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TRILOBITES OF THE UPPER CAMBRIAN PTYCHASPID BIOMERE,
WILBERNS FORMATION, CENTRAL TEXAS

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Ernest Lindholm

TRILOBITES OF THE UPPER CAMBRIAN PTYCHASPID BIOMERE,
WILBERNS FORMATION, CENTRAL TEXAS

by

SUSAN ANN BURTON LONGACRE, B.S.

DISSERTATION

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PREFACE

When I first approached Dr. W. C. Bell about doing graduate work under his supervision, he asked about the type of project I would like to attack. Fresh out of a computer course and still a bit "heady" over a successful encounter with one of the foremost computer-geologists, I suggested we seek a geological problem that would lend itself to computer application. Dr. Bell knew that Alan B. Shaw had written a soon-to-be-released book about statistical analysis of range data, and that Shaw had applied his method to faunal range data from the Riley Formation in central Texas. The computer could be used in such an analysis. In order to test the possibility of achieving "reproduceable results," we decided that I would try out his method and use the computer to analyze ranges of trilobites from the Wilberns Formation. More than adequate trilobite collections were already available; all I had to do was check the identifications, tabulate range data, and then apply Shaw's method. Because none of the trilobite species in the Wilberns Formation crossed the Elvinia-Conaspis zone boundary or the Saukia-Missisquoia zone boundary, species ranges from the interval between these two boundaries would yield a compact suite with a distinct base and top.

Beginning at the end, I started checking identifications of Saukia-zone species, and it wasn't long before I was

deeply involved in the nuances of taxonomy and the intricacies of zoological nomenclature. At the same time, I was becoming disenchanted with Shaw's method. Almost two years later the "identification check" of the Saukia zone was completed, and the range data analyzed. The result of all the numerical manipulations was that the quantitative range chart was almost identical to my intuitive one.

Two alternatives were then available--punt, or fall back and regroup. I regrouped. Consequently, this dissertation is concerned primarily with the biostratigraphy and systematic paleontology of trilobites between the base of the Taenicephalus (Conaspis) zone and the top of the Saukia zone. Shaw's analytical method and its application to ranges of Saukia-zone taxa are of secondary concern.

To coin a phrase, it's an ill wind that blows no good. One year after I began working on the project, A. R. Palmer defined and described the biomere. As chance would have it, the interval I was studying constituted another biomere immediately superjacent to Palmer's Pterocephaliid biomere.

Thus has evolved the rather elaborate title and the pages that follow. I only hope that I can enjoy the result after the numbness has receded.

I am deeply indebted to W. Charles Bell for his counsel, his guidance, and his champion-like support, without which the project could not have been completed. I am very

grateful to Keith Young, Ernest L. Lundelius, Jr., and A. R. Palmer for their reading of the manuscript and for offering constructive suggestions throughout its preparation. I was most fortunate in having a fellow graduate student, James H. Stitt, working simultaneously on comparable faunas from Oklahoma; I thank him for the innumerable hours spent discussing our projects and the problems they involved. For the loan of type specimens, thanks are extended to Porter Kier and Jesse Merida of the U. S. National Museum; René Bureau of Laval University, Quebec, Canada; Copeland MacClintock of the Peabody Museum of Natural History; and Bernhard Kummel of Harvard's Museum of Comparative Zoology. I thank Michael E. Taylor for sending information about some of the Trempealeauan trilobites from the Great Basin. I am grateful to the Department of Geological Sciences and the Bureau of Economic Geology at The University of Texas at Austin for financial support during the past four years, to the National Science Foundation for their generous Graduate Fellowship, and to The Geology Foundation of The University of Texas at Austin for providing a Whitney Memorial Fellowship to finance the printing of this dissertation. And I am deeply appreciative of the infinite patience and sense of humor of my husband during this whole project.

Submitted to the Committee: April 1968.

Susan Ann Burton Longacre
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A B S T R A C T

Trilobites collected during the past twenty years from the Morgan Creek, Point Peak, and San Saba members of the Wilberns Formation constitute the material basis for this paleontologic and statistical investigation.

Eighty-nine species assigned to forty-five genera belong to zones of the upper Franconian and Trempealeauan Stages of the Upper Cambrian Croixan Series. New zonal names are proposed in the interest of a regionally applicable nomenclature. Although none of the zonal nomenclature is identical to that of the Cambrian Correlation Chart, the four zones recognized in central Texas are equivalent to the eight highest zones of the Chart. Stratigraphically lowest is the Franconian Taenicephalus zone, with a locally recognized Parabolinoides subzone at its base; this is equivalent to the Conaspis zone of the Correlation Chart. The Franconian Idahoia zone, with a locally recognized Idahoia lirae subzone at its base, is equivalent to the Ptychaspis subzone of the Ptychaspis-Prosaukia zone of the Correlation Chart. The sparsely fossiliferous Ellipsocephaloides zone corresponds to the Prosaukia subzone

of the Ptychaspis-Prosaukia zone of the Chart. Almost two-thirds of the trilobite species occur in the Trempealeauan Saukia zone, which corresponds to the five highest zones of the Correlation Chart; local subzones, in ascending order, are the Saukiella pyrene subzone, the Saukiella junia subzone, the Saukiella serotina subzone, and the Corbinia apopsis subzone.

The succession of ptychoparioid trilobite faunas contained within these zones make up the Ptychaspid biomere. The base of the biomere is at the base of the Taenicephalus zone; the top coincides with the lowest occurrence of the Ordovician trilobite fauna. Trilobite families that characterize the Ptychaspid biomere are the Ptychaspididae and the Parabolinoiidae.

Regression analyses of range data for all Saukia-zone taxa were used to compile a quantitative range chart. Differences between the quantitative chart and my intuitive range chart were not significant.

Systematic descriptions include new species of Conaspis, Idiomesus, Euptychaspis, Keithiella, Saukiella, Prosaukia, Calvinella, and Westonaspis?; and one new variety of Orygmaspis.

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INTRODUCTION

Trilobites from the Morgan Creek limestone, the Point Peak siltstone, and the San Saba limestone members of the Wilberns Formation provide an ample base for this two-fold investigation. Primary emphasis is placed on the systematic paleontology and biostratigraphy of the ptychoparioid trilobites, most of which were collected from the Morgan Creek and San Saba limestones (Fig. 1). The second aim of the investigation is to present and evaluate a statistical analysis of species' range data, and to apply the method to range data from the Trempealeauan Saukia zone.

Figure 1. Index map showing location of measured sections.

HISTORY OF INVESTIGATIONS

This study has as its foundation the investigations and collections of many other people. The lithostratigraphy of the Wilberns Formation was described by Bridge, Barnes, and Cloud (1947) and by Cloud and Barnes (1948).

Fossil collecting from the Wilberns was begun by Virgil Barnes and others before 1947. During the summer of 1947 W. C. Bell collected from sections measured and painted by Barnes. While working as a field assistant to Barnes (1949-1950), Howard Ellinwood collected material from the Eoorthis bed to the top of the Wilberns Formation in numerous measured sections. These collections were the basis for his thesis (1953, Unpub. Ph.D. thesis, Univ. Minnesota), and his collections comprise the majority of the material used in this study. Thesis studies, under the supervision of W. C. Bell, by Alexander (1956, Unpub. M.A. thesis, Univ. Texas), Jansen (1957, Unpub. M.A. thesis, Univ. Texas), Winston (1957, Unpub. M.A. thesis, Univ. Texas), Wise (1964, Unpub. M.A. thesis, Univ. Texas), and Nicholls (unfinished) added greatly to the Texas collections. Collections by several graduate classes in "Systematics and Techniques of Preparation" have been added to the Texas collections.

As a part of a larger project by Barnes and Bell on the Cambrian of central Texas, Bell and Ellinwood (1962)

described and illustrated trilobite species then known to occur between the Eoorthis bed and the lower part of the San Saba limestone. Based on material from the calcitic San Saba on the western side of the Llano Uplift, Winston and Nicholls (1967) described and illustrated Cambrian and Ordovician trilobites from the remainder of the Wilberns Formation. I am deeply indebted to all of these gentlemen for their contributions, though inadvertent, to this study.

Although most of the trilobites were adequately prepared, many still required cleaning before the process of identification could begin. This additional preparation, the borrowing of type specimens, and four years of relatively uninterrupted work on the fauna have led to certain opinions that differ from those of Bell, Ellinwood, Winston, and Nicholls.

Frequent reference is made to trilobites collected in the Arbuckle Mountains of Oklahoma by James H. Stitt, and to his conclusions based on what he found. Although most species were common to both Oklahoma and central Texas, only one new species, Saukiella serotina, occurs in both areas. Because its proposal is based on specimens from central Texas, and because its name is borne by a subzone we both recognize, we have agreed that [?]this paper should appear in print before his. Where taxonomic problems common to both areas were resolved

by Stitt, I have given him the credit and the accompanying burden of defense.

THE PTYCHASPID BIOMERE

The biomere is a new and dynamic biostratigraphic unit recently recognized and named by A. R. Palmer (1965a). Although the environmental and biologic conditions responsible for the biomere are open to debate, the fact remains that the unit does exist. Palmer recognized the first one in the Upper Cambrian non-agnostid trilobites from the Great Basin (1965a, 1965b), and he urged that similar units be sought in other areas.

Palmer (1965a, p. 149) defined the biomere as "a regional biostratigraphic unit bounded by abrupt non-evolutionary changes in the dominant elements of a single phylum." In the interval between the boundaries is a complex of interrelated species and genera; dominant families in the complex are either unknown in or not significant elements of older or younger faunal complexes. Although the biomere is of stage magnitude, it should not be used as or substituted for the stage, because the boundaries are, or may be, time-transgressive (Palmer, 1962, p. 9; 1965a, p. 150; 1965b, p. 4).

Palmer (1965a, p. 150; 1965b) described the characteristics and faunal content of the type biomere, the Pteroccephaliid biomere, named after one of the two families that dominate the interval between the base of the Aphelaspis zone

and the top of the Elvinia zone.

Immediately above the Pterocephaliid biomere is a complex of interrelated ptychoparioid trilobites that constitute another biomere. The abrupt faunal change across the Elvinia-Taenicephalus (or Conaspis) zonal boundary has long been recognized (Frederickson, 1949; Wilson, 1951; Nelson, 1951; Bell, Feniak, and Kurtz, 1952; Bell, Berg, and Nelson, 1956; Lochman, 1965a; Grant, 1965). A comparable change in the trilobite fauna occurs between the top of the Cambrian Saukia zone and the lowest Ordovician trilobite fauna (Frederickson, 1941; Palmer, in Bass and Northrup, 1953; Lochman, 1964a, 1964b; Winston and Nicholls, 1967; Stitt, 1968). Between the base of the Taenicephalus zone and the top of the Saukia zone is a complex of trilobite genera and species dominated by two families, the Ptychaspididae and the Parabolinoiidae. These two families are not represented in older or younger faunas. The characteristics and faunal content of these families are fully discussed in the systematic descriptions, and are illustrated in Figure 2. The lower boundary of this biomere is at the Eoorthis coquina, a boundary that probably is time-transgressive (Bell, 1950, p. 493). The upper boundary may or may not be time-parallel.

The most appropriate name for this distinct complex of trilobites is the Ptychaspid biomere. The Ptychaspididae is the only family represented throughout the biomere, and

Figure 2. Inferred phylogenetic relationships in the families Parabolinoiidae and Ptychaspidae. Genera not represented in central Texas are enclosed in parentheses.

the ptychaspidid genus Conaspis is the probable progenitor of the three Ptychaspidae subfamilies that dominate the Saukia zone, Eurekaia, Ptychaspidinae, and Saukiinae.

The ranges of all species of the Ptychaspid biomere are illustrated on a composite range chart (Pl. 7, pocket). Evident on the chart is a tremendous species diversity and longer ranges of species in the upper part of the biomere relative to those in the lower part of the biomere. Relative abundance of each species is indicated by the width of the vertical bar: narrow bar for rare occurrence, wide for common to abundant occurrences, and variable width for significant changes in relative abundance. The vertical scale is composite; in 19 measured sections the Taenicephalus zone averaged about 45 feet, and the Idahoia zone averaged about 18 feet in thickness. Although the base of the Ellipsocephaloides zone is present in 9 sections, only in the James River, Morgan Creek, San Saba, and Threadgill Creek sections is the entire zone present, so the thickness of the zone (90 feet--fossiliferous; 80 feet--unfossiliferous) is a composite from those four sections. Thickness of the Saukia zone is based on the Threadgill Creek and James River sections, where total thickness averages 175 feet.

The complex of species in the Ptychaspid biomere is divided into four assemblage zones and several locally

recognized subzones that are discussed in detail in the following pages.

TRILOBITE ZONATION

General Statement

The trilobite zonation used in this paper is directly applicable in central Texas, most of it is applicable in Oklahoma, and I suggest that its use could be even more extensive. Although none of the zonal nomenclature is identical to that of the Cambrian Correlation Chart (Howell, et al., 1944), the four zones recognized in central Texas are equivalent to the eight highest zones of the Croixan Series of the Chart. In addition, the four Texas zones are either equivalent to or identical with zones locally recognized in the Montana-Wyoming area and in the Upper Mississippi Valley.

As Bell, Berg, and Nelson (1956, p. 429) so correctly stated,

The only rational test of a zonal nomenclature is the pragmatic test of its applicability. . . . Because the Cambrian rocks of Wisconsin and Minnesota constitute by current definition the type Croixan Series, biostratigraphic nomenclature applied to them must serve two purposes simultaneously: (1) the needs of local biostratigraphy, and (2) the needs of North American biostratigraphy. The Croixan zonal units carried by the Cambrian correlation chart (Howell, et al., 1944) resulted from unpublished investigations by Raasch in the type area, and are essentially a detailed local nomenclature.

At the time this was written, little was known and nothing was published, in comparable detail, that could be used to evaluate the regional application of Croixan zonal nomenclature.

Shaw (1954) and Shaw and Deland (1955) described the general stratigraphy and faunal zonation of the Cambrian in southwestern Wyoming. Grant (1965) published the systematic paleontology of Franconian and Trempealeauan faunas collected from measured sections in northwestern Wyoming and southwestern Montana; Bell and Ellinwood (1962) and Winston and Nicholls (1967) did the same for comparable collections from sections in central Texas. Apparent in these papers, or in the minds of their authors, is a dissatisfaction with the zonal nomenclature of the Cambrian Correlation Chart.

It is important to understand that during the Late Cambrian the Upper Mississippi Valley was an area of clastic accumulation. Conversely, carbonate accumulation predominated in the Montana-Wyoming and Texas-Oklahoma areas. That the composition of a benthic fauna would be at least in part affected by the environment is to be expected. Although the Franconian and Trempealeauan faunas of the Upper Mississippi Valley are comparable to those from the carbonate areas, there are differences. Not only are there different taxa, but the dominant elements of the faunas are different. If, as it appears, most of the Upper Cambrian marginal cratonic rocks of North America are carbonates, then the needs of North American biostratigraphy would best be served if zonal nomenclature were derived from faunas in the carbonate areas. Another zonal nomenclature will have to be established for trilobite

faunas in the detrital areas on the oceanic side of the carbonate belt (A. R. Palmer, personal communication). In any event, the Cambrian Correlation Chart needs to be revised.

In all fairness to the other side of the argument, I recognize that the zones are based on trilobite assemblages, and I realize that the name-giving taxon need not be present for its name to be applied to the assemblage. However, if the name-giving taxon is geographically or environmentally restricted, its choice as the source for a zonal name was a poor one. Workers in other areas will recognize and name local zones rather than use a name that has little or no local significance.

Now that the regional picture of Upper Cambrian trilobite faunas is crystallizing, we should devise and use a zonal nomenclature that is regionally applicable, and reserve subzonal nomenclature for local variations on the regional theme. It is to this end that I submit the following proposals.

Shaw (1955), Shaw and Deland (1956) and Grant (1965) used the Taenicephalus zone as a local equivalent of the Franconian Conaspis zone of the Correlation Chart. Taenicephalus is abundant through most of the Conaspis zone, or its equivalents, in central Texas, in Oklahoma (Frederickson, 1949), in the Upper Mississippi Valley (Nelson, 1951; Bell, Feniak, and Kurtz, 1952; Berg, 1953), and in the

Montana-Wyoming area (Shaw and Deland, 1955; Grant, 1965). Specimens assignable to species of Conaspis are rare outside of the Upper Mississippi Valley. I propose that the name Taenicephalus be substituted for Conaspis on a revised Correlation Chart. In addition, I agree with Grant (1965, p. 85) that we be consistent and use only trilobite names in our zonal nomenclature. Therefore, the Eoorthis subzone, based upon a genus of brachiopod, should be abandoned.

The name Ptychaspis-Prosaukia is inconsistent with the pattern of other zonal names in that it combines two generic names into one label. The hyphenated zonal name leads directly to its own subzonation, the Ptychaspis subzone and the Prosaukia subzone. Because I think subzonal nomenclature should reflect local subdivisions and bear locally applicable names, I suggest that the Ptychaspis-Prosaukia label be abandoned.

Evidently Twenhofel, Raasch, and Thwaites (1935, p. 1702, 1704) first used the hyphenated name, Ptychaspis-Prosaukia fauna, and until recently this lead has been followed. Although the entire fauna is characterized by species of Ptychaspis, the upper part also contains species of Prosaukia, a genus that is represented in stratigraphically higher faunas. The interval through which Ptychaspis and Prosaukia overlap is known as the Prosaukia division of the Ptychaspis-Prosaukia fauna (Twenhofel, Raasch, and Thwaites,

1935, p. 1704), the Prosaukia subzone of the Ptychaspis-Prosaukia zone (Howell, et al., 1944), and the Prosaukia zone (Moore, 1955, p. 564). Such a subdivision restricts Ptychaspis miniscaensis, the type species, to the Prosaukia zone or subzone, an esthetically untidy occurrence.

Outside the Upper Mississippi Valley, specimens assignable to species of Ptychaspis are not common, and specimens assignable to species of Prosaukia are exceedingly rare. In Minnesota and Wisconsin most of the Franconian species (and specimens) of Prosaukia have come from either cross-bedded or thin-bedded Mazomanie sandstone (Berg, 1954, p. 867); a few additional species (and specimens) have come from the Reno greensands (Berg, 1954, p. 869). Thus, not only are these genera restricted geographically, but most species of Prosaukia are environmentally segregated in the one area where the genus is well represented.

Not only should the name Ptychaspis-Prosaukia be abandoned, but I think the interval can and should be treated as two zones. In carbonate areas it can be divided into a lower, fossiliferous zone dominated by species of Idahoia, Saratogia, Drumaspis, and Wilbernia; and an upper, poorly fossiliferous zone containing species of Dartonaspis, Briscoia, Ptychaspis, Prosaukia, Ellipsocephaloides and, in Oklahoma, Saratogia. Grant (1965) called the lower of the two the Idahoia zone, and recognized three local subzones based on species of Idahoia;

above this he recognized a poorly fossiliferous Prosaukia zone. Stitt (1968) leaves the two parts in one zone, the Saratogia zone, the lower part divided into Idahoia lirae (basal) and Drumaspis subzones; the upper part of the Saratogia zone is not subzoned. I propose that the lower fossiliferous interval be named the Idahoia zone, a name that can be applied regionally, and that the upper, sparsely fossiliferous interval be named the Ellipsocephaloides zone, after a genus that is represented in all areas.

I agree with Raasch (1951); Bell, Berg, and Nelson (1956); and Grant (1965) that the Briscoia zone of the Correlation Chart should be abandoned. Furthermore, I follow Raasch (1951); Bell, Berg, and Nelson (1956); and Winston and Nicholls (1967) in recognizing only the Saukia zone as Trempealeauan, and in abandoning the five highest zones of the Cambrian Correlation Chart.

Table 1 compares the zonation of the Cambrian Correlation Chart, Raasch (1951); Bell, Berg, and Nelson (1956); Grant (1965); Winston and Nicholls (1967); Stitt (1968); and this paper.

Franconian Stage

The Franconian Stage is represented in the Wilberns Formation by the Elvinia, Taenicephalus, Idahoia, and

Ellipsocephaloides zones. Although a discussion of the Elvinia zone fauna is outside the scope of this paper, several species that originate in the Elvinia zone occur also in the Parabolinoides subzone of the Taenicephalus zone; these include Irvingella major, Sulcocephalus candidus, Comanchia amplooculata and Dellea? punctata.

TAENICEPHALUS ZONE

The Taenicephalus zone is present in 20 measured sections in central Texas. It occurs entirely within the Morgan Creek member of the Wilberns Formation. The base of the zone is usually marked by a coquina of brachiopods dominated by the genera Eoorthis and Billingsella; the lowest occurrence of species of Parabolinoides is normally in this brachiopod coquina. The base of the Taenicephalus zone is at B - 312, CO - 124, CR - 697, E - 848, EC - 1, GM - 546, GR - 118, HY - 53, JR - 121, LL - 671.8, MC - 660, PK - 885, SK - 200, SS - 46, ST - 478, SU - 56, TA - 0.6, TC - 934-934.5, TR - 291, and WC - 889. Trilobites of the Taenicephalus zone include Conaspis leptoholcus, n. sp., C. masonensis, C. parvafrons, Orygmaspis llanoensis, Parabolinoides contractus, P. granulosus, Taenicephalus gouldi, T. shumardi, T. sp., and Wilbernia halli. Wilbernia expansa and Pseudagnostus communis occur in this zone but are not confined to it. The top of the zone is at the base of the Idahoia zone. In most

sections, the zone is abundantly fossiliferous in its lower 15 feet, less fossiliferous toward the top.

Parabolinoides subzone.--Grant (1965, p. 84) defined a Parabolinoides subzone at the base of the Taenicephalus zone in Montana and Wyoming. A comparable limiting of species of Parabolinoides to the basal 1 to 3 feet of the Taenicephalus zone occurs in 19 measured sections in central Texas. The base of the Parabolinoides subzone is the base of the Taenicephalus zone; the top of the subzone is defined by the highest occurrence of Parabolinoides. In the measured sections, the top of the subzone is at B - 312.5, CO - 126, CR - 697, E - 849.5, GM - 547, GR - 119, HY - 55, JR - 122, LL - 673, MC - 663, PK - 886, SK - 201, SS - 47.5, ST - 478, SU - 58, TA - 2, TC - 935.5-936, TR - 292.5, and WC - 889. Trilobites confined to the Parabolinoides subzone include P. contractus and P. granulosus; other species not confined to the subzone include Orygmaspis llanoensis and Taenicephalus gouldi. Brachiopods abundant in the subzone include Eoorthis remnicha, E. indianola and Billingsella coloradoensis.

The Parabolinoides subzone of central Texas is almost identical to the Parabolinoides subzone of Oklahoma (Stitt, 1968); the only difference is that in Texas Orygmaspis llanoensis occurs through as much as half the subzone, and Taenicephalus gouldi occurs at the top of the subzone, whereas in

Oklahoma, Orygmaspis and Taenicephalus first occur above the range of Parabolinoides. The Parabolinoides subzone in Texas differs from that of Montana and Wyoming (Grant, 1965, p. 84) in that in Montana and Wyoming the lowest occurrences of most Taenicephalus zone species are in the Parabolinoides subzone, whereas in Texas most of them originate above the top of the subzone. Inasmuch as Parabolinoides is abundant in and confined to the lower part of the Conaspis zone in the Upper Mississippi Valley (Berg, 1953, p. 556), a Parabolinoides subzone can be delineated there. It appears that Parabolinoides is a subzonal name that is both locally applicable and regionally significant.

IDAHOIA ZONE

The Idahoia zone is present in the Morgan Creek and Point Peak members of the Wilberns Formation. Although some specimens were collected from siltstone in the lower part of the Point Peak, most of the fossil material is from Morgan Creek limestone. The lowest occurrence of Idahoia lirae, Wilbernia diademata and Saratogia americana marks the base of the zone. In measured sections the base of the Idahoia zone is at B - 346.5, CO - 162, CR - 743-747, E - 894, EC - 20.5, GM - 590, GR - 165, JR - 169, LL - 714, MC - 706, PK - 922, SK - 232, SS - 92.5, ST - 528, SU - 116, TA - 56, TC - 983, TR - 342, and WC - 925. The top of the Idahoia zone is at

the base of the Ellipsocephaloides zone. Trilobites confined to the Idahoia zone are Drumaspis texana, Idahoia lirae, I. wisconsensis, Ptychaspis bullasa, Saratogia americana, S. fria, Taenicephalina globula and Wilbernia diademata. Drumaspis idahoensis is common in the upper half of the zone; 3 cranidia, intermediate between D. idahoensis and Dartonaspis, but assigned to D. idahoensis, were collected in the middle of the Ellipsocephaloides zone. Other species not confined to the Idahoia zone are Pseudagnostus communis, Saratogia modesta, Wilbernia expansa and W. pero.

The Idahoia zone of central Texas is equivalent to the Idahoia lirae and Drumaspis subzones of the Saratogia zone in Oklahoma (Stitt, 1968), to the Idahoia zone in Montana and Wyoming (Grant, 1965, p. 85-87, plate 4) and to the Ptychaspis subzone of the Upper Mississippi Valley (Nelson, 1951, p. 769, Table 1; Bell, Feniak, and Kurtz, 1952, p. 177, Table 1; Grant, 1962, p. 974, Table 2).

Idahoia lirae subzone.--Idahoia lirae is abundant in and confined to a maximum interval of 6 feet at the base of the Idahoia zone. Although Wilbernia diademata is rare, it also is restricted to this interval. Saratogia americana and Pseudagnostus communis can occur in the interval, but they are not confined to it. No other trilobites occur in this interval. The association of Idahoia lirae and Wilbernia

diademata is so distinct from the rest of the fauna, and so persistent, that an Idahoia lirae subzone is defined from the base of the zone to the top of the range of I. lirae. The top of the I. lirae subzone is at CO - 162, CR - 743-747, E-894, EC - 21.5, GM - 594, GR - 171, JR - 177, LL - 719, MC - 707, PK - 922, SK - 233, SS - 94.5, ST - 528, TA - 56, TC - 987, TR - 344.5, and WC - 925.

The Idahoia lirae subzone of central Texas is almost identical to the I. lirae subzone at the base of the Saratogia zone in Oklahoma (Stitt, 1968); the only differences are that Saratogia americana occurs in the subzone only in Texas and Conaspis tumidus occurs in the subzone only in Oklahoma. The Idahoia lirae subzone is equivalent to at least the lower part of the I. wyomingensis subzone of Montana and Wyoming (Grant, 1965, p. 86), and is comparable to the Stigma- cephalus oweni faunule of the St. Croix Valley in Minnesota and Wisconsin (Nelson, 1951, p. 769, Table 1) and, thereby, to the Psalaspis zonule of southeastern Minnesota (Bell, Feniak, and Kurtz, 1952, p. 177, Table 1; Grant, 1962, p. 973-978, Table 2).

ELLIPSOCEPHALOIDES ZONE

The Ellipsocephaloides zone is represented in the Point Peak member of the Wilberns Formation in only nine measured sections. The base of the zone is normally marked by the

lowest occurrence of E. silvestris or, in the absence of E. silvestris, by the lowest occurrence of Chariocephalus whitfieldi. The base of the zone is at EC - 55, GR - 204, JR - 210, LL - 750, MC - 750, SS - 138.5, TA - 163, TC - 1085, and WC - 1060. The top of the zone is at the base of the Saukia zone.

The Ellipsocephaloides zone is not very fossiliferous; collections are small and widely spaced in the sections. The Point Peak is predominantly siltstone, with interspersed intraformational conglomerate and stromatolitic limestone units. Trilobites are not well preserved in the siltstone. Most of the Ellipsocephaloides zone fauna is from the limestone beds. Species limited to the zone include Briscoia sp., Chariocephalus whitfieldi, Dartonaspis wichitaensis, Ellipsocephaloides silvestris, Idiomesus infimus, n. sp., Prosaukia cf. P. curvicostata, P. cf. P. tuberculata, Ptychaspis sp., and Stigmacephaloides curvabilis. Four species common in the Idahoia zone also occur in the Ellipsocephaloides zone: Saratogia modesta is rare at the base of the zone; 3 cranidia assigned to Drumaspis idahoensis were collected above the middle of the fossiliferous part of the zone; Wilbernia pero occurs through the lower two-thirds of the zone; and Pseudagnostus communis occurs at the base.

Stratigraphically scattered and mostly broken or poorly preserved specimens comprise the evidence for this

truly composite Ellipsocephaloides zone. In spite of my definition and naming of the zone, and Grant's recognition of the equivalent Prosaukia zone, the problems inherent in this part of the section are not resolved, the type area notwithstanding. In the Montana and Wyoming area, in Oklahoma, and in central Texas, this interval is sparsely fossiliferous, and specimens assignable to Prosaukia are very rare. Grant (1965, p. 142) identified one pygidium as Prosaukia sp. Bell and Ellinwood (1962, p. 406) identified three cranidia as P. cf. P. curvicaudata and, by my count, three cranidia as P. cf. P. tuberculata. Stitt (1968) found no specimens assignable to Prosaukia in this part of the section. I think Prosaukia is not a regionally applicable or acceptable name for this zone, and prefer to use the name Ellipsocephaloides; not only is it most meaningful in Texas, but species of Ellipsocephaloides occur in the equivalent Prosaukia zone in Montana and Wyoming (Grant, 1965, p. 87), and in the equivalent Prosaukia subzone of the Upper Mississippi Valley (Bell, Feniak, and Kurtz, 1952, p. 177, Table 1; Berg, 1953, p. 557; Grant, 1962, p. 974, Table 2).

Trempealeauan Stage

The Trempealeauan Stage is represented by the Saukia zone. The number of species in the zone is almost twice that

of the underlying three zones combined; 55 species are present in the Saukia zone, as opposed to 33 species in the three Franconian zones above the Elvinia zone.

SAUKIA ZONE

The Saukia zone is present in 8 measured sections on the western side, and one section on the eastern side of the Llano Uplift. Although the base of the zone in the James River (JR) section is 45 feet below the top of the Point Peak member, in all other sections the zone is confined to the San Saba member of the Wilberns Formation. On the eastern side of the Uplift, the San Saba is in large part poorly fossiliferous, dolomitized limestone. In the one section, Morgan Creek (MC), on the east side of the Uplift, only the lowest part of the Saukia zone is represented. On the western side of the Llano Uplift the San Saba is fossiliferous calcitic limestone, and all parts of the Saukia zone are well represented. The zone is dominated by species of Saukiella, Calvinella, Bayfieldia, Euptychaspis, Corbinia and Eurekia.

The Saukia zone of central Texas is equivalent to the Saukia zone of the Upper Mississippi Valley (Raasch, 1951, p. 148-149, Chart No. 1) and to all except the lowest part of the Saukia zone of Oklahoma (Stitt, 1968).

Four subzones are recognized in the Saukia zone. In ascending order they are the Saukiella pyrene subzone, the

Saukiella junia subzone, the Saukiella serotina subzone, and the Corbinia apopsis subzone. Winston and Nicholls (1967) defined three subzones in that part of the Saukia zone studied by them: the Saukiella junia subzone, the Saukiella norwalkensis subzone, and the Corbinia apopsis subzone. I have used their subzonation with only one change, a new name for the Saukiella norwalkensis subzone because of what I regard as a misidentification by them. In the interest of consistent nomenclature, I have named the lowest part of the zone the Saukiella pyrene subzone.

