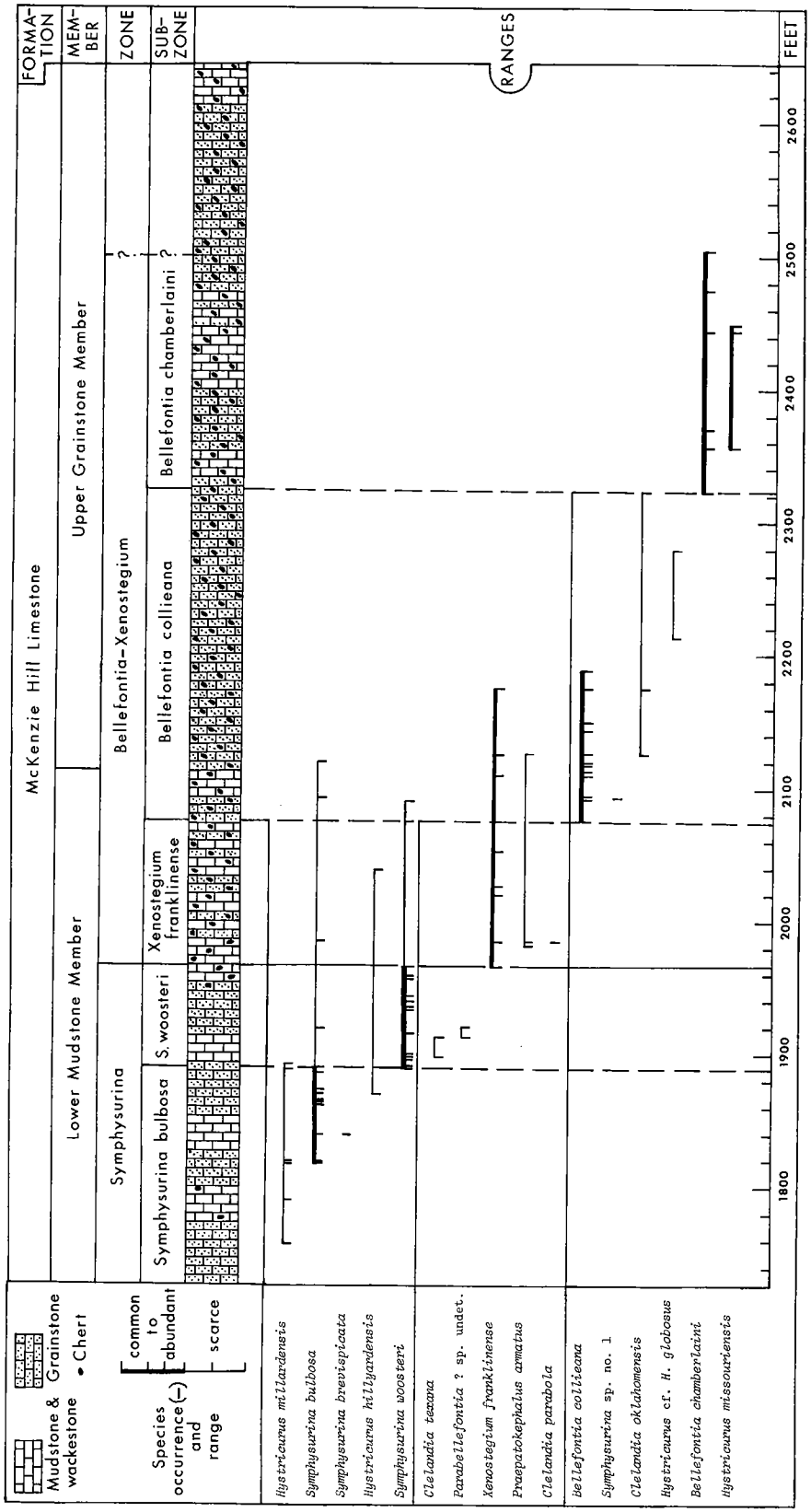

Figure 7. Diagram showing stratigraphic occurrences and ranges of identified trilobites, U.S. Highway 77 section (HS).

constitute the interval of the *S. bulbosa* Subzone in the U.S. 77 section.

Correlation of the *Symphysurina bulbosa* Subzone.—Of the taxa that make their first appearance in this subzone, *Hystricurus hillyardensis*, *Symphysurina bulbosa*, and Unassigned pygidium no. 2 Stitt are rather widespread and therefore potentially useful for correlations. *H. hillyardensis* is scarce and long ranging, both in Oklahoma (figs. 5, 7; pl. 7) and in central Texas (Winston and Nicholls, 1967, p. 76; Stitt, 1977, p. 34, fig. 10). Its lowest occurrence in Texas is in the underlying *S. brevispicata* Subzone in the upper part of the Wilberns Formation. This taxon was originally described as *Hystricurus* sp. D from the lower Garden City Formation in Idaho by Ross (1951, p. 14–16, 54), where it was part of his Zone A trilobite assemblage. Taylor and others (1981, p. 224–225) reported a pygidium similar to Unassigned pygidium no. 2 Stitt from the lower part of the Garden City Formation in Idaho. They used this taxon and others they collected to show that the Zone A fauna of Ross from the lowest Garden City Formation was equivalent to the faunas of the uppermost *S. brevispicata* Subzone and the *S. bulbosa* Subzone, which occur in the uppermost Signal Mountain Limestone and lowest McKenzie Hill Limestone in Oklahoma (fig. 2).

Symphysurina bulbosa was originally described from the subsurface Deadwood Formation in the Williston Basin (Lochman, 1964, p. 457, 470–471), where it occurs 30–40 feet below several collections of trilobites from the *Bellefontia–Xenostegium* Zone. Recently, Stitt and others (1981, p. 33–36) reported the *S. bulbosa* Subzone from the upper 16 feet of the Wilberns Formation in central Texas.

Symphysurina woosteri Subzone.—The following assemblage of species occurs in this subzone (figs. 5, 7; pl. 7), but none of these taxa are restricted to it.

Clelandia texana Winston and Nicholls
Hystricurus millardensis Hintze
Hystricurus hillyardensis Stitt, n. sp.
Parabellefontia? sp. undet.
Symphysurina brevispicata Hintze
Symphysurina bulbosa Lochman
Symphysurina woosteri Ulrich

The base of this subzone is defined by the lowest occurrence of *Symphysurina woosteri*, which is the type species of *Symphysurina* and the only abundant species in this subzone. All other taxa are rather scarce. *Hystricurus millardensis* and *Symphysurina brevispicata* end their long stratigraphic ranges in the lower part of this subzone, as does *Clelandia texana*. The unusual, narrow-bordered pygidia tentatively assigned to *Parabellefontia* occur in the middle of the subzone. The top of this subzone is the base of the overlying *Bellefontia–Xenostegium* Zone.

Correlation of the *Symphysurina woosteri* Subzone.—*Symphysurina woosteri* had a wide geographic range, having been reported from (1) the Cass Fjord Formation in eastern Greenland (Poulsen, 1937, p. 40), (2) near the top of the Conococheague Formation in Maryland (Sando, 1957, p. 137), (3) the Oneota Dolomite in Wisconsin (Walcott, 1925, p. 115–116), (4) the basal House Limestone in Nevada (Hintze, 1952, p. 73), (5) the basal Garden City Formation in Idaho (Ross, 1951, p. 18; Taylor and others, 1981, p. 224), (6) the subsurface Deadwood Formation in the Williston Basin in Montana (Lochman, 1964, p. 471), (7) British Columbia (Walcott, 1924a, p. 37), and (8) Jones Ridge near the Yukon-Alaska boundary (Kobayashi, 1936, p. 164). In most of these localities, *S. woosteri* does not occur with other taxa that would aid in assigning the collection to either the *Symphysurina* Zone or the *Bellefontia–Xenostegium* Zone. In Nevada, Idaho (Taylor and others, 1981), and Montana, *S. woosteri* occurs with other trilobites that are indicative of the *Bellefontia–Xenostegium* Zone (=Zone B of Ross, 1951, p. 29), a situation that occurs also in Oklahoma (figs. 5, 7; pl. 7), where *S. woosteri* ranges up into the *Bellefontia–Xenostegium* Zone. In one locality in Idaho, however, *S. woosteri* occurs 35 feet *below* the lowest occurrence of the *Bellefontia–Xenostegium* fauna (Ross, 1951, p. 18) and apparently is mixed with other species of *Symphysurina*. This is also the situation in Oklahoma, where *S. woosteri* has its lowest occurrence at 70–77 feet below the base of the *Bellefontia–Xenostegium* Zone, and occurs with *S. bulbosa* and *S. brevispicata*.

It is unfortunate that continuously fossiliferous sections through the biostratigraphic interval of the *S. woosteri* Subzone are apparently very hard to find. One hopes that future discoveries of such sections will show that *S. woosteri* does have a consistent and abundant lowest occurrence below the lowest occurrence of the *Bellefontia–Xenostegium* fauna. If that proves to be true, the *S. woosteri* Subzone as recognized in Oklahoma will be as useful a biostratigraphic unit as the underlying *S. bulbosa* and *S. brevispicata* Subzones, which are proving to be most useful in intracontinental correlations in the lowest Ordovician in North America.

Bellefontia–Xenostegium Zone

The *Bellefontia–Xenostegium* Zone extends through most of the McKenzie Hill Formation (fig. 2). The base of this zone in the Wichita and Arbuckle Mountains is defined by the lowest occurrence of *Xenostegium franklinense*. The top of the zone in the Chandler Creek section is the base of the overlying *Paraplethopeltis* Zone. Because no specimens of *Paraplethopeltis* were recovered in the U.S. 77 section, the base of the *Para-*

plethopeltis Zone cannot be located in this section, and the upper part of the *Bellefontia–Xenostegium* Zone fades into an unfossiliferous interval of limestone.

The *Bellefontia–Xenostegium* Zone is divided into three subzones (figs. 2, 3): a lower *Xenostegium franklinense* Subzone, a middle *Bellefontia collieana* Subzone, which is the thickest of the subzones, and an upper *Bellefontia chamberlaini* Subzone. The faunal content of the *Bellefontia–Xenostegium* Zone will be discussed in terms of the overlapping ranges of trilobite assemblages that characterize each subzone.

The *Bellefontia–Xenostegium* Zone is equivalent to Zone B of Ross (1951, p. 29) and the upper half of the *Symphysurina* (B) Zone of Hintze (1952, p. 608; see, for example, Taylor and others, 1981, p. 225, fig. 2). Because the "B" zones of Ross and Hintze are not equivalent, I prefer to refer to this biostratigraphic interval as the *Bellefontia–Xenostegium* Zone. Using the names of the two most characteristic genera presents an unambiguous nomenclatorial designation for the interval.

The *Bellefontia–Xenostegium* Zone in the Chandler Creek and U.S. 77 sections contains not only some of the familiar, geographically widespread trilobites from this interval in the Great Basin, but also several species known from isolated localities in the Appalachian Mountains, Missouri, and Texas that can now be placed in a more useful biostratigraphic context. Several new taxa from Oklahoma also can be added to the known fauna from this interval. Detailed correlations with these and other areas are discussed.

Xenostegium franklinense Subzone.—The following assemblage of species occurs in this subzone (figs. 5, 7; pl. 7), and those taxa that are restricted to the subzone are indicated by an asterisk.

Clelandia oklahomensis Stitt, n. sp.
Clelandia parabola (Cleland)*
Hystricurus hillyardensis Stitt, n. sp.
Parabellefontia? sp. undet.
Praepatokephalus armatus (Hintze)
Symphysurina bulbosa Lochman
Symphysurina woosteri Ulrich
Xenostegium franklinense Ross

The base of this subzone is defined by the lowest occurrence of *Xenostegium franklinense*, which, along with *Symphysurina woosteri*, are the most common trilobites in this subzone. *Clelandia parabola*, the type species of *Clelandia*, and *Parabellefontia*? sp. undet. occur only in the lower part of the subzone. The other taxa are scarce but range through most of the subzone. The top of this subzone is the base of the overlying *Bellefontia collieana* Subzone.

Bellefontia collieana Subzone.—The following assemblage of species occurs in this subzone (figs. 5, 7; pl. 7), and those taxa that are restricted to the subzone are indicated by an asterisk.

Bellefontia collieana (Raymond)*
Clelandia oklahomensis Stitt, n. sp.
Hystricurus globosus Stitt, n. sp.*
Hystricurus hillyardensis Stitt, n. sp.
Praepatokephalus armatus (Hintze)
Symphysurina bulbosa Lochman
Symphysurina woosteri Ulrich
Symphysurina sp. no. 1*
Xenostegium franklinense Ross

The base of this subzone is defined by the lowest occurrence of *Bellefontia collieana*, the type species of *Bellefontia*. *Symphysurina* sp. no. 1 also occurs in the basal bed of this subzone in the Chandler Creek section. *B. collieana*, *Symphysurina woosteri*, *Praepatokephalus armatus* (the type species of *Praepatokephalus*), and *Symphysurina woosteri* are all common to abundant in the lower half of the subzone. *Clelandia oklahomensis* and *Hystricurus globosus* are most abundant in certain beds.

The base of the upper lime grainstone member of the McKenzie Hill falls within this subzone in both the Arbuckle and the Wichita Mountains (fig. 2), and the limestones in this member become progressively less fossiliferous upsection. Many of the long-ranging trilobites of the *Symphysurina* and *Bellefontia–Xenostegium* Zones, such as *Symphysurina bulbosa*, *S. woosteri*, *Hystricurus hillyardensis*, *Xenostegium franklinense*, and *Praepatokephalus armatus*, end their stratigraphic ranges in the lower and middle parts of this subzone. The top of this subzone is the base of the overlying *Bellefontia chamberlaini* Subzone.

Bellefontia chamberlaini Subzone.—The following assemblage of species occurs in this subzone (figs. 5, 7; pl 7). Because the rocks in this interval are sparsely fossiliferous, the top of this subzone can be determined only in the Chandler Creek section. Therefore, I cannot reliably determine whether any of these taxa are restricted to this subzone, although *Bellefontia chamberlaini* may be.

Bellefontia chamberlaini Clark
Clelandia oklahomensis Stitt, n. sp.
Hystricurus missouriensis Ulrich

The base of this subzone is defined by the lowest occurrence of either *Bellefontia chamberlaini* or *Hystricurus missouriensis*, which are the common taxa in the subzone. *Clelandia oklahomensis* is present only at the base of the subzone in the U.S. 77 section.

The top of this subzone in the Chandler Creek section is the base of the overlying *Paraplethopeltis* Zone. In the U.S. 77 section, however, none of the diagnostic taxa of the *Paraplethopeltis* Zone were recovered, and therefore the base of the *Paraplethopeltis* Zone, which is the top of the

Bellefontia chamberlaini Subzone, cannot be determined in this section. The top of this subzone in the U.S. 77 section undoubtedly lies somewhere in the unfossiliferous upper 140 feet of the McKenzie Hill Limestone.

Correlation of the *Bellefontia–Xenostegium* Zone.—The subzones of the *Bellefontia–Xenostegium* Zone that I have established in the Arbuckle and Wichita Mountains are most useful for correlations between these two areas, but similar subzones have not been recognized in other areas where this fauna occurs. Ross (1951) and Hintze (1952) studied the entire Canadian Series in their classic studies of this interval in Idaho, Utah, and Nevada, and they relied almost entirely on silicified fossils for their biostratigraphic data. The zones they established have been widely used for correlations by other workers, a testament to their reliability. However, beds with abundant silicified fossils were not continuously available through the interval of the *Bellefontia–Xenostegium* Zone in any of the measured sections that they studied. This resulted in gaps of varying stratigraphic thickness between their collections that are usually greater than the gaps I found in collecting this zone in the Chandler Creek and U.S. 77 sections. This has made direct comparison of the ranges of individual taxa rather difficult. In addition, it appears that some of the key taxa in this interval in other areas (as reported in the literature) have ranges that are different from those in Oklahoma. This has made it impractical if not impossible at this time to extend into other areas the subzones of the *Bellefontia–Xenostegium* Zone that I have established and found useful in Oklahoma.

The individual taxa that characterize the *Bellefontia–Xenostegium* Zone in Oklahoma have been reported from many other areas, although the assemblage found in the Arbuckle and Wichita Mountains is not duplicated elsewhere. The occurrences of these taxa can be used to help correlate this part of the McKenzie Hill with equivalent strata in other parts of North America. *Xenostegium franklinense*, *Bellefontia chamberlaini*, and *Praepatokephalus armatus* are known in various combinations from the lower House Limestone in western Utah (Hintze, 1952, p. 7), the lower Garden City Formation in northeastern Utah and southeastern Idaho (Ross, 1951, p. 29, 99, 103; Taylor and others, 1981, p. 224), the lower Manitou Formation in Colorado (Berg and Ross, 1959, p. 113), and the subsurface Deadwood Formation in the Williston Basin in Montana (Lochman, 1964, p. 455–456). *Bellefontia collieana* is known from the Stonehenge Limestone in Pennsylvania (Bassler, 1919, p. 347) and Maryland (Sando, 1957, p. 135–136). *Hystricurus missouriensis* is known from the Gasconade Dolomite in Missouri (Ulrich *in* Bridge, 1930, p. 216) and the Tanyard Formation in central Texas (Cloud and Barnes, 1948, p. 449). *Clelandia parabola* is known from the Fonda Member of the Tribes Hill Formation in New York (Cleland, 1900, p. 255–256; Fisher, 1954, p. 90).

This mixture of trilobites in the *Bellefontia–Xenostegium* Zone in Oklahoma, previously known only from separate areas in the western, eastern, or midcontinental United States, helps to confirm the earlier correlation of these formations (based primarily on conodonts) by Ross (1976, p. 78–79, text-fig. 3). It also supports his interpretation (Ross, 1976, p. 81, text-fig. 5) of a fairly direct marine connection between Oklahoma and the Great Basin area.

Paraplethopeltis Zone

The following assemblage of species occurs in this zone at the Chandler Creek section only (fig. 5). None of these taxa were recovered from the U.S. 77 section (fig. 7), and hence this zone is not recognized at present in that section.

Hystricurus missouriensis Ulrich
Paraplethopeltis genacurva Hintze
Paraplethopeltis obesa Bridge and Cloud
Remopleuridiella caudilimbata Ross

The upper part of the McKenzie Hill is very unfossiliferous, as has been discussed. The discovery of *Paraplethopeltis obesa* at CC 2572, which marks the base of the *Paraplethopeltis* Zone, should be viewed as the lucky recovery of a scarce taxon rather than the lowest occurrence of a new and abundant fauna. In fact, the *Paraplethopeltis* Zone fauna is known from only five collections that span 75 feet in the Chandler Creek section. This fauna might not be recognized as a separate zone except that it can be used for biostratigraphic correlations to Texas, Colorado, and the Great Basin, utilizing the restricted range of *Paraplethopeltis* in these areas.

No top can be defined at present for the *Paraplethopeltis* Zone, because the 88 feet of strata above the highest occurrence of *Paraplethopeltis genacurva* yielded no identifiable trilobites. I expected to discover in the uppermost beds of the McKenzie Hill the lowest occurrence of trilobites characteristic of the *Leiostegium–Kainella* Zone, which overlies the *Paraplethopeltis* Zone in other areas. However, none of these trilobites were recovered, so the location of the top of the *Paraplethopeltis* Zone (=base of the *Leiostegium–Kainella* Zone) must await future collectors with better luck than I had, or a thorough faunal study of the overlying and apparently sparsely fossiliferous Cool Creek Limestone.