Saukiella pyrene subzone.--This is the lowest subzone of the Saukia zone, and its base is normally marked by the lowest occurrence of Monocheilus truncatus and Illaenurus quadratus. In measured sections the base is at BC - 23, JR - 347, MC 915±, SPH - 85.5, SS - 302.5, and TC - 1233. The top of the subzone is at the base of the Saukiella junia subzone. Species confined to the Saukiella pyrene subzone are Euptychaspis frontalis, n. sp., Eurekia granulosa, Geragnostus? insolitus, Illaenurus quadratus, Keithia cf. K. connexa, Keithiella scrupulosa, K. scapane, n. sp., Leiocoryphe occipitalis, Monocheilus truncatus, Plethopeltis sp., Rasettia magna, Saukiella fallax, S. pyrene, and Stenopilus pronus. The highest occurrence of Pseudagnostus communis is in the lowest part of this subzone. Euptychaspis jugalis and

Plethometopus convergens occur in the Saukiella pyrene, S. junia and S. serotina subzones. Bayfieldia binodosa and Idiomesus levisensis occur in both the Saukiella pyrene and S. junia subzones.

The Saukiella pyrene subzone is equivalent to the Illaenurus zone of Montana and Wyoming (Grant, 1965) and to at least the upper half of the Rasettia magna subzone of the Saukia zone of Oklahoma (Stitt, 1968).

Saukiella junia subzone.--The Saukiella junia subzone was first defined by Winston and Nicholls (1967, p. 69). The base of the subzone is at the lowest occurrence of Saukiella pepinensis. Species confined to the subzone are Briscoia hartti, Euptychaspis typicalis, Saukia tumida, Saukiella junia and S. pepinensis. Bayfieldia simata, Eurekia eos, Idiomesus intermedius, Saukia imperatrix and Stenopilus latus occur in both the Saukiella junia and S. serotina subzones. The base of the S. junia subzone is at BC - 70, CC - 27, JR - 453, SH - 12.6, SS - 345±, and TC - 1291. The top of the subzone is at the base of the S. serotina subzone.

The Saukiella junia subzone of central Texas is equivalent to the S. junia subzone of Oklahoma (Stitt, 1968).

Saukiella serotina subzone.--Winston and Nicholls (1967, p. 69) defined a Saukiella norwalkensis subzone above the S. junia subzone. Because I have placed S. norwalkensis

in synonymy with S. pyrene, and proposed a new species, S. serotina, for the specimens identified as S. norwalkensis by Winston and Nicholls, I therefore rename their S. norwalkensis subzone the S. serotina subzone.

The base of the subzone is normally marked by the lowest occurrence of Saukiella serotina, Euptychaspis kirki and Calvinella procera. Species confined to the S. serotina subzone are Bowmania americana, B. pennsylvanica, B. sagitta, Briscoia llanoensis, Calvinella prethoparia, n. sp., C. procera, C. tenuisculpta, Euptychaspis kirki, Heterocaryon tuberculatum, Leiocoryphe cf. L. longiceps, Macronoda prima, Prosaukia remora, n. sp., Rasettia wichitaensis, Saukiella planata, and Theodenisia brevis. Although Saukiella serotina is abundant throughout the subzone, it can occur in the base of the Corbinia apopsis subzone. Other species occurring in but not confined to the Saukiella serotina subzone are Acheilops masonensis, Bayfieldia simata, Euptychaspis jugalis, Eurekia eos, Idiomesus intermedius, Keithiella patula, Plethometopus convergens, P. obtusus, Saukia imperatrix, and Stenopilus latus. The base of the subzone is at CC - 58, JR - 484, LC - 32, LCS - 32, SH - 52, SS - 375, and TC - 1357. The top of the subzone is at the base of the Corbinia apopsis subzone.

The Saukiella serotina subzone of central Texas is equivalent to the S. serotina subzone of Oklahoma (Stitt, 1968).

Corbinia apopsis subzone.--The Corbinia apopsis subzone is the highest subzone of the Saukia zone; its base is marked by the lowest occurrence of Corbinia apopsis. Species confined to the subzone include Apatokephaloides clivosus, Corbinia apopsis, Leiobienvillia leonensis, Triarthropsis cf. T. limbata, T. nitida, T. princetonensis and Westonaspis? texana. Although Acheilops masonensis and Plethometopus obtusus are common in this subzone, they first occur in the top of the Saukiella serotina subzone. Other species not confined to the Corbinia apopsis subzone are Eurekia eos, Idiomesus intermedius, and Saukiella serotina. The base of the subzone is at CC - 67, JR - 538, LC - 48, LCS - 53, SH - 72, SS - 411, and TC - 1402. The top of the subzone is at the base of the Ordovician Missisquoia zone, at CC - 90, JR - 597, LCS - 108.5, SS - 417, and TC - 1415.

The Corbinia apopsis subzone of central Texas is equivalent to the Corbinia apopsis subzone of Oklahoma (Stitt, 1968).

SYSTEMATIC PALEONTOLOGY

Families of trilobites are arranged alphabetically under each order, subfamilies are alphabetized within the families, genera are alphabetized under each family or subfamily, and species are alphabetized under each genus. Unless stated otherwise in the descriptions, familial assignments of genera are those of the Treatise on Invertebrate Paleontology (Harrington, et al., 1959). Morphologic terminology for the trilobites is that of the Treatise (Harrington, 1959; Harrington, Moore, and Stubblefield, 1959). Terms for directional orientation are those of the Treatise (Harrington, 1959). Ornament terms include both those of the Treatise and others in common usage. Where applicable, orientation and location of measurements are indicated in the species descriptions.

Not all species described and commented upon are illustrated. This paper is designed for use in concert with those of Bell and Ellinwood (1962) and Winston and Nicholls (1967). If the photographic record of a species was sufficient or if additional photographs would not enhance that record, the species was not allotted space on the plates. The figured specimens are deposited with the Bureau of Economic Geology (BEG), The University of Texas at Austin; the support collections are stored at The University of Texas at Austin. Plates contain three columns of stereophotographs; the fossils

were magnified or reduced to make pictures slightly less than one inch by one inch.

At the end of each species description is a list of occurrences in measured sections. Each collection is alphanumeric: the initials refer to the specific measured section, the number refers to the footage of the collection above the base of that section. The bases of the sections are at various lithostratigraphic and biostratigraphic horizons: for the nine sections not discussed in Bell and Ellinwood (1962, p. 386-388), the location, section base, and footages of lithic boundaries are given below. Measured section locations are plotted in Figure 1. The sections are listed below, in alphabetic order according to their initials.

B - Backbone Ridge

BC - Bluff Creek - Near mouth of Bluff Creek, close to the Llano River, Bear Springs area, southwestern Mason County. Base of section is in Point Peak member of the Wilberns Formation. Top of the Point Peak member is at BC - 2; top of the San Saba member is at BC - 262.

CC - Calf Creek - On the Blockhouse Ranch, in northwestern Mason County, along the lower reach of Calf Creek and downstream along the San Saba River. Base of the section in the lower San

Saba member; top of the San Saba member is at
CC - 152.

CO - Cold Creek

CR - Carter Ranch

E - East Canyon

EC - Eckert's Crossing, Leon Creek area

GM - Gray Mountain, Goodrich Ranch area

GR - Gipson Ranch - Base of the section is about 2,500 feet west-southwest of the mouth of Hickory Creek, about 4 airline miles northwest of Johnson City, Blanco County. Base of the section in Cap Mountain member of the Riley Formation. Top of the Cap Mountain member is at GR - 1; top of the Lion Mountain member of the Riley Formation is at GR - 42; top of the Morgan Creek member is at GR - 197; top of the Point Peak member is at GR - 222.

HY - Hye - In a bluff on north side of Pedernales River, $1\frac{1}{2}$ miles due north of Hye on Wierhausen Ranch; Hye is on the Johnson City-Fredericksburg highway, western Blanco County. Base of the section is at the base of the Wilberns Formation.

JR - (Upper) James River

LC - Leon Creek (Ellinwood) - Along Leon Creek, two miles north of its junction with the Llano River, Mason County; located along prominent bend in

Leon Creek where its course changes from north-south to east-west. Base of the section is in the San Saba member; top of the San Saba member is at LC - 154.

LCS - Leon Creek Section (Winston) - The base of the section is in the bed of Leon Creek in a prominent bend of the creek about 1.4 miles southeast of the point where U. S. Highway 183 crosses Leon Creek. Base of the section is in the San Saba member; top of the section is at LCS - 154.

LL - Little Llano

MC - Morgan Creek

PK - Packsaddle

SH - Spring Hollow, Leon Creek area - The base of the section is in the bed of Spring Hollow, 40 feet west of a fence that crosses Leon Creek, and 1,650 feet south of the L. B. Eckert Ranch headquarters, western Mason County. The base of the section is in the San Saba member; the top of the section is at SH - 85.

SK - Klett-Walker

SPH - Sheep Pen Hollow, Leon Creek area - The base of the section is in the bed of Sheep Pen Hollow, 3,450 feet airline northeast of the Wes Eckert Ranch headquarters, western Mason County. The

base of the section is in the Point Peak member;
the top of the Point Peak is at SPH - 45; the
top of the section is at SPH - 166.

SS - Camp San Saba

ST - Streeter

SU - Sudduth

TA - Tanyard

TC - Threadgill Creek

TR - Taylor Ranch - The Taylor Ranch section is about 5 miles airline northeast of Pontotoc, San Saba County. Top of the section is about 3,000 feet north-northwest of the intersection of the Cherokee-Pontotoc road and the road to the Taylor Ranch headquarters, and about 1,000 feet east of the road to the Taylor Ranch headquarters. The base of the section is in the Cap Mountain member of the Riley Formation; the top of the Cap Mountain limestone is at TR - 165; the top of the Lion Mountain sandstone is at TR - 215; the top of the Welge sandstone is at TR - 240; the top of the Morgan Creek member is at TR - 366; the top of the Point Peak member is at TR - 443.

WC - White Creek

The occurrence data for the Trempealeauan taxa are not identical

to those of Winston and Nicholls (1967); additional data and changes in taxonomy and nomenclature contribute to the differences.

Phylum ARTHROPODA Siebold and Stannius, 1845

Class TRILOBITA Walch, 1771

Order AGNOSTIDA Kobayashi, 1935

Family AGNOSTIDAE McCoy, 1849

Genus GERAGNOSTUS Howell, 1935

GERAGNOSTUS? INSOLITUS Grant

Pl. 3, Figs. 19-21.

Geragnostus? insolitus GRANT, 1965, p. 107, pl. 15, figs. 9, 10, 12.

Remarks.--Numerous heads and tails from one locality are assigned to this species. Geragnostus? insolitus is characterized by its inflated, bi-lobed, deeply furrowed glabella, a complete preglabellar median furrow, and a narrow, distinctly furrowed and nonexpanding pygidial axial lobe that does not approach the border furrow (sag.). Surface of cranidial exoskeleton is not smooth, and may have fine granules; pygidial exoskeleton is granulate. Internal molds are smooth and have more distinct furrows.

These specimens appear to be conspecific with those in Grant's illustrations. Rather than establish a monotypic genus that differs from Geragnostus only in the complete

preglabellar median furrow, I prefer to follow Grant and make the generic assignment tentative. I suspect that this species could provide the basis for emending the generic diagnosis, but rather poor preservation and lack of exoskeleton material inhibit my doing so now.

G.? insolitus occurs in the Saukiella pyrene subzone in central Texas; in the Montana-Wyoming area it occurs also low in the Trempealeauan.

Occurrence.--Locally common in the Saukiella pyrene subzone at BC - 34, 37-37.5, 41, 41.5-44, 42.

Family PSEUDAGNOSTIDAE Whitehouse, 1936

Genus PSEUDAGNOSTUS Jaekel, 1909

PSEUDAGNOSTUS COMMUNIS (Hall and Whitfield)

Agnostus communis HALL AND WHITFIELD, 1877, p. 228, pl. 1, figs. 28, 29.

Pseudagnostus communis (Hall and Whitfield) PALMER, 1955a, p. 720, pl. 76, figs. 1-3; BELL AND ELLINWOOD, 1962, p. 389, pl. 51, figs. 7-21 (synonymy to date).

Remarks.--Pseudagnostus communis has been amply described and illustrated by previous workers. Bell and Ellinwood's (1962) figured specimens beautifully illustrate the variation in depth and completeness of furrows on the Texas specimens.

P. communis has been reported from the Aphelaspis,

Elvinia, Taenicephalus, Idahoia, and Ellipsocephaloides zones in central Texas. Two collections from the lowest part of the Saukia zone have two cranidia and two pygidia that are assigned to this species. The furrows are very shallow and in most respects they look like P. laevis Palmer (1955b, p. 97, pl. 19, figs. 8, 9, 11, 12), even to the slightly depressed axial part of the pygidial border. These four specimens are included in P. communis because the convex pygidia are nearly equidimensional, whereas P. laevis pygidia are distinctly elongate and flatly convex. Given more material and tighter biostratigraphic control, the two may be shown to be conspecific or chronospecific.

Occurrence.--Rare at the base but becoming more common toward the top of the Taenicephalus zone at E - 866, 875; EC - 9, 14; GM - 572, 575, 579; GR - 133, 159; MC - 661.5, 685; SS - 77, 83; ST - 511; TA - 34; TR - 324, 333, 335.5; WC - 889, 913.5, 917. Common to locally abundant in the lower half, becoming rare in the upper half of the Idahoia zone at B - 377.5; CO - 193; CR - 743-747; E - 875, 876, 877, 894, 897, 916, 917, 923, 930, 932, 935; GM - 594, 604, 606, 615; GR - 167, 168, 169, 173, 183, 185, 195; JR - 177, 188, 196, 204; LL - 725, 728, 738, 741; MC - 706, 707, 712, 714, 718, 721; SS - 109, 111.5, 116; ST - 574, 575, 578; SU - 116; TC - 994, 1009, 1015-1025, 1017, 1025; TR - 342; WC - 950, 968,

977, 988. Rare in the Ellipsocephaloides zone at GR - 204, 210; LL - 750. Rare in the Saukiella pyrene subzone of the Saukia zone at SPH - 93, 95.

Order PTYCHOPARIIDA Swinnerton, 1915

Family CATILLICEPHALIDAE Raymond, 1938

Genus ACHEILOPS Ulrich in Bridge, 1931

Acheilops Ulrich in BRIDGE, 1931, p. 218; RASETTI, 1954b, p. 611; WINSTON AND NICHOLLS, 1967, p. 77.

Type species.--Acheilops dilatus Ulrich in BRIDGE, 1931, p. 219, pl. 19, figs. 20-22.

Remarks.--Although Rasetti (in Harrington, et al., 1959) did not make a definite familial assignment for Acheilops, Winston and Nicholls (1967) discuss the current concept of this genus, and present a sound argument for its assignment to the Catillicephalidae.

ACHEILOPS MASONENSIS Winston and Nicholls

Pl. 6, Fig. 19.

Acheilops masonensis WINSTON AND NICHOLLS, 1967, p. 77, pl. 11, figs. 13-15.

Remarks.--Although this is the third most abundant species in the Corbinia apopsis subzone, it is not very common. Acheilops masonensis is characterized by an anteriorly expanded

and truncated glabella, the lack of a frontal area and anterior fixigenae, short palpebral lobes, and stout posterior limbs. The figured specimen shows the base of an occipital spine and a granular external surface ornament. Additional range data are provided below.

Stitt (1968) has found a different range for A. masonensis in Oklahoma. Small and widely scattered collections come from the top of the Saukiella junia subzone and throughout the S. serotina subzone, but none are from the Corbinia apopsis subzone.

Occurrence.--Rare in the Saukiella serotina subzone at CC - 61. Rare to common in the Corbinia apopsis subzone at CC - 67, 69.5; JR - 538, 539, 540; LC - 48; LCS - 53, 53.5, 55.5; SH - 72; SS - 411; TC - 1402, 1405, 1409.

Genus THEODENISIA Clark, 1948

Theodenisia CLARK, 1948, p. 643; RASETTI, 1954b, p. 607; 1963, p. 1012.

Type species.--Denisia eminens CLARK, 1924, p. 23, pl. 3, fig. 10.

Remarks.--Rasetti (1954b, p. 607; in Harrington, et al., 1959, p. 285) gives an excellent diagnosis, description, and discussion of this genus and the species included in it.

THEODENISIA BREVIS (Rasetti)

Acheilus brevis RASETTI, 1944, p. 236, pl. 36, figs. 36, 37.

Theodenisia brevis (Rasetti) RASETTI, 1954, p. 609; WINSTON AND NICHOLLS, 1967, p. 77, pl. 11, fig. 19.

Remarks.--This species is characterized by its equidimensional, anteriorly expanded glabella with recurved glabellar furrows. Anterior fixigenae are reduced, and frontal area is obsolete. Nine fragmentary cranidia are assigned to this species.

Occurrence.--Rare in the Saukiella serotina subzone at LCS - 45; SH - 54. Rare in the Corbinia apopsis subzone at LCS - 54.

Genus TRIARTHROPSIS Ulrich in Bridge, 1931

Triarthropsis Ulrich in BRIDGE, 1931, p. 214; RASETTI, 1954b, p. 606.

Type species.--Triarthropsis nitida Ulrich in BRIDGE, 1931, p. 214, pl. 19, figs. 3, 4.

Remarks.--Rasetti's (1954b, p. 606) description of the genus is an adequate diagnosis of Triarthropsis.

TRIARTHROPSIS cf. T. LIMBATA Rasetti

Pl. 6, Fig. 20.

Triarthropsis limbata RASETTI, 1959, p. 382, pl. 52, figs. 1-8.

Remarks.--Five fragmentary cranidia seem to be conspecific with Rasetti's types from the Conococheague Formation in Maryland. The stout, pointed glabella with four sets of shallow furrows, the long frontal area, the divergent anterior facial sutures, and the long posterior limbs set this taxon apart from other species of Triarthropsis. Because the anterior border is not clearly visible on any of the Texas specimens, the specific assignment is tentative.

Stitt (1968) reports Triarthropsis limbata only from the base of the Saukiella junia subzone.

Occurrence.--Rare in the Corbinia apopsis subzone at CC - 67; JR - 539, 540.

TRIARTHROPSIS NITIDA Ulrich

Pl. 6, Fig. 21.

Triarthropsis nitida Ulrich in BRIDGE, 1931, p. 241, pl. 9, figs. 3, 4; RASETTI, 1954, p. 607, text-fig. 2d; 1959, p. 382, pl. 55, figs. 6-13; WINSTON AND NICHOLLS, 1967, p. 78, pl. 11, figs. 27, 28.

Remarks.--Triarthropsis nitida is well described and illustrated. Texas cranidia differ from those illustrated by

Rasetti (1959) in that the glabellas are not so long, and that on many specimens, the anterior facial sutures diverge in front of the palpebral lobes, resulting in relatively wide anterior fixigenae. T. nitida is distinguished from the associated Triarthropsis cf. T. limbata in having only three glabellar furrows, a rounded instead of a pointed glabella, and relatively shorter, posteriorly curved limbs.

Occurrence.--Rare in the Corbinia apopsis subzone at CC - 67; JR - 540; LCS - 53, 53.3, 55.5; SH - 72.

TRIARTHROPSIS PRINCETONENSIS Kobayashi

Triarthropsis princetonensis KOBAYASHI, 1935, p. 56, pl. 8, fig. 1; WINSTON AND NICHOLLS, 1967, p. 78, pl. 11, fig. 26.

Theodenisia princetonensis (Kobayashi) RASETTI, 1954, p. 609.

Remarks.--Only four cranidia are assigned to this species. The nearly rectangular glabella, recurved glabellar furrows, broad fixigenae, and short but definite frontal area leave no room for confusion with other species of Triarthropsis or with species of the closely allied genus Theodenisia. Although these cranidia have slightly broader posterior fixigenae than does the holotype, I think they are conspecific.

Occurrence.--Rare in the Corbinia apopsis subzone at CC - 67; LCS - 55.5; SH - 72.

Family DIKELOCEPHALIDAE Miller, 1889

Genus BRISCOIA Walcott, 1924

Briscoia WALCOTT, 1924a, p. 37; 1925, p. 74; ULRICH AND
RESSER, 1930, p. 59; KOBAYASHI, 1935, p. 50.

Type species.--Briscoia sinclairensis WALCOT, 1924a,
p. 37, text-fig. 9.

Remarks.--Not only Briscoia but the entire family
needs to be re-evaluated, preferably with material from meas-
ured sections. A major problem encountered in the Dikelo-
cephalidae involves fragmented material from evidently large
specimens. Although the specimens from central Texas are not
sufficient for a generic diagnosis or revision, one of the
problems with Briscoia is evident in the Texas collections:
the pygidia of Briscoia sp. (Ellipsocephaloides zone) has sub-
equally divided pleurae, whereas the pleurae on pygidia of B.
llanoensis are markedly unequally divided. Both of these py-
gidial forms are represented in other species of Briscoia.

BRISCOIA HARTTI (Walcott)

Conocephalites hartti Walcott, 1879, p. 130.

Dikelocephalus hartti (Walcott) WALCOTT, 1914, p. 368, pl. 63,
figs. 1-7, 7a (synonymy to date).

Briscoia hartti (Walcott) KOBAYASHI, 1935, p. 51; WINSTON AND
NICHOLLS, 1967, p. 73, pl. 10, fig. 9.

Remarks.--The one specimen figured by Winston and Nicholls and two lesser fragments make up the total sample in the Texas collections. I offer no changes in the systematics or range data of Winston and Nicholls.

Occurrence.--Rare in the Saukiella junia subzone at SS - 372.5; TC - 1341-1346.

BRISCOIA LLANOENSIS Winston and Nicholls

Briscoia llanoensis WINSTON AND NICHOLLS, 1967, p. 73, pl. 10, figs. 1-3, 5.

Remarks.--The only addition to Winston and Nicholls' description is that the frontal areas on the smaller specimens are proportionally longer than on the larger ones. Additional range data are provided below.

Although Stitt (1968) has found a few specimens of Briscoia llanoensis in the upper half of the Saukiella serotina subzone, they are not so abundant as in Texas.

Occurrence.--Abundant in the Saukiella serotina subzone at CC - 58.2, 61, 63±; JR - 521.5, 529, 532; LCS - 40, 44, 45, 45.4, 45.8, 52-54; SH - 58.5-60, 61.5, 61.5-62, 65.5; SS - 409; TC - 1379-1385, 1388, 1391.5, 1392, 1394, 1395, 1400.

BRISCOIA sp.

Briscoia sp. BELL AND ELLINWOOD, 1962, p. 390, pl. 52, figs. 5, 6.

Remarks.--All that is known about this species is discussed and illustrated in Bell and Ellinwood (1962). The specific occurrence data for Briscoia sp. is listed below.

Occurrence.--Locally abundant in the Ellipsocephaloides zone at JR - 275, 283, 284, 284.5; MC - 864; SS - 188.

Family ILLAENURIDAE Vogdes, 1890

Genus ILLAENURUS Hall, 1863

Illaenurus HALL, 1863, p. 176; GRANT, 1965, p. 124.

Type species.--Illaenurus quadratus Hall, 1863, p. 176, pl. 7, figs. 52-57.

Diagnosis.--Cranidium moderately convex, rectangular, may be wider (across eyes) than long, or vice versa. Glabella only partly defined by axial furrow. Occipital and posterior border furrows faint to absent. Eyes behind, on, or in front of cranidial midlength. Anterior border narrow, almost flat, downsloping. Anterior facial sutures slightly convergent to divergent. Pygidium tapered-elliptical, without axial and pleural furrows.

ILLAENURUS QUADRATUS Hall

Illaenurus quadratus HALL, 1863, p. 176, pl. 7, figs. 52-57;
NELSON, 1951, p. 783, pl. 110, fig. 11 (synonymy to
date); BELL AND ELLINWOOD, 1962, p. 396, pl. 55,
figs. 1-3; GRANT, 1965, p. 125, pl. 15, fig. 23.

Remarks.--This species is characterized by its elongate cranidium, eyes that are posterior to the cranidial midline, and anterior facial sutures that are parallel to slightly divergent. One small specimen (SPH - 87) is quadrate, its eyes centered on the cranidial midline; it could belong to Illaenurus truncatus Feniak, but I prefer to think of it as an early juvenile of I. quadratus that reflects its ancestry, as Grant (1965) suggests.

Bell and Ellinwood (1962, pl. 55, fig. 2) figured a cranidium that has markedly divergent anterior facial sutures; one other specimen from the same collection is comparable to it, but the rest of the specimens have parallel or slightly divergent facial sutures. I have included these two specimens in I. quadratus and not in I. montanensis Kobayashi, which has divergent facial sutures, because I have reservations about the validity of the latter species. Direction of the anterior facial sutures is rather a poor feature for separation of species, especially as it can be affected by compaction or curling of the molt. In collections of more than three or four specimens, there is a continuous gradation from

strictly parallel to more or less divergent anterior facial sutures, without any relation to size of the specimen. If the divergence of facial sutures among specimens of I. quadratus figured by Hall (1863), Nelson (1951), and Bell and Ellinwood (1962) are compared with those of I. montanensis figured by Kobayashi (1935) and Grant (1965), the complete overlap in degree of divergence between the two species is readily apparent. Although I have seen neither Kobayashi's nor Grant's original material, I suggest two possible alternatives: (1) lump them into one species with a variable degree of anterior facial suture divergence, or (2) based on more intensive study of existing and new material, arrive at something more definitive for specific identification than facial suture divergence.

Occurrence.--Locally common in the Saukiella pyrene subzone at BC - 23; JR - 347, 369.5, 357, 374.5; SPH - 87, 91, 93, 94, 95, 96.5, 100, 114.5.

Family LECANOPYGIDAE Lochman, 1953

Genus RASETTIA Lochman, 1953

Platycolpus RAYMOND, 1913, p. 63; RASETTI, 1944, p. 250.

Rasettia LOCHMAN, 1953, p. 886; Lochman in HARRINGTON, et al., 1959, p. 380.

Type species.--Bathyrurus capax BILLINGS, 1860, p. 318,

fig. 20.

Remarks.--The diagnosis given by Lochman (in Harrington, et al., 1959, p. 380) summarizes the characteristics of this genus.

RASETTIA MAGNA Ellinwood

Pl. 3, Fig. 1.

Rasettia magna Ellinwood in BELL AND ELLINWOOD, 1962 (part), p. 397, pl. 55, fig. 9 (not fig. 10 = R. capax (Billings)).

Remarks.--Stitt (1968) has excellent collections of Rasettia capax (Billings), R. magna Ellinwood, and R. wichitaensis (Resser) from Oklahoma. The three species have non-overlapping ranges. Stitt found that the type of cranidium and pygidium assigned by Ellinwood to Rasettia magna were not associated with one another in Oklahoma; the tail assigned by Ellinwood (Bell and Ellinwood, 1962, pl. 55, fig. 10) was associated with cranidia Stitt assigned to R. capax, and the Oklahoma cranidia of R. magna were associated with pygidia that were different. The Texas material had come from a spot locality and could have been from one horizon or from an interval; thus it is difficult to ascertain whether or not the two taxa, R. capax and R. magna, have overlapping ranges in Texas. My assignments are based on Stitt's associations.

Three relatively small pygidia are assigned to this

species; they are characterized by the smooth curvature of the anterior edge of the pleural field, an articulating half-ring, two axial rings and a terminal axial piece with two low nodes. Two faint pleurae are present, and a third is suggested.

No cranidia were recovered from measured sections.

Occurrence.---Rare in the basal Saukiella pyrene subzone at MC - 1065-1075; TC - 1233, 1258.

RASETTIA WICHITAENSIS (Resser)

Pl. 4, Fig. 18.

Platycolpus wichitaensis RESSER, 1942b, p. 41, pl. 6, figs. 26-29.

Platycolpus oklahomensis RESSER, 1942b (part), p. 40, pl. 6, figs. 20, 21 (not figs. 22-25).

Remarks.--Stitt (1968) concluded from his Oklahoma material and from examination of Resser's types that some of the specimens Resser assigned to Platycolpus oklahomensis (not the holotype) actually belong in P. wichitaensis. Comparison of one poorly preserved pygidium from Texas with Stitt's excellent collections confirmed the assignment of the pygidium to Rasettia wichitaensis.

This pygidium is elliptical and characterized by an articulating half-ring, one axial ring and a terminal axial piece; the moderately convex pleural field is crossed by only

one furrow, the shallow anterior pleural furrow.

Occurrence.--Rare in the Saukiella serotina subzone at SH - 52.

Family OLENIDAE Burmeister, 1843

Genus LEIOBIENVILLIA Rasetti, 1954

Leiobienvillia RASETTI, 1954a, p. 583; HENNINGSMOEN, 1957, p. 159.

Type species.--Leiobienvillia laevigata RASETTI, 1954a, p. 583, pl. 61, figs. 3-6, text-fig. 3.

Remarks.--Henningsmoen (1957, p. 159) gives an excellent diagnosis and discussion of Leiobienvillia, the only olenid represented in the Ptychaspid biomere in central Texas.

LEIOBIENVILLIA LEONENSIS Winston and Nicholls

Leiobienvillia leonensis WINSTON AND NICHOLLS, 1967, p. 75, pl. 11, figs. 16, 20, 21.

Remarks.--I have included this species in order to give additional range data. Stitt (1968) also has recorded this species from the Corbinia apopsis subzone in Oklahoma.

Occurrence.--Rare in the Corbinia apopsis subzone at CC - 67; JR - 539, 540, 542, 543; LC - 48; LCS - 53, 55.5;

SH - 72; SS - 411; TC - 1402.

Family PLETHOPELTIDAE Raymond, 1925

Genus LEIOCORYPHE Clark, 1924

Leiocoryphe CLARK, 1924, p. 21; Lochman in HARRINGTON, et al., 1959, p. 409.

Type species.--Leiocoryphe gemma CLARK, 1924, p. 21, pl. 3, fig. 8.

Remarks.--The diagnosis given by Lochman (in Harrington, et al., 1959, p. 409) summarizes the characteristics of this genus.

LEIOCORYPHE cf. L. LONGICEPS Rasetti

Pl. 6, Fig. 13.

Leiocoryphe longiceps RASETTI, 1963, p. 1010, pl. 130, figs. 21-26.

Remarks.--Four poorly preserved cranidia are tentatively assigned to this species. The semielliptical outline, sinuous posterior margin, lack of palpebral lobes, and the longer and narrower proportions set this species apart from all others of Leiocoryphe. However, the Texas specimens are flatter, are fragmentary, and have longer, slightly elevated occipital segments that suggest blunt spines. These specimens may belong to L. longiceps, but the material is too poor to be

definitely assigned.

Occurrence.--Rare in the Saukiella serotina subzone at CC - 61.

LEIOCORYPHE OCCIPITALIS Rasetti

Leiocoryphe occipitalis RASETTI, 1944, p. 245, pl. 38, fig. 4;
BELL AND ELLINWOOD, 1962, p. 403, pl. 59, fig. 4.

Remarks.--Six cranidia are assigned to this species.

Leiocoryphe occipitalis is characterized by its lack of palpebral lobes, by a complete occipital furrow, and by its small size.

Occurrence.--Rare in the Saukiella pyrene subzone at MC - 915±; SS - 302.5, 307.5.

Genus PLETHOMETOPUS Ulrich in Bridge, 1931

Plethometopus Ulrich in BRIDGE, 1931, p. 221; RASETTI, 1944, p. 251; Lochman in HARRINGTON, et al., 1959, p. 410.

Type species.--Bathyurus armatus BILLINGS, 1860, p. 319, fig. 23.

Remarks.--The diagnosis given by Lochman (in Harrington, et al., 1959, p. 410) summarizes the characteristics of this genus.

PLETHOMETOPUS ARMATUS (Billings)

Bathyrurus armatus BILLINGS, 1860, p. 319, fig. 23; 1863, p. 238, fig. 273; 1865, p. 411, fig. 392.