Initial results of a brief reconnaissance study of the conodonts of the unfossiliferous upper part of the McKenzie Hill Limestone (Ethington, 1982, oral communication) suggest that the base of the *Leiostegium–Kainella* Zone occurs in the lower

part of the Cool Creek Limestone. A dozen small hand samples from the upper 100 feet of the McKenzie Hill in both sections were dissolved in acetic acid, and a few conodonts were recovered. In the Ibex area of Utah (Ethington and Clark, 1981, p. 7; fig. 3), conodonts of the *Loxodus bransoni* interval abruptly become extinct at the top of the *Paraplethopeltis* (C) Zone of Hintze (1952, p. 8), at the top of the House Limestone. A new conodont fauna characterized by *Drepanoistodus basiovalis* and aff. *Scolopodus rex* makes its lowest appearance in the basal Fillmore Formation (Ethington and Clark, 1981, p. 8; fig. 3), along with the trilobites of the *Leiostegium–Kainella* (D) Zone (Hintze, 1952, p. 9). Identifiable conodonts of the *Loxodus bransoni* fauna were recovered from hand samples 10 and 38 feet below the top of the McKenzie Hill in the Chandler Creek section, suggesting that the *Paraplethopeltis* Zone probably extends to the top of the formation in that section. Thus, the base of the overlying *Leiostegium–Kainella* Zone probably occurs in the lower part of the overlying Cool Creek Limestone. Cloud and Barnes (1948, p. 372) reported a "*Leiostegium*?" from about 40 feet above the base of the Cool Creek in the Wichita Mountains, an occurrence that supports the conodont data.

Conodont samples from the U.S. 77 section yielded similar results. Hand samples from 19, 27, and 52 feet below the top of the McKenzie Hill yielded conodonts of the *Loxodus bransoni* fauna, suggesting that the *Paraplethopeltis* Zone extends at least this high in the U.S. 77 section. Unfortunately, the dissolved hand samples from higher in the section yielded no conodonts, so nothing more precise about the location of the base of the *Leiostegium–Kainella* Zone in this section can be stated at present.

Correlation of the *Paraplethopeltis* Zone.—The *Paraplethopeltis* Zone as defined in the Chandler Creek section is not precisely equivalent to Zone C of Ross (1951, p. 29; also see Berg and Ross, 1959, p. 111) or the *Paraplethopeltis* (C) Zone of Hintze (1952, p. 8). That zone is defined by a trilobite fauna of several species (Hintze, 1952, p. 201–203; Berg and Ross, 1959, p. 112–113) that occurs in a thin interval (1) at the top of the House Limestone in western Utah (Hintze, 1952, p. 8), (2) in the Manitou Formation in Colorado (Berg and Ross, 1959, p. 107, text-fig. 1), and (3) in the Garden City Formation in southeastern Idaho (Ross, 1951, p. 16, 29, 56, 116). This trilobite fauna does not include *Paraplethopeltis obesa*, whose single occurrence in the Chandler Creek section defines a biostratigraphically lower base for the *Paraplethopeltis* Zone in Oklahoma than was used by Ross and Hintze in Utah and Idaho. Confirming that the base of this zone is lower in Oklahoma than in Utah and Idaho is the occurrence of *Remopleuridiella caudilimbata*, which is above *P. obesa* but below *Paraplethopeltis genacurva* in the *Paraplethopeltis* Zone in Oklahoma, but is confined to the upper part of the underlying Zone B in Idaho (Ross, 1951, p. 16) and Utah (Hintze, 1952, p. 29–30).

The *Paraplethopeltis* (C) Zone in Utah and Idaho is defined by the short stratigraphic ranges of *Paraplethopeltis genacurva* and *Paraplethopeltis genarecta* and their probable synonyms (see discussions by Hintze, 1952, p. 22; Berg and Ross, 1959, p. 112–113). *P. genacurva* also occurs at Chandler Creek, where it ranges through 5 feet of strata and is the stratigraphically highest taxon recovered in the McKenzie Hill Limestone. However, the conodont data previously presented suggest that the *Paraplethopeltis* Zone is much thicker in Oklahoma than it is in Utah and Idaho. These data suggest also that the top of the McKenzie Hill Limestone may correlate closely with the top of the House Limestone.

Paraplethopeltis obesa, the type species of this genus, was originally described from central Texas (Bridge and Cloud, 1947, p. 555–558). In Texas, *P. obesa* occurs in the upper 90–100 feet of the Tanyard Formation. In the Chandler Creek section, this species is known from only one collection that is 163 feet below the top of the McKenzie Hill. Considering the faster rate of sediment accumulation in the Southern Oklahoma Aulacogen, and the conodont data previously discussed, the top of the McKenzie Hill probably correlates rather well with the top of the Tanyard Formation, as suggested by Cloud and Barnes (1948, p. 64; pl. 15).

Symphysurinid Biomere

The biomere concept was introduced by Palmer (1965a, p. 149–150), who defined a biomere as "a regional biostratigraphic unit bounded by abrupt nonevolutionary changes in the dominant elements of a single phylum." In addition to the abrupt extinctions that characterize the boundaries, the biomere was a genetic package, with the abundant species and genera of a particular biomere belonging to families that either become extinct at the end of that biomere or were, at best, minor elements of the faunas that preceded or succeeded the biomere in which they were abundant. The Pterocephaliid Biomere (Palmer, 1965b) and the Ptychaspid Biomere (Longacre, 1970; Stitt, 1971b, 1977) have been described in detail, and older trilobite biomeres (Palmer, 1965a; Stitt, 1977, p. 19, fig. 4) can be recognized. Stitt (1971a; 1975; 1977, p. 18–21) suggested that the trilobite populations in the Pterocephaliid and Ptychaspid Biomeres passed through four evolutionary stages, beginning with an initial adaptive radiation (stage 1), followed by a period of consolidation (stage 2), which in turn was succeeded by a secondary expansion of the successful lineages (stage 3). A pronounced extinction oc-

curred at the end of stage 3 (Stitt, 1971a, p. 181; 1975, p. 385; 1977, p. 20), eliminating most of these trilobites, and the few survivors struggled on through a thin stratigraphic interval (stage 4) to their ultimate extinction as the biomere ended.

Palmer (1979) recently suggested redefining the boundaries of the biomeres (based on some additional detailed collecting), arguing that the most dramatic extinction occurs at the end of stage 3, and that this horizon should be recognized as the end of the biomere. Palmer would then recognize stage 4 (of Stitt) as the start of the next biomere. I do not agree with Palmer's proposed redefinition of the biomere concept, because important and abundant taxa (such as *Irvingella major* and *Corbinia apopsis*) from the dominant families of the Pterocephaliid and Ptychaspid Biomeres occur in stage 4 of these biomeres (as originally defined), and to change the biomere concept as Palmer proposed would place these taxa in the overlying biomere. Thus, the base of the overlying biomere would be *defined* by important and abundant elements from the dominant families of the underlying biomere, which would destroy the important concept of the phylogenetic entity of a biomere. I do not believe that it is necessary to redefine the biomere concept in order to discuss the dynamic changes that occur at biomere boundaries. In the discussion that follows, the original concept of the biomere is used.

Although Shaw and Fortey (1977, p. 435) suggested that no biomeres occur in the Ordovician, an extinction similar to those that characterize the boundaries of Cambrian biomeres occurs at the top of the *Paraplethopeltis* (or C) Zone. The trilobite genera that are abundant and that characterize the interval between the base of the *Missisquoia* Zone (= base of the Ordovician System in North America) and the top of the *Paraplethopeltis* Zone in Oklahoma are *Missisquoia*, *Plethopeltis*, *Symphysurina*, *Hystricurus*, *Clelandia*, *Xenostegium*, and *Bellefontia*. Although the overlying Cool Creek Formation has not been collected in detail, published data from other areas in the western United States and Canada indicate that *none* of these genera except *Hystricurus* are known from younger strata. This is true in Utah, Nevada, and Idaho (Ross, 1951, p. 29; Hintze, 1952, p. 6–8), in Montana and North Dakota (Lochman-Balk and Wilson, 1967, p. 895), and in the Canadian Rocky Mountains (Aitken and others, 1972, p. 38–40; Derby and others, 1972, p. 507). Moreover, none of the associated families (Missisquoiidae, Plethopeltidae) or specific subfamilies (Symphysurininae for the asaphids *Symphysurina*, *Xenostegium*, and *Bellefontia*) are known from younger strata, except for the Subfamily Hystricurinae (*Hystricurus*, *Parahystricurus*, etc.) and the genus *Pseudohystricurus* (Ross, 1951, p. 29–30; Hintze, 1952, p. 9–14). With these exceptions, the top of the *Paraplethopeltis* (C) Zone stands out as a major extinction horizon for the taxa that characterize the lowest part of the Ordovician. For this reason, I have chosen to recognize the biostratigraphic interval encompassing the *Missisquoia*, *Symphysurina*, *Bellefontia–Xenostegium*, and *Paraplethopeltis* Zones as a biomere. This biomere is called the Symphysurinid Biomere (pl. 7) from the dominant group of trilobites restricted to this interval, which belong to the Subfamily Symphysurininae. This biomere is bounded below by the abrupt faunal change between the *Saukia* and *Missisquoia* Zones, and bounded above by the similar abrupt faunal change between the *Paraplethopeltis* and *Leiostegium–Kainella* (D) Zones.

The lower part of this biomere had previously been informally named the "hystricurid" biomere (Stitt, 1977, p. 11, fig. 3; Ludvigsen, 1982, p. 32–42), because species of *Hystricurus* are abundant in this interval. Judging from the data on distribution and abundance of the various species of *Hystricurus*, *Parahystricurus*, and *Pseudohystricurus* supplied by Ross (1951, p. 29–30, 40–56) and Hintze (1952, p. 7–12), *Hystricurus* is nearly as diverse and abundant above the Symphysurinid Biomere as it is within the biomere interval. At present, this is an unexplained deviation from the usual biomere pattern. *Parahystricurus* and *Pseudohystricurus* do make their initial appearance in the Symphysurinid Biomere, but both are more diverse and abundant in higher zones.

It may be possible to recognize in the Symphysurinid Biomere some of the four evolutionary stages of the trilobite population that were previously recognized in the underlying Pterocephaliid and Ptychaspid Biomeres. Stage 1, the initial adaptive radiation characterized by low faunal diversity, marked intraspecific variability, and short stratigraphic ranges, occurs in the *Missisquoia* Zone. Stage 2, the consolidation phase of the adaptive radiation characterized by slightly longer stratigraphic ranges and less intraspecific variability, either occurs in the lower half of the *S. brevispicata* Subzone (pl. 7) or is absent. In the Symphysurinid Biomere, stage 1 may be succeeded by stage 3, which is characterized by long-ranging, relatively stable taxa such as occur in the *Symphysurina*, *Bellefontia–Xenostegium*, and lower *Paraplethopeltis* Zones. Almost all of the taxa in this interval become extinct below the base of the *Paraplethopeltis* (C) Zone of Ross and Hintze, which probably represents stage 4. This interval needs additional detailed study to clarify events at this extinction horizon.

Trilobite diversity is low in the *Leiostegium–Kainella* Zone immediately following the major extinction event at the top of the *Paraplethopeltis* Zone. Faunal diversity then increases upsection in succeeding zones in a manner similar to the diversity increases upsection in the Cambrian Pterocephaliid and Ptychaspid Biomeres [compare

the range charts in Palmer (1965b) and Stitt (1971b, 1977) with Demeter (1973, text-fig. 3) and Terrell (1973, text-fig. 2)]. Thus, the faunal recovery pattern following the Symphysurinid Biomere is similar to the recovery pattern following the extinction events that terminated earlier biomere faunas.

Miller (1978, p. 26; table 2) documented a major conodont extinction event at the base of the *Corbinia apopsis* Subzone, just below the top of the Ptychaspid Biomere. Ethington and Clark (1981, fig. 3; p. 7) recently demonstrated that an even more drastic conodont extinction event occurs at the top of the *Paraplethopeltis* (C) Zone in the Ibex area of Utah and elsewhere. Thus, the event that extinguished the trilobites of the Symphysurinid Biomere also eliminated many taxa of conodonts.

The lower part of the Ptychaspid Biomere is characterized not only by a rapidly evolving population of trilobites but also by several abundant genera of articulate brachiopods (*Eoorthis*, *Billingsella*). In a similar fashion, the articulate brachiopod *Apheoorthis* is abundant in the lower part of the Symphysurinid Biomere, beginning at the base of the *Missisquoia typicalis* Subzone.

Thus, the Symphysurinid Biomere shares many of the characteristics of the underlying Pterocephaliid and Pytchaspid Biomeres. The principal difference between this lower Ordovician biomere and the Cambrian biomeres is that the abundant trilobite genus *Hystricurus* is not restricted to the biomere.

SYSTEMATIC PALEONTOLOGY

Trilobites assigned to 4 families, 10 genera (1 new), 15 species (4 new), and 3 taxa that cannot be specifically assigned are described and illustrated. Three taxa (*Clelandia texana*, *Symphysurina brevispicata*, and Unassigned pygidium no. 2 Stitt) that occur sparingly at the base of the McKenzie Hill Limestone and that have been previously described and illustrated are not reillustrated, although their characteristics and stratigraphic occurrence are discussed. Families are listed alphabetically under each order, genera alphabetically under each family, and species alphabetically under each genus.

Morphological terms used in the trilobite descriptions are those defined in Part O of the *Treatise on Invertebrate Paleontology* (Harrington and others, 1959, p. 117–126).

The abundance and occurrence of each taxon are listed after the taxonomic discussion as well as in the descriptions of measured sections that follow this part of the report. Initials are used to refer to the measured sections (CC–Chandler Creek section, HS–U.S. Highway 77 section), and the numbers given correspond to footages above the base of the section. The exact number of specimens assigned to each taxon can be tabulated from the occurrence data included with the descriptions of the measured sections.

All figured specimens are stored with the School of Geology and Geophysics at The University of Oklahoma (OU). The rest of the fossils recovered in this study will eventually be stored at The University of Oklahoma when I have completed my studies of the fauna of the Arbuckle Group.

Phylum ARTHROPODA Siebold and Stannius, 1845
Class TRILOBITA Walch, 1771
Order PTYCHOPARIIDA Swinnerton, 1915
Family ASAPHIDAE Burmeister, 1843
Subfamily SYMPHYSURININAE Kobayashi, 1955
Genus **Bellefontia** Ulrich *in* Walcott, 1924

Bellefontia ULRICH *in* Walcott, 1924b, p. 54; 1925, p. 69–71; ROSS, 1951, p. 97–98; HINTZE, 1952, p. 140–141.

Remarks.—Differences between species in the genus *Bellefontia* involve small and sometimes subtle variations in morphologic features, rather than the presence or absence of key morphologic characters. Species discrimination is made additionally difficult by the thin exoskeleton of these frequently large trilobites, and its tendency to become cracked or crushed during compaction of the enclosing rock (see, for example, Lochman, 1964, pl. 64, figs. 17–20; pl. 65, figs. 24–31). The criteria used to recognize the various species usually cannot be applied successfully to crushed specimens, and hence only well-preserved specimens can be identified with certainty. As noted by Lochman (1964, p. 470), the pygidia and librigenae are usually better preserved than the cranidia, which is unfortunate because many of the features used to discriminate the species in *Bellefontia* occur on the cranidium.

Bellefontia and *Xenostegium* are very closely related genera. Cranidia of species of *Bellefontia* are most easily recognized by their shorter anterior borders, whose length (sag.) is one-tenth to one-ninth of the glabellar length. In *Xenostegium*, the length of the anterior border (sag.) varies from one-fifth to one-seventh of the glabellar length. This ratio, however, cannot be determined accurately on crushed specimens.

Holaspid pygidia of *Bellefontia* do not possess a terminal axial spine, which readily distinguishes them from the spine-bearing pygidia of *Xenostegium*. In addition, pygidia of *Bellefontia* are shorter and somewhat wider, usually with a wider border and a more elliptical outline. Pygidia of *Xenostegium* are more triangular in outline, and usually have a slightly narrower border.

Two species of *Bellefontia* are recognized in Oklahoma. *Bellefontia collieana* (Raymond), the stratigraphically lower species, ranges through about 120 feet in the middle of the McKenzie Hill Limestone. *Bellefontia chamberlaini*, the stratigraphically higher species, is less abundantly preserved but may range through as much as 180 feet in the upper part of of the formation.

Bellefontia chamberlaini Clark

Pl. 3, figs. 1–5

Bellefontia chamberlaini CLARK, 1935, p. 245, pl. 24, figs. 10, 11; ROSS, 1951, p. 98–99, pl. 22, figs. 1, 2; pl. 23, fig. 4; pl. 24, figs. 1–7; pl. 25, figs. 10–15; HINTZE, 1952, p. 142, pl. 4, figs. 9–13.

Bellefontia cf. *B. chamberlaini* Clark BERG AND ROSS, 1959, p. 113, pl. 21, figs. 18, 20, 22.

Remarks.—Among species of *Bellefontia*, *B. chamberlaini* is characterized by the following combination of features: (1) cranidium with a highly convex anterior end of the glabella, short anterior border whose length (sag.) is one-tenth of the glabellar length, and anterior facial sutures that diverge at 45°; (2) librigena with a moderately convex, medium-width genal field and medium-length genal spine; and (3) pygidium with a very smooth exoskeleton (axis barely visible) and more convex pleural fields than *B. collieana*. The axial rings are clearly visible on internal molds (see pl. 3, fig. 4; Ross, 1951, pl. 25, fig. 15; Berg and Ross, 1959, pl. 21, fig. 18), but the axis is hardly visible on the exoskeleton (see pl. 3, fig. 5; Ross, 1951, pl. 25, figs. 9–14).

The Oklahoma specimens agree very well with those described and illustrated by Ross (1951) and Hintze (1952) from Utah and Idaho, but they contain one prominent feature not mentioned by Ross or Hintze. The exoskeleton of the axis and pleural fields of the pygidium are covered by small pits that are either extremely faint or totally absent on internal molds. Faint pits occur also on the exoskeleton of the cranidium (exclusive of the anterior border) but do not seem to be present on the internal mold. Ross (1981, oral communication) confirmed that pits are present on nonsilicified specimens of *B. chamberlaini* from Utah, but that these pits are not preserved on silicified specimens and thus were not described earlier. The presence of pits on *B. chamberlaini* is thus another feature that may be used to distinguish that species from other species of *Bellefontia*.

Occurrence.—Common to scarce in the *Bellefontia chamberlaini* Subzone at CC 2515; HS 2322.5, 2356, 2369, 2444, 2474, 2504.

Bellefontia collieana (Raymond)

Pl. 3, figs. 6–8

Hemigyraspis collieana RAYMOND, 1910, p. 41, pl. 14, figs. 9–13; BASSLER, 1919, p. 346, pl. 32, figs. 11–15.

Bellefontia collieana (Raymond) ULRICH *in* Walcott, 1924b, p. 54, pl. 9, fig. 3; 1925, p. 72, pl. 23, figs. 1–6; SANDO, 1957, p. 135–136, pl. 10, figs. 4, 5, 7–10.

Remarks.—Among species of *Bellefontia*, *B. collieana* (Raymond), the type species, is characterized by the following combination of features: (1) cranidium with only a moderately convex anterior end, faintly defined glabella, and very faint occipital furrow; (2) librigena with a wide, only slightly convex genal field, wide border, and long, narrow genal spine; and (3) pygidium with length-to-width ratio from 0.40 to 0.60 (Sando, 1957, p. 136), prominent axis with as many as seven axial rings and a slightly bulbous terminal piece visible on internal molds, smooth and moderately convex pleural regions with no more than two or three pleurae faintly defined on internal molds, and a border defined on its inner edge more by a break in slope than by an incised border furrow. The Oklahoma specimens compare very well with those illustrated by Walcott (1925, pl. 23, figs. 1–6). Unfortunately, the cranidia are poorly preserved, and even the best one (pl. 3, fig. 6) is incomplete.

Occurrence.—Abundant to common in the lower half of the *Bellefontia collieana* Subzone at CC 2219, 2225, 2229, 2345; HS 2076, 2092, 2093, 2109, 2113, 2118, 2120, 2126, 2143, 2150, 2175, 2188.

Parabellefontia? sp. undet.

Pl. 3, fig. 9

Remarks.—Seven pygidia, mostly small or incompletely preserved, are tentatively assigned to this monotypic genus. The pygidia are nearly twice as wide as they are long, have a border whose width is one-sixth to one-seventh of the pygidial length (sag.), and are very smooth with almost no trace of the axis or pleurae on the exoskeleton. As such, these pygidia resemble those illustrated by Hintze (1952, p. 194–195, pl. 3, figs. 7, 8) for *Parabellefontia concinna*. The principal differences are that the pygidia of *P. concinna* are only three-fifths as long as they are wide, and the border is slightly narrower than on the Oklahoma specimens. More definite assignment of the Oklahoma specimens will have to await discovery of associated cranidia and librigenae, which so far have not been recovered.

Occurrence.—Scarce in the *Symphysurina woosteri* Subzone at CC 2062, 2066; HS 1912.5, 1921. Scarce in the base of the *Xenostegium franklinense* Subzone at CC 2103.

Genus **Symphysurina** Ulrich *in* Walcott, 1924

Symphysurina brevispicata Hintze

Symphysurina brevispicata HINTZE, 1952, p. 236, pl. 3, figs. 9–17; STITT, 1971b, p. 15, pl. 8, figs. 19–21 (synonymy to date); STITT, 1977, p. 37, pl. 4, fig. 10.

Remarks.—This species is characterized by its (1) spineless pygidium, which is at least twice as wide as it is long; (2) broad, gently convex librigenae with short genal spines; and (3) smooth, nonpitted exoskeleton and internal mold. The latter characteristic allows cranidia of *S. brevispicata* to be distinguished from the otherwise similar cranidia of *S. bulbosa*, which occurs with *S. brevispicata* in the upper part of the Signal Mountain

Limestone and the lower part of the McKenzie Hill Limestone.

Occurrence.—Scarce at the base of the McKenzie Hill Limestone (middle and upper parts of the *Symphysurina bulbosa* Subzone) at CC 1937, 1938, 1953, 1964, 2009, 2014; HS 1840. Scarce in the lower part of the *Symphysurina woosteri* Subzone at CC 2044, 2048.

Symphysurina bulbosa Lochman

Pl. 1, figs. 1–4

Symphysurina bulbosa LOCHMAN, 1964, p. 470–471, pl. 66, figs. 4–8; STITT, 1977, p. 37, pl. 5, figs. 1–6.

Remarks.—This species is characterized by its (1) pitted exoskeleton, which is easiest to observe on internal molds; (2) triangular, convex pygidium with a wide axis that ends in an inflated terminal piece; and (3) broad, only moderately convex librigena that bears a slender to medium-width, medium-length genal spine. The cranidium can be distinguished from that of *Symphysurina brevispicata* by its distinctive pitting; the cranidium of *Symphysurina woosteri* is slightly more convex and has a more prominent axial ridge or keel than that of *S. bulbosa*. However, cranidia and librigenae of *S. bulbosa* can be difficult to distinguish from those of *S. woosteri*, especially if they are incomplete specimens, and it is always best to search for associated pygidia and determine if they have the bulbous axial termination characteristic of *S. bulbosa* or the pygidial spine characteristic of *S. woosteri*.

Occurrence.—Abundant to common in the *Symphysurina bulbosa* Subzone at CC 1937, 1938, 1949.5, 1953, 1964, 1974, 1974.5, 2009, 2014, 2027.5, 2028, 2031; HS 1818, 1819, 1840, 1863, 1865, 1868, 1871, 1874, 1886. Scarce in the *Symphysurina woosteri* Subzone at CC 2033.5, 2056; HS 1889, 1918. Scarce in the *Xenostegium franklinense* Subzone at HS 1985. Scarce in the lower part of the *Bellefontia collieana* Subzone at HS 2093, 2120.

Symphysurina woosteri Ulrich

Pl. 1, figs. 5–10

Symphysurina woosteri ULRICH *in* Walcott, 1924a, p. 37, fig. 8; 1925, p. 115–116, pl. 21, figs. 1–11.

Symphysurina cf. *S. woosteri* Ulrich, POULSEN, 1937, p. 40, pl. 3, figs. 1–5; ROSS, 1951, p. 114–115, pl. 23, figs. 7–12; SANDO, 1957, p. 137, pl. 11, figs. 1, 2; LOCHMAN, 1964, p. 471, pl. 66, figs. 9–27.

Symphysurina aff. *S. woosteri* Ulrich KOBAYASHI, 1936, p. 164, pl. 21, figs. 9–14.

Remarks.—*Symphysurina woosteri*, the type species of *Symphysurina*, is characterized by its (1) medium-length terminal axial spine, which projects horizontally from the posterior of the pygidium as a continuation of the pygidial axis (see pl. 1, figs. 8–10; Walcott, 1925, pl. 21, figs. 10, 11); (2) strongly convex (sag. and trans.) cranidium with a prominent axial ridge or keel; (3) broad, gently to moderately convex librigenae with stout, medium-length genal spines; and (4) lightly pitted or rarely smooth exoskeleton with pitted internal molds. The pygidial axis is only faintly outlined on specimens that retain the exoskeleton, and the entire pygidium then appears to be smooth. On exfoliated pygidia (pl. 1, figs. 8–10) three faint axial rings and matching pleurae are present. As previously discussed (see remarks on *S. bulbosa*), *S. woosteri* is similar to *S. bulbosa*. Both taxa are pitted, although the pits on the exoskeleton of *S. woosteri* appear to be fainter. The cranidium of *S. woosteri* is slightly more convex and has a more prominent axial ridge, and the librigena has a slightly different shape and a stouter genal spine. However, these are differences of degree rather than presence or absence of morphologic features. Even the pygidia can be difficult to distinguish if the pygidial spine characteristic of *S. woosteri* is broken off, as some are.

The cranidia that Wilson (1954, p. 284, pl. 27, figs. 10, 14) tentatively referred to *S. woosteri* lack the axial ridge and are less convex than usual for this species, and probably belong to another species of *Symphysurina*.

Occurrence.—Common to abundant in the *Symphysurina woosteri* Subzone at CC 2033.5, 2058, 2084; HS 1889, 1891, 1895, 1898, 1900, 1915, 1932, 1935, 1940, 1944, 1957, 1959. Common to abundant in the *Xenostegium franklinense* Subzone at CC 2103, 2106, 2109.5, 2123, 2127, 2143, 2159, 2164, 2168, 2179, 2185, 2186, 2192, 2196, 2211, 2214; HS 1966. Common to abundant in the lower part of the *Bellefontia collieana* Subzone at CC 2219, 2229, 2236, 2264, 2280; HS 2076, 2092.

Symphysurina sp. no. 1

Pl. 2, figs. 6–8

Remarks.—One broken cranidium, three complete but small pygidia, and six fragmentary librigenae are associated together through a range of 35 feet in the upper part of the ranges of *Symphysurina woosteri* and *Symphysurina bulbosa*. These few specimens cannot be assigned with certainty to either of these species and are described together here owing to their stratigraphic association, although they may not represent a single taxon.

The cranidium is small, highly convex (sag. and trans.), smooth, and furrowless, with the axial length equal to the cranidial width at the palpebral lobes. The palpebral lobes, which measure one-third of the cranidial length, are centered just posterior to cranidial midlength. A thin, wirelike anterior border is present. The associated librigenae are only slightly convex, with a rounded, almost pointed genal angle and a shallow border furrow; both the exoskeleton and the internal

mold are pitted. The associated pygidia are small and smooth, with shallow axial furrows that faintly outline a low axis that has only one or two faintly defined axial rings. One or two faintly defined pleurae are present. In contrast to the low convexity of the pleurae, the borderless margin of the pygidium is steeply convex. The best specimens of the cranidium, pygidium, and librigena are illustrated.

The cranidium and pygidium are somewhat similar to those of *Symphysurina globocapitella* Hintze (1952, p. 232–233, pl. 1, figs. 1–9), especially the specimens illustrated in Hintze's figures 5b and 8b. However, the cranidium of *S. globocapitella* is wider than it is long (rather than being equidimensional), and the palpebral lobes are longer and narrower than on the Oklahoma specimens. The pygidium of *S. globocapitella* apparently has even less dorsal expression of the axial rings and pleurae and has a less steeply convex margin than the Oklahoma specimens.

The pitted librigenae may not be conspecific with the cranidium and pygidia with which they are associated. The pitting suggests an assignment to either *S. woosteri* or *S. bulbosa*, but both of those species have prominent genal spines. *Symphysurina* sp. A Ross (1951, p. 115–116, pl. 28, fig. 29; Stitt, 1977, p. 38, pl. 5, fig. 9) has a similar librigena, but it is more convex and has no pitting.

Whatever their eventual taxonomic assignment may be, these specimens have a biostratigraphically consistent and useful occurrence in the lowest part of the *Bellefontia collieana* Subzone in both the Arbuckle and the Wichita Mountains.

Occurrence.—Scarce in the lowest part of the *Bellefontia collieana* Subzone at CC 2219, 2229, 2236, 2264; HS 2093.

Genus **Xenostegium** Walcott, 1924

Xenostegium WALCOTT, 1924b, p. 60; 1925, p. 124–125; KOBAYASHI, 1934, p. 557–558; ROSS, 1951, p. 100–102.

Remarks.—As discussed by Kobayashi (1934, p. 557–558) and Ross (1951, p. 100–102), the original group of species assigned to *Xenostegium* by Walcott (1925, p. 125–129, pl. 24, figs. 1–23) included taxa belonging to several genera. Ross (p. 101–102) summarized the criteria that can be used to distinguish *Xenostegium* from the closely related genus *Bellefontia*. Hintze (1952, p. 241) modified Ross' criteria slightly by transferring *Bellefontia? acuminiferentis* Ross to *Xenostegium*, and I agree with Hintze's assignment of this species.

Because the exoskeleton of *Xenostegium* is thin in relation to the large size of many specimens of this taxon, many specimens assignable to this genus were crushed or distorted during preservation, probably by compaction. This is true for some of the specimens originally illustrated by Walcott (1925, pl. 24) as well as for my specimens from Oklahoma and those from Montana illustrated by Lochman and Duncan (1950, pl. 52, figs. 14, 15) and Lochman (1964, pl. 67). On crushed or incompletely preserved specimens, it is virtually impossible to reliably use differences in the divergence of the anterior facial sutures, the length of the anterior border, or the position of the palpebral lobes to discriminate cranidia of *Xenostegium* and *Bellefontia*, as suggested by Ross (1951, p. 101). The long, slender genal spines characteristic of librigenae of *Xenostegium* are commonly broken off, as is the terminal axial spine that characterizes the pygidia of species assigned to this genus. Therefore, only relatively well-preserved specimens can be assigned with confidence to *Xenostegium*, and many fragmentary specimens have to be left unassigned to any taxon.

Xenostegium franklinense Ross

Pl. 2, figs. 1–5

Xenostegium franklinense ROSS, 1951, p. 102–103, pl. 24, figs. 8–14; pl. 25, figs. 1–6; LOCHMAN, 1964, p. 472, pl. 67, figs. 1–19.

Remarks.—Pygidia assigned to this species are triangular in outline, with a tapering and convex axis, convex pleural fields, shallow border furrow, shelflike border, and a terminal axial spine. These pygidia can be distinguished from the pygidia of the associated *Symphysurina woosteri* by the shelflike border, the lack of pitting on either the exoskeleton or the internal mold, and the character of the terminal axial spine. Viewed from the side, the top of the terminal axial spine of *S. woosteri* continues posteriorly from the slope of the top of the axis, making a smooth profile with no prominent break that might mark where the axis ends and the terminal axial spine begins. In *X. franklinense*, the terminal axial spine is a definite continuation of the axis, but in lateral profile there is a clear break in slope from the well-defined end of the axis down to the spine (pl. 2, fig. 4), which continues posteriorly at a level about midway between the level of the end of the axis and the level of the border. The spine thus clearly interrupts the continuity of the border and the border furrow, distinguishing *X. franklinense* from *X. acuminiferentis*. A pygidial spine distinguishes species of *Xenostegium* from species of *Bellefontia*, which lack a pygidial spine in the holaspid state, although rarely there may be a small spine on immature specimens (Ross, 1951, p. 97).

Well-preserved cranidia of *Xenostegium franklinense* have a slightly concave anterior border whose length is one-eighth to one-ninth of the cranidial length, strongly diverging anterior facial sutures, and no pitting, which readily distinguishes them from the cranidia of the associated *S. woosteri*. As discussed earlier, *Xenostegium* cranidia can be difficult to distinguish from *Bellefontia* cranidia; the shorter anterior border on

Bellefontia appears to be the most reliable criterion.

The librigenae of *X. franklinense* have narrower genal fields and longer, more slender genal spines than do librigenae of species of *Bellefontia*. In addition (if preserved), the posterior border furrow nearly touches the edge of the librigena at the genal angle on *X. franklinense*, as noted by Ross (p. 102). The presence of borders and border furrows, and lack of pitting, readily distinguish librigenae of *X. franklinense* from those of the associated *S. woosteri*.

Although Lochman (1964, p. 472) reported a punctate inner surface for *X. franklinense*, the Oklahoma specimens are smooth, as are the Utah specimens of Ross and Hintze.

Occurrence.—Common to scarce in the *Xenostegium franklinense* Subzone at CC 2103, 2105, 2143, 2168, 2179, 2185, 2196, 2211; HS 1966, 1985, 2020, 2027, 2052.5. Scarce to common in the *Bellefontia collieana* Subzone at CC 2219, 2229, 2252, 2264, 2388; HS 2109, 2126, 2175.

Family PLETHOPELTIDAE Raymond, 1925

Genus **Paraplethopeltis** Bridge and Cloud, 1947

Paraplethopeltis genacurva Hintze

Pl. 2, fig. 10

Paraplethopeltis? genacurvus HINTZE, 1952, p. 202–204, pl. 7, figs. 1–5.

Hystricurus? sp. aff. *H.? genacurvus* (Hintze) BERG AND ROSS, 1959, p. 112–113, pl. 21, figs. 21, 23.

Remarks.—Hintze (1952, p. 201–204) and Berg and Ross (1959, p. 112–113) have discussed the problems associated with taxonomic assignment of this biostratigraphically useful species. Bridge and Cloud (1947, p. 555–557) and Lochman-Balk (*in* Harrington and others, 1959, p. 410) summarized the criteria that define the genus *Paraplethopeltis*, and *P. genacurva* possesses most of the morphological characteristics listed. The cranidium is elongate, only gently tapering, and very convex, with the frontal area equal to one-half of the glabellar length and about one-third of the cranidial length. The palpebral lobes are centered just posterior to the cranidial midlength, the posterior areas are narrow, glabellar furrows are absent, the occipital furrow is shallow, and the occipital ring is only slightly wider at the axis than at the axial furrows. My best specimen of *Paraplethopeltis obesa* (pl. 2, fig. 9) possesses faint eye ridges, and I believe that faint eye ridges can be seen on Bridge and Cloud's (1947, pl. 2, figs. 7, 11) specimens, which may negate one of Berg and Ross' (p. 112) two main objections to assigning this species to *Paraplethopeltis*. Their other objection was the presence of a distinct anterior border, delineated by a shallow border furrow, and this is a valid difference between *P. genacurva* and *P. obesa* and *P. depressa*. However, this difference is probably more useful as a species criterion than as a generic criterion, because my specimen of *P. obesa* does have a very faint anterior border furrow. Moreover, Lochman-Balk (*in* Harrington and others, 1959, p. 410), who presumably saw the type specimens, described for *Paraplethopeltis* an "anterior border visible on interior only." This border furrow is so faint that it does not show on photographs, but it is present.

I do not believe that *P. genacurva* is a species of *Hystricurus*. Among other differences, species of *Hystricurus* have much deeper axial and occipital furrows, and horizontal (not downsloping) palpebral areas, and the palpebral lobes are centered at or slightly anterior (rather than slightly posterior) to the glabellar midlength.

For the reasons listed above, I have retained *P. genacurva* in *Paraplethopeltis*. I hope that more specimens of this genus will be recovered from other areas and that we will learn more about the morphological variability of this biostratigraphically useful taxon.

Occurrence.—Scarce in the *Paraplethopeltis* Zone at CC 2642, 2647.

Paraplethopeltis obesa Bridge and Cloud

Pl. 2, fig. 9

Paraplethopeltis obesa BRIDGE AND CLOUD, 1947, p. 557–558, pl. 2, figs. 1–7, 12–14; CLOUD AND BARNES, 1948, pl. 38, figs. 4–9, 11–13.

Remarks.—Two cranidia were recovered from the upper part of the McKenzie Hill Limestone that match the description of *Paraplethopeltis obesa*. The cranidium of *P. obesa* is characterized by its strong convexity (especially sag.), long (sag.), convex, only slightly tapering glabella with no glabellar furrows, faint occipital furrow, narrow and straplike posterior areas, and palpebral lobes that are centered just posterior to the cranidial midlength. The maximum length (sag.) of the frontal area of the best Oklahoma specimen is one-third to one-fourth of the cranidial length, which makes that feature a little shorter in relation to the cranidium than on the Texas specimens described by Bridge and Cloud; otherwise, the Oklahoma and Texas specimens appear to be identical.

Occurrence.—Scarce in the *Paraplethopeltis* Zone at CC 2572.

Family REMOPLEURIDIDAE Hawle and Corda, 1847

Subfamily RICHARDSONELLINAE Raymond, 1924

Genus **Praepatokephalus** Lochman, 1964

Praepatokephalus armatus (Hintze)

Pl. 4, figs. 7–10

Pseudokainella? armatus HINTZE, 1952, p. 218, pl. 5, figs. 1–5.

Praepatokephalus armatus (Hintze) LOCHMAN, 1964, p. 472–473, pl. 66, fig. 3.