Plethopeltis armata (Billings) RAYMOND, 1913, p. 65, pl. 7, fig. 18; 1924, p. 416.

Plethometopus armatus (Billings) Ulrich in BRIDGE, 1931, p. 221; RASETTI, 1944, p. 251, pl. 39, fig. 25; 1959, p. 383, pl. 53, figs. 1-8; pl. 52, fig. 14.

Plethometopus convexus (Whitfield) BELL AND ELLINWOOD, 1962 (part), p. 403, pl. 59, fig. 6 (not fig. 5 = Plethometopus sp.).

Remarks.--The specimen with an occipital spine (Bell and Ellinwood, 1962, pl. 59, fig. 6) that Bell assigned to Plethometopus convexus is misnumbered in the explanation of the plate. It is from the spot locality 86T-5-13A, and not from the Saukiella pyrene subzone at MC - 1065. The associated fauna in the dolomitic San Saba at the spot locality is totally unfamiliar, and therefore I cannot relate this specimen to any subzone of the Saukia zone.

This specimen is assigned to Plethometopus armatus, the type species, because of its slender occipital spine and its faint circumglabellar furrow (see comments by Ulrich in Bridge, 1931, p. 221).

Because of lack of biostratigraphic control, Bell assigned this specimen to P. convexus, the first-described mid-continent species. However, I think this name should be avoided. Ulrich (p. 221) reports that Whitfield had ten

specimens upon which he based Illlaenurus convexus. Although nine of those cranidia belong to Stenopilus, the figured holotype is Plethometopus. The occipital ring on the holotype is missing, but it was restored in the original illustration by using the associated Stenopilus material. Although Ulrich restored a blunt occipital spine in two of his figures (pl. 19, figs. 30, 31), he also stated that none of his specimens preserve this feature. Because at this point we don't know what Plethometopus convexus looks like, I suggest that it be considered an indeterminate species and that the name be restricted to the holotype until more data from Wisconsin become available.

Occurrence.--Common at spot locality 86T-5-13A.

PLETHOMETOPUS CONVERGENS (Raymond)

Pl. 3, Figs. 11, 12.

Plethopeltis convergens RAYMOND, 1924, p. 419, pl. 13, fig. 2.

Plethometopus convergens (Raymond) Ulrich in BRIDGE, 1931, p. 221; RASETTI, 1944, p. 251, pl. 39, fig. 27; 1959, p. 384, pl. 53, figs. 15-19.

Remarks.--This species is characterized by convergent anterior facial sutures, palpebral lobes that are on or behind the cranidial midlength, triangular posterior limbs, very shallow furrows, and a broadly triangular occipital segment with a suggestion of a terminal node. The larger the specimen,

the more it looks like Rasetti's illustrations. The pygidia agree quite well with Rasetti's illustration except that the axial node is absent.

Plethometopus convergens occurs stratigraphically below P. obtusus and is distinguished from it by the rearward position of the palpebral lobes, convergence of the facial sutures, and by shallower furrows.

The range of P. convergens in Oklahoma (Stitt, 1968) is comparable to that in Texas.

Occurrence.--Rare in the Saukiella pyrene subzone at BC - 36, 41; SS - 302.5. Rare in the Saukiella junia subzone at BC - 70. Rare to common in the Saukiella serotina subzone at CC - 61; JR - 529, 532; LCS - 32.4, 35.7, 39, 40, 45; SH - 52.6, 54.

PLETHOMETOPUS OBTUSUS Rasetti

Pl. 6, Figs. 14, 15.

Plethometopus obtusus Rasetti, 1945b, p. 472, pl. 52, figs. 1, 2; 1959, p. 383, pl. 53, figs. 11-14.

Plethometopus modestus Ulrich, WINSTON AND NICHOLLS, 1967, p. 87, pl. 10, fig. 11.

Remarks.--Plethometopus obtusus is distinguished from the stratigraphically lower P. convergens by the central or forward position of the palpebral lobes, by divergent anterior facial sutures, and by deeper furrows. P. obtusus is

distinguished from P. modestus by divergent anterior facial sutures, by more anteriorly located palpebral lobes, and by broader triangular posterior limbs. A bluntly pointed occipital ring and lack of distinct circumglabellar furrow distinguishes P. obtusus from P. armatus.

The anterior facial sutures are straight and divergent just in front of the palpebral lobes; then they angle inward and curve gently across the anterior margin of the cranidium. Cranidia and pygidia agree quite well with Rasetti's descriptions.

Winston and Nicholls (1967) assigned all specimens of Plethometopus to P. modestus. I think there are two stratigraphically separated species of Plethometopus in the Saukia zone, neither of which is P. modestus. Winston and Nicholls' figured specimen (pl. 10, fig. 11) belongs to the higher species, P. obtusus.

The range of P. obtusus in Oklahoma (Stitt, 1968) is comparable to that in Texas.

Occurrence.--Very rare at the top of the Saukiella serotina subzone at TC - 1400. Rare to locally common in the Corbinia apopsis subzone at JR - 539, 540; LC - 48; LCS - 53.3, 55.5; SS - 411.

Genus PLETHOPELTIS Raymond, 1913

Pl. 4, Figs. 1-6.

Plethopeltis RAYMOND, 1913, p. 64; 1924, p. 412; FIELD, 1915, p. 37; Ulrich in BRIDGE, 1931, p. 219.

Type species.--Agraulos saratogensis WALCOTT, 1890, p. 276, pl. 21, fig. 14.

Diagnosis.--Cranidium moderately convex. Glabella subrectangular to slightly tapering, completely outlined by axial and preglabellar furrows; glabellar furrows may or may not be present. Frontal area not divided. Occipital ring may extend back into blunt spine. Palpebral lobes small, slightly elevated. Librigenae transversely convex, unfurrowed, with blunt genal spines. Pygidium wider than long; axis bluntly rounded; pleurae either strongly ribbed or with furrows of variable strength; no border furrow.

Remarks.--Plethopeltis is distinguished from all other genera of the Plethopeltidae by its distinct and complete circumglabellar furrow, and by its lack of an anterior border furrow.

The taxonomic and nomenclatorial history of the material from Hoyt's Quarry, 4 miles west of Saratoga Springs, New York, needs to be recorded. Walcott (1886) began the sequence with a faunal list that included Ptychoparia (Agraulos) saratogensis, a nomen nudum. Four years later he

proposed Agraulos saratogensis Walcott (1890, p. 276, pl. 21, fig. 14) and allied this species to Bathyurus armatus Billings (1860, p. 319, fig. 23). Only the holotype is mentioned by number (U.S.N.M. 23863); the drawing on pl. 21, fig. 14 is presumably of the holotype.

In 1912 Walcott again published on Agraulos saratogensis, described a granular ornament, and illustrated five specimens with poorly retouched photographs (pl. 43, figs. 11-15). Figures 11 and 11a (U.S.N.M. 58558) illustrate an internal mold of a cranidium (see pl. 4, fig. 1); the glabellar furrows are a product of artistic license. Written on the back of this specimen is "Type of Agraulos saratogensis." The holotype number, 23863, does not appear on this or any other specimen in the type collection or support material. Resser (1942a, p. 41) states that the two numbers refer to the same specimen. In the U. S. National Museum catalogue beside the number 58558 is a notation, in what appears to be Resser's handwriting, that the original type number is 23863 (Jesse Merida, U.S.N.M., letter of January 11, 1968). Thus, 58558 does equal 23863. Comparison of the specimen 58558 with Walcott's drawing of 23863 also indicates that 58558 is indeed the holotype.

Figure 12 illustrates a free cheek (U.S.N.M. 58559). It is an internal mold, and Bertillion ornament is vaguely apparent along the outer margin.

Figures 13 and 13a (U.S.N.M. 58560) are of a partly exfoliated pygidium (see pl. 4, fig. 4). Small granules crest the axial rings and pleural ribs, and low anastomosing lines cover the margin of the pleural field.

An unexfoliated cranidium (U.S.N.M. 58561) is illustrated in Walcott's figures 14, 14a (see pl. 4, fig. 3). A fine granular ornament covers this cranidium, and delicate Bertillion ornament crosses the frontal area, the fixigenae, and the occipital ring. The recurved glabellar furrows are distinct but not as deep as Walcott's photograph indicates. This is the specimen that became holotype of Plethopeltis granulosa Resser (1942a, p. 41).

An hypostoma is illustrated in figures 15, 15a. This specimen was not located in the type collection or in the support material.

Among the 50 specimens in Walcott's support collection there were two distinct groups. The first is characterized by a smooth internal mold and an exoskeleton that is smooth except for small granules that can occur on the occipital ring, posterior parts of the glabella and fixigenae, and on the posterior border; the transverse or anteriorly-bowed occipital ring is impressed only across the axial region; the axial furrow is faint on the exoskeleton, moderately well impressed on internal molds; and the glabellar furrows are faint to absent. When he restudied Walcott's collection, Resser (1942a) confined

P. saratogensis to this first set, and established P. granulosa for the second. P. granulosa is characterized by granules and Bertillion pattern ornament on the exoskeleton; internal molds that can preserve part or all of this ornament; glabellar furrows that are faint to well impressed (as on the holotype, U.S.N.M. 58561) on both exoskeleton and mold; axial furrow that is always distinct; and an occipital furrow that is transverse or bowed forward medially, that extends almost to the axial furrow, and has its lateral ends directed forward.

Raymond established the genus Plethopeltis in 1913, made Agraulos saratogensis Walcott the type species, and included Bathyrurus armatus Billings (1860) in his new genus.

Field (1915) studied material collected by Raymond from Hoyt's Quarry, and compared it with that illustrated by Walcott. He concluded that Plethopeltis was a valid genus quite distinct from Agraulos. He also declared that the two forms of P. saratogensis (one with faint glabellar furrow and no ornament, and the other with deeper furrows and granular ornament) came from the same collecting horizons, and belong in the same species.

Raymond made collections from Hoyt's Quarry, and in 1924 reevaluated the type species, based on his collections and the published literature. It can be inferred from his statements that he did not see any of Walcott's specimens.

Raymond thought that Walcott had figured three forms under the name P. saratogensis: one with no glabellar furrows (1890, pl. 21, fig. 14), one with faint glabellar and deep dorsal furrows (1912, pl. 43, figs. 11, 11a), and one with deep glabellar and dorsal furrows (1912, pl. 43, figs. 14, 14a). Raymond states that of the 37 cranidia he collected, 22 were of the unfurrowed form, 15 had the faint glabellar and deeper dorsal furrows, and none had the deep glabellar furrows. Because the species originally described by Walcott had faint glabellar furrows, Raymond restricted P. saratogensis to the form with faint glabellar furrows, and established P. walcotti for the form with no glabellar furrows (see pl. 4, fig. 2).

In Raymond's collections, the trays labeled P. walcotti contain 46 cranidia that are well enough preserved to discern presence or absence of glabellar furrows; 10 of these (only one unexfoliated) have smooth glabellas, 33 have faint glabellar furrows, and 3 granular cranidia have faint glabellar furrows. In the trays labeled P. saratogensis (Walcott), one cranidium has a smooth glabella, 10 have faint furrows, one has deep, recurved glabellar furrows, 5 granular cranidia have faint furrows, and one granular cranidium has deep and recurved glabellar furrows. Comparison of holotypes shows the only difference to be that P. saratogensis has very vague depressions where glabellar furrows would be, whereas

P. walcotti is smooth.

After looking at all of Walcott's and Raymond's material, I agree with Resser that there are two distinct species in Hoyt's Quarry material, P. saratogensis and P. granulosa, and I think that P. walcotti is a synonym of P. saratogensis. Therefore, P. saratogensis is characterized by a smooth to faintly furrowed glabella, a distinct circumglabellar furrow, an incomplete occipital furrow, and an elliptical pygidium with pleural furrows ranging from faint to well impressed. Raymond's drawing of the holotype of P. walcotti has a faint anterior border furrow that is not on the specimen. The holotypes and associated pygidia assigned to these three species are illustrated here in unretouched photographs (pl. 4, figs. 1-6).

Ulrich (in Bridge, 1931, p. 219) proposed that Plethopeltis be restricted to forms closely allied to P. saratogensis. He established the genus Plethometopus with Bathyrurus armatus Billings as the type species, and included in the new genus the following five of Raymond's species of Plethopeltis: P. arenicola, P. laevis, P. angusta, P. lata and P. convergens. Removal of these five species and Bathyrurus armatus restricts Plethopeltis to only those forms with a distinct circumglabellar furrow.

Species definitely assigned to Plethopeltis include P. saratogensis (Walcott), 1890; P. buehleri Ulrich, 1931; P.

platymarginatus Ulrich, 1931; and P. granulosa Resser, 1942a. P. walcotti Raymond, 1924, is here synonymized with P. saratogensis. Raymond (1924) assigned specimens identified as Agraulos saratogensis Walcott by Weller (1903) to Plethopeltis welleri, n. sp. Walcott (1912) thought that Weller's assignment was correct. Although I have not seen this material, I agree with Walcott. Another species that Raymond assigned to Plethopeltis, Agraulus hemisphericus Berkey (1898), was placed in synonymy with Camaraspis convexa (Whitfield) by Frederickson (1948, p. 798), and this assignment has not been disputed (Wilson, 1951, p. 630; Nelson, 1951, p. 774; Lochman and Hu, 1960, p. 813).

PLETHOPELTIS sp.

Pl. 4, Figs. 7, 8.

Remarks.--Four specimens from two localities belong to Plethopeltis; the specific assignment is uncertain because of poor preservation, a dearth of specimens, and the mixed character of observable morphology.

The specimens are closely allied to P. saratogensis (Walcott) on the basis of low convexity, shallow axial and almost nonexistent glabellar furrows, gently tapered glabella, and a recurved occipital furrow. On the other hand, the completeness of the occipital furrow, well-defined occipital segment, and the sharply recurved, almost crimped

appearance of the posterior border furrow and border indicate a close affinity to P. buehleri Ulrich. One of the specimens has the granular ornament and deeper, recurved glabellar furrows of P. granulosa Resser. The specimens are from the dolomitic facies of the San Saba member of the Wilberns Formation; none have been recovered from the calcitic facies.

Until more and better material is recovered from central Texas, I prefer to leave the specific assignment open.

Occurrence.--Rare in the Saukiella pyrene subzone at MC - 1065.

Genus STENOPILUS Clark, 1924

Stenopilus CLARK, (June) 1924, p. 22; RAYMOND, (July) 1924, p. 418; RASETTI, 1959, p. 385.

Type species.--Stenopilus intermedius CLARK, 1924, p. 22, pl. 3, fig. 9.

Remarks.--Although the diagnosis given by Lochman (in Harrington, et al., 1959, p. 412) is sufficient, the illustrations of the cranidia (fig. 313, 6a, 6b) can be misleading. Rasetti (1945a, 1959), Ulrich (in Bridge, 1931), and Bell and Ellinwood (1962) adequately illustrate the common form of the genus.

STENOPILUS LATUS Ulrich

Stenopilus latus Ulrich in BRIDGE, 1931, p. 222, pl. 19, figs. 27, 28, 32, 33; WINSTON AND NICHOLLS, 1967, p. 88, pl. 9, fig. 28; pl. 10, fig. 14.

Leiocoryphe halei WINSTON AND NICHOLLS, 1967, p. 87, pl. 10, figs. 10, 13.

Remarks.--Stenopilus latus is common in the Texas collections and corresponds well with Ulrich's figures and descriptions, so long as the specimens are larger than about 4 or 5 mm. At this length the palpebral lobes are long and narrow, and the notches or pits along the posterior margin become less distinct. Leiocoryphe halei Winston and Nicholls ranges in size from minute up to about 4 mm. In the larger specimens there is a trace of long, slender palpebral lobes and a hint of the notches in the posterior margin. The ranges of the two are nearly coincident.

Stitt (1968), based on extensive collections from Oklahoma, thinks that Leiocoryphe halei represents juvenile Stenopilus latus, and the smaller collections from Texas corroborate his conclusions. Thus, Leiocoryphe halei is synonymized with Stenopilus latus.

Occurrence.--Locally common in the Saukiella junia subzone at BC - 109-110; JR - 460, 481; SH - 12.6; SS - 356, 370; TC - 1320-1325, 1330-1335, 1341-1346. Locally common in the Saukiella serotina subzone at CC - 58.2, 61; JR - 521.5,

529; LCS - 33, 33.5, 34-36, 40, 44, 45, 45.4, 52-54; TC - 1379-1385, 1392, 1400. Rare in the Corbinia apopsis subzone at LCS - 53.

STENOPILUS PRONUS Raymond

Stenopilus pronus RAYMOND, 1924, p. 420, pl. 13, figs. 6, 7; RASETTI, 1944, p. 257, pl. 39, fig. 19; 1959, p. 385, pl. 53, figs. 20-24; BELL AND ELLINWOOD, 1962, p. 403, pl. 59, figs. 7-9.

Stenopilus elongatus RASETTI, 1944, p. 257, pl. 39, figs. 20, 21; 1945a, p. 122, pl. 1, figs. 10-16.

Remarks.--Two small collections are assigned to this species and both are from the very base of the Saukia zone. The specimens are markedly elongate (length-width ratio greater than 1.25) and thus are easily separated from the stratigraphically higher and more equidimensional Stenopilus latus. S. elongatus Rasetti looks like a small S. pronus, and examination of the types of S. elongatus revealed no significant difference other than size. Thus, I have placed S. elongatus in synonymy with S. pronus.

Occurrence.--Rare in the base of the Saukiella pyrene subzone at MC - 1075; SS - 315±.

Family PARABOLINOIDIDAE Lochman, 1956

Diagnosis.--Subisopygous ptychoparioid trilobites.

Glabella normally tapering, rounded to truncate anteriorly, with 2 or 3 pairs of usually distinct glabellar furrows; eye ridges strong to obsolete, eyes normally large and located near glabellar midlength, rarely small and more anteriorly located; frontal area one-third to two-thirds cranidial length, usually with distinct anterior border furrow; width (tr.) of posterior areas approximates basal glabellar width, length (exsag.) variable. Pygidium transversely elliptical, with well defined axis, 2 to 4 axial rings, terminal piece, no post-axial ridge; pleural furrows distinct; border furrow poorly defined or obsolete; margin smooth or spined. External surfaces commonly ornamented with granules and/or vermiform ridges.

Remarks.--Assembled in this family are genera assigned to the families Parabolinoiidae and Idahoiidae in Part O of the "Treatise on Invertebrate Paleontology" (Harrington, et al., 1959). I have grouped these genera into one family because of their morphologic similarities, and because I think they are probably genetically related. Palmer (1965b, p. 32-33) discusses the differences between the strictly morphological families of the Treatise and the more interpretive, evolution-oriented families he recognized

in the Pterocephaliid biomere. The families Palmer recognized represent complexes of genera that morphologically, spatially, and temporally have a high probability of being genetically related. I have tried to follow the concept he outlined in erecting families in the Ptychaspid biomere.

Three lineages are evident in the Parabolinoidea (Fig. 1): Parabolinoidea to Orygmaspis, Parabolinoidea to Taenicephalus to Idahoia and Saratogia, and Parabolinoidea to Wilbernia. Orygmaspis differs from Parabolinoidea in having larger, more posteriorly located palpebral areas, and in having a generally less convex, smoother cranidium; Orygmaspis llanoensis var. A is the tie between Parabolinoidea contractus and O. llanoensis (s.s.). The earliest species of Wilbernia, W. halli and W. halli var. A, differ from Parabolinoidea contractus in their larger, more posterior palpebral areas that are closer to the glabella, and in their modifications of the frontal area; later species of Wilbernia continue the modifications of the frontal area, and the glabella becomes proportionally larger and more rectangular. A few specimens of Parabolinoidea granulatus have larger than normal palpebral areas, a vermiform ridge ornament instead of granules, and deeper furrows--features suggesting that P. granulatus is ancestral to Taenicephalus gouldi. Continuation of the trend toward a shorter, more blunt glabella, and a deeper axial furrow, combined with modifications of the frontal area, relates

T. gouldi to T. shumardi. Although high in the range of T. shumardi there are some specimens that indicate affinities with Kendallina and Moustonia, none of these specimens could be assigned to either genus. Idahoia and Saratogia are related to Taenicephalus through T. sp., which shares characters of all three genera.

Genus IDAHOIA Walcott, 1924

Idahoia WALCOTT, 1924b, p. 58; Lochman in HARRINGTON, et al., 1959, p. 252; LOCHMAN AND HU, 1959, p. 420; BELL AND ELLINWOOD, 1962, p. 391; GRANT, 1962, p. 986; 1965, p. 117.

Meeria FREDERICKSON, 1949, p. 358; Lochman in HARRINGTON, et al., 1959, p. 252; LOCHMAN AND HU (as a subgenus of Idahoia), 1959, p. 419.

Type species.--Idahoia serapio WALCOTT, 1924b, p. 58, pl. 14, fig. 1.

Diagnosis.--Frontal area downsloping, generally longer than one-half the glabella (plus occipital ring). Glabellar furrows faint to absent. Occipital furrow shallow, medially obscured. Widely divergent anterior facial sutures. Exoskeleton and internal molds ornamented.

Remarks.--Grant (1965, p. 121) suggests eight criteria that can be used to differentiate between Idahoia and Saratogia. The 320 Texas specimens assigned to species of Idahoia

conform rather well with the criteria. The only significant discrepancy is that 64 specimens have relatively shorter frontal areas; of these, twenty-five are assigned to Idahoia lirae var. A, and many of the remaining are small (less than 3 mm) I. lirae (s.s.). The evaluation of the Texas idahooids according to Grant's criteria is summarized in Table 2.

Grant (1962, p. 986; 1965, p. 121) emphasizes that the critical feature for separating Idahoia from Saratogia is the length of the frontal area (sag.) relative to the length of the rest of the cranidium. The species of Idahoia recognized by Grant have frontal areas that are markedly longer than one-half the length of the glabella (plus occipital ring); his species of Saratogia have frontal areas with lengths ranging from less than one-fifth to just less than one-half the length of the glabella (plus occipital ring). Thus he was not confronted with the problem of an idahooid with a frontal area usually slightly longer than one-half the glabella.

Such an idahooid occurs at the base of the Saratogia zone in Texas and Oklahoma. Frederickson established the monotypic genus Meeria for this taxon. I do not believe Meeria to be significantly different from Idahoia and thus I follow Bell and Ellinwood (1962) in synonymizing Meeria with Idahoia.

Table 2. Summary of measurements and observations of all specimens assigned to species of Idahoia and Saratogia, according to Grant's (1965) eight criteria. For each criterion, the first alternative is characteristic of Idahoia, the second of Saratogia.

Species Grant's Criteria		<u>Idahoia</u> <u>lirae</u>	<u>Idahoia</u> <u>lirae</u> var. A	<u>Idahoia</u> <u>wisconsensis</u>	<u>Saratogia</u> <u>americana</u>	<u>Saratogia</u> <u>modesta</u>	<u>Saratogia</u> <u>fria</u>
Total number of specimens		183	92	30	100	70	130
Total number measured		122	74	8	62	62	126
Frontal area length relative to glabellar length	$>\frac{1}{2}$	83	49	8			4
	$<\frac{1}{2}$	39	25		62	62	88
Glabellar furrows	Faint to absent	116	74	26	13	60	91
	Normally visible	6			48	3	18
Occipital furrow depth	Shallow, not visible across axis	106	70	23	4	11	49
	Well impressed, visible across axis	23	4	1	57	47	46
Anterior fixigenae	Wide	110	72	26	5		73
	Narrow	7	2		56	58	44
Anterior facial sutures	Widely divergent	100	70	26	5		78
	Narrowly divergent	17	4		56	58	39
External and internal surface ornament	Smooth external	2	10			21	
	Ornamented external	30	5	13	22	4	43
	Smooth internal	5	35	1	3	41	
	Ornamented internal	85	21	14	42	10	80
Frontal area topop- raphy	Brim downsloping, border normally downsloping	122	74	18		4	
	Brim downsloping, border upturned			8	62	58	126
Palpebral lobes	Long, narrow	100	50	5	3		5
	Large, flat, semi- circular	5	8		55	53	100

IDAHOIA LIRAE (Frederickson)

Meeria lirae FREDERICKSON, 1949, p. 358, pl. 72, figs. 3-6;
GRANT, 1965, p. 121 (in discussion of Saratogia).

Idahoia lirae (Frederickson) BELL AND ELLINWOOD, 1962, p. 392, pl. 53, figs. 1-12.

Description.--Idahoia lirae is characterized by a downsloping frontal area that generally is slightly longer (sag.) than one-half the glabella (plus occipital ring), by faint to absent glabellar furrows, by an occipital furrow that is shallow laterally and partially to completely obscured across the axis, by widely divergent anterior facial sutures, and by surface ornament. In small specimens (less than 3-4 mm) length of the frontal area can be less than one-half the length of the glabella (plus occipital ring). The occipital ring can be spinose, nodose, or smooth. The stouter the occipital spine, the shallower is the medial segment of the occipital furrow and the longer (sag.) is the occipital ring; thus a stout spine can influence the axial length of the cranidium. Glabellar, occipital and palpebral furrows are more distinct on the internal mold than on the exoskeleton; this appears to be true for all idahoiids in central Texas. The anterior border furrow ranges from narrow and crisp in smaller specimens to broad and shallow in the larger ones. The specimens on which this furrow is indistinct to absent are grouped under I. lirae var. A. The

convex preglabellar field slopes gently downward. The slightly convex anterior border is horizontal to downsloping.

Exoskeleton ornament consists of elongate ridges on at least the base of the occipital spine, and these ridges splay out onto the occipital ring; ridges and granules can cover the posterior limbs, the occipital ring, and the posterior half of the glabella. Internal molds have longitudinal caecal venations on the preglabellar field, and they can have low ridges and granules on the occipital ring and posterior part of the glabella.

Remarks.--Based on material from the Arbuckle and Wichita Mountains in Oklahoma, Frederickson (1949) erected the genus Meeria and included in it only one species, M. lirae Frederickson. From Frederickson's description, M. lirae has the faint glabellar furrows, medially obscured occipital furrow, biconvex and downsloping frontal area, smooth outer surface and moderately wide anterior fixigenae that are characteristic of Grant's concept of Idahoia. Frederickson records that his specimens have smooth or nodose occipital rings; none have spines. No data were given on relative length of the frontal area.

Lochman and Hu (1959) recognized Meeria as a subgenus of Idahoia and described a new species, Idahoia (Meeria) modesta.

Bell and Ellinwood (1962) assigned Idahoia (Meeria) modesta Lochman and Hu to Saratogia, and they synonymized Meeria with Idahoia. They say (p. 392) that generally the frontal areas of I. lirae are longer than one-half the glabella (plus occipital ring) whereas the frontal areas of S. modesta are less than one-half.

In collections from the Arbuckle Mountains in Oklahoma Stitt (1968) has material conspecific with Frederickson's Meeria lirae. Most of these specimens have occipital rings that are broken off at the axial line, and thus their axial lengths cannot be accurately measured. The broken specimens have medially obscured occipital furrows. When a spine is broken off the occipital ring, part of the spine can remain or, if the spine is robust, part of the occipital ring is broken off. On specimens with well developed occipital spines, the medial part of the occipital furrow will be shallower; the stouter the spine, the more obscure the furrow. With these two observations in mind, it is reasonable to conclude that some of Frederickson's and Stitt's specimens did at one time have occipital spines. Possession of a spine would make Meeria lirae much more acceptable as a species of Idahoia.

The Texas cranidia from the basal part of the Idahoia zone are conspecific with Frederickson's and Stitt's taxon, and I think Bell and Ellinwood (1962) were correct in

synonymizing Meeria with Idahoia. Placement of M. lirae in Idahoia does not contradict Grant's concept of Idahoia-- rather, it emphasizes the close relationship between Idahoia and Saratogia and reiterates the point that the more we know about closely related taxa (species and genera), the less distinct and more artificial are the lines of separation.

I. lirae is distinguished from the stratigraphically higher I. wisconsensis (Owen) by its relatively shorter frontal area, generally smaller size, and absence of granules in the anterior border furrow of the internal molds. I. lirae has a brim-border ratio of about 2:1, whereas the type species, I. serapio Walcott, has a 1:1 ratio and a row of pustules in the anterior border furrow.

I. lirae occurs through a maximum interval of 6 feet at the base of the Idahoia zone in almost every measured section in central Texas. Together with Saratogia americana and Wilbernia diademata, it signals the base of the Idahoia zone.

Occurrence.--Abundant in the Idahoia lirae subzone at the base of the Idahoia zone at CO - 162; CR - 743-747; E - 894; EC - 20.5, 21.5; GM - 590, 591, 594; GR - 165, 167, 168, 169, 171; JR - 172, 173, 175.5, 177; LL - 714, 719; MC - 706, 707; PK - 922; SK - 232, 233; SS - 92.5, 94.5; ST - 528; TA - 56; TC - 983, 986, 987; TR - 342, 344.5; WC - 925.

IDAHOIA LIRAE (Frederickson), var. A, Bell

Meeria lirae FREDERICKSON, 1949, pl. 72, fig. 5.

Idahoia lirae (Frederickson), var. A, Bell in BELL AND ELLINWOOD, 1962, p. 393, pl. 53, figs. 10-12.

Remarks.--This morphologic variant occurs through the range of Idahoia lirae (s.s.) and is distinguished from it by the obscurely furrowed or undifferentiated frontal area and by the relatively longer preglabellar field. Variation is continuous between I. lirae (s.s.) and this variety. Two-thirds of the measurable specimens had frontal areas longer than one-half the length of the glabella (plus occipital ring); one-third had frontal areas slightly less than one-half the length of the glabella (plus occipital ring). This variant can have the same ornament distribution and pattern as I. lirae (s.s.).

Occurrence.--Common in the Idahoia lirae subzone at CR - 743-747; E - 894; GM - 590, 591, 594; GR - 165, 167, 168, 169, 171; JR - 173; MC - 706; SK - 232, 233; SS - 92.5; TC - 983, 986, 987.

IDAHOIA WISCONSENSIS (Owen)

Crepicephalus? wisconsensis OWEN, 1852, Table 1, fig. 13.

Idahoia wisconsensis (Owen) BELL, FENIAK, AND KURTZ, 1952 (part), p. 189, pl. 37, figs. 3b,c, 3e,f (figs. 3a,d =

I. serapio Walcott) (synonymy to date); BELL AND ELLINWOOD, 1962, p. 393, pl. 52, figs. 19-21 (synonymy to date); GRANT, 1962, p. 986, pl. 139, fig. 5a; 1965, p. 119, pl. 14, fig. 13.

Remarks.--Idahoia wisconsensis is characterized by a preglabellar field--anterior border ratio ranging from about 3:1 up to about 3:2; on 7 of the 16 measurable specimens this ratio is 2:1. On the 8 specimens with the entire axial length preserved, the length of the frontal area was 0.6 that of the glabella (plus occipital ring).

Exoskeleton ornament consists of two intersecting sets of ridges on the preglabellar field, a transverse set of ridges on the anterior border, a row of granules in the anterior border furrow and granules on the posterior edge of the occipital ring and back onto the occipital spine. Internal molds preserve only the ornament of the frontal area.

I. wisconsensis can range down as far as the transition zone between Drumaspis texana and D. idahoensis; it can range up as far as the first occurrence of Ellipsocephaloides silvestris.

Occurrence.--Locally common in the upper third of the Idahoia zone at JR - 204, 205.5, 210; SK - 260, 264, 265, 266; TC - 1022, 1029.

Genus ORYGMASPIIS Resser, 1937

Orygmaspis RESSER, 1937, p. 21; FREDERICKSON, 1949, p. 359;
GRANT, 1965, p. 132.

Type species.--Ptychoparia llanoensis Walcott, 1890,
p. 272, pl. 21, figs. 3-5.