Remarks.—Hintze (1952, p. 218) tentatively assigned this species to *Pseudokainella*, although he suggested that he might have assigned this taxon to a new genus if he had had more specimens to study. Ross (1957, p. 498) and Lochman (1964, p. 472–473) also believed that this taxon did not belong to *Pseudokainella*, and Lochman assigned it to her new genus *Praepatokephalus*. *P. armatus* is characterized by its large, crescentic palpebral lobes, prominent occipital ring, large glabella, and the absence of a preglabellar field and palpebral areas. The exoskeleton is covered by small granules. On very well-preserved specimens, three extremely faint glabellar furrows can be observed; these furrows have no granules in them. Well-spaced pits occur in the anterior border furrow, which have not been previously reported and which further associate this genus with other members of the Subfamily Richardsonellinae. Glabellae of specimens low in the stratigraphic range of *P. armatus* are less convex than the glabellae of specimens near the top of the range. The anterior axial ring on the pygidium is larger and better defined by the transverse ring furrows than is the posterior axial ring, which is smaller and only faintly outlined.

Occurrence.—Scarce in the lower half of the *Xenostegium franklinense* Subzone at CC 2130, 2143; HS 1982, 1985. Common in the lower half of the *Bellefontia collieana* Subzone at CC 2252, 2283, 2316, 2318, 2345; HS 2126.

Subfamily REMOPLEURIDINAE Hawle and Corda, 1847

Genus **Remopleuridiella** Ross, 1951

Remopleuridiella caudilimbata Ross

Pl. 3, fig. 10

Remopleuridiella caudilimbata ROSS, 1951, p. 84–87, pl. 20, figs. 1–12; HINTZE, 1952, p. 229, pl. 5, figs. 10–12.

Remarks.—One cranidium is assigned to this species on the basis of its large and unusual glabella, which dominates the cranidium. The anterior one-third of the furrowless glabella tapers rapidly, curving steeply downward. This unusual glabellar shape compares very well with the specimens of *R. caudilimbata* illustrated by Ross (1951, pl. 20, figs. 1–5, 9) and Hintze (1952, pl. 5, fig. 10). On the Oklahoma specimen, the palpebral lobes and anterior border are not preserved, but the occipital ring and shallow, curved occipital furrow match Ross' description very well (Ross, 1951, p. 85).

Occurrence.—Scarce in the lower part of the *Paraplethopeltis* Zone at CC 2604.

Family SOLENOPLEURIDAE Angelin, 1854

Subfamily HYSTRICURINAE Hupe, 1953

Genus **Hystricurus** Raymond, 1913

Hystricurus globosus Stitt, n. sp.

Pl. 5, figs. 1–6

Material available.—45 cranidia, 11 librigenae, 9 pygidia, mostly well preserved.

Description.—Cranidium subrectangular, strongly convex longitudinally, only moderately convex transversely; covered, except for furrows, by evenly spaced coarse, pointed pustules. Glabella globose, broadly rounded anteriorly, length three-fourths of cranidial length, tapers gently anteriorly and posteriorly from maximum width at line connecting posterior ends of palpebral lobes. Glabellar furrows absent, probably represented by two slightly depressed, slightly less densely pustulose patches on each side of glabella. Axial furrow deep, shallowing anteriorly; preglabellar furrow shallow. Occipital furrow broad and deep, narrowing abruptly to a deep slot or pit near axial furrow. Occipital ring narrow, convex, covered by three rows of pustules, curving anteriorly abaxially. Frontal area and anterior area of fixigenae steeply downsloping, length one-sixth to one-fifth of cranidial length. Anterior border furrow normally absent on exoskeleton of medium to large specimens, faintly impressed on some internal molds and on some smaller (less than 3 mm long) specimens (pl. 5, fig. 2). Faint eye ridges present. Palpebral areas slightly upsloping abaxially, gently convex (ex-sag.), width one-third of glabellar width; palpebral furrow broad, moderately impressed. Palpebral lobes arcuate, horizontal, covered with a single row of pustules, length four-tenths of glabellar length, lobes centered at glabellar midlength. Posterior areas narrow, sharply downsloping abaxially. Posterior furrows broad, deeply impressed; posterior areas narrow near axial furrow, widening abaxially. Anterior course of facial sutures slightly divergent anterior of palpebral lobes.

Librigenae crescentic, gently convex. Eye socle (infraocular ring of Ross, 1951) present. On larger librigenae (pl. 5, fig. 3), genal field covered by genal caeca, with medium to large pustules on top of the caeca throughout the middle of the genal field. Genal caeca not present on small librigenae (pl. 5, fig. 4). Border furrow moderately impressed, shallowing adaxially. Librigenal border convex, tubular, covered by medium to fine granules. Short genal spine present.

Pygidium elliptical in outline, strongly convex, length (sag.) one-half of width. Axis prominent, nearly triangular (trans.), gently tapering posteriorly, maximum width three-tenths to one-third of pygidial width, with articulating half-ring, three axial rings with prominent axial nodes separated by moderately impressed ring furrows,

and a terminal axial piece with a faint indication of a fourth axial ring and two prominent lateral nodes. Axial furrows only faintly impressed. Three pairs of pleurae present with broad, faintly to well-impressed pleural furrows and narrow, moderately impressed interpleural furrows. Pleural region gently downsloping near axis, then bending sharply downward to join tubular border. Pleural and interpleural furrows fade toward border. Prominent node on posterior edge of each pleura at break in slope, and as many as eight similar nodes are evenly spaced along border. Scattered medium-sized granules occur on axial rings and pleural region.

Holotype.—OU 10107, plate 5, figure 1.

Paratypes.—OU 10108, plate 5, figure 2; OU 10109, plate 5, figure 3; OU 10110, plate 5, figure 4; OU 10111, plate 5, figure 5; OU 10112, plate 5, figure 6. All holotype and paratype specimens from CC 2316, *Bellefontia collieana* Subzone of the *Bellefontia–Xenostegium* Zone, McKenzie Hill Limestone, Wichita Mountains, Oklahoma.

Etymology.—*Globosus*, L., spherical, referring to the inflated glabella characteristic of this species.

Remarks.—Ross (1951, p. 39–40) delineated the modern concept of the genus *Hystricurus*, which has been accepted and used by subsequent authors. As thus defined, cranidia of *Hystricurus* are characterized by low, uninflated glabellae, relatively long, horizontal palpebral areas, raised lunate palpebral lobes set off by palpebral furrows and usually centered on the glabellar midlength, and slender posterior areas. Librigenae have an eye socle. This combination of features separates species assigned to *Hystricurus* from those assigned to *Parahystricurus* or *Pseudohystricurus*, although Ross admitted (p. 57) that glabellar shape alone is not definitive in dealing with these genera, and he assigned (at least tentatively) several taxa to *Hystricurus* that have tall glabellae (see *Hystricurus* sp. D, *H.*? sp. F, and *H.*? sp. H. of Ross, 1951, p. 54–56).

Hystricurus globosus matches the criteria for species assigned to *Hystricurus*, except that it has a large and inflated glabella. *H. globosus* does possess the large palpebral areas, the palpebral lobes centered on the glabellar midlength and set off by palpebral furrows, the slender posterior areas, and the librigenal eye socle characteristic of *Hystricurus* as defined by Ross; for this reason the species is assigned to *Hystricurus*.

H. globosus is characterized by the large, inflated glabella, the faint or absent anterior border furrow, the librigenae with a short spine, and the unusual pattern of nodes on the axis, pleural field, and border of the pygidium. This combination of features distinguishes *H. globosus* from other described species of *Hystricurus* (excellent summaries of the characteristics of most of the other species assigned to *Hystricurus* are presented in Ross, 1951, p. 39–62, 74–75, and Hintze, 1952, p. 164–168).

Occurrence.—Abundant in the middle of the *Bellefontia collieana* Subzone at CC 2316, 2318; scarce in the same subzone at CC 2353, 2368, 2372.5, 2426; HS 2214, 2278.

Hystricurus hillyardensis Stitt, n. sp.

Pl. 4, figs. 3–6

Hystricurus sp. D Ross, 1951, p. 54, pl. 9, figs. 35, 36, 38–41.

Hystricurus cf. *H.* sp. D Ross Winston and Nicholls, 1967, p. 76, pl. 12, figs. 12, 22, 25.

Material available.—13 cranidia, 6 librigenae, 1 pygidium, moderately well preserved.

Description.—Cranidium quadrate, moderately convex (except for glabella). Glabella globose, anteriorly rounded, well outlined by deep axial and occipital furrows. Glabellar furrows absent, apparently represented by two pairs of smooth patches on sides of glabella, one pair even with the front of the palpebral areas, the second pair even with the center of the palpebral lobes. Preglabellar furrow shallower than axial furrows. Occipital furrow deep, curves anteriorly abaxially to meet axial furrows. Occipital ring convex (trans.), curving anteriorly abaxially. Frontal area one-fifth of cranidial length; preglabellar field downsloping, slightly convex, slightly wider than anterior border. Anterior border furrow moderately to deeply impressed. Anterior border convex, tapering abaxially. Anterior fixigenae slightly convex, steeply downsloping abaxially; may be ornamented by fine, irregular ridges. Palpebral area slightly convex, width one-half of basal glabellar width. Palpebral furrow deeply impressed, palpebral lobes arcuate, centered at glabellar midlength; length four-tenths to one-half of glabellar length. Faint eye groove present in position normally occupied by eye ridge; eye groove fades abaxially and appears to end just before reaching palpebral furrow. Posterior areas very narrow, posterior border furrow well impressed. Anterior course of facial sutures slightly divergent, curving adaxially after intersecting anterior border. Surface of cranidium covered by coarse to medium pustules (except in furrows).

Librigenae crescentic, gently convex, eye socle present. Genal field somewhat narrow, with faint genal caeca overlain by two (ant.) to four (post.) rows of coarse to medium pustules. Border furrow deeply impressed. Librigenal border wide, convex, tubular, covered by coarse to medium pustules. Genal spine of medium length.

Pygidium elliptical in outline, strongly convex, length (sag.) three-fifths of width. Axis wide (max. width three-sevenths of max. pygidial width), moderately tapering, with articulating half-ring, three axial rings, and a terminal piece, all set off by deeply impressed ring furrows. Axial furrows

moderately impressed. Small, moderately convex pleural field consisting of three pleurae with faint pleural furrows and deeply impressed interpleural furrows. Pleurae extend down to shallow border furrow that sets off tubular border. Pygidium covered by medium to fine granules (except in the furrows); each axial ring has an axial node, and each pleura has a similar node on the anterior band near the pleural furrow at the break in slope above the border furrow.

Holotype.—OU 10100a, plate 4, figure 3.

Paratypes.—OU 10101, plate 4, figure 4; OU 10102, plate 4, figure 5; OU 10100b, plate 4, figure 6. Holotype cranidium and paratype librigena and pygidium from CC 2252, *Bellefontia collieana* Subzone of the *Bellefontia* Zone, McKenzie Hill Limestone, Wichita Mountains, Oklahoma. Paratype cranidium from HS 1871, *Symphysurina bulbosa* Subzone of the *Symphysurina* Zone, McKenzie Hill Limestone, western Arbuckle Mountains, Oklahoma.

Etymology.—*Hillyardensis*, named for the first-reported occurrence of this taxon from Hillyard's Canyon in Idaho (Ross, 1951, p. 14–16).

Remarks.—This taxon was first described (Ross, 1951, p. 54) from a few incomplete cranidia and a possible pygidium from Idaho and was initially called *Hystricurus* sp. D. Winston and Nicholls (1967, p. 76) assigned similar cranidia from central Texas to *H.* sp. D Ross. The description of this species can now be completed with the discovery in Oklahoma of this type of cranidium with associated librigenae and a pygidium. It also seems appropriate at this time to assign a formal species name to this widespread and stratigraphically useful taxon.

The Oklahoma cranidia possess the characteristics described by Ross (1951, p. 54) for this species: (1) the coarsely pustulose prosopon; (2) the high, anteriorly rounded glabella with two pairs of lateral smooth patches, one pair even with the front of the palpebral area, one pair even with the center of the palpebral lobes; (3) the slightly divergent anterior facial sutures; and (4) the faint eye grooves (not eye ridges). One cranidium has the fine ridges on the anterior fixigenae described by Ross. On the Oklahoma specimens, the anterior border furrow is moderately (rather than deeply) impressed, and the palpebral lobes, which are usually broken off, are not as thickened (when preserved) as on Ross' specimens.

Compared with the Oklahoma pygidium, the pygidium tentatively assigned to this species by Ross has less axial taper, lacks the axial and pleural nodes, and loses the expression of the pleurae well above the border. I conclude that the Utah pygidium is better assigned to *Pseudohystricurus rotundus*, as suggested by Ross (1951, p. 54, 75).

The nodes on the anterior bands of the pygidial pleurae are similar to those on the stratigraphically higher *Hystricurus globosus* Stitt, except that on *H. globosus* the terminal piece has two nodes (none on *H. hillyardensis*), and the pleural nodes are on the posterior pleural bands rather than on the anterior bands. Other differences between the pygidia of these two species include the wider, more tapered axis of *H. hillyardensis* and the well-impressed pleural furrows and nearly smooth areas immediately above the border furrow in *H. globosus*.

Ross reported *Hystricurus* sp. D (=*H. hillyardensis*) from only one locality (Hillyard's Canyon) in the Garden City Formation, occurring there with other taxa of his Zone A fauna. Taylor and others (1981, p. 223–224) recently determined that (1) there is an unconformity between the St. Charles Formation and the Garden City Formation; (2) most of the *Symphysurina brevispicata* Subzone is missing; and (3) Ross' Zone A fauna (p. 224) "corresponds to the upper part of the *Symphysurina brevispicata* Subzone and the *Symphysurina bulbosa* Zubzone of the *Symphysurina* Zone of Stitt (1977)." The occurrence of *Hystricurus hillyardensis* in Oklahoma helps to substantiate that correlation, for the lowest occurrence of this species is in the *S. bulbosa* Subzone. However, *H. hillyardensis* ranges upward into the overlying *Symphysurina woosteri* Subzone and continues through the lower one-third of the *Bellefontia–Xenostegium* Zone (=Zone B of Ross). At Hillyard's Canyon, Ross (1951, p. 16) did not find any fossils above the occurrence of *H. hillyardensis* for at least 34 feet (about the lower one-third of what would probably be Zone B in that section), so this species may range higher in the Garden City Formation but simply was not recovered from the poorly fossiliferous (Ross, p. 30) lowest part of the formation.

Occurrence.—Scarce in the upper part of the *Symphysurina bulbosa* Subzone at CC 2028; HS 1871. Scarce in the lower part of the *Symphysurina woosteri* Subzone at CC 2058. Scarce in the *Xenostegium franklinense* Subzone at CC 2143, 2214; HS 2039. Scarce to common in the lower part of the *Bellefontia collieana* Subzone at CC 2229, 2252, 2280.

Hystricurus millardensis Hintze

Pl. 4, figs. 1, 2

Hystricurus millardensis HINTZE, 1952, p. 168, pl. 6, figs. 17–21; WINSTON AND NICHOLLS, 1967, p. 76, pl. 12, figs. 14, 18; STITT, 1971b, p. 46, pl. 8, figs. 17, 18; TAYLOR AND HALLEY, 1974, p. 31–32, pl. 3, figs. 10–16.

Remarks.—This species has been well described by Hintze (1952), and Winston and Nicholls (1967) further added to our knowledge of its variability. *Hystricurus millardensis* is characterized by its anteriorly tapering, truncated glabella and its fossulae (pl. 4, fig. 1), which may become shallower (pl. 4, fig. 2) at the top of the stratigraphic range of the species.

Occurrence.—Scarce in the *Symphysurina bulbosa* Subzone at CC 1964, 1974.5; HS 1758, 1790, 1818, 1819. Scarce at the base of the *Symphysurina woosteri* Subzone at HS 1889.

Hystricurus missouriensis Ulrich

Pl. 5, figs. 7–10

Hystricurus missouriensis ULRICH *in* Bridge, 1930, p. 216, pl. 21, figs. 1–2.

Hystricurus aff. *H. missouriensis* Ulrich CLOUD AND BARNES, 1948, pl. 38, figs. 17, 19–20.

Remarks.—Seventeen incomplete cranidia are assigned to this species because they possess the features described by Ulrich (*in* Bridge, 1930, p. 216) for this taxon. These features include (1) large size; (2) a tall, anteriorly rounded glabella; (3) no glabellar furrows (but two pairs of slightly depressed, nonpustulose patches are on the sides of the glabella); (4) deeply impressed axial, preglabellar, and occipital furrows; (5) anterior course of facial sutures only slightly divergent; (6) strongly convex, arched, prominent anterior border with deeply impressed anterior border furrow; and (7) cranidial prosopon of coarse pustules that are usually surrounded by a circle of five or six small to medium granules or pustules. The palpebral lobes are arcuate, length three-eighths of the glabellar length, centered at the glabellar midlength, and set off by palpebral furrows. The only real difference between the Oklahoma specimens and Ulrich's description is that the Oklahoma specimens have one to three irregular rows of pustules crossing the preglabellar field, whereas Ulrich described two or three rows for the Missouri specimens. The type species, *Hystricurus conicus* (Billings), has a cranidium similar to the Oklahoma specimens and has only one row of pustules crossing the preglabellar field, but *H. conicus* has a concave anterior border.

No librigenae or pygidia were described for *H. missouriensis* by Ulrich, but six fragmentary librigenae and five fragmentary pygidia from Oklahoma allow composite descriptions of these exoskeletal parts. The librigena has an eye socle, a moderately convex genal field, well-impressed border furrow, and a prominent, convex border covered by medium to small granules. The genal field is covered by genal caeca, on top of which occur scattered large pustules surrounded by circles of five or six small to medium pustules. The genal caeca are not covered by pustules near the border furrow or immediately below the eye socle. Genal spines of unknown but probably of medium length are present. The best specimen is illustrated.

The associated pygidium is elliptical in outline, with the width greater than length. The axis has an articulating half-ring, three axial rings separated by deep ring furrows that end in deep pits near the axial furrow, and a terminal piece. The axial furrows are shallow. The pleural field is convex, with three pleurae that have well-impressed pleural furrows and faint interpleural furrows. The pleurae fade into a shallow border furrow, which sets off a wirelike border. The axial rings, terminal piece, and pleurae are covered by scattered coarse to medium pustules surrounded by irregular circles of smaller granules. The best specimens are illustrated.

Ross (1951, p. 41, 52–53) suggested that *H. missouriensis* might best be assigned to *Parahystricurus*, but because the crucial palpebral lobes and posterior areas were not preserved on the holotype of *H. missouriensis* (see Ross, p. 52–53), he was not able to make a positive assignment. On the Oklahoma specimens, the posterior areas are somewhat triangular for *Hystricurus*, and the preglabellar field is short, which would favor an assignment to *Parahystricurus* (see Ross, p. 56–57). However, the palpebral lobes are the right size and shape for *Hystricurus* (see Ross, p. 39–40), they are located at the glabellar midlength, and the librigena has an eye socle (infraocular ring of Ross), all features that favor an assignment to *Hystricurus*.

Examination of Ulrich's holotype of *H. missouriensis* reveals that, although the palpebral lobes are not preserved, the palpebral furrow, which indicates the position and probable size of the palpebral lobe, is preserved on the right side of the cranidium. The palpebral furrow (and therefore probably the missing palpebral lobe) is nearly one-half the length of the glabella and is centered at the glabellar midlength. The left posterior area is preserved as Ulrich illustrated it (*in* Bridge, 1930, pl. 21, fig. 1), but the tip of the right posterior area and the adjacent part of the posterior furrow are covered by rock, and Ulrich simply drew in the outside 3 mm of this feature on his picture. In doing so, he made the right posterior area appear more triangular than it is. On the holotype, the posterior areas are slender and are similar to those of *Hystricurus genalatus* Ross and *Hystricurus contractus* Ross (see Ross, 1951, pl. 8, figs. 2, 3, 5, 6, 11, 13; pl. 10, figs. 7, 10).

Hystricurus missouriensis, as exemplified by the holotype and the Oklahoma specimens, has a prominent, tapering, anteriorly rounded glabella; deep axial, occipital, and anterior border furrows; no glabellar furrows (but two pairs of nonpustulose patches on the sides of the glabella); convex fixigenae; large, arcuate palpebral lobes centered on the glabellar midlength; slender posterior areas; an eye socle on the librigena; and a typical hystricurid pygidium. These are the characteristics that Ross (1951, p. 39–40) listed when he refined the definition of *Hystricurus*. *H. missouriensis* fits the definition, and is therefore retained as a valid species of *Hystricurus*.

Occurrence.—Common to scarce in the *Bellefontia chamberlaini* Subzone at CC 2452, 2515,

2521; HS 2356, 2444, 2448. Scarce in the *Paraplethopeltis* Zone at CC 2572, 2605.

Family UNCERTAIN

Genus **Clelandia** Gossman, 1902

Clelandia oklahomensis Stitt, n. sp.

Pl. 6, figs. 4–7

Material available.—27 cranidia, 13 well preserved, fair size range, plus 3 librigenae.

Description.—Cranidium small (usually 3–4 mm long), subtrapezoidal in outline, length about two-thirds of width, moderately convex (sag.), strongly convex (trans.). Glabella subconical, length eight- to nine-tenths of basal glabellar width, one pair of faint, posteriorly curved glabellar furrows, some specimens with an extremely faint second pair of glabellar furrows. On exoskeleton (pl. 6, figs. 4, 5), axial furrows narrow but deeply incised; preglabellar furrow very faint; occipital furrow narrow, faint, slightly posteriorly curved and fainter abaxially, not intersecting axial furrow. On internal molds (pl. 6, fig. 6), axial and preglabellar furrows broad and deep; occipital furrow deeply incised across axis, becoming moderately incised abaxially. Occipital ring tapers abaxially, length (sag.) slightly more than one-third of glabellar length; axial occipital node and small, horizontal axial spine along posterior margin of occipital ring. Frontal area downsloping, length (sag.) slightly more than one-half of glabellar length, no anterior border; faint axial ridge on exoskeleton extending from preglabellar furrow to anterior margin of cranidium, ridge absent on internal molds. Fixigenae convex, downsloping, minimum width about four-tenths of glabellar length; faint eye ridges cross fixigenae near anterior end of glabella, no palpebral lobes visible. Posterior areas of fixigenae widen posterior of glabellar midlength; posterior border furrow faint on exoskeleton, deeper on internal molds, dies out before reaching lateral margin of cranidium. Anterior course of facial sutures initially only slightly convergent, then swinging adaxially to meet along anterior margin of cranidium. Posterior areas of fixigenae of exoskeleton covered by faint pits, remainder of cranidium apparently smooth. Librigena gently convex, smooth, with no border; genal spine present but of unknown length.

Pygidium unknown.

Holotype.—OU 10119, plate 6, figure 4.

Paratypes.—OU 10120, plate 6, figure 5; OU 10121, plate 6, figure 6; OU 10122, plate 6, figure 7. All holotype and paratype specimens from CC 2345, *Bellefontia collieana* Subzone of the *Bellefontia–Xenostegium* Zone, McKenzie Hill Limestone, Wichita Mountains, Oklahoma.

Etymology.—*Oklahomensis*, named for the occurrence of this species in Oklahoma.

Remarks.—This species is characterized by the combination of (1) one or two pairs of faint glabellar furrows; (2) an axial occipital node and a small, horizontal, axial occipital spine; (3) a faint axial ridge on the frontal area; (4) the very faint preglabellar furrow on the exoskeleton, in constrast to the narrow but deeply incised axial furrows; and (5) the faint pits on the posterior areas of the fixigenae. *C. oklahomensis* can be distinguished from other species assigned to this genus in the following ways: (1) *C. utahensis* (Ross, 1951, p. 117, pl. 29, figs. 1–4, 6–9), *C. bispina* (Ross, 1967, p. 31, pl. 10, figs. 1–16), *C. aspina* (Ross, 1967, p. 31, pl. 10, figs. 17–22), *C. wilsoni* (Norford, 1969, p. 10–11, pl. 2, figs. 1–17), and *C. reliqua* (Rushton and Tripp, 1979, p. 325–326, pl. 1, figs. a–h), all have no glabellar furrows; (2) *C. parabola* (see pl. 6, fig. 1) has a large occipital spine, *C. utahensis* has a medium to large occipital spine (compare Ross, 1951, pl. 4, fig. 17, and Norford, 1969, pl. 1, figs. 2, 3), and *C. bispina*, *C. wilsoni*, and *C. reliqua* have vestigial to well-developed glabellar spines as well as occipital spines; and (3) *C. texana* (Winston and Nicholls, 1967, p. 89–90, pl. 12, figs. 11, 26) has two pairs of glabellar furrows and, along with *C. aspina*, no occipital spine.

The species most similar to *C. oklahomensis* is *C. albertensis* (Norford, 1969, p. 8–9, pl. 1, figs. 15–18, 22–40) from the underlying *Symphysurina* Zone at Mount Wilson, Alberta, Canada. *C. albertensis* has a similar-sized occipital node and spine, although the spine has a more dorsal inclination (Norford, pl. 1, fig. 35) than the spine on *C. oklahomensis*. Further, *C. oklahomensis* lacks the deep pits in the occipital furrow (Norford, p. 9, pl. 1, figs. 15, 40) characteristic of *C. albertensis*, and the glabella of *C. oklahomensis* is much more anteriorly pointed than the broadly rounded glabella of *C. albertensis*.

Occurrence.—Scarce in the *Xenostegium franklinense* Subzone at CC 2143, 2185, 2211. Scarce to abundant in the lower half of the *Bellefontia collieana* Subzone at CC 2219, 2345; HS 2126, 2175. Scarce at the base of the *Bellefontia chamberlaini* Subzone at HS 2322.5.

Clelandia parabola (Cleland)

Pl. 6, figs. 1–3

Harrisia parabola CLELAND, 1900, p. 255–256, pl. 16, figs. 1–3.

Clelandia parabola (Cleland) COSSMAN, 1902, p. 52; RAYMOND, 1937, pl. 1, fig. 25; FISHER, 1954, pl. 4, fig. 11; NORFORD, 1969, p. 5–6, pl. 1, figs. 1, 6, 7, 11, 12.

Remarks.—This species was originally described by Cleland (1900) from the Tribes Hill Formation in New York, and it had not been reported from anywhere else until now. Cossman (1902) made this taxon the type species of his new genus *Clelandia*. The occipital ring is not preserved on the holotype cephalon, so Raymond

(1937) illustrated a second specimen of *C. parabola* from the Tribes Hill showing the large occipital spine characteristic of this species. Norford (1969) provided an excellent description and reillustration of the holotype, showing the damaged occipital ring and other characteristics of the specimen.

Clelandia parabola is characterized by its tall, conical glabella and its large, posterodorsally directed occipital spine, which also has a small mesial node. On internal molds, the axial furrows are deeply impressed and meet in a broad axial depression in front of the glabella (pl. 6, fig. 3; Norford, 1969, pl. 1, figs. 1, 6, 7), whereas on the exoskeleton the axial furrows are only moderately impressed beside the glabella and become very shallow in front of the glabella (pl. 6, fig. 1). The exoskeleton is pitted (pl. 6, figs. 1, 2), whereas the internal mold is smooth (pl. 6, fig. 3). The characteristic small bump on the librigena, near the intersection of the axial and posterior furrows, is prominent on internal molds (pl. 6, fig. 3; Norford, 1969, pl. 1, figs. 1, 6, 7) but barely visible on the exoskeleton. The two very faint glabellar furrows described from the exfoliated holotype by Norford (1969, p. 5) are best seen on internal molds and are not present on the exoskeleton. Librigenae have a long genal spine (pl. 6, fig. 2), and one cephalon from Oklahoma (pl. 6, fig. 3) shows the narrow librigenae, broad fixigenae, genal spine, small eye, and part of the yoke connecting the librigenae characteristic of this species.

Occurrence.—Abundant in the lower part of the *Xenostegium franklinense* Subzone at HS 1985.

Clelandia texana Winston and Nicholls

Clelandia texana WINSTON AND NICHOLS, 1967, p. 89–90, pl. 12, figs. 11, 26; STITT, 1977, p. 45–46, pl. 6, figs. 4, 5 (synonymy to date).

Remarks.—Four incomplete cranidia are assigned to this species, which had been reported (Stitt, 1977) from the uppermost part of the underlying Signal Mountain Limestone. *Clelandia texana* is characterized by two pairs of glabellar furrows, an occipital node, wide, flaring posterior areas of the fixigenae, and moderate convexity. Norford (1969, p. 8) correctly pointed out that smaller specimens are more convex and have better impressed furrows than larger specimens. All the Oklahoma specimens of this species have fainter glabellar furrows than those illustrated from Texas or Canada.

Occurrence.—Scarce in middle of the *Symphysurina bulbosa* Subzone at CC 1938. Scarce in the lower half of the *Symphysurina woosteri* Subzone at HS 1898, 1912.5.

Genus **Mannschreekia** Stitt, n. gen.

Type species.—*Mannschreekia* parva Stitt, n. sp.

Remarks.—Because this genus is monotypic at present, the description of the type species also serves as the generic description. Another species that may belong in this genus is Genus and species D Ross (1951, p. 126, pl. 35, figs. 1, 2). These small trilobites appear to be granulated, and have a similar cylindrical glabella with no preglabellar furrow, well-impressed occipital and posterior border furrows, and similarly shaped fixigenae. These two taxa with the prominent glabellae, wide posterior areas, and no preglabellar furrow are most similar to species of the Upper Cambrian genus *Phoreotropis* Raymond. The Lower Ordovician taxa differ in that they lack palpebral lobes and the axial furrows extend relatively farther forward and do not end in a pit.

A few of the features that distinguish specimens of *Mannschreekia* from immature specimens of *Missisquoia* spp. are the absence of an anterior border and palpebral lobes, the anteriorly terminating axial furrows, the less prominent glabellar furrows, the narrower anterior fixigenae, and the smaller number of pygidial axial rings and pleurae.

Etymology.—*Mannschreekia* is named after Mr. E. H. Mannschreek, the gracious rancher who has allowed me access to the Chandler Creek section for some years and on whose land this trilobite was discovered.

Mannschreekia parva Stitt, n. sp.

Pl. 6, figs. 8–10

Material available.—21 cranidia and 4 pygidia, mostly well preserved.

Description.—Cranidium small (less than 2 mm long), semicircular in outline, strongly convex (sag. and trans.). Glabella prominent, cylindrical, elevated above fixigenae; two pairs of short, moderately impressed glabellar furrows, a third pair very faintly impressed on some specimens. Axial furrows well impressed on posterior two-thirds of cranidium, becoming progressively fainter anteriorly and dying out near anterior margin of cranidium. No preglabellar furrow, no anterior border or border furrow. Anterior end of glabella reaches nearly to anterior margin of cranidium and merges with frontal area. Occipital furrow well impressed, widening and curving anteriorly at intersection with axial furrow. Occipital ring slightly less than one-sixth of cranidial length, tilted toward occipital furrow, curving slightly anteriorly near axial furrow. Fixigena triangular, steadily widening posteriorly, no apparent palpebral lobe. Posterior border furrows well impressed, intersect axial furrows opposite occipital ring, abruptly shallow and die out laterally before reaching margin of cranidium. Entire surface of cranidium covered by small granules.

Librigenae not known.

Pygidium triangular, covered by small gran-

ules. Axis prominent, convex, posteriorly tapering with an articulating half-ring and four axial rings, moderately to well-impressed ring furrows, and a small, rounded terminal piece. Anterior two pairs of pleurae with well-impressed interpleural and moderately impressed pleural furrows; posterior two pairs of pleurae only faintly visible. No border furrow or border present.

Holotype.—OU 10123, plate 6, figure 8. Holotype specimen from CC 1974.5, *Symphysurina bulbosa* Subzone of the *Symphysurina* Zone, McKenzie Hill Limestone, Wichita Mountains, Oklahoma.

Paratypes.—OU 10124, plate 6, figure 9; OU 10125, plate 6, figure 10. Both paratypes from CC 1964, *Symphysurina bulbosa* Subzone of the *Symphysurina* Zone, McKenzie Hill Limestone, Wichita Mountains, Oklahoma.

Etymology.—*Parvus*, L., little, referring to the very small size of this trilobite.

Remarks.—This species is characterized by its small size, strong convexity, granular prosopon, prominent axis, and the absence of a preglabellar furrow, anterior border, palpebral lobes, and pygidial border. *M. parva* differs from Genus and species D Ross in that the latter has a prominent occipital spine and no glabellar furrows.

Occurrence.—Abundant in the middle part of the *Symphysurina bulbosa* Subzone at CC 1964, 1974.5.

Unassigned pygidium no. 2 Stitt

Unassigned pygidium no. 2 STITT, 1977, p. 49, pl. 6, fig. 7.

Remarks.—Eleven pygidia from the basal part of the McKenzie Hill Limestone are assigned to this taxon, which was previously described and illustrated (Stitt, 1977) from the uppermost part of the underlying Signal Mountain Limestone. These pygidia are distinguished by their overall smoothness and the concave, shelflike part of the pleural field that is restricted to the posterior margin of the pygidium. Unfortunately, no associated cranidia or librigenae have been discovered that could be assigned to this taxon, so further knowledge of this species probably must await discovery of a complete specimen. Taylor and others (1981, p. 224) reported finding a similar pygidium in the basal beds of the Garden City Formation, which they assigned to *Symphysurina* sp.

Occurrence.—Scarce at the base of the McKenzie Hill Limestone (middle part of the *Symphysurina bulbosa* Subzone) at CC 1937, 1938, 1949.5.

MEASURED SECTIONS

The measured sections are listed alphabetically, and the location of each section is shown on the regional index map (fig. 1) and in more detail on maps accompanying the section descriptions (figs. 4, 6). A geologic map of the area immediately surrounding each section is included with the section description, along with a road log to facilitate location of the section. Both of the sections are on private ranches, and permission must be obtained from the landowners before visiting the sections. Each section was measured with a 5-foot Jacob's staff, and the rocks were painted every 5 feet with a stripe of red paint. Stripes were numbered every 25 feet above the base of the section.

Fresh, wetted sufaces of the limestones were examined in the field and in the laboratory, and the descriptions utilize Dunham's (1962) limestone classification. Lime mudstone intraclasts are common in these rocks, and their maximum diameters are indicated as follows: small = 0.2 to 1 mm; medium = 1 to 3 mm; and large = greater than 3 mm. Pellets were distinguished from interclasts by using Folk's (1962, p. 63–65) criteria and suggested size cutoff (pellets are less than 0.2 mm in diameter). Colors were estimated from the fresh, wet surfaces. Descriptions of weathering were recorded in the field. Thin beds are 6 inches thick or less (usually 3–4 inches), medium beds are 6 inches to 1 foot thick, and thick beds are more than 1 foot thick. "Massive" is occasionally used to indicate very thick or seemingly unbedded units. Offset directions assume an upsection traverse.

Beds from which trilobites were collected, and the taxa identified in each collection, are listed after the lithologic description of the interval involved. Genera and species are listed alphabetically in each collection, and the number of cranidia, pygidia, and librigenae assignable to each taxon is given in parentheses after the name. For example, "CC 2316 *Hystricurus globosus* (29–7–11)" means that, at 2,316 feet above the base of the Chandler Creek measured section, 29 cranidia, 7 pygidia, and 11 librigenae assignable to *Hystricurus globosus* were collected.

Chandler Creek Section (CC)

This painted section is approximately 14 miles north-northwest of Lawton, Oklahoma, in a northwest-trending outcrop belt of Upper Cambrian and Lower Ordovician rocks. The lower part of this section that traverses the interval of Reagan Sandstone to Signal Mountain Limestone has been collected and described (Stitt, 1977), and the section was extended through the McKenzie Hill Limestone for this study. To tie these two studies together, as well as to make it easier to locate the upper part of the section, the entire section traverse is shown on the geologic map of the area surrounding the section (fig. 4). Refer to figure 5 for a diagram of trilobite occurrences and ranges for the McKenzie Hill part of this section.

The lowest part of the section crops out on land leased by Mr. E. DeMarcus (home located on north side of paved road on south edge of sec. 9, T. 3 N., R.

12 W.). The rest of the measured section, including the entire McKenzie Hill interval, is owned by Mr. E. H. Mannschreek of Anadarko, Oklahoma. Permission must be secured from both of these cooperative gentlemen before proceeding to the outcrop. Township and range coordinates for the McKenzie Hill part of this section are the NW¼ sec. 16, T. 4 N., R. 12 W., Richards Spur, Oklahoma, 7½-minute quadrangle map, 1956 edition. The following road log should make location of the section easier.

Mileage

0.0 Junction of U.S. 281, 277, and 62 at northeast edge of Lawton, Oklahoma. Drive north on 281, 277, and 62.

6.3 Leave U.S. 281, 277, and 62, turn left at stop sign and travel west on State 49.

9.7 Turn north on paved road.

10.7 Turn west on paved road, and stop at pink house (first house on right) to obtain permission from Mr. E. DeMarcus to cross lower part of Chandler Creek section. Continue west on paved road.

11.8 Turn right (northwest) on State 58. Lake Lawtonka and Mount Scott can be seen to west.

14.2 Leave State 58 and drive north on paved road. Cross two east–west roads, one paved and one gravel.

17.7 Paved road ends. Turn right through wire gate and follow dirt road across dry creek, curve left past wooden and tin sheds, bear right over crest of hill, and continue downhill toward farm pond.

19.0 Park vehicle at farm pond. Proceed due east from pond across creek and fence to outcrops of Reagan Sandstone near base of hill. Turn northeast and continue up hillside, crossing outcrops of Reagan Sandstone, Honey Creek Limestone, and thick-bedded Fort Sill Limestone; notice yellow paint stripes and numbers on Fort Sill beds. Pass crest of hill, continue to follow numbers northeast down dip slope of Fort Sill (top at dry creek bed marked by algal stromatolites), and cross broad, 1¼-mile-wide swale containing outcrops of Signal Mountain Limestone. Base of McKenzie Hill Limestone placed at prominent thick-bedded unit near bottom of next hill; locate red paint stripes and numbers and begin McKenzie Hill traverse.