Diagnosis.--Palpebral lobes at least 0.3 of glabellar length; posterior edge of palpebral lobes behind glabellar midlength. Fixigenae broad; posterior area triangular, long (tr.). Frontal area usually longer than one-half glabellar length.

Remarks.--Orygmaspis is distinguished from Parabolinoidea, Maustonia, Kendallina and Taenicephalus by its relatively large, posteriorly-located palpebral lobes, broad fixigenae, shorter (exsag.) posterior limbs, ornament, and relatively longer frontal area.

Only one species, Orygmaspis llanoensis (Walcott), is included in the genus. O. firma Frederickson, 1949, is synonymized with the type species, and O. eryon (Hall) Resser, 1937, was designated the type species of Kendallina (= Kendallia) by Raasch (1939).

ORYGMASPIS LLANOENSIS (Walcott)

Pl. 1, Figs. 7-16.

Ptychoparia llanoensis WALCOTT, 1890, p. 272, pl. 21, figs. 3-5; 1899, p. 458, pl. 64, fig. 4.

Conaspis llanoensis (Walcott) WALCOTT, 1914, p. 358 (foot-note).

Orygmaspis llanoensis (Walcott) RESSER, 1937, p. 22; FREDERICKSON, 1949, p. 359, pl. 71, figs. 19-22; BELL AND ELLINWOOD, 1962, p. 398, pl. 55, figs. 11-15; GRANT, 1965, p. 133, pl. 12, figs. 4, 7.

Orygmaspis firma FREDERICKSON, 1949, p. 359, pl. 71, figs. 15-18; BELL AND ELLINWOOD, 1962, p. 398, pl. 55, fig. 16; pl. 56, fig. 1; GRANT, 1965, p. 132, pl. 12, figs. 3, 5, 6.

Description.--Cranidium usually longer than wide, flatly to moderately convex. Glabella tapered, the front broadly rounded or truncate; two or three pair of glabellar furrows that are more deeply impressed in the lower three feet of the range of the species; glabella usually keeled. Axial furrow distinct; preglabellar furrow can be shallower. Occipital furrow broad and shallow; occipital ring broad, tapers laterally, bears a median node. Frontal area highly variable; in the lower three feet of the range it is subequally divided into a flatly to moderately convex preglabellar field that is horizontal or downsloping, and a flatly convex anterior border that is horizontal or downsloping; anterior border furrow distinct and transverse on most specimens from lower part of range. About three feet above the base of

the range almost all frontal areas are smooth and lack an anterior border furrow; a few specimens with a smooth frontal area and all gradations toward the divided frontal area do occur together in the basal three feet of the range. Fixigenae broad, crossed by faint ocular ridges. Palpebral lobes relatively large, at least 0.3 the length of the glabella; posterior edges of the palpebral lobes opposite or behind glabellar midlength; these posterior edges of the palpebral lobes are usually opposite the lateral ends of the posterior pair of glabellar furrows, with the palpebral lobes straddling the interval between the posterior and middle pairs of glabellar furrows. Palpebral furrow usually absent. Posterior areas triangular, long (tr.); posterior border furrow very broad and shallow. Anterior facial sutures markedly divergent in front of the palpebral lobes; however, they can be only slightly divergent on specimens from the lower three feet of the range. Although the external surface is usually smooth, very low and longitudinally oriented ridges can be seen on the preglabellar field; a few specimens have a low, transverse ridge crossing the otherwise undifferentiated frontal area. Internal molds have longitudinally oriented irregular ridges on the preglabellar field, a row of granules in the anterior border furrow, or a smooth but usually granulate ridge where this furrow should be; a few specimens have coarse granules scattered over the glabella, fixigenae and frontal

area, as indicated in Walcott's original figure (1890, pl. 21, fig. 3) and mentioned in Resser's generic diagnosis (1937, p. 21).

Pygidium transversely elliptical; axis raised, consists of an articulating half-ring, three axial rings, and a terminal piece that can have two very low nodes or a low ridge across it. Furrows across pleural field shallow but distinct. Three or four pairs of marginal spines that can be slender, or short and stout, or mere stubs along the margin.

Remarks.--Orygmaspis llanoensis occurs throughout the lower half of the Taenicephalus zone. Although it is entirely absent from the basal foot of the Parabolinoides subzone, it is common to very abundant in the six feet above that point. There is a vast degree of morphologic variation throughout the lowest three feet of the range; above that the specimens conform well with O. llanoensis of all previous workers.

Both O. llanoensis and O. firma have been recognized in central Texas. The two were distinguished on the basis of presence or absence of an anterior border furrow. Although there are specimens that can easily be assigned to O. firma, there are numerous specimens that close the gap between it and O. llanoensis. All the specimens that could be assigned to O. firma and the intermediates between it and good O. llanoensis occur in the basal three feet of the range. I prefer to think

of this group in terms of one variable species that, on extension through time, morphologically settled down to the taxon heretofore called O. llanoensis. Thus, I have synonymized O. firma with O. llanoensis.

The spectrum of variation in this species extends even farther from O. llanoensis than O. firma. In the lower three feet of the range of O. llanoensis (s.s.) there are specimens that would not be assigned to that species were it not for the fact that they grade continuously into it. All these specimens have the large, posteriorly placed eyes and slender limbs of Orygmaspis, and most of the frontal areas are longer than one-half the glabellar length. The variation is in the depth of all furrows, especially the anterior border furrow, and in the topography of the frontal area. There are several collections from the basal two feet of the range (E - 849, 849.5; JR - 122, 124; GR - 120; TC - 935.5, 935.5-936) in which the variation can best be seen. If the specimens from a collection are arranged in order of crispness of furrows, the few specimens easily assignable to O. llanoensis are all at the less distinct end of the array, with specimens that could be called O. firma next in line. Beyond this, the furrows are quite distinct, the frontal area is subdivided and there is variation in the topography of the frontal area. It is this distinctly furrowed group that I am calling O. llanoensis var. A; a stratigraphically significant and morphologically

different group that is still included within O. llanoensis.

The pygidia associated with O. llanoensis are very similar to the one Frederickson figured (1949, pl. 71, fig. 22) except that the spines are shorter. These pygidia are also much like those associated with Parabolinoides contractus.

Occurrence.--Common to locally abundant in the Parabolinoides subzone and in the lower half of the Taenicephalus zone at B - 315.5, 316; CO - 129, 131; CR - 711; E - 849, 849.5, 850, 852, 855, 857; GM - 547, 555, 559; GR - 119, 120, 123, 124; HY - 54, 55; JR - 122, 124, 125, 126, 126.3, 127, 131, 132; LL - 673, 676, 680.5, 682, 682.5; MC - 661, 661.5, 662, 665, 667, 668, 671, 673; PK - 886, 888, 895; SK - 202, 204, 206; SS - 48.25, 54, 55, 58, 60, 60.5, 62, 67, 68; ST - 480, 481, 484; SU - 60, 61; TA - 10, 12; TC - 935.5-936, 936-936.5, 939, 944.5; TR - 292.5, 294, 296, 297.5, 300.5, 302.5; WC - 891, 891.5, 894.5, 896, 898.

ORYGMASPIS LLANOENSIS (Walcott), var. A, Longacre, n. var.

Pl. 1, Figs. 7-10.

Description.--This variant is characterized by its distinct furrows, particularly the anterior border furrow, and a frontal area that has topographic relief and that is subequally divided into a preglabellar field and anterior

border. The variety can have all or part of the ornament characteristic of Orygmaspis llanoensis (s.s.). Palpebral furrows can be distinct.

Remarks.---Although this variant is distinct from O. llanoensis of previous workers, it grades continuously into that morphologic group. Because it is difficult to draw a line between the two, I have purposely left the boundary vague. This variety occurs in the lower three feet of the species range. Although respectable O. llanoensis can occur with its variety, the collections are dominated by the variety. I think that the data indicate that in its early stages O. llanoensis was a variable species that in time restricted itself to a morphotype that originally was an end member in the morphologic distribution.

O. llanoensis var. A can occur with Parabolinoides contractus and looks very much like that species in the depth of furrows and character of the frontal area. However, the palpebral lobes are longer and more posteriorly located, and the posterior limbs are correspondingly shorter (exsag.). I think O. llanoensis var. A represents the evolutionary tie between Parabolinoides and Orygmaspis, that initially the population was morphologically variable, and that eventually it settled on that combination of features we call O. llanoensis.

Occurrence.---Common in the interval one to four feet

above the base of the Taenicephalus zone at E - 849, 849.5, 850; GR - 119, 120; HY - 54, 55; JR - 122, 124; LL - 673; MC - 661, 661.5, 662; SK - 202; SS - 48.25; ST - 480; TC - 935.5-936, 936-936.5; TR - 292.5, 294; WC - 891, 891.5. Occurs with O. llanoensis (s.s.) at E - 849; GR - 120; HY - 55; JR - 124; MC - 661.5; TC - 935.5-936.

Genus PARABOLINOIDES Frederickson, 1949

Parabolinoides FREDERICKSON, 1949, p. 360; BERG, 1953, p. 564; BELL AND ELLINWOOD, 1962, p. 398; GRANT, 1965, p. 133.

Bernia FREDERICKSON, 1949, p. 357.

Type species.--Parabolinoides contractus FREDERICKSON, 1949, p. 361, pl. 71, figs. 4-10.

Diagnosis.--Palpebral lobes small. Posterior end of palpebral lobes opposite or forward of glabellar midlength. Posterior fixigenae long (exsag.) and broadly triangular.

Remarks.--Parabolinoides differs from all other genera in the family in its smaller and more anteriorly-located palpebral lobes and in the correspondingly longer (exsag.) triangular posterior limbs. In addition, the frontal area is always divided into a preglabellar field and anterior border by a distinct anterior border furrow.

Three described species are included in Parabolinoides:

P. contractus Frederickson, 1949, P. palatus Berg, 1953, and P. granulatus Ellinwood, 1962.

PARABOLINOIDES CONTRACTUS Frederickson, 1949

Pl. 1, Figs. 2-6.

Parabolinoides contractus FREDERICKSON, 1949, p. 361, pl. 71, figs. 4-10; BERG, 1953, p. 564, pl. 59, fig. 3; BELL AND ELLINWOOD, 1962, p. 399, pl. 56, fig. 12; GRANT, 1965, p. 134, pl. 10, figs. 20, 23-27.

Parabolinoides hebe FREDERICKSON, 1949, p. 361, pl. 70, figs. 7, 8; pl. 71, figs. 1-3; BERG, 1953, p. 564, pl. 59, figs. 2, 4; BELL AND ELLINWOOD, 1962, p. 400, pl. 56, figs. 6-11; GRANT, 1965, p. 135, pl. 10, fig. 19.

Parabolinoides expansus NELSON, 1951, p. 776, pl. 107, figs. 1, 3; LOCHMAN AND HU, 1960, p. 811, pl. 95, figs. 32-35; GRANT, 1965, p. 135, pl. 10, figs. 18, 21, 22.

Maustonia cordillerensis LOCHMAN, 1950, p. 331, pl. 47, figs. 6-13.

Parabolinoides cordillerensis (Lochman) BERG, 1953, p. 563 (in discussion of Maustonia); GRANT, 1965, p. 134, pl. 11, figs. 1-5.

Bernia obtusa FREDERICKSON, 1949, p. 358, pl. 70, figs. 1-6; BERG, 1953, p. 559, pl. 59, fig. 1.

Description.--Cranidium usually wider than long, many specimens nearly quadrate. Glabella flatly to moderately convex, tapered, rounded to slightly truncated anteriorly, may be keeled; three pair of glabellar furrows may be well impressed, the posterior pair may connect, particularly on small specimens. Axial and preglabellar furrows distinct. Occipital furrow broad, shallow, better impressed on molds than on

exoskeleton. Occipital ring tapers laterally; occipital node usually present. Frontal area extremely variable: the preglabellar field and anterior border normally are subequal in length (sag.), but either one may be longer; the preglabellar field is moderately to flatly convex, horizontal or downsloping; the anterior border is flat to slightly convex and can be raised, slope up or down, or be horizontal; the variation in topography runs the gamut of possibilities. Although the distinct anterior border furrow is usually slightly curved or nearly transverse, it can have a suggestion of recurvature at the axial line. The length of the frontal area relative to the glabella ranges from 0.25 to greater than 0.60. Fixigenae relatively narrow, flatly convex, horizontal to downsloping laterally, narrowest opposite palpebral lobes, crossed by ocular ridges. Palpebral lobes small, length never greater than one-quarter glabellar length; posterior edge of eye opposite glabellar midlength or forward of this point, usually opposite anterior 0.4 of glabella; the posterior end of the eye is usually opposite the lateral end of the second set of glabellar furrows. Palpebral furrow faint. Posterior areas broadly triangular; posterior border furrow broad, shallow. Anterior facial sutures range from nearly parallel to markedly divergent in front of the palpebral lobes. Surface of exoskeleton usually smooth. Internal molds can be ornamented, usually with just a longitudinally oriented pattern of caecal venations

on the preglabellar field; low transverse pattern of ridges can be seen on some of the anterior borders. Eleven specimens from seven localities have a row of granules in the anterior border furrow, in addition to the caecal venations.

Pygidium transversely elliptical. Raised, convex axis consists of an articulating half-ring, two well-defined axial rings, a third axial ring that is partly or completely fused to a terminal axial piece that can bear two low nodes or a ridge. Pleural field crossed by shallow but distinct furrows. Two to five pair of marginal spines, ranging from stubs to long and slender spines. Margin of exoskeleton covered by fine terrace lines; internal molds smooth.

Remarks.--More than 150 specimens from the basal two feet of the Taenicephalus zone in 19 measured sections yielded the information upon which this species is revised. The specimens were measured for glabellar length, length of the palpebral lobes, length of frontal area and distance from the base of the glabella to a line connecting the posterior edges of the palpebral lobes.

The palpebral lobes are small and situated well forward on the cranidium. The ratios of palpebral lobe length and glabellar length ranged from 0.14 to 0.25; most of the ratios were between 0.20 and 0.25. The eyes were never more than one-quarter glabellar length. The posterior edges of

the palpebral lobes were always opposite the anterior half of the glabella; more than half the specimens had the base of the eyes opposite the anterior two-fifths of the glabella. Another consistent relationship was that the posterior edges of the eyes were usually opposite or forward of the lateral ends of the second set of glabellar furrows; the palpebral lobes straddled the interval between the anterior and middle pair of glabellar furrows.

The length of the frontal area relative to glabellar length is quite variable. Values of the ratio ranged from 0.25 to 0.60, with major concentrations around 0.40 to 0.45 and 0.48 to 0.53. Bell and Ellinwood (1962) set the cutoff between Parabolinoides hebe and P. contractus at 0.50; my data indicate that although there appear to be two major clusters with respect to this ratio, there is a complete gradation between the two. There is no relation apparent between length of frontal area and anterior facial suture divergence. Thus, I have placed the two species in synonymy, the name of the type species prevailing.

There is a marked degree of variation in the topography of the frontal area; the preglabellar field is flatly to moderately convex, horizontal or downsloping; the anterior border is flatly to moderately convex, upsloping, horizontal and raised, or downsloping. Because this range in topography includes that of P. expansus Nelson, 1951, P. expansus is

synonymized with P. contractus.

P. cordillerensis (Lochman) is characterized by the low topography of its frontal area, caecal venations on the preglabellar field, and, according to Grant (1965), granules in the anterior border furrow. The topography and caecal venations are features common to many specimens of P. contractus; the granules are present on a few, not always in association with the caecal venations. There is no reason sufficient for separating P. cordillerensis from P. contractus.

Four or five cranidia conform to Bernia obtusa Fredrickson; I agree with Bell and Ellinwood (1962) and Grant (1965) that it is not a separate taxon, and here include it in P. contractus.

In the upper foot or less of the range of P. contractus and just above its range are cranidia very similar to, yet distinct from, P. contractus. Although the glabella and frontal areas are quite like those of P. contractus, the palpebral lobes are larger and are farther back on the cranidium. I think this associate and successor, Orygmaspis llanoensis (Walcott), var. A, Longacre, n. var., represents the tie between Parabolinoides and Orygmaspis; that there was a shift in the size and position of eyes in the population of P. contractus, with O. llanoensis and its variety being the ultimate and penultimate results.

The pygidia of P. contractus and O. llanoensis are remarkably similar. In P. contractus the third axial ring is more or less fused to the terminal axial piece; three distinct axial rings can usually be seen on O. llanoensis pygidia. In all other respects the two are identical.

Occurrence.--Abundant in the basal Parabolinoides subzone at B - 312, 312.5; CO - 124, 125, 126; CR - 697; E - 848.3, 848.7, 849, 849.5; GM - 546, 547; GR - 118, 119; HY - 53, 55; JR - 121, 122; LL - 672.5, 673; MC - 660, 661.5, 663; PK - 885, 885.5, 886; SK - 200-201, 201; SS - 46, 46.5, 47, 47.5; ST - 478; SU - 56, 58; TA - 0.6, 0.8, 1, 2; TC - 934-934.5, 934.5-935, 935.25, 935.5-936; TR - 291.2, 292.5; WC - 889.

PARABOLINOIDES GRANULOSUS Ellinwood

Parabolinoides granulosus Ellinwood in BELL AND ELLINWOOD, 1962, p. 399, pl. 56, figs. 13-18.

Remarks.--Parabolinoides granulosus is characterized by its ornament, transversely convex preglabellar field that is flattened anterior to the glabella, and the convex anterior border with a recurved to backward-pointed posterior margin. In small specimens at least the posterior set of glabellar furrows may connect.

Occurrence.--Common to locally abundant in the basal one foot of the Parabolinoides subzone at B - 312, 312.5; CO - 124; CR - 697; E - 848, 848.7; GM - 546; GR - 118; HY - 53; JR - 121, 122; LL - 672, 672.5; MC - 660, 661, 662; PK - 885; SS - 46, 46.5, 47; SU - 56; TA - 0.8, 1; TC - 934-934.5, 934.5-935.

Genus SARATOGIA Walcott, 1916

Saratogia WALCOTT, 1916, p. 195; LOCHMAN AND HU, 1959, p. 420; BELL AND ELLINWOOD, 1962, p. 393; GRANT, 1962, p. 988; 1965, p. 120.

Minkella LOCHMAN AND HU, 1959, p. 414.

Type species.--Conocephalites calciferous WALCOTT, 1879, p. 129; 1912, pl. 43, figs. 7-10a.

Diagnosis.--Frontal area less than one-half the length of glabella (plus occipital ring). Glabellar furrows usually distinct. Occipital furrow well impressed, visible across axis. Anterior facial sutures narrowly to widely divergent. Preglabellar field downsloping, anterior border normally upturned. Exoskeleton and internal mold ornamented.

Remarks.--The two most consistent features among species of Saratogia are the frontal area-length that is less than one-half that of the glabella (plus occipital ring), and the upturned anterior border. These two features readily

distinguish Saratogia from Idahoia. All Texas specimens assigned to species of Saratogia were evaluated according to Grant's (1965, p. 121) eight criteria; the results are summarized in Table 2, along with those for species of Idahoia.

SARATOGIA AMERICANA (Lochman and Hu)

Minkella americana LOCHMAN AND HU, 1959, p. 414, pl. 58, figs. 1-20.

Saratogia americana (Lochman and Hu) BELL AND ELLINWOOD, 1962, p. 393, pl. 54, figs. 1-5.

Remarks.--Saratogia americana is characterized by a frontal area that is normally about two-fifths the length of the glabella (plus occipital ring), distinct glabellar and occipital furrows, narrowly divergent anterior facial sutures, surface ornament, and a convex, strongly downsloping preglabellar field and sharply upturned anterior border. Of the three Texas species of Saratogia, S. americana best conforms with Grant's criteria for the genus (see Table 2). As Bell and Ellinwood (1962, p. 393) mention, S. americana has a striking ornament, is relatively convex and the length of the blunt, tapered glabella is equal to its basal width.

S. americana is abundant through the Idahoia lirae subzone and occurs as high in the Idahoia zone as the transition interval between Drumaspis texana and D. idahoensis.

Occurrence.--Abundant in the Idahoia lirae subzone and rare in the Idahoia zone at B -346.5, 347.5; CR - 743-747; E - 894, 897; EC - 25, 26, 30, 32.5; GR - 173, 180, 183; JR - 169, 177, 189; LL - 725, 728; MC - 706, 707, 712, 718; SK - 233, 245; ST - 531, 536, 541, 572, 574.5, 575, 578; SU - 116; TA - 56; TC - 986, 987, 994; WC - 925, 950, 968.

SARATOGIA FRIA Lochman and Hu

Saratogia fria LOCHMAN AND HU, 1959, p. 422, pl. 59, figs. 1-11; BELL AND ELLINWOOD, 1962, p. 394, pl. 53, figs. 13-21; GRANT, 1965, p. 122, pl. 13, fig. 21.

Remarks.--Saratogia fria is characterized by a frontal area that is slightly less than one-half the length of the glabella (plus occipital ring), faint to absent glabellar furrows, an occipital furrow that may or may not be visible across the axis (depends on the stoutness of the occipital spine), widely divergent anterior facial sutures, and its surface ornament. The preglabellar field is gently convex, slightly downsloping.

Texas specimens assigned to this species are very much like those from Montana assigned to S. fria by Grant (1965, p. 121). However, some specimens from both areas violate some of Grant's criteria for assignment to Saratogia (see Table 2): the glabellar furrows are faint to absent, the occipital furrow may or may not be well impressed, and the anterior facial

sutures may be narrowly or widely divergent. In spite of these discrepancies and variation, S. fria is a compact and distinct species.

S. fria occurs with S. modesta but does not range so high as does the latter. A few specimens of S. americana occurs in the lower half of the range of S. fria.

Occurrence.--Abundant in the middle of the Idahoia zone at B - 364.5, 377.5; CO - 176, 184, 193; E - 916, 932, 934, 935; EC - 35, 36; GM - 604; GR - 180, 183; JR - 188, 189, 195.5, 196, 200; LL - 725, 728; MC - 718, 721; SK - 245, 248, 250.5, 260, 264; SS - 101, 109, 111, 111.5; ST - 536; SU - 116; TC - 1003, 1009, 1017; WC - 950, 968, 977.

SARATOGIA MODESTA (Lochman and Hu)

Idahoia (Meeria) modesta LOCHMAN AND HU, 1959, p. 420, pl. 59, figs. 33-45.

Saratogia modesta (Lochman and Hu) BELL AND ELLINWOOD, 1962, p. 394, pl. 54, figs. 6-8.

Meeria modesta Lochman and Hu, GRANT, 1965, p. 121 (in discussion of Saratogia).

Remarks.--Saratogia modesta is characterized by a frontal area that is about one-third the length of the glabella (plus occipital ring), its broadly rounded and normally unfurrowed glabella, its very wide, shallow, and uninterrupted occipital furrow, its smoothly curved and narrowly divergent

anterior facial sutures, gently convex and downsloping preglabellar field and horizontal to gently upsloping anterior border. The occipital ring normally has a very low node. Palpebral furrows are not evident on exoskeletons, faint on internal molds.

The only ornament observed on the exoskeleton was a set of low transverse irregular ridges on the occipital ring. A few internal molds have longitudinal caecal venations on the preglabellar field and rare low granules in the anterior border furrow.

Grant (1965, p. 121) creates confusion by his unique reference, without discussion, to Saratogia (Meeria) lirae Frederickson and S. (M.) modesta Lochman and Hu. I can understand that confusion would arise from placing these two species in the same genus. According to Grant's criteria, that genus could be neither Idahoia nor Saratogia. However, the confusion can be resolved by putting Idahoia (Meeria) modesta Lochman and Hu, with a frontal area less than one-half the length of the glabella (plus occipital ring), in the genus Saratogia; and by putting Meeria lirae Frederickson, with a frontal area longer than one-half the length of the glabella (plus occipital ring), into the genus Idahoia.

With the exception of its having very faint to absent glabellar furrows, S. modesta conforms well with Grant's criteria for the genus (see Table 2).

S. modesta occurs with and above S. fria. Their lowest occurrences are approximately 12 feet above the base of the Saratogia zone, and S. modesta extends up into the lower part of the range of Ellipsocephaloides silvestris.

Occurrence.--Common to locally abundant in the middle and upper Idahoia zone at B - 377.5; CO - 176, 184, 202; E - 917, 923, 932; GM - 606, 615; GR - 195; JR - 188, 189, 200; LL - 738, 741; MC - 721; SK - 248, 250.5, 264, 265; SS - 109, 116, 119, 120; TC - 1009, 1017, 1025; WC - 968. Rare at the base of the Ellipsocephaloides zone at GR - 204, 210; LL - 750.

Genus STIGMACEPHALOIDES Ellinwood in
Bell and Ellinwood, 1962

Stigmacephaloides Ellinwood in BELL AND ELLINWOOD, 1962, p. 401.

Type species.--Stigmacephaloides curvabilis Ellinwood in BELL AND ELLINWOOD, 1962, p. 401, pl. 56, figs. 2-5.

Remarks.--The characteristics of this monotypic genus are well described in Bell and Ellinwood (1962, p. 401).

STIGMACEPHALOIDES CURVABILIS Ellinwood

Stigmacephaloides curvabilis Ellinwood in BELL AND ELLINWOOD, 1962, p. 401, pl. 56, figs. 2-5; GRANT, 1965, p. 135, pl. 14, fig. 21.

Remarks: This species is well described and illustrated by Bell and Ellinwood (1962). It is distinguished from species of Stigmacephalus by convexity of the anterior end of the cranidium, general smoothness of features, and shallow furrows.

Exoskeleton is without ornament. Internal molds may have longitudinal caecal venations across the anterior fixigenae and preglabellar field. One internal mold has a short row of low granules in its anterior border furrow adjacent to the axial line. A very low occipital node can be seen on internal molds.

Bell and Ellinwood (1962, p. 401) suggest that Stigmacephalus may be ancestral to Stigmacephaloides. A second possible ancestor could be Saratogia; greater cranidial convexity and shallower furrows distinguish Stigmacephaloides curvabilis from stratigraphically lower Saratogia modesta.

Occurrence.---Rare but locally common in the lower Ellipsocephaloides zone at TC - 1085-1090, 1093, 1095-1100, 1100, 1100-1105; WC - 1060-1075, 1069.

Genus TAENICEPHALUS Ulrich and Resser in Walcott, 1924

Taenicephalus Ulrich and Resser in WALCOTT, 1924b, p. 59; 1925, p. 116; BERG, 1953, p. 565; Lochman in HARRINGTON, et al., 1959, p. 0274; GRANT, 1965, p. 136.

Type species.--Conocephalites shumardi HALL, 1863, p. 154, pl. 7, figs. 1, 2; pl. 8, fig. 32.

Remarks.--The diagnosis given by Lochman (in Harrington, et al., 1959, p. 0274) and the description given by Berg (1953, p. 565) adequately describe the genus, with the exception of one point; the eyes are opposite the anterior half of the glabella, not just the anterior third.

TAENICEPHALUS GOULDI (Frederickson)

Bemaspis gouldi FREDERICKSON, 1949, p. 357, pl. 71, figs. 11-14.

Taenicephalus gouldi (Frederickson) BELL AND ELLINWOOD, 1962, p. 401, pl. 57, figs. 1-9; GRANT, 1965, p. 137, pl. 12, figs. 1, 2.

Remarks.--The cranidium of Taenicephalus gouldi is wider across the palpebral lobes than it is long, lacks fossulae, and usually lacks an occipital node. The exoskeleton may be covered with granules, and a coarse longitudinally oriented vermiform ridge-pattern may cross the preglabellar field. The vermiform ridge-pattern is usually preserved on internal molds, and the granular ornament may be preserved;

some internal molds are smooth.

T. gouldi occurs in the lower Taenicephalus zone, normally just above the Parabolinoides subzone. In the 12 measured sections from which it has been recovered, T. gouldi commonly has a maximum range of two feet, but it may extend two feet more. T. gouldi is separated from T. shumardi by a minimum of four feet of section.

A few specimens of Parabolinoides granulosus look quite similar to Taenicephalus gouldi, and seem to indicate an ancestor-descent relationship between the two species, and hence the two genera.

Occurrence.---Common in the lower Taenicephalus zone at B - 315.5, 316; CO - 129; GM - 551, 555(?); GR - 120, 124(?); JR - 125, 126, 126.3, 127; LL - 676; PK - 886; SK - 202, 204; SS - 50, 54; ST - 484(?); TC - 939; TR - 296, 297.5.

TAENICEPHALUS SHUMARDI (Hall)

Conocephalites shumardi HALL, 1863, p. 154, pl. 7, figs. 1, 2; pl. 8, fig. 32.

Taenicephalus shumardi (Hall) WALCOTT, 1924b, p. 59, pl. 13, fig. 1; BELL AND ELLINWOOD, 1962, p. 402, pl. 57, figs. 10-21 (synonymy to date); GRANT, 1965, p. 137, pl. 12, figs. 21, 22, 25, 26 (synonymy to date).

Remarks.--Taenicephalus shumardi is very common

throughout most of the Taenicephalus zone in central Texas. It is characterized by its cranidial length being greater than its palpebral width, and by the glabella being broader at its base than it is long. Grant (1965, p. 137) suggests as a third diagnostic character that the preglabellar field is at least as long as the anterior border. This character does not always prevail in my specimens. Seventy-five of the nearly 500 specimens of T. shumardi have borders that are longer than the preglabellar fields (see Bell and Ellinwood, 1962, pl. 57, fig. 18); in all other respects these specimens are assignable only to T. shumardi. Although on some specimens the difference in relative length of the border may have resulted from compaction, there are numerous specimens on which the distinctly longer border is not a product of flattening of the border or curling of the preglabellar field.

In addition to the puckered anterior border furrow mentioned by Bell and Ellinwood (1962, p. 402), internal molds can preserve the vermiform ridge-pattern on the preglabellar field, or this field can bear scattered pits.

T. shumardi ranges from a minimum of eight feet above the Eoorthis bed up to the top of the Taenicephalus zone.

Occurrence.---Common to locally abundant in the Taenicephalus zone at B - 323, 328.5, 330; CO - 136, 143; CR - 711; E - 857, 860, 861, 864, 866; EC - 1, 3.5, 6, 7, 9, 14;

GM - 559, 568, 572, 573, 575; GR - 126, 127, 131, 133, 137, 144, 148; JR - 131, 132, 136, 156, 169; LL - 682, 682.5, 686, 691, 693, 700; MC - 671, 673, 678, 678.5, 682, 685; PK - 895; SK - 210, 213, 215; SS - 58, 60, 60.5, 62, 67, 68, 69, 72, 83; ST - 494, 511, 514, 520; SU - 66; TA - 10, 12, 14, 34, 40, 42; TC - 944.5, 946, 948, 952, 975, 982; TR - 302.5, 304.5, 309.5, 312, 314.5, 319, 324; WC - 898, 901.5, 910, 913.5.

TAENICEPHALUS sp. BELL AND ELLINWOOD

Pl. 2, Figs. 1, 2.

Taenicephalus sp. BELL AND ELLINWOOD, 1962, p. 402, pl. 56, figs. 19-21.

Remarks.--I agree with Bell and Ellinwood that the systematic position of this taxon not be solidified until more data are available from the upper Taenicephalus zone. The more than seventy-five cranidia assigned to Taenicephalus sp. all have large, elevated and well-defined palpebral lobes, a preglabellar field-anterior border ratio between 2:1 and 1:4, and taenicephalid ornament. Most specimens have an occipital node. Seven specimens have a very short preglabellar field and a thick, yet laterally tapering anterior border that is medially expanded on both anterior and posterior edges, giving the border a diamond shape (pl. 2, fig. 2).

Fossulae, a short frontal area, and depth of furrows will distinguish this species from species of Idahoia.

Elevated palpebral lobes and the highly convex but very slightly downsloping preglabellar field will distinguish Taenicephalus sp. from species of Saratogia. In one collection (JR - 169) Taenicephalus sp. and Saratogia americana do occur together and are very difficult to separate. This mixture may represent the transition from Taenicephalus sp. to S. americana. Detailed collecting from this part of the section would be most helpful.

Taenicephalus sp. occurs through a maximum interval of seven feet, with or just above the range of T. shumardi.

Occurrence.--Rare to locally common at the top of the Taenicephalus zone at CO - 143; CR - 730; E - 875; EC - 14; GM - 572, 575; JR - 169; MC - 685, 689; SK - 220; SS - 76, 84, 90; TA - 35; TC - 975, 982; TR - 333.5, 337; WC - 912, 917.

Genus WILBERNIA Walcott, 1924

Wilbernia WALCOTT, 1924b, p. 60; 1925, p. 123; Lochman in HARRINGTON, et al., 1959, p. 0252.

Type species.--Ptychoparia pero WALCOTT, 1890, p. 274; pl. 12, fig. 6.

Remarks.--The characteristics of this genus are summarized by Lochman (in Harrington, et al., 1959, p. 0252).

Because the palpebral lobes are posteriorly located and the fixigenae are not very wide, the eye ridges are angled back rather sharply.

WILBERNIA DIADEMATA (Hall)

Conocephalites diadematus HALL, 1863 (part), p. 167, pl. 7, fig. 36; pl. 8, fig. 21.

Wilbernia diademata (Hall) RESSER, 1937, p. 28; NELSON, 1951, p. 782, pl. 109, figs. 8, 11, 12; BELL AND ELLINWOOD, 1962, p. 395, pl. 54, figs. 9, 10; GRANT, 1965, p. 123, pl. 13, fig. 27.

Remarks.--Wilbernia diademata is distinguished by its gently convex anterior border that is about twice the length (sag.) of the preglabellar field, its parallel-sided to gently tapered glabella that can be broadly rounded or truncated, and generally by its large size. There are a few specimens in the collections that seem to be intermediate between W. diademata and W. pero.

Exoskeleton smooth except for terrace lines on posterior half of occipital ring. Internal molds have a row of granules in the anterior border furrow. Occipital node may be present.

W. diademata is restricted to the lowest six feet of the Idahoia zone, in association with Idahoia lirae.

Occurrence.--Common to locally abundant in the Idahoia

lirae subzone at B - 346.5; CR - 743-747; E - 894, 897; EC - 20.5, 21.5; GM - 590; GR - 168, 171; JR - 172, 173, 178; MC - 706, 707; PK - 922; SK - 232, 233; SS - 94.5; ST - 528; SU - 116; TC - 983, 987.

WILBERNIA EXPANSA Frederickson

Wilbernia expansa FREDERICKSON, 1949, p. 362, pl. 72, figs. 13-16; BELL, FENIAK, AND KURTZ, 1952, p. 187, pl. 32, figs. 3a-c; BELL AND ELLINWOOD, 1962, p. 395, pl. 54, figs. 11, 12; GRANT, 1965, p. 123, pl. 14, fig. 5.

Wilbernia halli Resser, var. A, NELSON, 1951, p. 777, pl. 107, figs. 9, 16.

Remarks.--This species is characterized by its concave frontal area, particularly the anterior border, and by its very short (sag.) preglabellar field. Preglabellar field-anterior border ratio is between 1:4 and 1:7.

Surface of exoskeleton smooth. Internal molds can preserve longitudinal caecal venations on the anterior fixigenae and anterior border. Many molds preserve a row of granules in the anterior border furrow; these granules or low irregularities may be evident on the exoskeleton. A small occipital node can be present.

Wilbernia expansa occurs with the other three species of Wilbernia: W. halli, in the Taenicephalus zone and W. diademata and W. pero in the Idahoia zone.

Occurrence.--Rare to common in the Taenicephalus zone at CO - 143; EC - 1, 9, 14.5; LL - 686; MC - 685; SS - 83, 84; ST - 511, 520; TA - 40; TC - 952; TR - 314; WC - 913.5, 917. Rare but locally common in the Idahoia zone at E - 897, 920, 923, 932; EC - 20.5, 21.5, 25, 26, 30; GM - 591; GR - 171, 188, 195; MC - 706, 721; SK - 233, 266; SS - 92.5, 94.5, 116, 119, 120; ST - 572, 578; TR - 344.5.

WILBERNIA HALLI Resser

Conocephalites diadematus HALL, 1863 (part), p. 167, pl. 7, figs. 37, 38.

Wilbernia halli RESSER, 1937, p. 28; NELSON, 1951, p. 777, pl. 107, figs. 17, 19; BELL, FENIAK, AND KURTZ, 1952, p. 188, pl. 32, figs. 5a, b; BELL AND ELLINWOOD, 1962, p. 395, pl. 54, figs. 13-18.

Remarks.--Wilbernia halli is characterized by a preglabellar field-anterior border ratio between 2:1 and 1:2, a tapering glabella, a convex preglabellar field and a nearly flat anterior border. It is rare to locally common in the lower half of the Taenicephalus zone through a maximum interval of about 20 feet. Ellinwood's informal variety occupies the lower one-third of the species range.

Ornament on the exoskeleton consists of granules and a few low vermiform ridges over all areas behind the preglabellar field, a longitudinally directed system of ridges on the preglabellar field and a smooth anterior border. Internal

molds usually preserve the ridge pattern on the preglabellar field, a row of granules in the anterior border furrow, and the occipital ring can be pitted.

Occurrence.--Rare to locally common in the lower half of the Taenicephalus zone at B - 317, 323; CO - 131; CR - 711; E - 852, 855; GR - 144; JR - 131; LL - 676, 680.5, 682; MC - 665, 667, 668, 671, 673; PK - 888; SK - 204, 206, 210; SS - 55, 60, 60.5, 62, 67, 68, 69; ST - 481; SU - 60, 61; TA - 12; TC - 944.5, 946, 948; TR - 296, 300.5, 301.5, 302.5; WC - 898.

WILBERNIA HALLI Resser, var. A, Ellinwood

Wilbernia halli Resser, var. A, Ellinwood in BELL AND ELLINWOOD, 1962, p. 395, pl. 54, figs. 16-18.

not Wilbernia halli Resser, var. A, NELSON, 1951, p. 777, pl. 107, figs. 9, 16 (= Wilbernia expansa Frederickson).

Remarks.--This variety is characterized by a preglabellar field-anterior border ratio from 2:1 (at the base of the range of the variety) up to but not including 1:1 (at the top of the range of the variety). Wilbernia halli var. A occurs stratigraphically below W. halli (s.s.).

Occurrence.--Locally common in the lower part of the Taenicephalus zone at B - 317; CO - 131; CR - 711; E - 852, 855; GR - 144; JR - 131; LL - 676, 680.5, 682; MC - 665, 667, 668; PK - 888; SK - 204, 206, 210; SS - 55, 60; ST - 481;

SU - 60, 61; TA - 12; TR - 296, 300.5, 301.5, 302.5.

WILBERNIA PERO (Walcott)

Conocephalites diadematus HALL, 1863 (part), pl. 8, fig. 18.

Ptychoparia pero WALCOTT, 1890, p. 274, pl. 21, fig. 6.

Wilbernia pero (Walcott) WALCOTT, 1924b, p. 60, pl. 13, fig. 4; BELL AND ELLINWOOD, 1962, p. 396, pl. 54, figs. 19-21 (synonymy to date); GRANT, 1962, p. 989, pl. 139, figs. 8a-c; 1965, p. 124, pl. 14, fig. 6.

Remarks.--Wilbernia pero is characterized by a raised and convex anterior border that is more than twice the length (sag.) of the preglabellar field and by a parallel-sided, gently convex glabella. The convex anterior border distinguishes this species from W. expansa; the relatively longer and raised anterior border distinguishes W. pero from the stratigraphically lower W. diademata.

Ornament on the exoskeleton consists entirely of fine terrace lines that are transverse on the posterior half of the occipital ring; they are longitudinally directed across the posterior border, posterior and palpebral areas of fixigenae and then swirl around and become transverse on the anterior border. Ornament on the glabella unknown because of poor preservation. A row of granules in the anterior border furrow and vague impressions of the terrace lines on the anterior border are the only ornament on the internal mold. A very low

occipital node usually present.

Occurrence.--Common to locally abundant in the Idahoia zone at B - 364.5; CO - 193; E - 917; EC - 25, 26, 29, 30, 35; GR - 183; JR - 188, 189, 195.5, 200; LL - 725, 728; MC - 721; SK - 245, 260, 266; SS - 109, 111.5; ST - 574.5; TC - 1009, 1022; WC - 977. Rare in the Ellipsocephaloides zone at JR - 232, 233, 255; MC - 764.

Family PTYCHASPIDIDAE Raymond, 1924

Diagnosis.--Isopygous ptychoparioid trilobites, with prominent, well-defined glabella that exhibits considerable variation in shape, convexity, and furrows; cranidial margins extremely variable when the family is considered as a whole, but relatively consistent within the subfamilies. Pygidium with prominent axis, with numerous axial rings and pleurae, may or may not have marginal spines.

Remarks.--In addition to being the dominant family in the Ptychaspid biomere, the Ptychaspididae is the only family represented throughout the biomere. Four subfamilies are recognized within the family; the Drumaspidinae, Eurekaia, and Saukiinae represent major offshoots from the main Ptychaspidinae line.

By virtue of similarities in glabellar shape,

convexity, and furrowing, a reduced and pointed frontal area, and narrow fixigenae, the Drumaspidinae are probably derived from Conaspis through Drumaspis. By virtue of similarities in glabellar shape and furrows accompanied by general flattening of the cranidium, the Saukiinae are derived from Ptychaspis through Prosaukia. Less clearly, the cranidial similarities (exclusive of the frontal area) between Maladia and Conaspis lead me to think that Maladia is the intermediate form between Conaspis and the Eurekiinae.

DRUMASPIDINAE Longacre, n. subfam.

Diagnosis.--Ptychaspididae with relatively large, nearly rectangular glabella; frontal area reduced, preglabellar field usually lacking; width of fixigenae up to half basal glabellar width. Pygidium with prominent axis, pleural region no wider than axis.

Remarks.--Three genera assigned to two closely related families in the Treatise are combined here into one subfamily, which probably is descended from Conaspis. Because of specimens intermediate between Drumaspis and Dartonaspis, I think that the one gave rise to the other. Chariocephalus could also have been derived from Drumaspis.

Palmer (1965b) revised the family Elvinidae, and included in it genera representative of the Pterocephaliid biomere.

The revision left Chariocephalus and Drumaspis without a definite familial assignment. Bell and Ellinwood (1962) placed Chariocephalus in the Komaspididae, the family to which Dartonaspis is assigned in the Treatise. Komaspis, the Komaspididae, and the Komaspidacea are in dire need of massive revision (Palmer, personal communication). No name was available in the literature that would be suitable for the lineage that I think is represented by the three Franconian genera Drumaspis, Chariocephalus and Dartonaspis. Because Drumaspis is the earliest of the three to occur in the Ptychaspid biome, and because I think it gave rise to the other two genera, the subfamily is appropriately named after Drumaspis.

Genus CHARIOCEPHALUS Hall, 1863

Chariocephalus HALL, 1863, p. 175; RESSER, 1942b, p. 4; Lochman in HARRINGTON, et al., 1959, p. 0297.

Type species.--Chariocephalus whitfieldi HALL, 1863, p. 175, pl. 6, figs. 49-51; pl. 10, fig. 20.

Remarks.--The diagnosis given by Lochman (in Harrington, et al., 1959, p. 0297) adequately describes the genus. If you agree that Resser (1942b, p. 4-13) included in Chariocephalus one or more species that belong to Dartonaspis (e.g., C. wichitaensis Resser, 1942b, p. 10, pl. 2, figs. 1-8), his diagnosis for Chariocephalus should not be followed.

CHARIOCEPHALUS WHITFIELDI Hall

Chariocephalus whitfieldi HALL, 1863, p. 175, pl. 6, figs. 49-51; pl. 10, fig. 20; BELL, FENIAK, AND KURTZ, 1952, p. 188, pl. 37, figs. 4a-d; BELL AND ELLINWOOD, 1962, p. 396, pl. 55, figs. 7, 8; GRANT, 1962, p. 983, pl. 139, fig. 4.

Remarks.--This species is characterized by an anteriorly tapered glabella with faint furrows, fossulae, palpebral lobes up to one-half the length of the glabella, and situated opposite the anterior half of the glabella. Chariocephalus whitfieldi is distinguished from the closely related Dartonaspis by its shorter (exsag.), narrower and more anteriorly located palpebral areas of the fixigenae and by its slightly tapered glabella. Although biostratigraphic data are sparse, the range of C. whitfieldi overlaps with at least the lower part of the range of D. wichitaensis.

Occurrence.--Rare in the Ellipsocephaloides zone at EC - 67; JR - 225, 245, 251; MC - 844; TA - 164; TC - 1109.

Genus DARTONASPIS Miller, 1936

Dartonaspis MILLER, 1936, p. 29; Lochman in HARRINGTON, et al., 1959, p. 0295.

Type species.--Dartonaspis knighti MILLER, 1936, p. 29, pl. 8, figs. 34, 35.

Remarks.--The diagnosis given by Lochman (in Harrington, et al., 1959, p. 0295) summarizes the characters of the genus, with the exception that the American species in the genus all have glabellas that expand anteriorly.

DARTONASPIS WICHITAENSIS (Resser)

Pl. 2, Fig. 11

Chariocephalus wichitaensis RESSER, 1942b, p. 10, pl. 2, figs. 1-8.

Dartonaspsis wichitaensis (Resser) BELL AND ELLINWOOD, 1962, p. 397, pl. 55, fig. 6.

Remarks.--Eight fragmentary cranidia and two pygidia are assigned to this species. Dartonaspsis wichitaensis is characterized by its anteriorly expanded glabella, the inflated palpebral areas of the fixigenae, short (exsag.) posteriorly-directed limbs, and finely pitted exoskeleton and internal molds. These features distinguish D. wichitaensis from its stratigraphically associated close relative, Chariocephalus whitfieldi.

In addition to placing Dartonaspsis in synonymy with Chariocephalus, Resser (1942b) named 14 new species of Chariocephalus, 11 from Oklahoma and three from western Canada. It appears that at least all of the Oklahoma "species" are conspecific. Size, intraspecific variation, nature of preservation and external versus internal surfaces of the test could

easily account for the slight variability in width of fixigenae and depth of furrows that separate Resser's Oklahoma species. Stitt (1968) has sufficient material from the Arbuckle Mountains to have a basis for synonymizing all of Resser's Oklahoma species.

Occurrence.--Rare in the Ellipsocephaloides zone at JR - 255, 265; MC - 840, 844.

Genus DRUMASPIS Resser, 1942

Drumaspis RESSER, 1942b, p. 28; BELL AND ELLINWOOD, 1962, p. 390; GRANT, 1962, p. 983; 1965, p. 114.

Type species.--Drumaspis walcotti RESSER, 1942b, p. 28, pl. 4, figs. 37-41.

Diagnosis.--Glabella quadrate to slightly elongate, parallel-sided to slightly tapering, gently rounded to strongly truncated anteriorly. Two to four sets of glabellar furrows that may or may not connect. Frontal area short. Palpebral and posterior fixigenae wide, downsloping. Long palpebral lobes with distinct palpebral furrow.

Remarks.--Species of Drumaspis can be separated into two morphologic groups: one, with disconnected glabellar furrows, and a second in which at least the posterior pair of glabellar furrows are continuous. Biostratigraphic data from

Texas (Bell and Ellinwood, 1962), Minnesota (Grant, 1962), Montana and Wyoming (Grant, 1965) and Oklahoma (Stitt, 1968) demonstrate that the set with disconnected furrows is stratigraphically below the set with connected glabellar furrows, and there is an overlap or transition zone between the two. This biostratigraphic information coupled with the comparison of the Texas cranidia with Resser's and Grant's illustrations indicate that Drumaspis was represented by two moderately variable species that succeeded one another in time. What I have done with the species of Drumaspis does not solve the problem but does suggest a solution. I heartily agree with Bell and Ellinwood that an intensive study of material with good biostratigraphic control from all areas is very much in order.

Three described species are included in Drumaspis: D. walcotti Resser, (1942b), D. texana Resser, (1942b), and D. idahoensis Resser, (1942b).

D. walcotti, the type species, seems to be of mixed morphologic character; the holotype (Resser, 1942b, pl. 4, figs. 37-39) has disconnected glabellar furrows, whereas the paratype (pl. 4, figs. 40, 41) has one set of connected furrows. As Grant (1962, p. 984) mentioned, the paratype is smooth whereas the holotype has an ornamented occipital ring and border. Lochman and Hu (1959, p. 416, pl. 60, figs. 1-14) discuss and illustrate specimens of D. walcotti from near the

type locality in Idaho. Their illustrated specimens include both morphologic forms. Grant (1962, p. 984; 1965, p. 115) has found the two forms associated at about the midpoint of the range of Drumaspis, and he thinks they may not be conspecific.

When compared with the Texas cranidia, the holotype of D. walcotti can be included in D. texana and the paratype can be included in D. idahoensis from low in the range of that species. If subsequent investigation of the genus indicates that Drumaspis is composed of only two geographically widespread chronospecies that are distinguished by means of disconnected-connected glabellar furrows, the lower species would include the holotype of D. walcotti and would bear that name; the paratype would be included in the stratigraphically higher species with connected glabellar furrows, and because of page priority, and the action by Palmer (1968, p. B85), the appropriate name would be D. idahoensis.

DRUMASPIS IDAHOENSIS Resser

Pl. 2, Figs. 8-10.

Drumaspis idahoensis RESSER, 1942b, p. 29, pl. 4, figs. 32-36;
GRANT, 1965, p. 115, pl. 14, fig. 11; PALMER, 1968, p. 385, pl. 13, figs. 1-5.

Drumaspis alberta RESSER, 1942b, p. 29, pl. 5, figs. 1-3.

Drumaspis goodsirensis RESSER, 1942b, p. 30, pl. 5, fig. 9.

Drumaspis sabinensis RESSER, 1942b, p. 31, pl. 5, figs. 10, 11.

Drumaspis deckeri RESSER, 1942b, p. 31, pl. 5, figs. 14-16;
BELL AND ELLINWOOD, 1962, p. 391, pl. 52, figs. 10-12, 15.

Drumaspis utahensis RESSER, 1942b, p. 34, pl. 5, figs. 31-33.

Drumaspis tanycodia GRANT, 1962, p. 985, pl. 139, fig. 7.

Remarks.--Drumaspis idahoensis is distinguished by its connected posterior pair of glabellar furrows. Although the connection is faint on specimens from low in the range, it is quite distinct in stratigraphically higher specimens. The glabella is quadrate to almost equidimensional, and can be slightly tapered. Width of fixigenae at the base of the palpebral lobes ranges from one-quarter to one-third the basal glabellar width on specimens from the transition zone and low in the range of the species; in stratigraphically higher specimens, the fixigenae are at least one-third as wide as the base of the glabella. Low in the range, the exoskeleton and particularly the occipital ring may be covered with a subtle ridge-and-pit pattern of ornament; internal molds and exoskeletons of specimens from high in the range are smooth.

I am following Palmer (1968, p. B85) in synonymizing D. deckeri with D. idahoensis.

D. idahoensis is common in the upper Idahoia and rare in the middle part of the Ellipsocephaloides zone. It occurs above D. texana and is distinguished from it by the connected

glabellar furrows. In the transition zone or overlap interval, specimens of D. idahoensis can have some features normally associated with D. texana: ornament, narrower fixigenae, slightly longer frontal area and tapered glabella.

A few fragmentary specimens from the middle of the fossiliferous part of the Ellipsocephaloides zone appear to straddle the gap between Drumaspis and Dartonaspis. Two of these specimens are illustrated (pl. 2, figs. 9, 10).

Occurrence.--Common in the Idahoia zone at CO - 193, 202, 219; E - 930, 932, 934, 935; GM - 615; GR - 195; JR - 195, 195.5, 196, 200, 202, 204; LL - 738, 741, 750; SK - 248, 260, 264, 265, 266; SS - 109, 111, 116, 119, 120, 138.5; TC - 1015-1025, 1017, 1022, 1025; WC - 968, 977. Rare in the Ellipsocephaloides zone at MC - 1095-1100, 1100.

DRUMASPIS TEXANA Resser

Pl. 2, Figs. 6, 7.

Drumaspis texana RESSER, 1942b, p. 32, pl. 5, figs. 27-30;
BELL AND ELLINWOOD, 1962, p. 391, pl. 52, figs. 7-9,
13, 14; GRANT, 1965, p. 114.

Drumaspis osella RESSER, 1942b, p. 32, pl. 5, figs. 17-20.

Drumaspis clara RESSER, 1942b, p. 33, pl. 5, figs. 23-26.

Drumaspis nitida RESSER, 1942b, p. 34, pl. 5, figs. 34, 35.

Drumaspis wichitaensis RESSER, 1942b, p. 33, pl. 5, figs. 21,
22.

Drumaspis briscoensis RESSER, 1942b, p. 30, pl. 5, figs. 4-8;

GRANT, 1965, p. 115, pl. 14, figs. 7-9.

Drumaspis maxwelli RESSER, 1942b, p. 31, pl. 5, figs. 12, 13.

Drumaspis sabulosa GRANT, 1962, p. 984, pl. 139, fig. 6.

Remarks.--Drumaspis texana is distinguished by the discontinuous posterior pair of glabellar furrows. Fixigenae at the base of the palpebral lobes are less than one-third and usually about one-quarter the basal glabellar width. Shape of the glabellar ranges from nearly quadrate to slightly elongate and tapering; anterior end of glabella normally is rounded-truncate but a few specimens have distinctly truncated and medially indented glabellas. Although most specimens have three pair of glabellar furrows, there may be as few as two or as many as four pair of furrows.

Distinct granules or vermiform ridges and granules normally cover all areas of the exoskeleton; although most of the cranidium can be nearly smooth, the occipital ring will be distinctly ornamented. Internal molds can be partially imprinted with exoskeleton ornament, or can have a "roughened" appearance. Ornament becomes less distinct in the upper part of the range.

The holotype of D. texana Resser (1942b, pl. 5, fig. 29) beautifully illustrates the glabellar furrows, relatively narrower fixigenae and granular ornament common to the Texas cranidia. Most of the cranidia in the collections have

glabellas that are not quite so tapered or anteriorly rounded and they have relatively shorter frontal areas (see Bell and Ellinwood, 1962, pl. 52, figs. 7-9).

Within the variation of the Texas cranidia there is room for inclusion of the morphology of the holotypes of all species in the synonymy, even the rather distinctive D. osella with its straight-sided, tapering glabella and longer frontal area.

Occurrence.--Common in the lower half of the Idahoia zone at B - 357.5, 364.5, 377.5; CO - 176, 184; CR - 743-747, 765; E - 904, 916, 917, 920; EC - 36, 38; GM - 604, 606; GR - 180, 183, 185; JR - 188, 189, 195, 196; LL - 725, 728, 738; MC - 712, 714, 718, 721; SK - 245, 248, 260; SS - 109, 111; ST - 541; SU - 116; TC - 1003, 1009, 1017; WC - 950, 968.

Subfamily EUREKIINAE Longacre, n. subfam.

Diagnosis.--Ptychaspididae with tapered, rounded to truncate glabella; frontal area variable; palpebral area generally small, close to the glabella, with distinct palpebral furrow; posterior limbs strap-like. Pygidium with prominent axis, distinct axial rings and pleurae; margin with spines.

Remarks.--The composition of this subfamily is essentially that of the family Eurekiidae of Lochman (in Harrington,

et al., 1959, p. 0325). Because of its probable relation to Conaspis, this group of genera is included in the same family but set off in its own subfamily, the Eurekaiaae.

Genus BAYFIELDIA Clark, 1924

Bayfieldia CLARK, 1924, p. 31; RASETTI, 1944, p. 239; WINSTON AND NICHOLLS, 1967, p. 83.

Type species.--Bayfieldia tumifrons Clark, 1924, p. 31, pl. 4, fig. 6.

Diagnosis.--Eurekaiaae with anteriorly rounded glabella; glabellar furrows, if present, shallow and recurved. Occipital furrow broad, shallow, laterally bifurcating. Fixigenae and palpebral lobes narrow. Posterior limbs long and wide; posterior border furrow shallow and wide. Cranidium smooth or granulose. Pygidial axis elevated, terminal axial piece can be binodose. All furrows on the pygidium deep and wide. At least three pairs of marginal spines are present.

Remarks.--This genus differs from Eurekaia in its bifurcate occipital furrow, shallow or absent glabellar furrows, wider (exsag.) posterior limbs, and nearly flat palpebral areas of the fixigenae. Bayfieldia differs from Corbinia in its bifurcate occipital furrow, anteriorly rounded glabella, and its generally shallower axial, occipital and border

furrows.

Four species are included in Bayfieldia: B. barabuen-
sis (Whitfield), 1878, B. binodosa (Hall), 1863, B. tumifrons
Clark, 1924, and B. simata Winston and Nicholls, 1967. I
agree with Winston and Nicholls that B. ulrichi Rasetti,
1945b, belongs in Corbinia, as does Bayfieldia sp. undet.
Rasetti, 1959.

BAYFIELDIA BINODOSA (Hall)

Pl. 3, Figs. 13, 14.

Conocephalites? binodosus HALL, 1863, p. 160, pl. 7, fig. 47.

Ptychoparia binodosa (Hall) CLARK, 1924, p. 32.

Eurekia binodosa (Hall) WALCOTT, 1925, p. 89; GRANT, 1965, p.
116, pl. 15, figs. 15, 18.

Bayfieldia finkelburgi CLARK, 1924, p. 32, pl. 4, fig. 7.

Eurekia finkelburgi (Clark) RESSER, 1935, p. 28.

Bayfieldia binodosa (Hall) WINSTON AND NICHOLLS, 1967, p. 83,
pl. 9, figs. 1, 2.

Corbinia implumis WINSTON AND NICHOLLS, 1967, p. 86, pl. 9,
fig. 3.

Remarks.--This species is very common in the Saukiella
pyrene and Saukiella junia subzones. Bayfieldia binodosa ex-
hibits a remarkable degree of variation, particularly in the
glabellar furrows, the ornament, and the rounding of the front
of the glabella. Most specimens have anteriorly rounded gla-
bellas, but some are rounded-truncate. Glabellar furrows are

usually absent but a few specimens have one or two pair of faintly impressed, strongly recurved furrows as in Eurekia. Although most specimens are smooth, many are granulate (pl. 5, figs. 13, 14). Because these three variable features exhibit neither correlation with one another nor stratigraphic trend, I attribute them to either intraspecific variation or sexual dimorphism.

Corbinia implumis Winston and Nicholls is represented by one collection (TC - 1290) from the middle of the range of Bayfieldia binodosa in that section. The features mentioned by Winston and Nicholls as diagnostic of Corbinia implumis occur in specimens of Bayfieldia binodosa in varying quantities and qualities. Thus I have placed C. implumis in synonymy with B. binodosa.

The associated pygidium has a high axis, an articulating half-ring, one well-defined axial ring, two axial rings partly fused together, and a binodose terminal axial piece that is fused to the third axial ring. The four or five pairs of marginal spines are pointed.

Bayfieldia binodosa is associated with Eurekia granulosa Walcott, and is distinguished from all species of Eurekia by its weak but usually absent glabellar furrows, a bifurcating occipital furrow, and broad posterior limbs with medium to small posterior fixigenae.

Stitt (1968) has reported that B. binodosa is rare in

the upper part of the Rasettia magna subzone and common through the lower two-thirds of the Saukiella junia subzone.

Occurrence.--Common to locally abundant in the Saukiella pyrene subzone at BC - 23, 34, 36, 41, 42; JR - 357, 369.5, 394; SPH - 93, 95, 96.5, 98, 99, 103, 114, 114.5, 140; SS - 356; TC 1237, 1265, 1286, 1287. Common in the Saukiella junia subzone at BC - 70; JR - 459; TC - 1290, 1291, 1305, 1305-1310.

BAYFIELDIA SIMATA Winston and Nicholls

Pl. 4, Fig. 12.

Bayfieldia simata WINSTON AND NICHOLLS, 1967, p. 84, pl. 9, figs. 20, 23-26.

Remarks.--Although few representatives of this species occur in the Saukiella junia subzone, it is quite abundant in the Saukiella serotina subzone. Bayfieldia simata is characterized by its medially expanded glabella, long and nearly flat frontal area, elongate palpebral lobes and fixigenae, bifurcate occipital furrow, and stout, nearly parallel-sided posterior limbs. The only variable part of the cranidium is the frontal area. There seem to be two types, one in which the facial sutures diverge slightly, and in which a faint, arcuate, anteriorly bowed border furrow is present (Winston and Nicholls, pl. 9, fig. 20); the second type of frontal

area has parallel facial sutures, and the anterior border furrow is bowed backward, terminating laterally at or close to the anterior corners of the cranidium (Winston and Nicholls, pl. 9, fig. 24). Both types occur throughout the range of B. simata, and they could be an expression of sexual dimorphism. The one specimen figured here has the recurved anterior border furrow.

Stitt (1968) recognizes B. simata and its variety in the same stratigraphic position in Oklahoma that Winston and Nicholls reported from central Texas. However, Stitt has found that the lowest occurrence of B. simata (s.s.) is in the upper Saukiella junia subzone, and not in the base of the Saukiella serotina subzone as it is in Texas.

Occurrence.--Rare in the Saukiella junia subzone at BC - 149; CC - 27; LCS - 11, 31; SS - 360.5. Common in the Saukiella serotina subzone at CC - 58.2; JR - 484, 519, 532, 536; LC - 32; LCS - 32, 33, 33.5, 34-36, 35.7, 40, 44, 44.5, 45, 45.4; SH - 52, 52.6, 65.5; SS - 375, 381, 383, 398; TC - 1357-1363, 1368-1374, 1379-1385, 1379-1385a, 1387.5, 1388, 1391.5, 1392, 1393, 1394, 1395, 1400.

BAYFIELDIA SIMATA Winston and Nicholls,
var. A, Winston and Nicholls

Bayfieldia simata Winston and Nicholls, var. A, WINSTON AND NICHOLLS, 1967, p. 84, pl. 9, figs. 24, 26.

Remarks.--This possible link between Bayfieldia bino-
dosa and B. simata is recognized by its pygidium with long
 and bluntly rounded marginal spines, and with two nodes on
 the terminal axial piece. The few cranidia with preserved
 frontal areas are of the type with recurved anterior border
 furrows; an equal number of cranidia do not have the frontal
 area preserved. I hesitate to suggest that all B. simata var.
 A have this type of frontal area until more material is col-
 lected.

Stitt (1968) reports finding the binodose tail of B.
simata var. A in the middle of the Saukiella junia subzone in
 Oklahoma. The cranidia associated with those tails do not
 differ from the cranidia he assigned to B. simata, a parallel
 to the situation in central Texas. Stitt also found that the
 pygidium of B. simata without nodes occurs in the upper part
 of the Saukiella junia subzone; in central Texas, B. simata
 occurs only in the Saukiella serotina subzone.

Occurrence.--Locally common in the Saukiella junia
 subzone at BC - 109-110; JR - 481; SH - 12.6; SS - 356.

Genus CORBINIA Walcott, 1924

Corbinia WALCOTT, 1924b, p. 55; 1925, p. 81; Lochman in HAR-
 RINGTON, et al., 1959, p. 0325; WINSTON AND NICHOLLS,
 1967, p. 85.