Description	Thickness in feet	Feet above base
McKenzie Hill Limestone: 809 feet thick		
Upper grainstone member: 349 feet thick		
17. Pelletal and intraclastic lime grainstone. Pellets, small- to medium-sized lime-mudstone intraclasts, and sparse fossil fragments; scattered dolomite rhombs, especially along stylolites. Oolitic lime grainstone at 2,616, 2,621, and 2,650 feet; lime wackestone at 2,627, 2,630, and 2,734 feet; dolomitic lime mudstone at 2,618, 2,634–2,636, 2,655–2657, and 2,692 feet. Dark chert nodules common, some in layers. Medium to dark brownish gray, mostly thick to massive slabby beds; medium to thin beds in lower ¼ and upper ¼ of unit; weathers medium gray.	113	2,602–2,735
Paraplethopeltis Zone		
CC 2647 *Paraplethopeltis genacurva* (1–0–0) CC 2642 *Paraplethopeltis genacurva* (1–0–0) CC 2605 *Hystricurus missouriensis* (2–0–0) CC 2604 *Remopleuridiella caudilimbata* (1–0–0)		
16. Interbedded lime mudstone and dolomitic intraclastic lime grainstone. Dark chert nodules common. Medium to dark brownish gray, thin to medium beds; weathers medium gray. Interval partly covered.	13	2,589–2,602
15. Intraclastic lime grainstone. Small to medium lime-mudstone intraclasts and pellets; scattered dolomite rhombs along stylolites. Lime wackestone at 2,570 feet; lime mudstone at 2,585 feet. Dark chert nodules common. Medium to dark brownish gray, thin to thick beds, weathers medium gray. Interval partly covered.	20	2,569–2,589
Paraplethopeltis Zone		
CC 2572 *Hystricurus missouriensis* (2–0–0) *Paraplethopeltis obesa* (2–0–0)		
14. Lime mudstone. Intraclastic lime wackestone at 2,563 feet. Medium to dark brownish gray, medium to thick beds; weathers medium gray. Interval mostly covered (creek valley).	19	2,550–2,569
13. Intraclastic and pelletal lime grainstone. Small to large lime-mudstone intraclasts, pellets, scattered trilobite fragments. Lime mudstone at 2,483–2,485, 2,513, 2,523, 2,529, and 2,535 feet; lime wackestone at 2,515 feet. Dark chert nodules common. Medium to dark brownish gray, mostly medium beds; weathers medium gray. Interval mostly covered.	82	2,468–2,550
Bellefontia–Xenostegium Zone *Bellefontia chamberlaini* Subzone		
CC 2523 *Hystricurus* sp. undet. (1–0–0) CC 2522 Hystricurid fragment		

Description	Thickness in feet	Feet above base
CC 2521 *Hystricurus missouriensis* (1–0–0) CC 2515 *Bellefontia chamberlaini* (4–9–2) *Hystricurus missouriensis* (1–0–0)		
12. Mostly lime mudstone. Intraclastic lime grainstone at 2,434, 2,455, and 2,462 feet; dolomite at 2,451 feet. Dark chert nodules common. Medium to dark brownish gray, medium to thin beds; weathers medium gray. Interval mostly covered.	36	2,432–2,468
Bellefontia chamberlaini Subzone		
CC 2452 *Hystricurus missouriensis* (7–2–1)		
11. Pelletal, intraclastic, and oolitic lime grainstone. Pellets, small to medium lime-mudstone intraclasts, and ooliths; scattered dolomite rhombs, especially along stylolites. Dark chert nodules common. Medium to dark brownish gray, mostly medium beds; weathers light to medium gray. Interval mostly covered.	46	2,386–2,432
Bellefontia collieana Subzone		
CC 2426 *Hystricurus globosus* (0–0–1) CC 2388 *Xenostegium* cf. *X. franklinense* (0–1–0)		
Lower lime-mudstone member: 460 feet thick		
10. Lime mudstone. Scattered dolomite rhombs, especially along joints and stylolites. Intraclastic lime grainstone at 2,354–2,358 and 2,369 feet. Dark chert nodules common. Dark to medium brownish gray, mostly medium beds; weathers light to medium gray. Interval partly covered.	41	2,345–2,386
Bellefontia collieana Subzone		
CC 2372.5 *Hystricurus globosus* (1–0–0) CC 2368 *Hystricurus globosus* (0–0–3) CC 2353 *Hystricurus globosus* (1–0–0) CC 2345 *Bellefontia collieana* (1–0–0) *Clelandia oklahomensis* (13–0–1) *Praepatokephalus armatus* (7–1–4)		
9. Intraclastic lime grainstone. Small to medium lime-mudstone intraclasts. Dark chert nodules common. Medium brownish gray, mostly medium beds; weathers medium gray. Interval partly covered.	13	2,332–2,345
8. Lime mudstone. Scattered trilobite fragments, sponge spicules, and dolomite rhombs. Pelletal lime grainstone at 2,315 feet; trilobite lime wackestone at 2,320 feet. Dark chert nodules common. Dark to medium brownish gray, medium to thin platy beds; weathers medium to dark gray. Interval partly covered.	18	2,314–2,332
Bellefontia collieana Subzone		
CC 2318 *Hystricurus globosus* (14–2–0) *Praepatokephalus armatus* (3–0–1) CC 2316 *Hystricurus globosus* (29–7–11) *Praepatokephalus armatus* (18–2–2)		
7. Dolomitic intraclastic lime wackestone and lime grainstone. Small to medium lime-mudstone intraclasts, scattered trilobites, brachiopods, and dolomite rhombs. Lime mudstone at 2,299 feet. Dark chert nodules common. Medium brownish gray, mostly thin to medium platy beds; weathers medium to dark gray. Interval partly covered.	19	2,295–2,314
Section offset 300 feet to southeast on resistant bed at 2,303 feet, to within 20 feet of fence.		
6. Mostly lime mudstone and trilobite lime wackestone. Dolomite rhombs concentrated along stylolites. Intraclastic lime grainstone at 2,203, 2,219, 2,236, 2,246 and 2,256 feet. Dark chert nodules common. Medium to dark brownish gray, thin to thick (mostly medium) slabby beds; weathers medium gray. Base of upper cherty member of Brookby (1969) at 2,189 feet.	106	2,189–2,295
Bellefontia collieana Subzone		
CC 2283 *Praepatokephalus armatus* (0–0–1) CC 2280 *Hystricurus hillyardensis* (1–0–0) *Symphysurina woosteri* (1–0–0) CC 2264 *Symphysurina woosteri* (10–2–1) *Symphysurina* sp. no. 1 (0–1–1) *Xenostegium franklinense* (1–2–2) CC 2252 *Hystricurus hillyardensis* (7–1–2) *Praepatokephalus armatus* (3–0–1) *Xenostegium franklinense* (0–0–1) CC 2236 *Symphysurina woosteri* (2–5–0) *Symphysurina* sp. no. 1 (0–1–0) CC 2229 *Bellefontia collieana* (0–0–1) *Hystricurus hillyardensis* (0–0–1) *Symphysurina woosteri* (2–4–3) *Symphysurina* sp. no. 1 (0–1–1) *Xenostegium franklinense* (0–1–1) CC 2225 *Bellefontia collieana* (0–1–0) CC 2219 *Bellefontia collieana* (0–0–2) *Clelandia oklahomensis* (2–0–0) *Symphysurina woosteri* (8–3–1) *Symphysurina* sp. no. 1 (0–0–1) *Xenostegium franklinense* (0–1–0)		

	Description	Thickness in feet	Feet above base
	Xenostegium franklinense Subzone		
CC 2214	*Hystricurus hillyardensis* (0–0–1) *Symphysurina woosteri* (6–0–1)		
CC 2211	*Clelandia oklahomensis* (1–0–0) *Symphysurina woosteri* (0–1–1) *Xenostegium franklinense* (1–1–2)		
CC 2196	*Symphysurina woosteri* (1–0–1) *Xenostegium franklinense* (0–0–2)		
CC 2192	*Symphysurina woosteri* (0–1–0)		
	5. Intraclastic trilobite lime grainstone. Small to large lime-mudstone intraclasts, trilobite fragments. Brownish gray, slightly orange tinted, medium to thick slabby beds; weathers medium gray.	10	2,179–2,189
	Xenostegium franklinense Subzone		
CC 2186	*Symphysurina woosteri* (0–1–0)		
CC 2185	*Clelandia oklahomensis* (2–0–1) *Symphysurina woosteri* (5–2–2) *Xenostegium franklinense* (0–2–0)		
CC 2179	*Symphysurina woosteri* (3–0–0) *Xenostegium franklinense* (0–0–1)		
	4. Lime mudstone and trilobite lime wackestone. Trilobites concentrated in thin layers, some crushed; scattered dolomite rhombs, especially along stylolites and joints. Intraclastic lime grainstone at 2,133.5 and 2,159 feet. Fine-grained quartz sand at 2,103, 2,109, and 2,133.5 feet. Dark to medium brownish gray, mostly medium to thick beds; weathers medium gray.	83	2,096–2,179
	Xenostegium franklinense Subzone		
CC 2168	*Symphysurina woosteri* (1–1–0) *Xenostegium franklinense* (1–2–0)		
CC 2164	*Symphysurina woosteri* (2–0–0)		
CC 2159	*Symphysurina woosteri* (0–1–1)		
CC 2143	*Clelandia oklahomensis* (2–0–0) *Hystricurus hillyardensis* (1–0–1) *Praepatokephalus armatus* (3–1–3) *Symphysurina woosteri* (4–1–1) *Xenostegium franklinense* (0–3–0)		
CC 2130	*Praepatokephalus armatus* (1–0–1)		
CC 2127	*Symphysurina woosteri* (1–0–1)		
CC 2126	*Symphysurina* sp. undet. (1–0–0)		
CC 2123	*Symphysurina woosteri* (1–0–0)		
CC 2109.5	*Symphysurina woosteri* (15–4–1)		
CC 2106	*Symphysurina woosteri* (1–0–0)		
CC 2105	*Xenostegium franklinense* (0–0–1)		
CC 2103	*Parabellefontia*? sp. undet. (0–1–0) *Symphysurina woosteri* (11–4–2) *Xenostegium franklinense* (1–1–0)		
	3. Trilobite lime wackestone. Intraclastic lime grainstone at 2,036 and 2,094 feet; lime mudstone at 2,041 and 2,081 feet. Fine-grained quartz sand at 2,048 and 2,056 feet. Scattered dolomite rhombs in orange mottles and along stylolites and joints. Medium to dark brownish gray, mostly thick to medium slabby beds; weathers medium gray. Interval partly covered.	65	2,031–2,096
	Section offset 50 feet to southeast across fold at 2,046 feet.		
	Symphysurina Zone		
	Symphysurina woosteri Subzone		
CC 2085	*Symphysurina* sp. undet. (1–0–0)		
CC 2084	*Symphysurina woosteri* (6–2–2)		
CC 2070	*Symphysurina* sp. undet. (1–0–0)		
CC 2066	*Parabellefontia*? sp. undet. (0–1–0)		
CC 2063	*Symphysurina* sp. undet. (0–1–0)		
CC 2062	*Parabellefontia*? sp. undet. (0–2–0) *Symphysurina* sp. undet. (1–1–0)		
CC 2058	*Hystricurus hillyardensis* (1–0–1) *Symphysurina woosteri* (34–14–14)		
CC 2056	*Symphysurina bulbosa* (1–0–1)		
CC 2048	*Symphysurina brevispicata* (0–0–1)		
CC 2044	*Symphysurina brevispicata* (0–0–1) *Symphysurina* sp. undet. (1–1–0)		
CC 2033.5	*Symphysurina bulbosa* (10–4–2) *Symphysurina woosteri* (0–1–0)		
	Symphysurina bulbosa Subzone		
CC 2031	*Symphysurina bulbosa* (6–3–0)		
	2. Intraclastic lime grainstone. Small to large lime-mudstone intraclasts, scattered trilobite fragments. Fine-grained quartz sand at 1,964 feet. Lime mudstone at 2,026 and 2,028 feet. Medium brownish gray, mostly medium to thick slabby beds; weathers medium gray. Interval mostly covered.	67	1,964–2,031
	Symphysurina bulbosa Subzone		
CC 2028	*Hystricurus hillyardensis* (1–0–0) *Symphysurina bulbosa* (1–1–0)		
CC 2027.5	*Symphysurina bulbosa* (0–2–0)		
CC 2014	*Symphysurina brevispicata* (0–0–1) *Symphysurina bulbosa* (1–1–0)		
CC 2009	*Symphysurina brevispicata* (1–0–0) *Symphysurina bulbosa* (3–1–0)		
CC 1974.5	*Hystricurus millardensis* (5–0–0) *Mannschreekia parva* (2–0–0) *Symphysurina bulbosa* (4–0–1)		
CC 1974	*Symphysurina bulbosa* (1–0–1)		
CC 1964	*Hystricurus millardensis* (3–0–1) *Mannschreekia parva* (19–4–0) *Symphysurina brevispicata* (7–4–2) *Symphysurina bulbosa* (20–21–5)		
	1. Trilobite lime wackestone and trilobite lime mudstone. Scattered pellets, lime-mudstone intraclasts, and dolomite rhombs. Fine-grained quartz sand at 1,949.5 and 1,958 feet.	38	1,926–1,964

Description		Thickness in feet	Feet above base
Medium brownish gray, thick to medium slabby beds; weathers to medium gray. Interval partly covered.			
Section offset about 180 feet to northwest along base of McKenzie Hill Limestone at 1,926 feet.			
	Symphysurina bulbosa Subzone		
CC 1953	*Symphysurina brevispicata* (2–0–0) *Symphysurina bulbosa* (0–1–0)		
CC 1949.5	*Symphysurina bulbosa* (0–1–0) Unassigned pygidium no. 2 (0–1–0)		
CC 1938	*Clelandia texana* (1–0–0) *Symphysurina brevispicata* (3–1–1) *Symphysurina bulbosa* (5–1–1) Unassigned pygidium no. 2 (0–3–0)		
CC 1937	*Symphysurina brevispicata* (0–0–1) *Symphysurina bulbosa* (2–5–2) Unassigned pygidium no. 2 (0–6–0)		
Signal Mountain Limestone: Not measured or described in this report. See Stitt (1977) for description.			

U.S. Highway 77 Section (HS)

This painted section is approximately 13 miles north of Ardmore, Oklahoma, in a northwest-trending outcrop belt of Upper Cambrian and Lower Ordovician rocks. The lower part of this section that traverses the interval of Reagan Sandstone to Butterly Dolomite has been collected and described (Stitt, 1971b); the section has been offset approximately 0.6 mile to the southeast at the top of the Butterly and extended through the McKenzie Hill Limestone for this study. To tie these two studies together, the entire section traverse is shown on the geologic map of the area surrounding the section (fig. 6). Refer to figure 7 for a diagram of trilobite occurrences and ranges for the McKenzie Hill part of this section.

This section is on land that is part of the large Chapman Ranch and is presently leased to the Spade Cattle Co. Before visiting the section, permission must be secured at the ranch headquarters (see road log), from Mr. Bruce Loard of the Spade Cattle Co., and also from the owner of the Chapman Ranch, Mr. Fred Chapman, Jr., who lives in Ardmore. Township and range coordinates for the McKenzie Hill part of this section are the NW¼ sec. 12, T. 2 S., R. 1 E., Turner Falls, Oklahoma, 7½-minute quadrangle map. The following road log should make location of this part of the section easier.

Mileage

- 0.0 Intersection of I–35 and U.S. 70 in Ardmore. Drive north on I–35 after obtaining permission to visit the section from Mr. Fred Chapman, Jr., of Ardmore.
- 12.0 First road cuts of the Arbuckle Mountains.
- 15.0 Leave I–35 at first exit to the Turner Falls area.
- 15.3 Stop sign. Turn right on U.S. 77 and drive 1.2 miles south; turn left through cattle guard on narrow paved road to Mr. Bruce Loard's house (on left) and obtain permission to visit the section. Retrace route to I–35 exit road, pass under I–35 and continue north on U.S. 77.
- 15.7 Turn left off U.S. 77 onto pasture road and go through aluminum gate. Road turns to right past gate, then curves left and continues downhill.
- 15.9 Intersection of pasture roads. Continue straight and uphill around south edge of mountain composed of Carlton Rhyolite Group.
- 16.1 Road forks; bear left and pass through wire gate.
- 16.2 Cross two bridges over small creeks.
- 16.4 Crest of hill. Continue downhill on Signal Mountain dip slope.
- 16.6 Low-water bridge.
- 16.7 Pull off to right and park. Section begins approximately 150 feet northwest of the road, in the edge of the trees at the contact between the Butterly Dolomite and the McKenzie Hill Limestone. Section continues to the southwest across the creek and up the gentle scarp slope.