Type species.--Corbinia horatio WALCOTT, 1924b, p. 55, pl. 10, fig. 5.

Remarks.--Winston and Nicholls (1967, p. 85) give the most comprehensive diagnosis for Corbinia.

CORBINIA APOPSIS Winston and Nicholls

Corbinia apopsis WINSTON AND NICHOLLS, 1967, p. 86, pl. 11, figs. 13, 14, 17, 22.

Remarks.--This is the most abundant species in the Corbinia apopsis subzone, where it occurs in coquinoid profusion through as much as eight feet of section. An addition to Winston and Nicholls' excellent description is that the pygidial exoskeleton is covered with granules, and the margin ornamented with coarse terrace lines that zig-zag in and out of the marginal spines.

Stitt (1968) reports that at the very top of the Saukia zone in Oklahoma is a fauna, comparable to the one in central Texas, that is also dominated by Corbinia apopsis. Noticeably absent from the Oklahoma fauna are the Catillicephaliid genera Acheilops, Theodenisia and Triarthropsis.

Occurrence.--Very abundant in the Corbinia apopsis subzone at CC - 67, 69.5; JR - 538, 539, 539.5, 540, 542, 543, 545; LC - 48; LCS - 53, 53.3, 53.5, 53.8, 55, 55.5, 56; SH -

72; SS - 411, 413, 416; TC - 1402, 1409.

Genus EUREKIA Walcott, 1924

Eurekia WALCOTT, 1924b, p. 56; 1925, p. 89; RESSER, 1935, p. 28; Lochman in HARRINGTON, et al., 1959, p. 0325; WINSTON AND NICHOLLS, 1967, p. 84.

Type species.--Eurekia granulosa WALCOTT, 1924b, p. 56, pl. 12, fig. 1.

Remarks.--Winston and Nicholls (1967) give the most complete diagnosis for this genus.

EUREKIA EOS (Hall)

Pl. 4, Fig. 15.

Conocephalites eos HALL, 1863, p. 151, pl. 7, figs. 24, 25; pl. 8, figs. 8, 9.

Eurekia eos (Hall) WALCOTT, 1925, p. 89 (list); RESSER, 1935, p. 28 (list); WINSTON AND NICHOLLS, 1967, p. 85, pl. 10, figs. 15, 17.

Remarks.--Eurekia eos has been well described and illustrated by previous workers. I am repeating the discussion of the species in central Texas because more concrete range data are available.

Eurekia eos is quite abundant in the Saukiella serotina subzone, with few specimens in the underlying and overlying subzones. Although the one pygidium from the Saukiella

junia subzone (TC - 1346) listed by Winston and Nicholls is poor, two cranidia from TC - 1352-1357 occur in the S. junia subzone. In addition, the holotype of S. junia (Walcott), a S. junia var. A in this scheme, has a beautiful specimen of Eurekia eos right next to it. No E. eos was identified below the upper part of the S. junia subzone. Only one collection of E. eos occurs in the base of the Corbinia apopsis subzone.

Further preparation and examination of stratigraphically lower specimens assigned by Winston and Nicholls to E. eos revealed that those from the Saukiella pyrene and lower S. junia subzones belong to E. granulosa Walcott, as do the three specimens assigned to E. sedgwicki (Billings) by Winston and Nicholls.

Pygidia are characterized by the binodose terminal axial piece, rugged appearance, and the unusual configuration of the marginal spines. The four or five pairs of spines look like silhouettes of feet, with the toes pointing toward the axis (pl. 4, fig. 15). Internal molds can be covered with closely spaced pits.

Stitt (1968) records Eurekia eos from the Saukiella junia and S. serotina subzones in Oklahoma. There the associated pygidia are the same rugged-looking, binodose forms with the "footed" spines that occur in central Texas.

Occurrence.--Rare in the Saukiella junia subzone at

TC - 1346-1352, 1352-1357. Common in the Saukiella serotina subzone at BC - 149; CC - 63±; JR - 529, 532; LC - 32; LCS - 32, 35.7, 39, 40, 44; SH - 52, 52.6, 53.5, 54, 55, 65.5; SS - 375, 398, 409; TC - 1357-1363, 1368-1374, 1379-1385, 1391.5, 1392, 1393, 1394, 1395. Rare in the Corbinia apopsis subzone at LCS - 54.

EUREKIA GRANULOSA Walcott

Pl. 3, Figs. 15-17.

Eurekia granulosa WALCOTT, 1924b, p. 57, pl. 12, fig. 1; 1925, p. 90, pl. 16, figs. 13-17; RESSER, 1935, p. 28.

Eurekia sedgwicki (Billings) WINSTON AND NICHOLLS, 1967, p. 85, pl. 10, figs. 12, 16.

Remarks.--Eurekia granulosa, the type species, is characterized by its divergent anterior facial sutures, its recurved border, its moderately tapered and rounded-truncate glabella, its deep, recurved glabellar furrows, the coarse surface granulation, the relatively broad and convex anterior fixigenae, and its narrow eyes, posterior fixigenae and posterior limbs. E. granulosa is distinguished from E. eos by divergent anterior facial sutures, larger anterior fixigenae, and a recurved anterior border. If these features cannot be exposed, the more tapered and not so truncate glabella will distinguish E. granulosa.

E. granulosa is associated with another eurekiid,

Bayfieldia binodosa, from which it is distinguished by its deep, recurved glabellar furrows, its deep, non-bifurcate occipital furrow, its narrow raised palpebral area, and its very slender posterior limbs. There is only one binodose pygidium associated with these two species, and I have concluded that it belongs to E. binodosa. A pygidium with the cropped spines of E. granulosa Walcott (1925, pl. 16, fig. 17) has not been found in central Texas nor in Oklahoma (Stitt, 1968).

E. granulosa ranges through the Saukiella pyrene subzone and one collection comes from the base of the Saukiella junia subzone. The shape of the anterior end of the glabella is the most variable feature, ranging from broadly rounded to truncate (pl. 3, figs. 15-17); most specimens are more or less truncate. I have assigned the specimens identified as E. sedgwicki (Billings) by Winston and Nicholls to E. granulosa. The status of Menocephalus sedgwicki Billings is uncertain because of poor material, but I doubt that it should be placed in Eurekia; the glabellar furrows are like those of Eurekia but the rest of the features are not.

Stitt (1968) has found a comparable range for E. granulosa in Oklahoma.

Occurrence.--Common in the Saukiella pyrene subzone at BC - 23, 41, 42; JR - 354, 374.5; SPH - 91, 94, 95, 96.5,

106.5, 110; TC - 1244, 1287. Rare at the base of the Saukiella junia subzone at TC - 1291.

Subfamily PTYCHASPIDINAE Longacre, n. subfam.

Diagnosis.--Ptychaspididae with prominent, very well-defined, anteriorly rounded glabella that usually tapers or is parallel-sided; anterior lobe of glabella usually swollen in later genera; at least two pairs of distinct glabellar furrows, posterior pair commonly connected, second pair may connect; frontal area variable, preglabellar field commonly absent; fixigenae variable; eye ridges and palpebral lobes commonly distinct. Pygidium with usually well-defined axis that is narrower than pleural region; axial rings and pleural furrows normally distinct; border furrow absent or very shallow, margin smooth.

Remarks.--This is the only subfamily represented throughout the Ptychaspid biomere (fig. 2). I have relied on studies in the Upper Mississippi Valley (Nelson, 1951; Bell, Feniak, and Kurtz, 1952) for demonstrating the lineage from Conaspis through Eoptychaspis to Ptychaspis. Morphologically and temporally, it is logical that Eoptychaspis was a derivative of Ptychaspis. Although I agree with Lochman (1953, p. 892; 1956, p. 451, text-fig. 3; in Harrington, et al., 1959, p. 0322) that Keithia and Keithiella are members of the

Ptychaspididae, I think Ptychaspis is a more reasonable ancestor for them than the east-Asian genus Andersonella. I have followed Lochman (1964a, p. 53) in recognizing Macronoda, and I think it probably represents an offshoot from Euptychaspis.

Genus CONASPIS Hall, 1863

Conaspis HALL, 1863, p. 152; WALCOTT, 1914, p. 357 (footnote); RESSER, 1937, p. 6; BERG, 1953, p. 560; Lochman in HARRINGTON, et al., 1959, p. 320.

Type species.--Conocephalites perseus HALL, 1863, p. 152, pl. 7, fig. 17; pl. 8, fig. 33.

Remarks.--Berg (1953, p. 560) gives the most complete cranidial diagnosis. The only pygidium assigned to Conaspis is the one Hall (1863, p. 153) described and assigned to Conocephalites perseus, but that Berg (1953, p. 562) assigned to Conaspis tumidus. No other pygidium has been reported, described, or illustrated in the literature, the Treatise notwithstanding.

CONASPIS LEPTOHOLCUS Longacre, n. sp.

Pl. 1, Figs. 19-21.

Description.--Cranidium strongly convex longitudinally and transversely. Glabella strongly convex, anteriorly down-sloping, tapered, gently rounded to slightly truncated in

front. Three sets of glabellar furrows: posterior pair well-impressed, recurved and usually not connected; middle set shallow and slightly recurved; anterior set composed of faint, anteriorly-directed depressions that are not connected with the axial furrow. Axial furrow distinct, with subtle fossulae at anterior corners of the glabella. Preglabellar furrow faint to obsolete. Occipital furrow distinct, curved forward medially and laterally. Laterally tapered occipital ring has a very low occipital node. Preglabellar field strongly deflected downward, almost at the same angle as the front of the glabella. Anterior border furrow distinct and broadly curved. Anterior border gently convex, crescentic, slightly longer (sag.) than preglabellar field. Frontal area less than one-quarter cranidial length. Fixigenae narrow, gently convex, with a slight bulge where an ocular ridge would be. Palpebral furrow distinct, complete. Palpebral lobes narrow and elongate. Posterior area of fixigenae triangular. Posterior border furrow broad, shallow and almost straight; posterior border widens laterally. Anterior facial sutures slightly divergent in front of palpebral lobes. Exoskeleton and internal molds smooth.

Librigena and pygidium unknown.

Available material.---8 cranidia, well preserved.

Holotype.---BEG 36479, from B-316.

Etymology.--leptos, Greek, fine, weak, thin; holcos, m., Greek, furrow; named for its weak to nearly obsolete preglabellar furrow.

Remarks.--Conaspis leptoholcus is distinguished from all other species of Conaspis by its weak to almost obsolete preglabellar furrow. Its faint fossulae, subequal preglabellar field and anterior border, and the gently tapered, crescentic anterior border also characterize this species. It is distinguished from the associated C. testudinatus by its smooth surfaces and crescentic border. It differs from the stratigraphically higher C. masonensis by its downsloping frontal area and relatively narrower fixigenae.

C. leptoholcus is distinguished from the holotype of C. perseus (Hall) (Berg, 1953, pl. 60, fig. 5) by its convexity, glabellar shape, and wider fixigenae. It differs from C. parvafrons Kurtz (in Bell, Feniak, and Kurtz, 1952, p. 185, pl. 31, figs. 7a-b) in having a distinct anterior border furrow. The closest resemblance is to C. tumidus Kurtz (in Bell, Feniak, and Kurtz, 1952, p. 185, pl. 31, fig. 5), but C. leptoholcus can be distinguished by its longer frontal area, wider fixigenae, more rounded and tapered glabella, and by its laterally tapered occipital ring.

C. leptoholcus occurs in the lower part of the Taenicephalus zone only on the eastern side of the Llano Uplift.

It ranges through a maximum interval of 10 feet, beginning at the top of the range of Taenicephalus gouldi and extending into the lower part of the range of T. shumardi. C. leptoholcus can be associated with C. testudinatus.

Occurrence.--Rare in the lower Taenicephalus zone at B-316; E - 852; PK - 888; SU - 61; WC - 895.

CONASPIS MASONENSIS Ellinwood

Conaspis masonensis Ellinwood in BELL AND ELLINWOOD, 1962, p. 403, pl. 58, figs. 1-9.

Remarks.--Conaspis masonensis is well described and illustrated by Bell and Ellinwood (1962). Its lowest occurrence is normally about 40 feet above the base of the Taenicephalus zone, and in one section it has a range of 7 feet. C. masonensis occurs in association with Taenicephalus sp. and T. shumardi. It does not occur with Idahoia lirae, although they can be separated by as little as one foot of section.

At JR - 169, C. masonensis, Taenicephalus sp. and T. shumardi occur with Saratogia americana, one of the earliest species of the Saratogia zone; the first occurrence of Idahoia lirae is at JR - 172. The mixture of Saratogia americana with Taenicephalus sp. and other taxa characteristic of the highest Taenicephalus zone may represent the transition

interval between Taenicephalus sp. and S. americana.

Occurrence.--Locally abundant at the top of the Taenicephalus zone at E - 875; JR - 168, 169; SS - 90; TC - 975, 982.

CONASPIS PARVAFRONS Kurtz

Pl. 2, Fig. 3.

Conaspis parvafrons Kurtz in BELL, FENIAK, AND KURTZ, 1952, p. 185, pl. 31, figs. 7a, b; BERG, 1953, p. 561, pl. 60, fig. 9.

Remarks.--One internal mold is assigned to Conaspis parvafrons, a species distinguished from all others assigned to Conaspis by its unfurrowed frontal area. It is also characterized by its rectangular glabella, faint and gently curved palpebral furrows and markedly divergent anterior facial sutures.

The specimen in the Texas collections is slightly different from the holotype; neither the smooth frontal area nor the anterior end of the glabella are quite so convex, the fossulae are absent, all furrows are shallower and the posterior areas of the fixigenae are longer (exsag.). The Texas cranidium closely resembles the paratype and it is almost identical to the cranidium figured by Berg (1953). The differences separating the Texas cranidium from those in the Upper Mississippi River Valley are small. The cranidium has the same

stratigraphic position in Texas a C. parvafrons in Minnesota and Wisconsin. Although this specimen may be a geographic variant, I think it is at least conspecific with C. parvafrons. Additional material is necessary to say more about its subspecific status.

C. parvafrons occurs at the very top of the Conaspis zone in association with C. masonensis and Taenicephalus sp. The base of the Idahoia zone is 2.5 feet above this unique occurrence of C. parvafrons.

Occurrence.--Rare at the top of the Taenicephalus zone at SS - 90.

CONASPIS TESTUDINATUS Ellinwood

Pl. 1, Figs. 17, 18.

Conaspis testudinatus Ellinwood in BELL AND ELLINWOOD, 1962, p. 404, pl. 58, figs. 10-13.

Remarks.--The coarse granular ornament on external surfaces of Conaspis testudinatus is reflected on internal molds as reduced yet distinct pustules. Two partly exfoliated cranidia (pl. 1, figs. 17, 18) illustrate the ornament of the internal mold: the granules on the specimen in fig. 17 are obvious; on the two exposed surfaces visible in fig. 18, low pustules crest the palpebral area of the left fixigena, and distinct granules ornament the anterior end of the

right fixigena. The internal mold figured by Bell and Ellinwood (1962, pl. 58, fig. 13) is in fact granulate. As Bell and Ellinwood (1962, p. 404) state, internal molds do look much like the two cranidia assigned to C. perseus (Hall) by Berg (1953, pl. 60, figs. 6, 7), but they differ somewhat from the holotype of C. perseus (Berg, 1953, pl. 60, fig. 5).

The range of C. testudinatus overlaps that of C. leptoholcus; the former is distinguished by its granular ornament, lesser glabellar convexity, deeper glabellar furrows, almost straight anterior border furrow, and bluntly pointed anterior border. C. testudinatus can occur through a 6 to 8 foot interval from the middle of the range of Taenicephalus gouldi up to the first occurrence of T. shumardi. In one collection (GR - 144) C. testudinatus and Wilbernia halli var. A occur about 20 feet above the range base of T. shumardi; this may represent an extremely late occurrence of these two associates, or it may be a misnumbered collection.

Occurrence.--Rare in the lower Taenicephalus zone at CO - 131; E - 852, 855; GM - 555; GR - 126, 144; JR - 126; LL - 682, 686; PK - 888; SK - 206; TA - 10; TC - 944.5; WC - 895.

Genus EUPTYCHASPIS Ulrich in Bridge, 1931

Euptychaspis Ulrich in BRIDGE, 1931, p. 217; Lochman in HARRINGTON, et al., 1959, p. 0322; WINSTON AND NICHOLLS, 1967, p. 78.

Type species.--Euptychaspis typicalis Ulrich in BRIDGE, 1931, p. 218, pl. 19, figs. 5-7.

Diagnosis.--Glabella parallel-sided up to the generally inflated anterior glabellar lobe; two pairs of usually connected glabellar furrows present, a third pair may be present. Frontal area usually undivided, downsloping. Fixigenae variable in width and topography. Occipital ring expands back into bluntly pointed spine. External surface smooth or ornamented with elongate ridges or vermiform ridges. Librigena and pygidium unknown.

Remarks.--The discussion by Ulrich (in Bridge, 1931, p. 217) and the diagnosis by Lochman (in Harrington, et al., 1959, p. 0322) are based only on the type species and therefore are restricted in their application. Except for the statement that E. typicalis is the stem from which the other species were derived (E. jugalis Winston and Nicholls and E. frontalis n. sp. occur below E. typicalis Ulrich in central Texas), Winston and Nicholls (1967, p. 78) give a good description of differences among the included species.

EUPTYCHASPIS FRONTALIS Longacre, n. sp.

Pl. 3, Figs. 2-5.

Description.--Cranidium bluntly triangular, slightly longer than wide. Glabella elongate, parallel-sided, broadly rounded anteriorly; although some glabellas are rounded across the top, most are flattened. Glabella crossed by two sets of furrows that are deep notches on the side, becoming shallower across the top; if a third set is present, they are shallow, straight creases that do not connect. Axial furrow deep and wide posteriorly, becoming shallower around anterior end of the glabella. Occipital furrow wide, well-impressed; occipital segment tapers back into broad, blunt spine. The most variable feature is the length (sag.) of the preglabellar field: it can be about one-third as long as the glabella, gently sloping down to a thin (sag.), laterally tapering anterior border that is the same width (tr.) as the glabella; the preglabellar field can be absent, with the tapering anterior border separated from the glabella by the confluence of the preglabellar and anterior border furrows; intermediates between these two are common. This variation exhibits no trend or separation with respect to stratigraphic position or size of the cranidia. Anterior fixigenae one-fourth to one-half the width of the glabella. Palpebral lobes very narrow, short, upsloping, with posterior ends opposite second set of

glabellar furrows. Anterior facial sutures diverge slightly in front of palpebral lobes, then broadly sweep adaxially, giving the anterior half of the cranidium an elliptical appearance. Posterior facial sutures strongly divergent behind the palpebral lobes; posterior fixigenae broadly triangular. Posterior border furrow distinct, continuous into the occipital furrow without interruption at the juncture with the axial furrow; likewise, the posterior border continues unbroken into the occipital segment. All glabellas are notched in the front, particularly on internal molds. A strong vermiform ridge and pit pattern covers all areas of the exoskeleton. Internal molds may be smooth or carry a partial imprint of the vermiform pattern; the vermiform pattern may also be translated into pits on the molds, especially on the posterior fixigenae.

Librigena and pygidium unknown.

Available material.--55 cranidia, well preserved.

Holotype.--BEG 36504, from JR - 369.3.

Etymology.--frontalis, named for its unusual frontal area.

Remarks.--This is the stratigraphically lowest species of Euptychaspis in central Texas. E. frontalis is characterized by its parallel-sided, somewhat flattened glabella, its

preglabellar field and anterior border, its broadly triangular posterior fixigenae, and medially constricted cranidial outline. It is not difficult to imagine this species as an ancestral form for both E. typicalis and E. jugalis.

Occurrence.---Common in the Saukiella pyrene subzone at BC - 36, 41, 42; JR - 369.5; SPH - 140; SS - 302.5, 307.5; TC - 1237, 1238.

EUPTYCHASPIS JUGALIS Winston and Nicholls

Pl. 3, Fig. 18.

Euptychaspis jugalis WINSTON AND NICHOLLS, 1967, p. 79, pl. 9, fig. 13.

Remarks.---Winston and Nicholls give a very good description of this species, and I agree with their comments about specimens in the Saukiella junia subzone being intermediate between Euptychaspis jugalis and E. typicalis, and between E. jugalis and E. kirki. However, E. jugalis can be distinguished by its laterally expanded anterior glabellar lobe, the yoked outline of the cranidium, and by its posterior glabellar rings that are flattened across the top.

One fragmental specimen has a rugose vermiform ridge and pit pattern (pl. 3, fig. 18). Almost all glabellas are notched in front, a character common to most Texas specimens assigned to Euptychaspis.

Stitt (1968) has found this species in the upper part of the Saukiella junia subzone and all through the Saukiella serotina subzone.

Occurrence.---Rare in the Saukiella pyrene subzone at JR - 357. Rare in the Saukiella junia subzone at CC - 27; TC - 1303, 1341-1346, 1346-1352. Rare in the Saukiella serotina subzone at LCS - 32.4; TC - 1395.

EUPTYCHASPIS KIRKI Kobayashi

Euptychaspis kirki KOBAYASHI, 1935, p. 56, pl. 10, figs. 4, 5; WINSTON AND NICHOLLS, 1967, p. 79, pl. 9, fig. 18.

Remarks.---This species is well described and illustrated by Kobayashi and by Winston and Nicholls. Euptychaspis kirki is confined to the Saukiella serotina subzone and is associated with E. jugalis, but it is stratigraphically higher than E. frontalis and E. typicalis. The highly expanded and convex anterior glabellar ring that overhangs the narrow frontal area distinguishes E. kirki from all other species of Euptychaspis.

Stitt (1968) reports that E. kirki ranges through the Saukiella serotina subzone in Oklahoma.

Occurrence.---Common to locally abundant in the Saukiella serotina subzone at CC - 58.2, 61, 63±; JR - 521.5, 529,

532, 536; LCS - 32.4, 33, 35.7, 39, 40, 44, 45, 45.4, 45.8, 52-54; SH - 52, 54, 55, 58.5-60, 61.5, 65.5, 71; SS - 398, 409; TC - 1368-1374, 1379-1385, 1388, 1391.5, 1392, 1395, 1400.

EUPTYCHASPIS TYPICALIS Ulrich

Pl. 4, Fig. 9.

Euptychaspis typicalis Ulrich in BRIDGE, 1931, p. 218, pl. 19, figs. 5-7; DAKE AND BRIDGE, 1932, p. 740, pl. 12, fig. 3; RASETTI, 1959, p. 393, pl. 52, figs. 11-13; WINSTON AND NICHOLLS, 1967, p. 78, pl. 9, fig. 17.

Remarks.--Several cranidia in the Texas collections have a short (sag.) smooth, flat anterior border that has not been previously noticed, but that can be seen in Winston and Nicholls' figure (pl. 9, fig. 17). This shelf-like projection is difficult to expose, and none of the specimens have the complete border.

Euptychaspis typicalis is distinguished by its nearly parallel-sided glabella, its wide fixigenae, and by the ornament on the frontal area. Although this ornament is usually a set of separated transverse ridges, a few specimens have a strong vermiform ridge pattern across the frontal area. E. typicalis occurs above E. frontalis, below E. kirki, and is associated with E. jugalis.

Occurrence.--Rare in the Saukiella junia subzone at

BC - 109-110, 149; JR - 479, 481; SH - 12.6; SS - 345±, 356, 372.5; TC - 1301, 1305-1310.

Genus KEITHIA Raymond, 1924

Keithia RAYMOND, 1924, p. 451; Lochman in HARRINGTON, et al., 1959, p. 0322.

Type species.--Keithia schucherti RAYMOND, 1924, p. 452, pl. 14, figs. 5, 9.

Remarks.--The diagnosis given by Lochman (in Harrington, et al., 1959, p. 0322) summarizes the characteristics of this genus, which is closely related to Keithiella (see Rasetti, 1945b, p. 468, in discussion of Keithia connexa).

KEITHIA cf. K. CONNEXA Rasetti

Pl. 2, Figs. 20, 21.

Keithia connexa RASETTI, 1945b, p. 468, pl. 61, figs. 3-5.

Remarks.--Keithia connexa is characterized by its tumid, cylindrical glabella that drops steeply down to the preglabellar furrow, one set of glabellar furrows that connect across the top and two faint sets that are laterally impressed, no preglabellar field, and fixigenae that maintain their width and continue around and down into the anterior border. Internal molds are smooth.

Six cranidia seem to be identical with Keithia connexa except for the number of connected pairs of glabellar furrows and for the character of the frontal area and its continuation around into the anterior fixigenae. K. connexa has a wide border that is strongly deflected downward, and the anterior fixigenae are correspondingly wide. The Texas cranidia have relatively narrow borders and anterior fixigenae, and they are not quite so convex. K. connexa has one pair of connected glabellar furrows, whereas the Texas cranidia have two connected pairs. In all other features they appear to be identical with K. connexa, even to the fine granular ornament on the exoskeleton. I think these six cranidia might be conspecific, but I refrain from making more precise alliances until more material is found in Texas, and until more information is available on the stratigraphic position of Keithia connexa.

Occurrence.--Rare in the Saukiella pyrene subzone at BC - 41; JR - 351.

Genus KEITHIELLA Rasetti, 1944

Keithiella RASETTI, 1944, p. 243; Lochman in HARRINGTON, et al., 1959, p. 0322.

Type species.--Arionellus cylindricus BILLINGS, 1860, p. 406, fig. 385.

Diagnosis.--Glabella parallel-sided to slightly tapering, downsloping in front; posterior glabellar furrow continuous, one to three additional sets of short furrows may be present. Fixigenae elevated above axial furrow, anterior fixigenae deflected downward. No preglabellar field. Border separated from anterior fixigenae by anterior border furrow. Palpebral lobes small, ocular ridges can be present. Occipital node can be present.

Remarks.--Euptychaspis and Ptychaspis are closely related to Keithiella, but they can easily be differentiated from it by the moderately to deeply impressed anterior border furrow of Keithiella that separates border from the anterior fixigenae. Keithiella is distinguished from Keithia by its less tumid anterior part of the cranidium, by the wider anterior fixigenae and anterior border, and usually by the more elongate glabella with a transglabellar furrow.

Eight described species are included in Keithiella:
K. cylindrica (Billings), 1860; K. depressa Rasetti, 1944;
K. brevis Rasetti, 1944; K. maior Rasetti, 1945b; K. speciosa Rasetti, 1946; K. scrupulosa Ellinwood, 1962; K. patula Winston and Nicholls, 1967, and K. scapane, n. sp.

KEITHIELLA PATULA Winston and Nicholls

Keithiella patula WINSTON AND NICHOLLS, 1967, p. 79, pl. 10, figs. 4, 7.

Remarks.--This species occurs stratigraphically above Keithiella scapane, n. sp., and is distinguished from it by its lesser convexity, shorter anterior border, narrower anterior border furrow, and parallel-sided glabella.

Occurrence.--Locally common in the Saukiella serotina subzone at JR - 536; LCS - 35.6, 39, 44; SH - 54, 61.5-62; SS - 409; TC - 1400. One cranidium from the Saukiella pyrene subzone at TC - 1286.

KEITHIELLA SCAPANE Longacre, n. sp.

Pl. 3, Figs. 8-10.

? Keithiella sp. BELL AND ELLINWOOD, 1962, p. 405, pl. 58, fig. 18.

Description.--Cranidium elongate. Glabella transversely convex, tapering, slightly truncated, anterior end dropping quickly down to the preglabellar furrow; posterior pair of glabellar furrows very deeply impressed and posteriorly directed on the sides of the glabella, but become shallower and continuous across the top; second pair of moderately deep notches do not connect; third and fourth pairs of glabellar furrows are short, very shallow and anteriorly directed.

Axial furrow deep, wide; preglabellar furrow not so wide or deep. Occipital furrow deep and wide, transverse medially but swings forward and becomes deeper at the lateral extremities. Occipital ring of uniform width medially but slightly tapered laterally; occipital node present. Anterior border furrow extremely wide and arcuate, with an indistinct posterior edge but a very crisp anterior edge where the furrow rises up to the raised anterior border; there is a row of granules just behind the anterior edge of the border furrow. Anterior border transversely and longitudinally convex, greatly expanded medially, and bluntly to sharply pointed anteriorly; there is also a slight medial expansion of the posterior edge of the border, giving the appearance of pointing to the rear; this posterior expansion usually obliterates the central part of the row of granules in the border furrow, and it is also reflected in a small depression on the anterior end of the glabella. Fixigenae wider than one-half glabellar width, rising steeply out of axial furrow. Palpebral areas strongly elevated, almost as high as the glabella, crossed by distinct ocular ridges. Palpebral lobes narrow, opposite or behind glabellar midpoint; palpebral furrow distinct. Anterior fixigenae strongly deflected downward. Posterior area deflected down, posterior border furrow broad and distinct. Anterior facial sutures straight, divergent in front of palpebral lobes. Carapace smooth. Several of the internal molds

have a very rough surface, suggesting that at least the inside of the exoskeleton was covered with shallow depressions or a coarse ridge and pit pattern.

Librigena and pygidium unknown.

Available material.--38 cranidia, many broken.

Holotype.--BEG 36510, from BC - 32.

Etymology.--skapane, Greek, a digging tool, spade; named for its unusual anterior border that looks like a garden tool.

Remarks.--Cranidia have been collected from the Saukiella pyrene subzone in four measured sections. Keithiella scapane is probably a stratigraphic associate of K. scrupulosa Ellinwood, but is considerably lower in the section than K. patula Winston and Nicholls. With the exception of the expanded anterior border, this species conforms well with Keithiella; straight-sided and tapering glabella, deep glabellar furrows with the posterior pair continuous across the glabella, elevated fixigenae and palpebral lobes, divergent anterior facial sutures, and downward deflected anterior fixigenae. The anterior border furrow is deep and relatively wide; the angle subtended by the arc of the border furrow increases with an increase in the size of the specimens; curvature of this furrow on smaller specimens is comparable to other species of

Keithiella, but it markedly increases with an increase in size. The expanded and bluntly to sharply pointed anterior border is unique for the genus. Although Rasetti specifically excludes ocular ridges and occipital spines from his generic concept, suggestions of ridges and occipital nodes can be seen on some of his illustrations (1944, pl. 39, figs. 39, 42; 1946, pl. 1, fig. 6). In spite of the unusual anterior border, this species is included in Keithiella rather than in a new, monotypic genus.

Stitt (1968) did not find any representatives of this species in the Arbuckle Mountains.

Occurrence.--Locally common in the Saukiella pyrene subzone at BC - 23, 36, 41, 42; JR - 369.5, 374.5, 394; SPH - 93; TC - 1237, 1244, 1263.

KEITHIELLA SCRUPULOSA Ellinwood

Keithiella scrupulosa Ellinwood in BELL AND ELLINWOOD, 1962, p. 405, pl. 58, figs. 19-21.

Remarks.--This species occurs at the base of the Saukiella pyrene subzone in only two sections. It is well described and illustrated by Bell and Ellinwood.

Occurrence.--Rare in the Saukiella pyrene subzone at MC - 915±; SS - 302.5, 307.5.

Genus MACRONODA Lochman, 1964

Macronoda LOCHMAN, 1964a, p. 53.

Type species.--Macronoda prima LOCHMAN, 1964a, p. 53, pl. 14, figs. 12-23.

Remarks.--All that is known of this genus is discussed by Lochman (1964a, p. 53).

MACRONODA PRIMA Lochman

Pl. 6, Fig. 6.

Macronoda prima LOCHMAN, 1964a, p. 53, pl. 14, figs. 12-23;
WINSTON AND NICHOLLS, 1967, p. 79, pl. 9, fig. 19.

Remarks.--Eleven cranidia are assigned to this species, with reservation. Although these granular cranidia are very much like those illustrated by Lochman, there are differences that should be mentioned. The swollen anterior glabellar lobe is somewhat squared-off anteriorly and tapers slightly posteriorly; the posterior glabellar lobe is flattened across the top, producing corners on its lateral edges as in Euptychaspis jugalis. As Winston and Nicholls mentioned, the Texas specimens lack palpebral lobes. The facial sutures swing slightly inward where an eye would be located, and there is a trace of an ocular ridge. The occipital ring lacks any trace of a node or spine, and thus the species is differentiated

from any of Euptychaspis.

Although I am not content with the assignment to this species, and although I think it possible that monotypic Macronoda could be suppressed as a synonym of Euptychaspis, I will leave the Texas specimens where Winston and Nicholls placed them until more and better preserved material is available from the Montana-Wyoming province.

Occurrence.--Rare in the upper half of the Saukiella serotina subzone at JR - 521.5, 529; TC - 1387.5, 1388, 1392, 1400.

Genus PTYCHASPIS Hall, 1863

Ptychaspis HALL, 1863, p. 170; BELL, FENIAK, AND KURTZ, 1952, p. 192; Lochman in HARRINGTON, et al., 1959, p. 0320.

Type species.--Dikelocephalus miniscaensis OWEN, 1852, p. 574, pl. 1, fig. 3a; pl. 1A, figs. 4, 5.

Remarks.--Except for the fact that the palpebral width of the fixigenae can be about half the basal glabellar width, Lochman (in Harrington, et al., 1959, p. 0320) has nicely summarized the characters of the genus. The generic discussion of Bell, Feniak, and Kurtz (1952) is concerned with the problem of which species is the type of the genus.

Genus PTYCHASPIS Hall, 1863

PTYCHASPIS BULLASA Lochman and Hu

Pl. 2, Figs. 4, 5.

Ptychaspis bullasa LOCHMAN AND HU, 1959, p. 422, pl. 58, figs. 21-42; BELL AND ELLINWOOD, 1962, p. 405, pl. 58, figs. 14-17.

Remarks.--Ptychaspis bullasa is represented by about 50 cranidia scattered through 11 measured sections; most specimens are internal molds and few are complete. These cranidia compare quite well with Lochman and Hu's illustrations but differ in one respect: the palpebral lobes are opposite the middle third or anterior half of the glabella, rarely the anterior third. Bell and Ellinwood (1962, p. 405) indicate that the occipital ring and lateral ends of the basal glabellar lobes are free of ornament, but the unexfoliated cranidium here illustrated (pl. 2, fig. 5) has granules on the back edge of the occipital ring.

P. bullasa is characterized by its nearly parallel-sided glabella that is higher than the flatly convex fixigenae, granules on most areas behind the ocular ridges, and by transverse ridges across the steeply downsloping frontal area.

P. bullasa usually occurs in association with Drumaspis texana, but it can extend up into the range of D. idahoensis. High in its range, P. bullasa becomes rather variable: the back end of frontal area can be smoothed out and the

glabella can be more equidimensional (pl. 2, fig. 4). This variability may be intraspecific, or a few representatives of other species of Ptychaspis might be mixed with P. bullasa. These unusual forms come from TC - 1025, ST - 574.5, 578 and GR - 195. These horizons should be intensively recollected in order to determine the source and continuity of the variation.

Occurrence.--Common in the Idahoia zone at CR - 743-747; EC - 25, 26, 35; GM - 604; GR - 183, 195; LL - 725-728; SK - 245, 248; SS - 101, 103, 109; ST - 541, 574.5, 578; SU - 116; TC - 1003, 1025; WC - 950, 968.

PTYCHASPIS sp.

Pl. 2, Figs. 12-14.

Description.--Glabella subrectangular, may taper slightly, anteriorly rounded to rounded-truncate. Posterior glabellar furrow deep and angled back on the sides but shallower and continuous across the axis; middle furrow gently bowed back, continuous; if present, the anterior pair of furrows are short, shallow and angled forward. Fixigenae wide, moderately convex and raised, with the crests of the fixigenae slightly lower than the glabella. Frontal area convex and downsloping but not vertical. Palpebral lobes usually opposite glabellar midlength. Ornament on internal molds consists

of granules on the palpebral areas of the fixigenae and on the glabella in front of the posterior transglabellar furrow; although the preoccipital segment of the glabella is usually smooth, a few low granules can be scattered across this area. Ornament on frontal area unknown; it appears to be smooth. Ornament on exoskeleton unknown.

Remarks.--Above the range of Ptychaspis bullasa and in association with Prosaukia cf. P. tuberculata, Dartonaspis wichitaensis, Chariocephalus whitfieldi, and Stigmacephaloides curvabilis are fragments of 14 cranidia and several librigenae that are assigned to this genus. Although they cannot be included in any existing species of Ptychaspis, the specimens are too fragmentary a basis for a new species. When more and better preserved material is available, then would be the time for creating a new name, if it proved necessary.

Ptychaspis sp. differs from P. granulosa (Owen) in ornament-distribution, height of the glabella above the fixigenae, and slope of the frontal area. It differs from P. arcolensis Nelson in ornament-distribution, in having two sets of continuous glabellar furrows, and in biostratigraphic position. Ptychaspis sp. is a biostratigraphic equivalent of P. miniscaensis (Owen), the type species, from which it differs in ornament, shape and furrowing of the glabella, slope of the front of the cranidium, width of the fixigenae, and position

of the palpebral lobes. From the stratigraphically lower P. bullasa this species differs in ornament-distribution and in having relatively narrower fixigenae.

Occurrence.--Rare in the middle Ellipsocephaloides zone at MC - 840, 844; TC - 1095, 1095-1100, 1105; WC - 1060-1075.

Subfamily SAUKIINAE Ulrich and Resser, 1933

Remarks.--Ulrich and Resser (1933, p. 136) established the subfamily Saukiinae as part of the Dikelocephalidae, with the genus Saukia as the type of the subfamily. Although I think the subfamily Saukiinae is genetically part of the family Ptychaspidae (Fig. 2), the complex of genera in the subfamily that I recognize is essentially the same as that in the Saukiinae recognized by Ulrich and Resser. Although Ulrich and Resser (1933, p. 137) discuss several differences between the Saukiinae and the Dikelocephalinae, they do not give a diagnosis of the Saukiinae. The diagnosis given by Lochman (in Harrington, et al., 1959, p. 0322) for the family Saukiidae can serve as the diagnosis for the subfamily Saukiinae, with two modifications: (1) surfaces can be smooth, granulose, or bear elongate ridges, and (2) the Saukiinae is derived from the Ptychaspidae, possibly from Ptychaspis.

Saukia and Calvinella are morphologically quite similar,

and they may be genetically more closely related to each other than they are to either Prosaukia or Saukiella. By the same token, Prosaukia and Saukiella may be more closely related to each other than they are to Saukia or Calvinella.

Genus CALVINELLA Walcott, 1914

Calvinella WALCOTT, 1914, p. 388; ULRICH AND RESSER, 1933, p. 215; Lochman in HARRINGTON, et al., 1959, p. 0323.

Type species.--Dikelocephalus spiniger HALL, 1863, p. 143, pl. 10, figs. 1, 2, 3?.

Diagnosis.--Glabella subrectangular, slightly tapered, rounded-truncate anteriorly; 2 or 3 pairs of glabellar furrows, posterior pair usually connected, second pair may connect. Preglabellar field absent; anterior border furrow transverse, may be diagonal from corners of glabella to cranidial margin; anterior border of variable length (sag.). Width of fixigenae variable. Occipital ring spined. Librigenae with border furrows that connect, then fade on genal spine. Pygidium transversely elliptical, with prominent axis about half the length (sag.) of pygidium; 3 to 5 axial rings, postaxial ridge extending out onto border; 3 to 5 unequally divided pleurae, with pleural furrows approaching anterior edge of pleurae; pleural furrows fade into border. Surfaces granulose or ornamented with raised, elongate ridges.

Remarks.--The unequally divided pleurae and the occipital spine distinguish Calvinella from other genera in the Saukiinae.

CALVINELLA PRETHOPARIA Longacre, n. sp.

Pl. 6, Figs. 7-12.

Calvinella ozarkensis Walcott, WINSTON AND NICHOLLS, 1967, p. 80, pl. 11, figs. 5, 9.

Description.--Cranidium subrectangular. Glabella almost straight-sided, tapering, strongly truncated, with moderate transverse convexity. Three of four pairs of glabellar furrows; posterior pair continuous and broad, deeply gouged laterally but shallower across the axis; second pair deep laterally, becoming shallower adaxially, may be continuous; third pair short, shallow, gently recurved, not connected, do not intersect the axial furrow; fourth pair, if present, narrow, faint, and anteriorly directed. Axial furrow broad and shallow; preglabellar furrow confluent with anterior border furrow. Occipital furrow broad and deep, recurved medially and curved forward laterally. Occipital ring long (sag.). Long, slender occipital spine projects up and back. The more robust the spine, the more medially expanded is the occipital ring and the more anteriorly bowed and shallower is the medial part of the occipital furrow. Preglabellar field absent. Anterior border furrow shallow, becoming relatively broader in

larger specimens. Anterior border gently convex, slightly tapered laterally, with broadly rounded or pointed anterior margin. Fixigenae very wide and gently convex. Palpebral area usually between one-third and one-half the greatest width of the glabella; this ratio is greater than one-half for the relatively small specimens. Palpebral furrow broad and very distinct on exoskeleton, but narrow on internal molds. Slender palpebral lobe tapered on both ends. Anterior fixigenae broad, flatly convex, gently downsloping. Posterior fixigenae broadly triangular, sloping both posteriorly and laterally. Posterior border furrow distinct, intersects axial furrow behind the occipital furrow. Posterior border of uniform width (exsag.). Anterior facial suture divergent to slightly convergent in front of palpebral lobes, becomes slightly more convergent just after passing the anterior border furrow, and then cuts sharply toward the axis, where it can define a broad point. Posterior facial suture divergent, straight to slightly concave. Ornament on the exoskeleton is spectacular: glabella, occipital ring and posterior border covered with coarse granules, some of which are elongate; fixigenae covered with vermiform ridges and granules that are longitudinal on the posterior and palpebral areas, and that swirl around and become transverse on the front edge of the anterior fixigenae; vermiform ridges and granules transverse the anterior border; a row of squashed granules rim the

inside edge of the palpebral lobe. Internal molds bear similar ornament; granules on the occipital ring and glabella can be swirled in a pattern reminiscent of a Bertillion ornament; vague impressions of the vermiform ridges and granules on fixigenae and anterior border. Internal molds of small specimens may be smooth, possibly because they lack ornament, or because the ornament is too delicate to be easily preserved.

Pygidium transversely elliptical, length almost one-half width. Relatively broad, tapered axis consists of an articulating half-ring, five axial rings and a terminal axial piece that extends into the pleural field as a low postaxial ridge. Five well-defined unequally divided pleurae; anterior pleural band of first pleura subequal to posterior band; anterior pleural bands of the more posterior pleurae progressively reduced and almost absent on the hindmost pleura. Furrows narrow and deep on convex area adjacent to axis, become shallower and fade out on the flatly concave margin. Posterior border furrow absent. Axial rings and pleurae covered with closely spaced granules. Elongate granules and low ridges swirl around the end of the terminal axial piece and along the concave margin. Internal molds preserve only the granules.

Available material.--42 cranidia, 3 pygidia, many well preserved.

Holotype.--UT 12589, from TC - 1400.

Etymology.--pretho, Greek, swell, blow up, inflated; pareion, Greek, cheek; named for its enlarged fixigenae.

Remarks.--Calvinella prethoparia is characterized by its extremely wide fixigenae, relatively thin anterior border, its relatively short and broad glabella with three or four pairs of glabellar furrows, and ornament on both cranidium and pygidium. These features serve to distinguish it from C. procera and C. tenuisculpta, both of which can occur with C. prethoparia.

C. prethoparia differs significantly from C. ozarkensis Walcott; the fixigenae are considerably wider, particularly in the juveniles, the frontal area is not divided into a preglabellar field and anterior border by a faint anterior border furrow, the glabella is more tapered and not so convex, and the long (trans.) anterior border has a nearly straight posterior edge and an anterior margin that comes to a slight point at the axial line.

C. prethoparia looks very much like Saukia marica Walcott (1914, p. 380, pl. 64, figs. 6, 6a); the fixigenae are of comparable width, and glabellar shape and furrows are similar. The holotype of S. marica cannot be located (Jesse Merida, U.S.N.M., letter of Nov. 9, 1967). S. marica does not come from the Dunderberg shale but from higher in the section (A. R. Palmer, letter of Oct. 23, 1967). Bowmania americana

(Walcott) occurs with S. marica in Nevada (Walcott, 1914, p. 361) and with C. prethoparia in central Texas. These two nominal species could be conspecific, but until the holotype is located and until more complete specimens are available, they must remain separate.

Occurrence.--Common in the upper Saukiella serotina subzone at CC - 61, 63±; JR - 529, 536; LCS - 44, 45, 45.4, 45.8; TC - 1388, 1400. Rare in the Corbinia apopsis subzone at LCS - 53.

CALVINELLA PROCERA Winston and Nicholls

Pl. 4, Fig. 16.

Calvinella procera WINSTON AND NICHOLLS, 1967, p. 80, pl. 10, fig. 22; pl. 11, figs. 1, 3.

Remarks.--Most specimens of Calvinella procera agree quite well with Winston and Nicholls' description. However, there are a substantial number that possess one or more of the outstanding features of its stratigraphic associate, C. tenuisculpta. The most commonly shared characters are a short, transverse anterior border furrow, more posterior palpebral lobes, a more rectangular glabella, and shorter (ex-sag.) posterior limbs. Likewise, there are specimens of C. tenuisculpta that possess C. procera features: a longer (sag.) more rounded anterior border or stouter posterior

limbs. I have left the two as separate species, although they may later be shown to be conspecific, and the variation the consequence of sexual dimorphism or intraspecific variation.

This species is distinguished from C. spiniger, the type species, by the inflated anterior border, a tapered glabella, and wider fixigenae.

Occurrence.--Common to locally abundant in the Saukiella serotina subzone at LCS - 32.4, 35.7, 39, 40, 45, 45.4, 45.8, 52-54; SH - 52, 52.6, 54, 55; SS - 383; TC - 1357-1363, 1368-1374. Rare in the base of the Corbinia apopsis subzone at LCS - 53.

CALVINELLA TENUISCULPTA Walcott

Pl. 4, Fig. 17.

Calvinella tenuisculpta WALCOTT, 1914, p. 391, pl. 64, figs. 7, 7a; WINSTON AND NICHOLLS, 1967, p. 80, pl. 11, fig. 4.

Remarks.--Although Calvinella tenuisculpta is very similar to its stratigraphic associate, C. procera, it can be distinguished by a shorter frontal area with a near-transverse anterior margin, by the more rectangular glabella with a transglabellar furrow, by the generally more posterior palpebral lobes, by shorter (exsag.) posterior limbs, and by the narrower anterior fixigenae.

The holotype, an internal mold, bears a Bertillion

ornament on its glabella and occipital ring. Preservation of the Texas material usually is not good enough to show ornament, but vague impressions of a Bertillion pattern can be seen. Fragments of exoskeleton preserve a transverse set of ridges on the anterior border that are not preserved on the internal mold.

C. tenuisculpta is distinguished from C. spiniger (Hall) by its longer (sag.) anterior border and wider fixigenae.

Stitt (1968) had comparable difficulty in assignment of his specimens to C. procera and/or C. tenuisculpta; he decided in favor of the latter.

Occurrence.--Rare in the Saukiella serotina subzone at JR - 519, 521.5; LCS - 33, 33.5, 35.7, 40; SS - 375.

Genus PROSAUKIA Ulrich and Resser, 1933

Prosaukia ULRICH AND RESSER, 1933, p. 137; Lochman in HARRINGTON, et al., 1959, p. 0324.

Type species.--Dikelocephalus misa HALL, 1863 (part), p. 144, pl. 8, fig. 15; pl. 10, figs. 4, 5.

Remarks.--The diagnosis of Lochman (in Harrington, et al., 1959, p. 0324) summarizes the characteristics of the genus.

Prosaukia is distinguished from Saukia and Calvinella

by its having a definite preglabellar field. Possession of an occipital spine or granular ornament (or both), and a generally subequally divided frontal area on which the medial part of the anterior border furrow can be obscured, will distinguish species of Prosaukia from Saukiella. The lateral border furrow and the posterior border furrow on the librigenae of species of Prosaukia do not connect.

PROSAUKIA cf. P. CURVICOSTATA Ulrich and Resser

Prosaukia curvicostata ULRICH AND RESSER, 1933, p. 145, pl. 25, figs. 1-7; NELSON, 1951, p. 778, pl. 110, figs. 6, 16, 18; RAASCH, 1951, p. 142 (synonymy to date).

Prosaukia cf. P. curvicostata Ulrich and Resser, BELL AND ELLINWOOD, 1962, p. 406, pl. 59, fig. 1.

Remarks.--I agree with Bell and Ellinwood that the specific assignment remain tentative until additional and better preserved material is available. The smooth exoskeleton, lack of an occipital spine, and the gently convex and arcuate anterior border distinguish this species.

The three cranidia assigned to this species come from the highest Ellipsocephaloides zone collections in the two sections; two of them are associated with Idiomesus infimus, n. sp.

Occurrence.--Very rare in the Ellipsocephaloides zone at JR - 284, 284.5; TC - 1142.

PROSAUKIA REMORA Longacre, n. sp.

Pl. 4, Figs. 19-21.

Prosaukia longicornis Ulrich and Resser, WINSTON AND NICHOLLS,
1967, p. 80, pl. 10, fig. 6.

Description.--Cranidium moderately convex, elongate.

Glabella strongly convex, almost straight-sided, slightly tapering; anterior end truncated but anterior corners rounded. Posterior glabellar furrow continuous, deep and curved laterally but shallower and straight across the top; second and third pairs of furrows shallow and laterally impressed, second pair directed slightly back, third pair directed forward. Axial furrow broad and deep, widens to form fossulae at anterior corners of the glabella; preglabellar furrow broad and shallow. Occipital furrow as deep and wide as the transglabellar furrow, curved forward laterally and slightly bowed forward medially. A broad, curved anterior border furrow divides the frontal area into a raised, thin and tapered border and a long (sag.) asymmetrically convex preglabellar field that is unusual for the genus. Some specimens appear to have a transverse, curved ridge crossing the preglabellar field; this represents the change in slope between the anterior edge of the broad preglabellar furrow and the posterior edge of the preglabellar field; also present in this field may be two small longitudinal ridges that seem to connect the glabella and the anterior border; these can also be seen in many of

Ulrich and Resser's figured specimens of Prosaukia. Fixigenae of moderate width, slope gently down into the axial furrow; greatest width of palpebral area just opposite lateral ends of posterior transglabellar furrow. Palpebral furrow broad, palpebral lobes narrow. Anterior facial sutures strongly divergent in front of palpebral lobes, curve downward and swing adaxially before intersecting the border furrow. Posterior facial suture defines a broad (tr.) posterior fixigena, but leaves a relatively stout, short posterior limb. All areas of exoskeleton granulate; internal molds may or may not preserve the ornament.

Librigena and pygidium unknown.

Available material.--7 cranidia, fairly well preserved.

Holotype.--BEG 36536, from LCS - 40.

Etymology.--remora, Latin, delay; named for its occurrence late in the Trempealeauan.

Remarks.--Prosaukia remora occurs in the middle of the range of Saukiella serotina, n. sp., and its associates are Trempealeauan and not Franconian as are those of Prosaukia longicornis. P. remora differs from all other species of Prosaukia in that its preglabellar field is at least twice as long (sag.) as the anterior border. It also differs from P. longicornis in its granular ornament. Because of its convexity,

long preglabellar field, and its occipital spine, P. remora cannot be confused with either of Ulrich and Resser's two Trempealeauan species, P. lodensis (1933, p. 162, pl. 28, fig. 9) or P. incerta (1933, p. 161, pl. 28, figs. 12-17).

Occurrence.--Rare in the middle of the Saukiella serotina subzone at LCS - 33, 40, 45; SH - 55.

PROSAUKIA cf. P. TUBERCULATA Ulrich and Resser

Prosaukia tuberculata ULRICH AND RESSER, 1933, p. 159, pl. 28, fig. 5; DECKER, 1945, p. 39, pl. 9, fig. 14; BERG, 1951, p. 106, pl. 3, figs. 2-4; RAASCH, 1951, p. 143, 149 (synonymy to date).

Prosaukia cf. P. tuberculata Ulrich and Resser, BELL AND ELLINWOOD, 1962, p. 406, pl. 59, figs. 2, 3.

Remarks.--This taxon has recently been discussed and illustrated by Bell and Ellinwood (1962). I can only add the specific range data for the three cranidia.

Occurrence.--Very rare in the Ellipsocephaloides zone at JR - 245; TC - 1105; and Decker's locality 159T - 5 - 50A.

Genus SAUKIA Walcott, 1914

Saukia WALCOTT, 1914, p. 373; ULRICH AND RESSER, 1933, p. 168; Lochman in HARRINGTON, et al., 1959, p. 0323.

Type species.--Dikelocephalus lodensis WHITFIELD, 1880,

p. 51; 1882, p. 188, pl. 10, fig. 14; p. 341, pl. 27, figs. 12, 13.

Diagnosis.--Glabella subrectangular, sides slightly converging or medially constricted; two pairs of glabellar furrows with at least the posterior pair connected; glabella anteriorly rounded-truncate; antero-lateral corners pointed or broadly rounded. Fixigenae narrow. No preglabellar field. Anterior border furrow confluent with at least the medial part of preglabellar furrow; anterior border of moderate length (sag.). Librigenae with posterior border furrow meeting lateral border furrow; genal spines long and slender. Pygidium transversely subelliptical, with strongly tapered axis; subequally divided pleurae die out on narrow, smooth concave border. Surfaces granulate.

Remarks.--Saukia is distinguished from Prosaukia and Saukiella by its lack of a preglabellar field and by its granular ornament. The subequally divided pleurae and the lack of an occipital spine distinguish Saukia from Calvinella.

SAUKIA IMPERATRIX Ulrich and Resser

Saukia imperatrix ULRICH AND RESSER, 1933, p. 192, pl. 31, figs. 21-25; RAASCH, 1951, p. 144; WINSTON AND NICHOLLS, 1967, p. 81, pl. 9, figs. 15, 16, 21.

Remarks.--An usual feature noticed on some of the Texas

specimens is a small node on the occipital ring. This is difficult to see on large, granulate specimens (see Winston and Nicholls, pl. 9, fig. 15) but easy to see on the smaller ones. It is not found on all specimens and I doubt that it should be construed as anything more than an interesting feature. If it was thought to be an important character, or if it was found on all specimens, one might be tempted to place this species in Calvinella, but the pygidium is certainly not calvinellid. The holotype and paratype cranidia do not possess the central segment of the occipital ring, so they are of no help in this matter. I conclude that this species belongs to the genus Saukia.

The axes of some pygidia have a partial fifth axial ring, as does S. tumida. Granules are present on the crests of the axial rings and pleurae.

Occurrence.--Locally common in the upper Saukiella junia subzone and the lower Saukiella serotina subzone at BC - 109-110, 149; CC - 58.2, 61; JR - 484, 492; SH - 12.6.

SAUKIA TUMIDA Ulrich and Resser

Pl. 4, Figs. 10, 11.

Saukia tumida ULRICH AND RESSER, 1933, p. 192, pl. 30, figs. 11, 12; WINSTON AND NICHOLLS, 1967, p. 81, pl. 9, figs. 7, 9, 11.

Remarks.--Saukia tumida is characterized by its convex

and steeply downsloping glabella and frontal area. The cranidium figured here (pl. 4, fig. 10) shows the granule-crested palpebral lobe separated from the narrow fixigena by a broad, steep-sided palpebral furrow. One of Winston and Nicholls' (pl. 9, fig. 11) figured specimens illustrates the slender, somewhat posteriorly-directed posterior limb.

Two fragments of librigenae are assigned to this species. The arrangement of a row of granules adjacent to the ocular furrow, and the low, coarse, vermiform ridge-pattern on the rest of the cheek provide a striking ornament (pl. 4, fig. 11). This librigena is distinguished from that of S. imperatrix by its narrower (tr.) posterior side of the inner area; other features of the two cheeks are remarkably similar.

On well-preserved pygidia there is an indication of two granules on the highest part of at least the first two axial rings. A fifth axial ring is suggested by an incomplete shallow furrow across the terminal axial piece.

S. tumida occurs stratigraphically below S. imperatrix, and is distinguished from it by greater convexity, greater downward deflection of the frontal area, more rounded anterior end of the glabella, narrower fixigenae, and deeper glabellar furrows.

Occurrence.--Locally common in the Saukiella junia subzone at JR - 481; SS - 356, 360.5; TC - 1305-1310, 1320-1325.

Genus SAUKIELLA Ulrich and Resser, 1933

Saukiella ULRICH AND RESSER, 1933, p. 194; Lochman in HARRINGTON, et al., 1959, p. 0325.

Type species.--Dikelocephalus pepinensis OWEN, 1852, p. 574, pl. 1, figs. 9, 9a, 9b.

Remarks.--Ulrich and Resser (1933, p. 194) have the most complete and definitive diagnosis for this genus. The only modification I would make is that surfaces usually are not smooth; external surface ornament consists of elongate ridges on marginal cranidial features, or a Bertillion pattern; internal molds generally bear only a partial imprint of the external ornament.

Saukiella is distinguished from Saukia and Calvinella by its having a preglabellar field, by its shallower furrows, by ornament, and by its lack of a strong occipital node or spine. Saukiella is distinguished from Prosaukia by its relatively longer frontal area, nongranular ornament, lack of occipital spine, and confluent lateral border and posterior border furrows on the librigena.

SAUKIELLA FALLAX (Walcott)

Pl. 5, Figs. 1-3.

Saukia fallax WALCOTT, 1914 (part), p. 378, pl. 67, figs. 21, 21a (not 22, 22a = Briscoia sp.)

Description.--Cranidium quadrate, with low transverse convexity and moderate longitudinal convexity anterior to the palpebral lobes. Glabella subquadrate to subelongate, slightly tapered, truncated in front, with only the anterior corners showing any rounding. Axial furrow broad, straight along the anterior half of the glabella but bowed slightly outward posteriorly, resulting in a slight expansion of the posterior half of the glabella. This glabellar expansion is more noticeable in the small specimens. Posterior glabellar furrow continuous, deep on the sides and shallower across the top; second pair of furrows very shallow, slightly recurved, connecting on some specimens. Occipital furrow transverse or bowed slightly forward medially, as broad and deep as the transglabellar furrow. Occipital ring of uniform width and almost as wide as the posterior glabellar lobe. Anterior border furrow broad and deep, bowed gently forward, confluent with preglabellar furrow across at least the middle third of the glabella. Anterior border highly raised, very narrow and laterally tapering. Fixigenae narrow; palpebral area long, flat, sloping down laterally, widest point opposite junction of axial and transglabellar furrows. Palpebral furrow distinct; palpebral lobes broad, flat and elongate. Anterior facial sutures divergent in front of palpebral lobes; anterior angles of cranidium rounded. Posterior facial sutures fairly straight to the posterior margin. Posterior areas of fixigenae

tapering, crossed by broad, deep posterior border furrow. Surface of palpebral area, anterior fixiginae, and lateral part of the anterior border furrow covered with elongate ridges. Ornament seems to continue up onto the anterior border and up the sides of the glabella. Other ornament unknown. Internal molds smooth.

Pygidium (pl. 5, fig. 2) transversely elliptical. Tapered axis consists of articulating half-ring, three axial rings, a terminal axial piece that has a suggestion of a fourth axial ring on its anterior end, and a postaxial ridge that extends almost to the posterior edge. Four pleurae are subequally divided by pleural furrows on the convex part of the pleural region; pleurae fade out in the concave margin. Concavity of the margin decreases toward postaxial ridge, where the margin becomes slightly convex. Pleural furrows broad, deep; interpleural furrows shallower, with anterior edges quite sharply raised relative to the gentle upslope of the posterior part of the furrow. No border apparent on exoskeleton; small raised border may be present on molds in the vicinity of the postaxial ridge. Fine ridges ornament the pleural region on the exoskeleton; ornament on the axial region unknown. Internal molds smooth.

Remarks.--Although the holotype of Saukiella fallax (Walcott) is from the eastern side of the Llano Uplift and

all of my specimens are from the western side, comparison of the western specimens with the holotype leaves no doubt but that they are conspecific. I think this species belongs in Saukiella (and not in Saukia) because of its short, flat preglabellar field adjacent to the raised border, because the ornament is a ridged pattern and not granules as in Saukia, and because the shape of the pygidium is more like that of other species of Saukiella. The pygidium that I have assigned to S. fallax is not like that figured by Walcott--which I have assigned to Briscoia sp.

This is the stratigraphically lowest species of Saukiella found in central Texas, and it possibly is ancestral to the next oldest species, S. pyrene.

Occurrence.--Rare in the basal Saukiella pyrene subzone at JR - 351, 354; SS - 302.5, 307.5.

SAUKIELLA JUNIA (Walcott)

Pl. 5, Figs. 12-21.

Saukia junia WALCOTT, 1914, p. 378, text-fig. 17.

Saukiella junia (Walcott) RESSER, 1938, p. 43; WINSTON AND NICHOLLS, 1967, p. 81, pl. 9, figs. 8, 10, 12, 14, 22.

Description.--Several additions to Winston and Nicholls' descriptions should be made. In numerous medium-sized (15-20 mm) specimens with anteriorly expanded and truncated glabellas,

the preglabellar furrow is slightly recurved medially, producing a broad, shallow depression or notch on the front of the glabella. Almost all specimens have a second pair of short, narrow, very shallow glabellar furrows; many have a third pair of very faint furrows, and a few have a fourth, anteriorly directed pair.

Two slight changes in the pygidial furrows occur through the range of Saukiella junia. In the lower part of the range of S. junia var. B the pleural furrow is almost as distinct as the interpleural furrow (pl. 5, fig. 18). The division of pleurae is quite unequal adjacent to the axis, but more equal farther out in the pleural field. Higher in the range the furrow becomes less distinct and the subdivision of the pleurae more equal. Pygidia of S. junia var. A (pl. 5, fig. 21) have subequally divided pleurae, and the pleural furrow is reduced to a narrow groove relative to the broad, deep, straight-sided interpleural furrow. Many axes have a strong indication of a fifth axial ring.

Ornament is similar to that of S. pepinensis. Bertillion pattern covers the glabella, occipital ring, fixigenae, and librigenae; transverse ridges cross the anterior border. Pygidia appear to be smooth. The only ornament on some specimens is a set of terrace lines on the back end of the occipital ring; the rest of the cranidium is smooth. Impressions of the terrace lines and of the ridges and Bertillion pattern

is preserved on the internal mold.

Remarks.---I agree with Winston and Nicholls' interpretation of this species as one with a "rather broad range of characteristics," and with their subdivision into varieties that reflect stratigraphic shifts in morphology. In addition, I am willing to go one step farther and propose that the small specimens associated with S. junia var. B that look very much like S. pepinensis are not small representatives of the latter, but rather juvenile S. junia var. B. Similarity of these smaller specimens (pl. 5, figs. 12, 14) with S. pepinensis is very close, but the furrows are somewhat shallower and the border slightly longer. If a good collection of S. junia var. B is arranged in order of size, and if the S. pepinensis-like specimens are included, it is reasonably easy to see that the smaller ones could mature into respectable S. junia var. B. It should also be pointed out that adults of S. junia var. B become less like adults of S. pepinensis the farther they range stratigraphically from S. pepinensis (pl. 5, figs. 13, 15, 17): the border furrow (if present) becomes more obscure and the border becomes quite long (sag.) higher in the range of S. junia. Thus, I propose that S. junia is descended from S. pepinensis; they represent a cline or chronospecies.