Description	Thickness in feet	Feet above base
McKenzie Hill Limestone: 920 feet thick		
Upper grainstone member: 532 feet thick		
19. Lime mudstone. Scattered brachiopod fragments; fine-grained quartz sand from 2,638 to 2,645 feet. Intraclastic lime grainstone at 2,615 and 2,626 feet; dolomite at 2,638 feet. Dark chert nodules common. Medium brownish gray, mostly medium beds; weathers light to medium gray. Interval partly covered.	30	2,615–2,645
18. Pelletal and intraclastic lime grainstone. Pellets and mostly small to medium lime-mudstone intraclasts. Scattered dolomite rhombs. Ooliths at 2,486–2,487.5 feet; fine-grained quartz sand at 2,605–2,608 feet. Lime mudstone at 2,493–2,495 and 2,568–2,570 feet; lime wackestone at 2,565 and 2,583–2,590 feet. Dark chert nodules common. Medium to dark brownish gray, mostly medium beds; weathers light to medium gray. Interval partly covered.	141	2,474–2,615
	Bellefontia–Xenostegium Zone *Bellefontia chamberlaini* Subzone		
HS 2592	Hystricurid fragment		
HS 2550	*Hystricurus* sp. undet. (0–1–0)		
HS 2545	*Hystricurus* sp. undet. (1–0–0)		
HS 2515	Hystricurid fragment		
HS 2504	*Bellefontia chamberlaini* (0–0–1)		
HS 2474	*Bellefontia chamberlaini* (0–4–0)		
17. Interbedded pelletal intraclastic lime grainstone, intraclastic lime wackestone,	30	2,444–2,474

Description	Thickness in feet	Feet above base
and lime mudstone. Mostly small to medium lime-mudstone intraclasts and pellets. Dark chert nodules common. Medium brownish gray, thin to thick beds; weathers light to medium gray. Interval partly covered.		
Bellefontia chamberlaini Subzone		
HS 2448 *Hystricurus missouriensis* (0–2–2) HS 2444 *Bellefontia chamberlaini* (3–1–1) *Hystricurus missouriensis* (2–0–0)		
16. Lime mudstone. Pelletal intraclastic lime grainstone at 2,407 and 2,431 feet. Dark chert nodules common. Dark to medium brownish gray, thick to thin beds; weathers medium gray. Interval partly covered.	47	2,397–2,444
15. Pelletal and intraclastic lime grainstones. Pellets and mostly small to medium mudstone intraclasts; scattered dolomite rhombs, especially along stylolites. Lime mudstone at 2,360 and 2,377 feet; intraclastic lime wackestone at 2,356 and 2,380 feet; laminated dolomite at 2,375 feet. Dark chert nodules common. Medium to dark brownish gray, thin to thick beds; weathers light to medium gray. Interval partly covered.	41	2,356–2,397
Bellefontia chamberlaini Subzone		
HS 2369 *Bellefontia chamberlaini* (0–3–2) HS 2356 *Bellefontia chamberlaini* (1–3–0) *Hystricurus missouriensis* (3–1–2)		
14. Lime mudstone. Scattered small lenses of intraclastic lime grainstone. Dark chert nodules common. Medium to dark brownish gray, medium to thick beds; weathers medium gray.	23	2,333–2,356
Section offset 80 feet to northwest on resistant bed at 2,335 feet.		
13. Dark pelletal lime grainstone. Mostly pellets, some small to medium lime-mudstone intraclasts; scattered trilobite fragments and dolomite rhombs. Dark chert nodules common. Dark brownish gray, thin to thick beds; weathers medium to dark gray. Interval partly covered.	85	2,248–2,333
Bellefontia chamberlaini Subzone		
HS 2322.5 *Bellefontia chamberlaini* (1–2–0) *Clelandia oklahomensis* (2–0–0)		
Bellefontia collieana Subzone		
HS 2278 *Hystricurus* cf. *H. globosus* (1–0–0) HS 2273 *Bellefontia* sp. undet. (0–0–1)		
12. Pelletal and intraclastic trilobite lime grainstones. Mostly pellets, small to medium mudstone intraclasts and trilobite fragments. Fine-grained quartz sand at 2,118 feet. Lime mudstone at 2,122, 2,135, and 2,215 feet; dolomite at 2,198 and 2,241 feet. Dark chert nodules common. Mostly medium brownish gray, thin to medium beds; weathers light to medium gray, with whitish mottled areas common. Interval partly covered.	135	2,113–2,248
Bellefontia collieana Subzone		
HS 2214 *Hystricurus* cf. *H. globosus* (1–0–0) HS 2188 *Bellefontia collieana* (0–1–0) HS 2175 *Bellefontia collieana* (0–1–5) *Clelandia oklahomensis* (1–0–0) *Xenostegium franklinense* (0–2–1) HS 2150 *Bellefontia collieana* (0–1–1) HS 2143 *Bellefontia collieana* (0–1–0) HS 2126 *Bellefontia collieana* (1–5–5) *Clelandia oklahomensis* (5–0–1) *Praepatokephalus armatus* (1–0–0) *Xenostegium franklinense* (2–5–2) Hystricurid fragment HS 2120 *Bellefontia collieana* (1–5–10) *Hystricurus* sp. undet. (1–1–0) *Symphysurina bulbosa* (0–1–0) HS 2118 *Bellefontia collieana* (1–3–1) HS 2113 *Bellefontia* cf. *B. collieana* (1–0–0)		
Lower lime-mudstone member: 388 feet thick		
11. Lime mudstone. Dolomite at 2,095 feet, intraclastic lime grainstone at 2,100 feet. Dark chert nodules common. At 2,109 feet, thin to medium trilobite lime-mudstone bed thickens periodically along strike to form 4–5-foot-thick biohermal lenses of trilobite lime mudstone. Medium brownish gray, mostly thin to medium beds; weathers light to medium gray with whitish mottles. Interval partly covered.	18	2,095–2,113
Bellefontia collieana Subzone		
HS 2109 *Bellefontia collieana* (3–8–1) *Xenostegium franklinense* (2–0–0)		
10. Trilobite intraclastic lime grainstone. Mostly small	22	2,073–2,095

Description	Thickness in feet	Feet above base
to medium lime-mudstone intraclasts and trilobite fragments. Dark chert nodules common. Medium brownish gray, thin to medium beds; weathers medium to light gray with whitish mottles. Interval partly covered.		
Bellefontia collieana Subzone		
HS 2093 *Bellefontia collieana* (0–2–1) *Symphysurina bulbosa* (0–1–0) *Symphysurina* sp. no. 1 (2–4–0)		
HS 2092 *Bellefontia collieana* (0–1–0) *Symphysurina woosteri* (0–0–2)		
HS 2081 *Bellefontia* sp. undet. (0–1–1) *Symphysurina* sp. undet. (1–0–0)		
HS 2080 Hystricurid fragment		
HS 2076 *Bellefontia collieana* (1–3–2) *Symphysurina woosteri* (1–0–0)		
9. Interbedded lime mudstone and intraclastic trilobite lime grainstone. Small to large mudstone intraclasts; scattered dolomite rhombs. Trilobite fragments common in lower half of interval. Fine-grained quartz sand at 1,997, 2,034, 2,048, and 2,052.5 feet. Dark chert nodules common. Medium to dark brownish gray, thin to medium beds; weathers light to medium gray with whitish mottles. Interval partly covered.	88	1,985–2,073
Section offset 400 feet to northwest on resistant bed at 2,003 feet.		
Xenostegium franklinense Subzone		
HS 2052.5 *Xenostegium franklinense* (2–1–2)		
HS 2039 *Hystricurus hillyardensis* (1–0–0)		
HS 2027 *Xenostegium franklinense* (1–0–0)		
HS 2020 *Xenostegium franklinense* (3–0–1)		
HS 1985 *Clelandia parabola* (19–0–9) *Praepatokephalus armatus* (0–0–1) *Symphysurina bulbosa* (0–1–0) *Xenostegium franklinense* (3–5–3)		
8. Interbedded lime mudstone, trilobite lime wackestone, and trilobite intraclastic lime grainstone. Fine-grained quartz sand at 1,966 and 1,974 feet. Dark chert nodules common. Medium to dark brownish gray, thin to medium beds cropping out in places as massive units; weathers light to medium gray. Section crosses small fault with 2-foot displacement at 1,970 feet.	28	1,957–1,985
Xenostegium franklinense Subzone		
HS 1982 *Praepatokephalus armatus* (1–0–0)		
HS 1966 *Symphysurina woosteri* (2–1–1) *Xenostegium franklinense* (1–1–2)		
Symphysurina Zone		
Symphysurina woosteri Subzone		
HS 1959 *Symphysurina woosteri* (1–0–0)		
HS 1957 *Symphysurina woosteri* (4–2–0)		
7. Arenaceous, dolomitic trilobite intraclastic lime grainstone. Trilobite fragments, large to small lime-mudstone intraclasts, and fine-grained quartz sand. Dolomite rhombs common, especially along stylolites. Dark chert nodules above 1,946 feet. Medium brownish gray, thin to medium wavy beds usually cropping out as massive units; weathers light to medium gray, with yellowish mottles common. Base of upper cherty member of Ham (1955, fig. 1) at 1,946 feet.	42	1,915–1,957
Symphysurina woosteri Subzone		
HS 1944 *Symphysurina woosteri* (0–1–0)		
HS 1940 *Symphysurina woosteri* (0–0–1)		
HS 1935 *Symphysurina woosteri*? (3–0–0)		
HS 1932 *Symphysurina woosteri* (2–2–0)		
HS 1921 *Parabellefontia*? sp. undet. (0–1–0)		
HS 1918 *Symphysurina bulbosa* (0–2–0) Hystricurid fragment		
HS 1915 *Symphysurina woosteri* (1–1–0)		
6. Arenaceous trilobite lime wackestone and lime mudstone. Scattered dolomite rhombs. Medium brownish gray, thin to medium wavy beds usually cropping out as massive units; weathers light to medium gray with yellowish mottles.	20	1,895–1,915
Symphysurina woosteri Subzone		
HS 1912.5 *Clelandia texana* (1–0–0) *Parabellefontia*? sp. undet. (0–2–0) *Symphysurina* sp. undet. (1–0–0)		
HS 1910 *Symphysurina* sp. undet. (1–0–0)		
HS 1903 *Symphysurina* sp. undet. (1–0–0)		
HS 1900 *Symphysurina woosteri* (1–3–0)		
HS 1899 *Clelandia texana* (2–0–0) *Symphysurina woosteri* (0–1–0)		
HS 1895 *Symphysurina woosteri* (2–1–1)		
5. Dolomitic trilobite intraclastic lime grainstone. Mostly small to medium lime-mudstone intraclasts. Fine-grained quartz sand common from 1,882.5 to 1,889 feet. Medium brownish gray, thin to medium wavy beds usually cropping out as massive units; weathers light to medium gray with yellowish mottles.	39	1,856–1,895

Description	Thickness in feet	Feet above base
Symphysurina woosteri Subzone		
HS 1891 *Symphysurina woosteri* (0–1–0)		
HS 1889 *Hystricurus millardensis* (1–1–0)		
Symphysurina bulbosa (1–2–1)		
Symphysurina woosteri (1–0–0)		
Symphysurina bulbosa Subzone		
HS 1886 *Symphysurina bulbosa*? (1–0–0)		
HS 1874 *Symphysurina bulbosa* (0–1–0)		
HS 1871 *Hystricurus hillyardensis* (1–0–0)		
Symphysurina bulbosa (3–2–0)		
HS 1868 *Symphysurina bulbosa* (2–0–0)		
HS 1865 *Symphysurina bulbosa* (1–0–1)		
HS 1863 *Symphysurina bulbosa* (2–1–2)		
4. Lime mudstone. Intraclastic lime grainstone at 1,840–1,843 feet. Scattered dolomite rhombs. Medium gray, medium to thin beds cropping out in places as massive units; weathers light to medium gray with yellowish mottles.	29	1,827–1,856
Section offset 110 feet to northwest on resistant, yellowish-brown–mottled bed at 1,835 feet.		
3. Mostly pelletal and intraclastic trilobite lime grainstone. Pellets, small to medium intraclasts, and trilobite fragments. Dolomitic trilobite mudstone at 1,815–1,818 feet. Coarse- to fine-grained quartz sand at 1,807 and 1,819 feet. Medium brownish gray, medium to thin beds cropping out in places as massive units; weathers light to medium gray with yellowish mottles.	28	1,799–1,827
Symphysurina bulbosa Subzone		
HS 1840 *Symphysurina brevispicata* (0–1–0)		
Symphysurina bulbosa (1–1–0)		
HS 1819 *Hystricurus millardensis* (0–1–0)		
Symphysurina bulbosa (0–1–0)		
HS 1818 *Hystricurus millardensis* (1–0–0)		
Symphysurina bulbosa (3–0–1)		
2. Lime mudstone. Scattered trilobite fragments; scattered dolomite rhombs along stylolites and joints. Intraclastic lime grainstone at 1,779 and 1,790 feet. Dark chert nodules from 1,773 to 1,775 feet and 1,795 to 1,799 feet. Medium to dark brownish gray, mostly thick beds with rough tops; weathers medium to dark gray with scattered yellowish-brown mottles.	28	1,771–1,799
Symphysurina bulbosa Subzone		
HS 1790 *Hystricurus millardensis* (1–0–0)		
HS 1788 Hystricurid fragment		
1. Dolomitic pelletal lime grainstone. Pellets, small lime-mudstone intraclasts. Scattered dolomite rhombs, especially along stylolites and joints. Lime mudstone at 1,761 feet. Medium to dark brownish gray, medium to thick beds with rough tops; weathers medium to dark gray with scattered yellowish-brown mottles.	46	1,725–1,771
Symphysurina woosteri Subzone		
HS 1765 Hystricurid fragment		
HS 1758 *Hystricurus millardensis* (0–0–1)		

Butterly Dolomite: Not measured or described in this report. See Stitt (1971b) for description.

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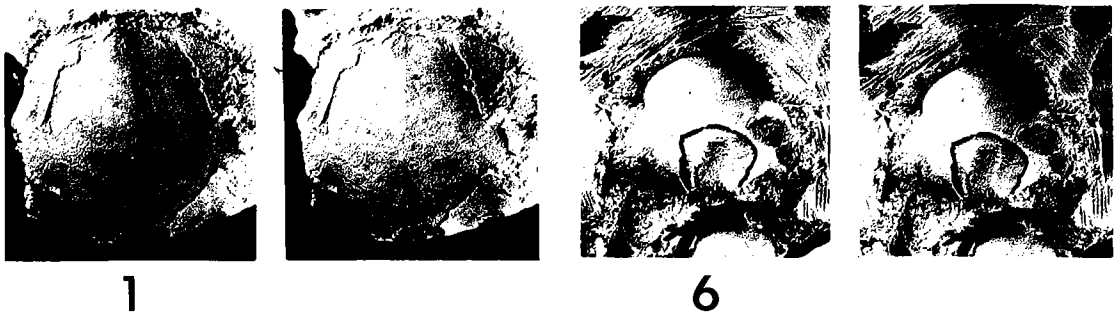

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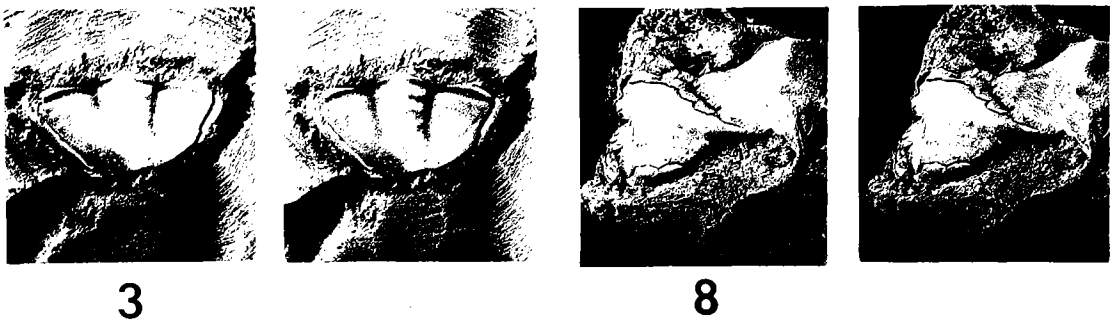

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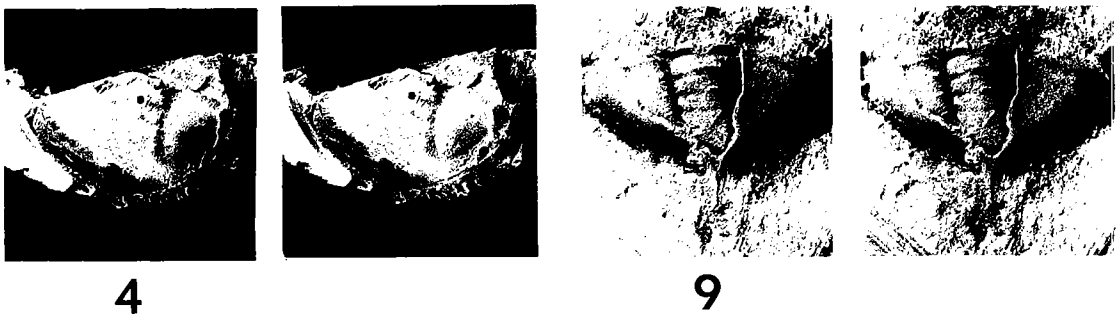

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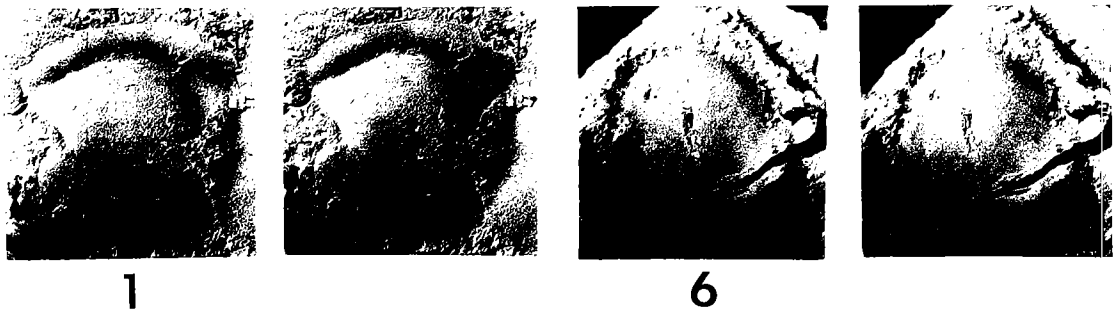
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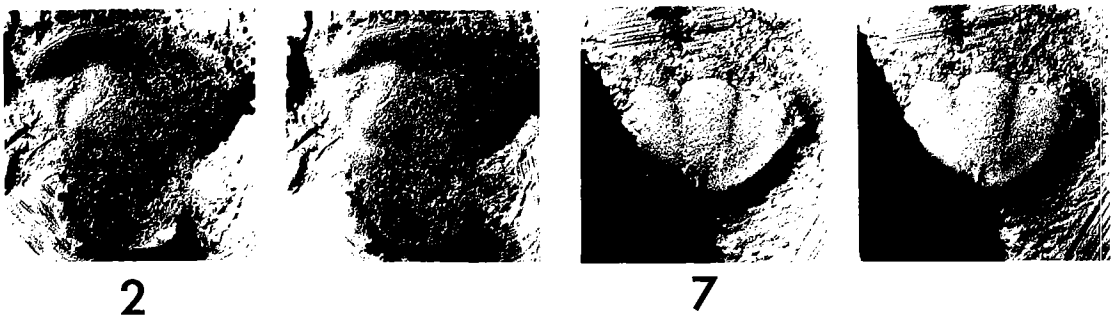
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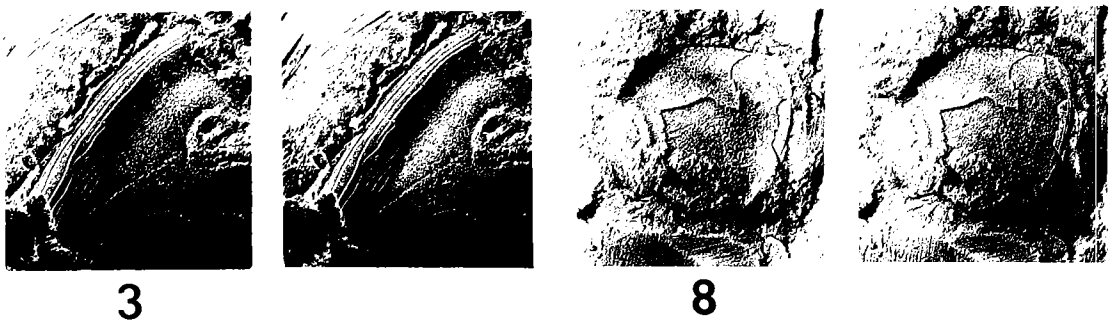
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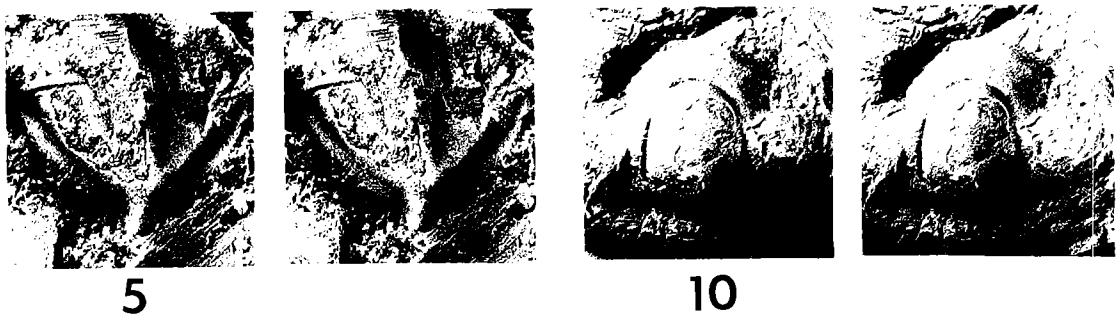
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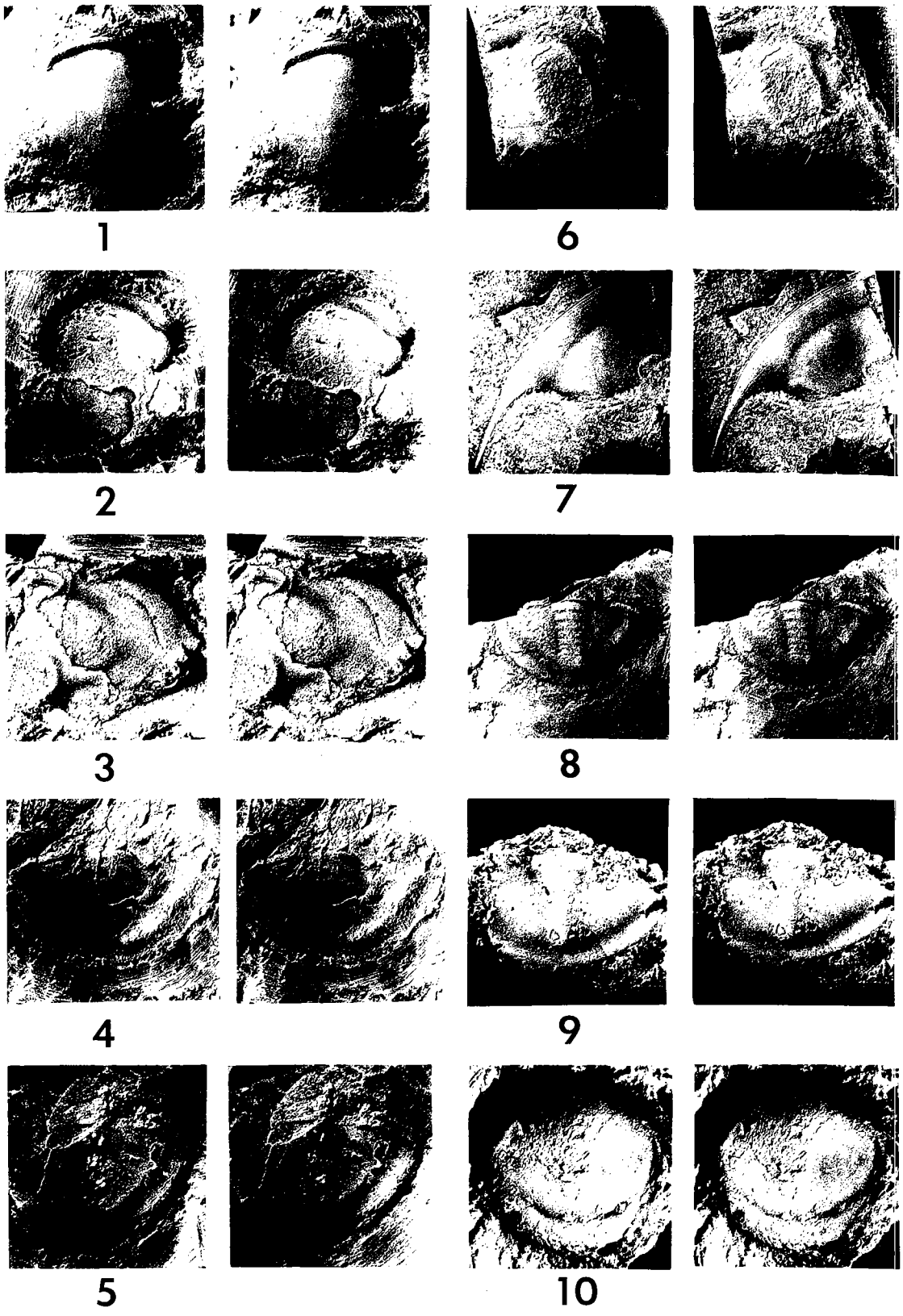
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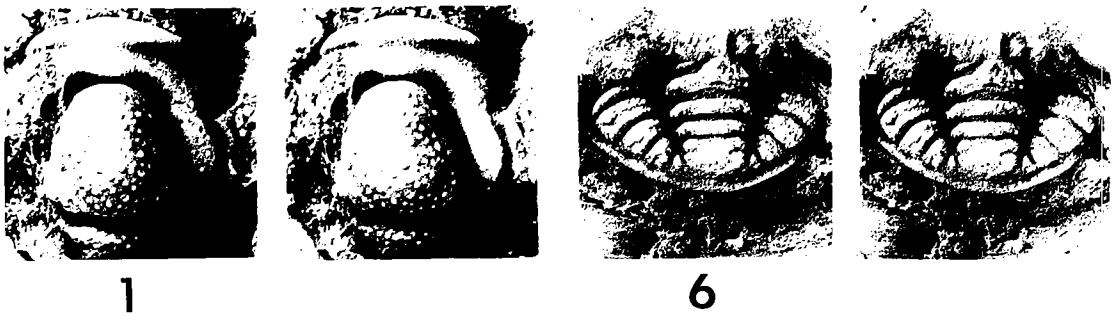
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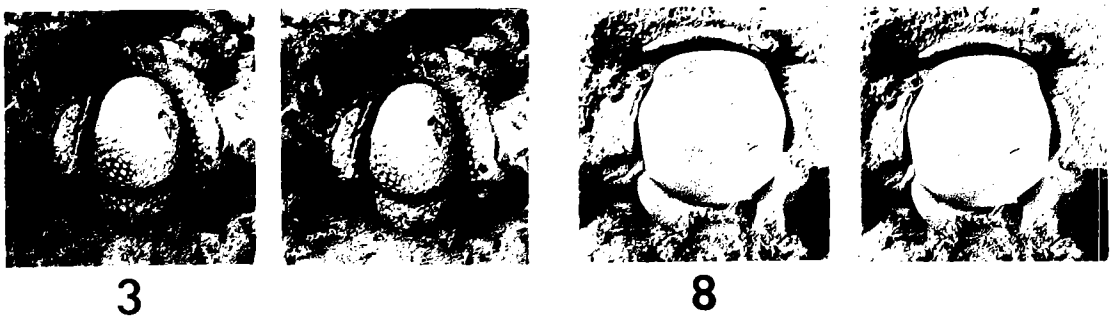
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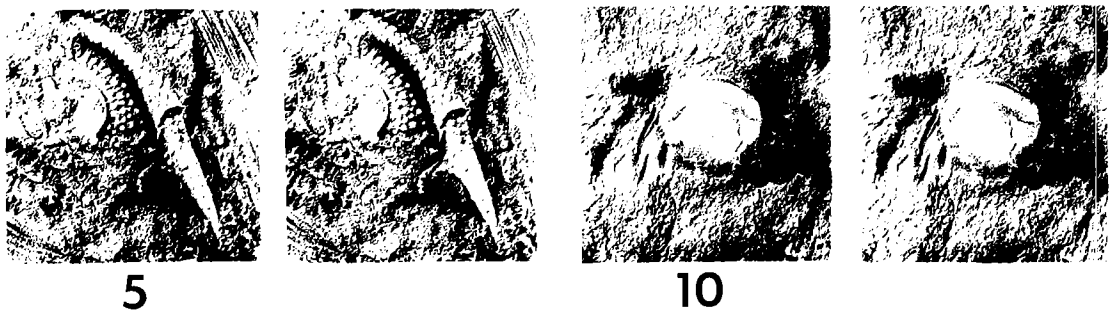
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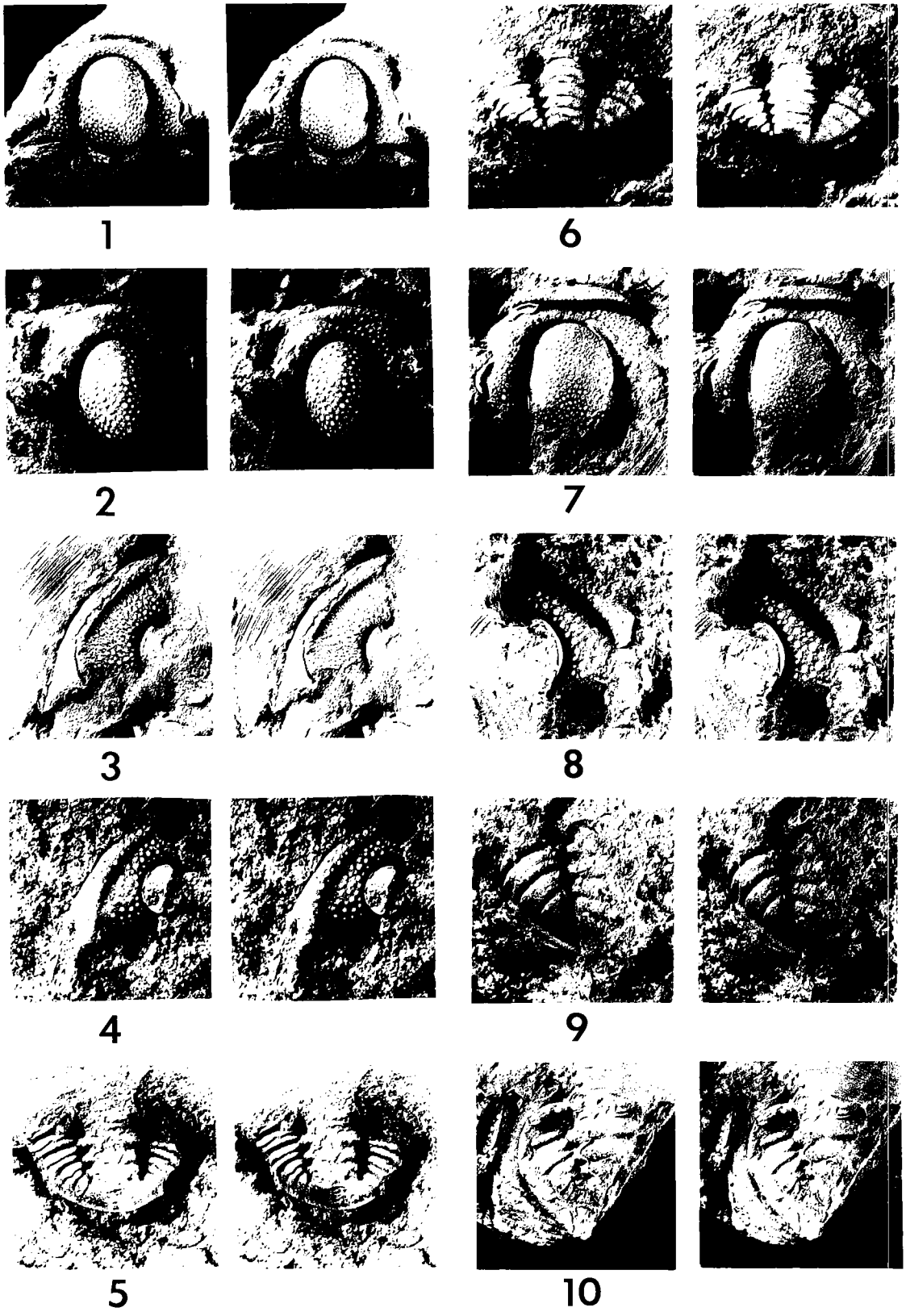
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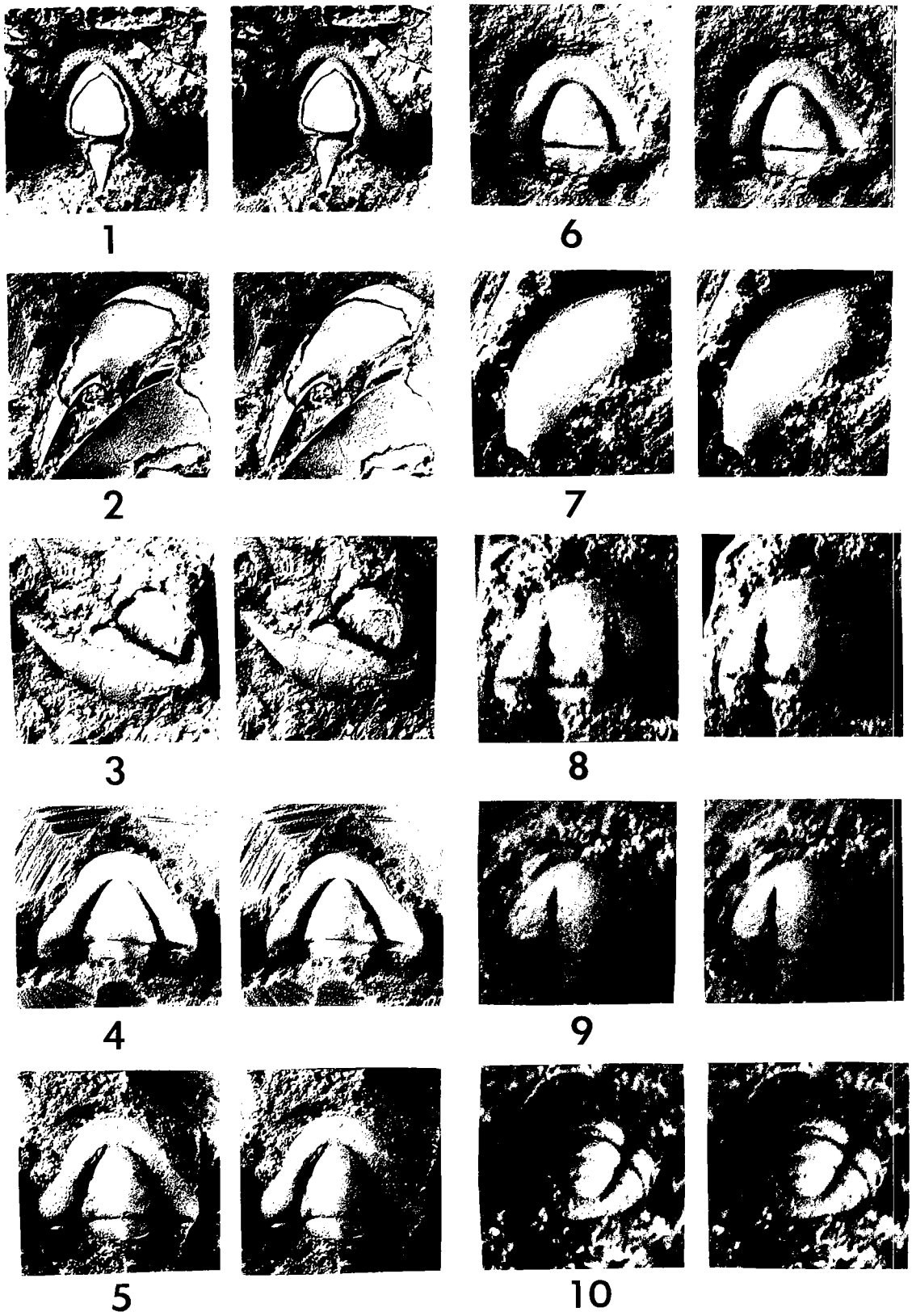
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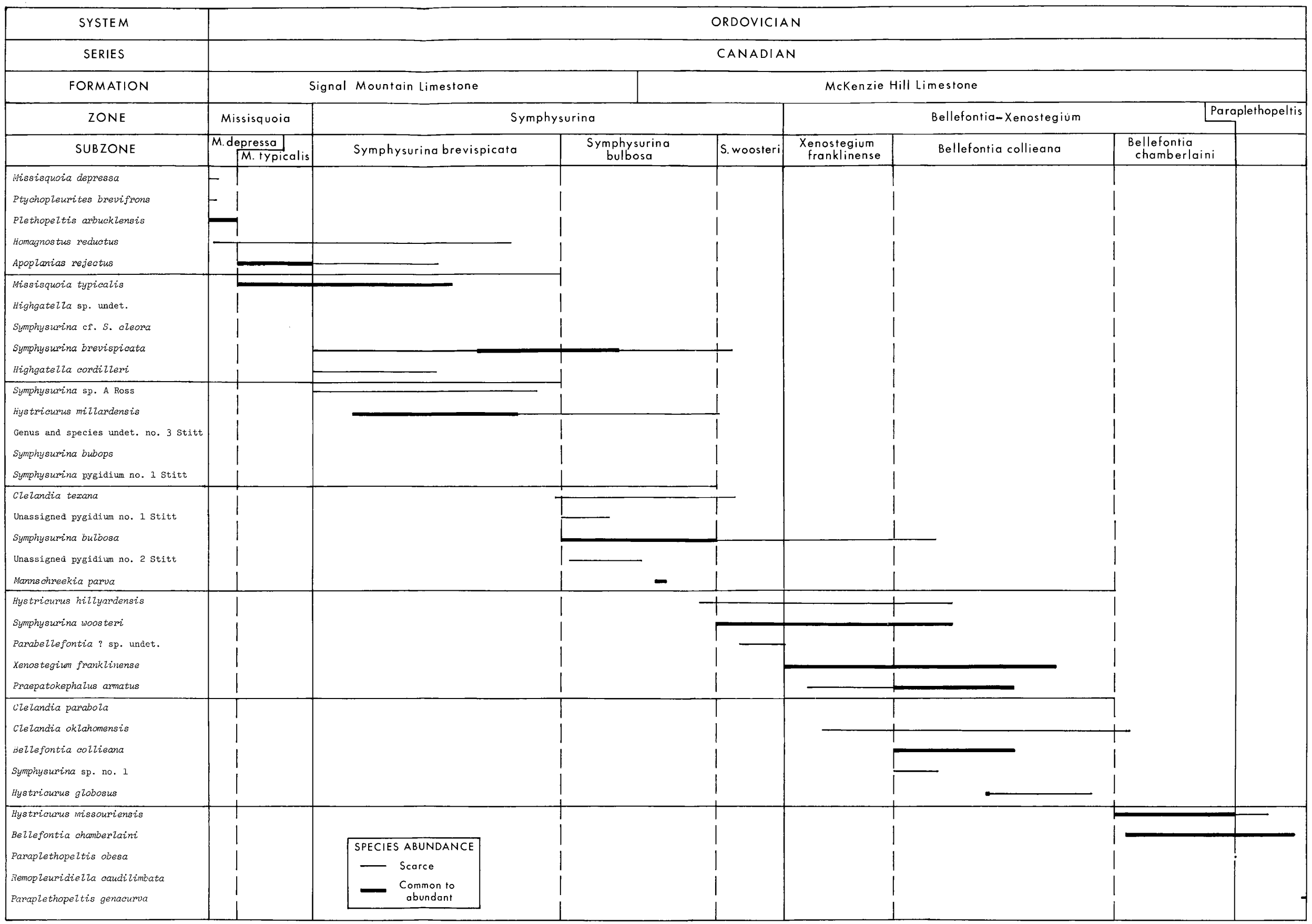

DIAGRAM SHOWING COMPOSITE RANGES OF TRILOBITE SPECIES OF THE SYMPHYSURINID BIOMERE WICHITA AND ARBUCKLE MOUNTAINS, OKLAHOMA

JAMES H. STITT

1983