Occurrence.---Locally abundant in the middle and upper

Saukiella junia subzone at CC - 27; JR - 479; SS - 345±, 356, 370; TC - 1301, 1303, 1305, 1305-1310, 1310-1315, 1315-1320, 1335-1340, 1341-1346.

SAUKIELLA JUNIA (Walcott), var. A, Winston and Nicholls

Pl. 5, Figs. 19-21.

Saukiella junia (Walcott), var. A, WINSTON AND NICHOLLS, 1967, p. 82, pl. 9, figs. 10, 12.

Remarks.--The smaller specimens are distinct from Saukiella pepinensis. The pygidia can be distinguished from those of S. junia var. B by the relatively obscure pleural furrow and the more equal subdivision of the pleurae.

Examination of the holotype of S. junia (Walcott) confirms Winston and Nicholls' statement that this variety most nearly resembles Walcott's species. To the right of the holotype is a cranidium of Eurekia eos, one of S. junia var. A's associates in central Texas. On another piece of matrix in Walcott's collection of Saukia junia is a pygidium of Bayfieldia simata, another associate of this variety.

Occurrence.--Rare in the upper part of the Saukiella junia subzone at TC - 1341-1346.

SAUKIELLA JUNIA (Walcott), var. B, Winston and Nicholls

Pl. 5, Figs. 12-18.

Saukiella junia (Walcott), var. B, WINSTON AND NICHOLLS, 1967,
p. 82, pl. 9, figs. 8, 14, 22.

Remarks.--Low in the range of Saukiella junia var. B some adult and all the juvenile cranidia strongly resemble the stratigraphically lower S. pepinensis, but they can be distinguished by shallower furrows and slightly longer borders. Higher in the range, the differences are more pronounced. Pygidia of S. junia var. B have less equally divided pleurae and deeper pleural furrows than S. junia var. A, but the differences diminish as the lower variety ranges up toward the lowest occurrence of S. junia var. A.

Occurrence.--Abundant in the middle and upper part of the Saukiella junia subzone at CC - 27; JR - 479; SS - 345±, 356, 370; TC - 1301, 1303, 1305, 1305-1310, 1310-1315, 1315-1320, 1335-1340.

SAUKIELLA PEPINENSIS (Owen)

Pl. 5, Figs. 9-11.

Dikelocephalus pepinensis OWEN, 1852, p. 574, pl. 1, figs. 9, 9a, b.

Saukia pepinensis (Owen) WALCOTT, 1914, p. 381, pl. 67, figs. 1-13, 13a (synonymy to date).

Saukiella pepinensis (Owen) ULRICH AND RESSER, 1933, p. 202, pl. 33, figs. 22-24; RAASCH, 1951, p. 144; WINSTON

AND NICHOLLS, 1967, p. 82, pl. 9, figs. 4-6 (synonymy to date).

Remarks.--The Texas specimens provide additional information about ornament. Bertillion pattern on the exoskeleton covers the glabella, occipital ring, anterior border, all areas of the fixigenae, the librigenae, and at least the pleural region of the pygidium. On most specimens this pattern is a braided system of fine, distinct raised lines. On the largest cranidia with carapace (pl. 5, fig. 9), the lines on the sides of the glabella are disconnected, irregular ridges; the ridges break up into smaller irregular bodies higher up on the glabella, finally culminating in coarse pustules on the crest of the glabella. Faint impressions of the Bertillion pattern are apparent on internal molds; on one large mold (unillustrated) the impression of a coarse pattern on the border yielded pits. Most specimens have relatively longer borders than do those figured by Ulrich and Resser.

S. pepinensis occurs stratigraphically above S. pyrene, from which it differs in the much reduced to nonexistent preglabellar field, the proportionally longer border, and the wider fixigenae. There are collections stratigraphically between good S. pyrene and good S. pepinensis that suggest a phylogenetic relationship between the two.

S. pepinensis occurs stratigraphically below S. junia var. B, and is distinguished by means of deeper furrows, a

shorter anterior border, the distinct rise of the anterior border above the preglabellar field or anterior border furrow, giving a crisp posterior edge to the border, and by the nearly equal division of the pleurae by the pleural furrows on the pygidia. These differences are very subtle, especially when dealing with juvenile S. junia var. B or adult specimens from low in its range. Although more collections from the transition zone might be desirable, the present collections strongly suggest that the characters of the S. pepinensis population shifted toward longer borders and shallower furrows, culminating in a remarkably similar but distinct population named S. junia var. B, whose juveniles are nearly identical with the antecedent S. pepinensis.

Occurrence.--Common in the lower part of the Saukiella junia subzone at BC - 70; JR - 453, 459, 460; LCS - 32; TC - 1291, 1293.

SAUKIELLA PLANATA Winston and Nicholls

Saukiella planata WINSTON AND NICHOLLS, 1967, p. 82, pl. 11, figs. 2, 10.

Remarks.--Saukiella planata also has the Bertillion pattern of ornament common in the other Saukiella species. Faint impressions of these lines are obscure on internal molds but can be seen on the occipital ring, glabella and anterior

border. The ornament on the exoskeleton is distinct, especially on the occipital ring and the posterior glabellar lobe. Librigenae and pygidia are unknown.

S. planata occurs in the upper part of the range of S. serotina, and in one section it ranges slightly higher than does S. serotina.

Occurrence.--Locally common in the upper part of the Saukiella serotina subzone at CC - 61; LCS - 44, 45, 45.8, 52-54; SH - 61.5, 61.5-62, 65.5; TC - 1400.

SAUKIELLA PYRENE (Walcott)

Pl. 5, Figs. 4-8.

Saukia pyrene WALCOTT, 1914, p. 382, pl. 67, figs. 18-20.

Saukiella pyrene (Walcott) ULRICH AND RESSER, 1933, p. 204, pl. 34; pl. 35, figs. 1-8; RAASCH, 1951, p. 145; NELSON, 1951, p. 783, pl. 110, figs. 4, 7.

Saukiella cf. pyrene ULRICH AND RESSER, 1933, p. 204, pl. 35, figs. 9, 11 (not 10).

Saukiella pyrene limbata ULRICH AND RESSER, 1933, p. 206, pl. 35, figs. 12-14.

Saukiella frontalis ULRICH AND RESSER, 1933, p. 207, pl. 35, fig. 22.

Saukiella indenta ULRICH AND RESSER, 1933, p. 208, pl. 35, figs. 23-30; pl. 36, figs. 1-3.

Saukiella indenta intermedia ULRICH AND RESSER, 1933, p. 208, pl. 36, fig. 4.

Saukiella norwalkensis ULRICH AND RESSER, 1933, p. 209, pl. 36, figs. 5-27.

Saukiella signata ULRICH AND RESSER, 1933, p. 206, pl. 35,
figs. 15-21.

not Saukiella norwalkensis Ulrich and Resser, WINSTON AND
NICHOLLS, 1967, p. 82, pl. 11, figs. 6-8, 12.

Description.--Cranidium quadrate to elongate. Glabella elongate, well-defined by axial furrows that usually are bowed outward along the posterior half and slightly divergent along the anterior third of the glabella, resulting in a medial constriction. This constriction and the adjacent anterior expansion of the glabella are most obvious on the larger specimens; the smaller ones exhibit these features but they are subtle. Some specimens have a slightly tapered glabella. At the anterior corners of the glabella the axial furrow broadens and deepens, then becomes shallower across the front of the glabella. Posterior transglabellar furrow usually a deep gouge laterally that becomes shallower across the top; the lateral extremities of this furrow seldom intersect the axial furrow. A second pair of short, shallow glabellar furrows are located opposite the anterior edge of the palpebral areas. A third pair of furrows that are directed slightly forward are apparent on a few specimens. Occipital ring broad, uniform in width (sag.), well-defined by transverse furrow or one that is bowed forward medially. Anterior border furrow bowed forward, narrow in smaller specimens but broader in larger ones. Convex anterior border short (sag.),

tapers laterally in most specimens, and has a slight crescentic shape. The character of the preglabellar field is the most variable feature. The smaller cranidia have a definitely convex preglabellar field that is just as convex and almost as long (sag.) as the border, and that extends laterally into the anterior fixigenae. Thus the frontal area is biconvex. The larger the specimen, the less convex the preglabellar field. In the larger specimens, the anterior fixigenae fade into a nearly flat preglabellar field that is delineated by broad, very shallow preglabellar and border furrows. Anterior facial sutures are slightly divergent in front of palpebral lobes; anterior corners of cranidium are rounded. Anterior area of fixigena narrows just in front of palpebral area, widens anteriorly. Palpebral areas are long, relatively flat and of moderate width. Palpebral furrows are distinct; palpebral lobes are long and broad. Posterior facial sutures swing in very close to axial furrows just behind the palpebral lobes, then strongly diverge, defining a long and slender limb. Posterior area of the fixigena is very small in front of posterior border furrow. Posterior border furrow is broad and deep, intersecting the facial suture near the midpoint of the limb.

The character of the associated free cheek is not clear because of poor preservation, but fragments appear to be like those illustrated by Walcott (1914, pl. 67, fig. 19) and

Ulrich and Resser (1933, pl. 35, figs. 2-4).

Remarks.--The features used by Ulrich and Resser to separate the "species" I have synonymized are a combination of glabellar furrows, glabellar shape, and frontal area configuration. All five "species" are associated with one another and many are from the same collections.

Four measured sections in central Texas yielded about 100 cranidia, 25 pygidia and 15 free cheeks of this variable taxon. Saukiella pyrene occurs above S. fallax and below S. pepinensis. Within this taxon, all the pygidia are remarkably similar and agree quite well with those Ulrich and Resser assigned to S. pyrene, S. signata, S. indenta, and S. norwalkensis. Most of the free cheeks are like those of S. pyrene and S. indenta; there are two that look like those assigned to S. norwalkensis.

The cranidia demonstrate the greatest amount of variation, but even this is restricted to the frontal area and glabella. The two end members with respect to variation in the frontal area (small ones with a biconvex frontal area and larger specimens with a planoconvex frontal area), and all gradations between them, occur together in numerous collections from all four sections. The outline of the glabella ranges from straight-sided and slightly tapering to medially constricted and anteriorly expanded; the anterior end of the

glabella ranges from broadly rounded to sharply truncated. There is always one pair of glabellar furrows and they are joined across the top of the glabella. On most specimens there is a second pair of furrows and these can be joined. A few specimens have a faint third pair that is anteriorly directed. I found no relation between number of glabellar furrows and shape of the glabella, and these features show no trend or separation with respect to stratigraphic position. I think that differences in the frontal area are a result of successive growth stages, and that variations as a whole fall within the realm of intraspecific variation.

From a comparison of the Texas collections with Ulrich and Resser's type material of all taxa in the synonymy, I conclude that the material before me belongs to one variable species, for which the appropriate name is Saukiella pyrene (Walcott). S. cf. pyrene, S. pyrene limbata, S. signata, S. indenta, S. indenta intermedia, S. frontalis and the three varieties of S. norwalkensis are junior synonyms of S. pyrene. This re-combination undoes all of Ulrich and Resser's splitting of Walcott's original Saukia pyrene.

Saukiella pyrene is distinguished from the stratigraphically lower S. fallax by the character of its frontal area, configuration of its glabella and glabellar furrows, and by the very slender posterior fixigenae. S. pyrene is distinguished from the stratigraphically higher S. pepinensis by its

markedly shorter (sag.) anterior border and by its possession of a definite preglabellar field. There are a few specimens from Bluff Creek section that suggest that S. pyrene is a derivative of S. fallax and is ancestral to S. pepinensis. The relative position of S. pyrene and S. pepinensis oppose Ulrich and Resser's statement (p. 204) that S. pyrene is a derivative of S. pepinensis; rather, they indicate that the reverse may be true.

The matrix in which Ulrich and Resser's type material occurs contains remains of other species that are associated in the Saukiella pyrene subzone: Illaenurus quadratus Hall, Plethometopus convergens Rasetti and a eurekaid that is either Bayfieldia binodosa (Hall) or Eurekia granulosa Walcott. The same taxa occur with S. pyrene in central Texas.

Occurrence.--Common to locally abundant in the Saukiella pyrene subzone at BC - 34, 36, 37-37.5, 41, 42, 41.5-44; JR - 394, 406.5; SPH - 86, 110, 114, 114.5, 140; TC - 1286, 1287.

SAUKIELLA SEROTINA Longacre, n. sp.

Pl. 6, Figs. 1-3.

Saukiella norwalkensis Ulrich and Resser, WINSTON AND NICHOLLS, 1967, p. 82, pl. 11, figs. 6-8, 12.

Description.--Cranidium low to moderately convex,

length about twice glabellar width. Glabella subrectangular or slightly tapered; anterior end moderately convex, broadly rounded, or truncated at its tip. Most specimens have only one glabellar furrow, generally a posteriorly-bowed transglabellar furrow that is deeply impressed laterally. Occipital furrow transverse or bowed forward medially, as well-impressed as the transglabellar furrow. Occipital ring as broad as posterior glabellar lobe. Anterior border furrow curved, convex anteriorly. Anterior border raised, slightly convex, of uniform width or slightly tapering. Preglabellar field of approximately the same length (sag.) as the border, flat to slightly concave, though on some specimens this area is ever so slightly convex and appears as an adaxial extension of the anterior fixigenae. Palpebral area about two-thirds glabellar length and one-third glabellar width, rising gently out of axial furrow. Palpebral lobes maintain great width except for slight tapering on anterior end; they are separated from fixigenae by distinct but narrow palpebral furrows. Posterior facial suture swings in close to axial furrow just behind the palpebral lobe, and then diverges, defining a very small posterior fixigena. Posterior limbs long and slender, angled slightly back, composed almost entirely of posterior border with only a very small posterior fixigena separated from the border by a short posterior border furrow. Anterior segment of the facial suture diverges moderately in front of the palpebral

lobes; after passing the anterior border furrow the suture swings adaxially. Bertillion pattern of ornament covers all areas of the exoskeleton and can be seen on some internal molds.

Librigenae (Winston and Nicholls, 1967, pl. 11, fig. 7) with sharply defined border furrow; border extends medially in front of facial sutures, maintains an even curvature back into long genal spine. Ocular field rises steeply above border furrow, covered with two intersecting sets of elongate ridges that do not seem to be preserved on internal molds. Ornament on border and genal spine unknown.

Pygidium (Winston and Nicholls, 1967, pl. 11, fig. 12) narrow and high for genus, with conical axis consisting of articulating half-ring, four axial rings, a long pointed terminal piece, and a short postaxial ridge. Pleural regions convex, with four pleurae subequally divided by deep pleural furrows that are nearly straight, that angle sharply back and fade out on a wide, nearly flat margin. Internal molds smooth; ornament on exoskeleton unknown.

Available material.--264 cranidia, 79 pygidia, most well preserved.

Holotype.--BEG 36560, from CC - 61.

Etymology.--serotinus, Latin, late; named for its

occurrence late in the Trempealeauan.

Remarks.--Although the Texas specimens may conform in part to the concept of Saukiella norwalkensis Ulrich and Resser (see Winston and Nicholls, 1967, p. 82), they do not conform entirely; the faunal associates are entirely different, and the type material cannot be included within the hypodigm at hand (see Remarks under S. pyrene). I have synonymized S. norwalkensis with S. pyrene, and here erect a new species that is similar to but distinct from S. pyrene. S. serotina is distinguished from the stratigraphically lower S. pyrene by its straight-sided, tapering glabella with only one glabellar furrow, the crescentic shape of its frontal area, the exceedingly wide palpebral areas of the fixigenae and palpebral lobes, its wider anterior fixigenae, and its distinctly different pygidium. In the upper part of its range, S. serotina is associated with S. planata. Some of the other faunal associates are Bayfieldia simata, Eurekia eos, three species of Calvinella, and Stenopilus latus.

Occurrence.--Common to locally abundant in the Saukiella serotina subzone at CC - 58, 58.2, 61, 63±; JR - 521.5, 529, 536; LC - 32; LCS - 33, 33.5, 35.7, 39, 40, 44, 45, 45.4, 52-54; SH - 52, 52.6, 54, 55, 61, 61.5-62; TC - 1379-1385, 1387.5, 1388, 1392, 1400. Rare in the Corbinia apopsis subzone at LC - 48.8; LCS - 53, 54.

Family REMOPLEURIDIDAE Hawle and Corda, 1847

Genus APATOKEPHALOIDES Raymond, 1924

Apatokephaloides RAYMOND, 1924, p. 425.

Type species.--Apatokephaloides clivosus RAYMOND, 1924, p. 425, pl. 13, fig. 13 (not fig. 17 = Bayfieldia ulrichi RASETTI, 1945b, p. 465 = Corbinia ulrichi (Rasetti) WINSTON AND NICHOLLS, 1967, p. 85).

Remarks.--Although Raymond's description (1924, p. 425) is brief, he does emphasize differences between Apatokephaloides and Apatokephalus. Inadvertently, Apatokephaloides is not mentioned in the Treatise (Harrington, et al., 1959). However, Rasetti (1959, p. 387) assigned this genus to the Remopleurididae, and I have followed him in that assignment.

APATOKEPHALOIDES CLIVOSUS Raymond

Apatokephaloides clivosus RAYMOND, 1924 (part), p. 425, pl. 13, fig. 13 (not fig. 17 = Bayfieldia ulrichi RASETTI, 1945b, p. 465 = Corbinia ulrichi (Rasetti) WINSTON AND NICHOLLS, 1967, p. 85); RASETTI, 1963, p. 1010, pl. 130, figs. 19, 20; WINSTON AND NICHOLLS, 1967, p. 86, pl. 11, fig. 11.

Remarks.--This is the second most abundant taxon in the Corbinia apopsis subzone, and is distinguished from C. apopsis by its glabellar furrows that are more like gouges,

by its greatly expanded palpebral lobes that almost or completely isolate the palpebral area of the fixigenae from the rest of the fixigenae, and by its depressed preglabellar field that is long (sag.) relative to the length of the raised border.

Occurrence.--Abundant in the Corbinia apopsis subzone at CC - 67; LC - 48; SH - 72; SS - 411; LCS - 53, 53.3, 53.5, 53-54, 55.

Genus IDIOMESUS Raymond, 1924

Idiomesus RAYMOND, 1924, p. 397; RASETTI, 1946, p. 538; Poulsen in HARRINGTON, et al., 1959, p. 0245.

Stigmametopus RASETTI, 1944, p. 257.

Type species.--Idiomesus tantillus RAYMOND, 1924, p. 397, pl. 12, fig. 10.

Remarks.--Poulsen (in Harrington, et al., 1959, p. 0245) briefly summarizes the characteristics of this genus.

Although I recognize three species of Idiomesus, I. infimus, n. sp., I. intermedius Rasetti, and I. levisensis (Rasetti), I am not entirely convinced they are congeneric with I. tantillus. With respect to I. tantillus, I had the opportunity to examine the holotype (Yale Peabody Museum no. 4726), several plesiotypes (Laval Univ. nos. 1042 a-b) and

several specimens in Raymond's support collections (now at Harvard, Museum of Comparative Zoology). I. tantillus has two unique features: no lateral glabellar pits, and thin, elevated posterior borders that continue across into the thin occipital ring without being interrupted by the axial furrows. At least 5 totally unfamiliar taxa were associated with the specimens of I. tantillus. The type locality for this species is the upper zone of the Gorge Formation at Highgate Falls, Vermont. I. tantillus may be a member of an extra-cratonic faunal complex. If future studies of I. tantillus, in both biostratigraphic and lithostratigraphic frameworks, indicate that it could be spatially, temporally and possibly genetically related to the marginal cratonic species included in the genus, then my doubts are without foundation. If such a relationship cannot be postulated, Stigmametopus Rasetti (1944, p. 257) should be resurrected for the marginal cratonic species. Spatially, temporally, and morphologically the marginal cratonic species could be related to the Ptychaspidae.

IDIOMESUS INFIMUS Longacre, n. sp.

Pl. 2, Figs. 15-19.

Description.--Cranidium semielliptical, moderately convex. Glabella transversely convex; posterior half of glabella parallel-sided or slightly tapering, whereas the anterior half

is markedly tapered; anterior end truncate; width across base three-quarters glabellar length. Posterior glabellar furrow continuous, laterally deep and angled back, shallower and transverse across the axis. Second and third pairs of furrows are laterally impressed notches on the sides of the glabella; the posterior pair of notches may be as deep or deeper than the anterior pair. Axial furrow very broad posteriorly, becomes narrower and steeper-sided anteriorly; preglabellar furrow ranges from moderately impressed to obscure. Occipital furrow deep and oblique laterally, shallower and either transverse or bowed forward across the axis. Occipital segment medially expanded, posteriorly elevated and longer (sag.) than the preoccipital glabellar segment; occipital node may be present. Frontal area gently convex, unfurrowed, downsloping. Anterior fixigenae as wide as frontal area is long, posteriorly increasing in convexity and height above axial furrow. Behind a faint ocular ridge the fixigenae are very broad and convex, with steeply downsloping lateral margins. Palpebral lobes apparently absent. Posterior border furrow very wide, deep, and gently curved posteriorly. Posterior border seems to widen laterally. Anterior facial sutures smoothly curved from ocular ridges to the axial line. Behind area where eyes would be located, the posterior facial sutures diverge and curve broadly to the posterior margin. A row of widely-spaced low granules rim the interior edges of the fixigenae; one or

more granules can ornament the preoccipital glabellar segment. Very fine concentric Bertillion lines cover the margins of the fixigenae and frontal area. Some or all of this ornament may be transmitted to the internal mold. Several molds have a rough surface texture that could be granules or a precipitate; one of these rough surfaces has so regular a pattern as to suggest granulation. The occipital segments of one or two molds appear to be pitted.

Librigena and pygidium unknown.

Available material.--10 cranidia, most poorly preserved.

Holotype.--BEG 36497, from TC - 1242.

Etymology.--infimus, Latin, lowest; named for its being the stratigraphically lowest species of Idiomesus in central Texas.

Remarks.--Idiomesus infimus is characterized by its stout, blunt glabella with two pairs of lateral glabellar pits, its medially expanded and elevated occipital segment, very wide posterior axial furrow, and granules on the inside edges of the fixigenae. These features easily separate I. infimus from I. tantillus Raymond and I. intermedius Rasetti. I. infimus is differentiated from the very similar I. levisensis (Rasetti) by its relatively shorter and wider glabella,

broader posterior axial furrows, more convex, ornamented and elevated fixigenae, and by the more medially expanded occipital segment.

I. infimus occurs in the highest Ellipsocephaloides zone collections from three measured sections; faunal associates are Briscoia sp. and Prosaukia cf. P. tuberculata. Fifty to ninety feet of nontrilobite bearing rock intervene between this species and the lowest Saukia zone collections. Both I. levisensis and I. intermedius occur in the Saukia zone.

Occurrence.--Rare in the upper Ellipsocephaloides zone at JR - 284.5; MC - 862; TC - 1142, 1145.

IDIOMESUS INTERMEDIUS Rasetti

Pl. 4, Figs. 13, 14.

Idiomesus intermedius RASETTI, 1959, p. 393, pl. 51, figs. 25, 26; WINSTON AND NICHOLLS, 1967, p. 73, pl. 10, fig. 21.

Remarks.--Idiomesus intermedius is well represented in the Texas collections. There is some variation in number of lateral glabellar pits, ranging from no pits in two poorly preserved specimens, 34 with a suggestion of one pair of pits, 115 with one very distinct set of pits, and 56 with one distinct set of lateral glabellar pits and a faint to good indication of a second set of pits. Very generally, there is a stratigraphically upward trend toward fewer sets of glabellar

pits, whether they be distinct or obscure.

Ornament on exoskeleton consists of a Bertillion pattern on the fixigenae that originates in the axial furrows, that is directed forward and outward on the adaxial slope of the cheek, and that swirls around and becomes roughly parallel to the cranidial outline on the abaxial slope of the cheeks. Some of the pattern of the abaxial slope of the fixigena is continued around onto the frontal area. On internal molds, Bertillion pattern is vaguely apparent all around the margin of the cranidium and up onto the crests of the fixigenae. The adaxial slope of the fixigena is finely pitted, and some specimens possess an occipital node.

Stitt (1968) has good collections of Idiomesus comparable to those in central Texas. He has noticed a similar stratigraphic trend in the number of lateral glabellar pits, and ornament is similar. Because Stitt feels that I. levisensis and I. intermedius are members of the same variable species, he has synonymized the two under I. levisensis.

Occurrence.--Rare in the Saukiella junia subzone at BC - 109-110. Abundant in the Saukiella serotina subzone at BC - 149; CC - 61, 63±; JR - 521.5, 529, 532; LCS - 32.4, 34-36, 39, 40, 44, 45, 45.4, 45.8, 52-54; SH - 54, 58.5-60, 61.5, 61.5-62; SS - 375; TC - 1379-1385, 1392, 1394, 1400. Rare in the Corbinia apopsis subzone at CC - 67; JR - 539, 540; LCS -

55.5; SS - 411.

IDIOMESUS LEVISENSIS Rasetti

Pl. 3, Figs. 6, 7.

Stigmametopus levisensis RASETTI, 1944, p. 257, pl. 37, figs. 8, 9.

Idiomesus levisensis (Rasetti) RASETTI, 1946, p. 539.

Remarks.--Idiomesus levisensis is rare in the Saukiella pyrene and Saukiella junia subzones, and occurs stratigraphically below I. intermedius. Examination of Rasetti's and Raymond's types confirms the specific identification. I. levisensis is distinguished from I. intermedius Rasetti and I. tantillus Raymond, not only by its two distinct pairs of glabellar pits, but also by the relationship between the posterior half of the axial furrow and the fixigenae. In I. intermedius and I. tantillus the fixigenae rise immediately from a distinct axial furrow, giving the fixigenae the appearance of wrapping around the glabella. I. levisensis has a distinct axial furrow along the anterior half of the glabella, but it broadens posteriorly and merges with the fixigenae, so that it is difficult to find a furrow along the posterior half of the glabella. In that posterior region the adaxial parts of the fixigenae are triangular, nearly flat shelves that slope gently down and intersect the glabella. These regions are in deep shadow in Rasetti's figures. These triangular

regions can be pitted. Although it is difficult to see, there is a faint axial line or depression on the front of the glabella (pl. 3, fig. 7). This depression is also faintly impressed on the holotype of I. intermedius.

The glabella of I. levisensis is somewhat distinctive in that the posterior sides are nearly parallel or slightly divergent anteriorly, but anterior to the glabellar pits the sides are markedly convergent.

Stitt (1968) has recognized this species in his Oklahoma material. Paleontologically, his taxon includes the two forms that here are assigned to I. intermedius and I. levisensis; the latter form is very rare in his material.

Occurrence.--Rare in the Saukiella pyrene subzone at BC - 23, 41, 42; JR - 369.5; SPH - 85.5. Rare in the Saukiella junia subzone at JR - 453, 460.

Family Uncertain

Genus BOWMANIA Walcott, 1925

Bowmania WALCOTT, 1925, p. 73; Rasetti in HARRINGTON, et al., 1959, p. 0517.

Type species.--Arethusina americana WALCOTT, 1884, p. 62, pl. 9, fig. 27.

Remarks.--The diagnosis by Rasetti (in Harrington, et al., 1959, p. 0517) summarizes the characteristics of this

genus.

BOWMANIA AMERICANA (Walcott)

Arethusina americana WALCOTT, 1884, p. 62, pl. 9, fig. 27.

Bowmania americana (Walcott) WALCOTT, 1925, p. 73, pl. 15, figs. 15, 16; WINSTON AND NICHOLLS, 1967, p. 89, pl. 10, fig. 18.

Remarks.--This species is represented by 11 cranidia from three measured sections. Exfoliated specimens exhibit an ornament ranging from fine granules to a fine vermiform ridge pattern; some specimens also have coarse pustules scattered on the fixigenae posterior to the ocular ridges, and a few pustules on the anterior fixigenae or preglabellar field.

Bowmania americana is distinguished from B. sagitta Winston and Nicholls by its smoothly rounded frontal margin, tapering glabella, flat border, and gentle convexity. The only consistent difference between B. americana and B. pennsylvanica Rasetti is the tapering glabella of the former versus the anteriorly expanded glabella of the latter.

B. americana and B. pennsylvanica are stratigraphic associates, and the separation into two species may prove to be artificial. The material in Texas does not yet permit the two to be combined.

Occurrence.--Rare in the Saukiella serotina subzone

at CC - 63±; LCS - 40, 45.8; SH - 52, 54, 55, 61.5-62.

BOWMANIA PENNSYLVANICA Rasetti

Pl. 6, Figs. 4, 5.

Bowmania pennsylvanica RASETTI, 1959, p. 395, pl. 55, figs. 1-5, text-fig. 1.

Remarks.--Eight cranidia from two measured sections are assigned to this species. They all have the anteriorly expanded glabella, strong convexity, coarse granules, and narrow, convex border characteristic of this species. Although Bowmania pennsylvanica occurs with B. americana and ranges close to B. sagitta, it is distinguished from the former by its expanded glabella, granules, convexity, and narrow border, and from the latter by its smoothly rounded anterior margin of the cranidium.

Occurrence.--Rare in the Saukiella serotina subzone at CC - 58.2, 61, 63; LCS - 40.

BOWMANIA SAGITTA Winston and Nicholls

Bowmania sagitta WINSTON AND NICHOLLS, 1967, p. 89, pl. 10, figs. 19, 20.

Remarks.--All parts of the cranidium can be covered with scattered, medium-sized granules. On the anterior fixigenae and preglabellar field a subtle vermiform ridge pattern

occurs between the granules and is directed toward the anterior border furrow. This pattern becomes more distinct in a band posteriorly adjacent to the anterior border furrow; few or no granules are in this area, and the posterior edge of the band is delineated by a slight ridge. The band can be seen in Winston and Nicholls' fig. 20 of a paratype, and is present also in the holotype (fig. 19), although it is not evident in the illustration.

Occurrence.--Locally common in the Saukiella serotina subzone at LCS - 45, 45.4, 45.8, 52-54; SH - 58.5-60, 61.5-62, 65.5; TC - 1392, 1400.

Genus DELLEA Wilson, 1949

DELLEA? PUNCTATA Palmer

Pl. 1, Fig. 1.

Dellea? punctata PALMER, 1965, p. 84, pl. 3, fig. 8.

Remarks.--Two specimens from the Eoorthis coquina in two measured sections are assigned to this species. Although the pitted surface is difficult to see on one specimen, both have the bluntly rounded glabella and fossulae characteristic of the species. The brim-border ratio of one specimen is about 2:1; the ratio is about 1:1 in the other.

Stitt (1968) has found Dellea? punctata in the Irvingella coquina in Oklahoma. Although the specimens recorded

here came from the stratigraphically higher Eoorthis coquina in central Texas, the species may range below that horizon.

I have followed Palmer (1965) in his familial assignment of Dellea.

Occurrence.--Rare at the base of the Parabolinoides subzone at LL - 671.8; WC - 889.

Genus ELLIPSOCEPHALOIDES Kobayashi, 1935

Ellipsocephaloides KOBAYASHI, 1935b, p. 196; RESSER, 1942b, p. 62; Rasetti in HARRINGTON, et al., 1959, p. 517.

Type species.--Ellipsocephalus curtus WHITFIELD, 1878, p. 58; 1882, p. 191, pl. 1, fig. 18.

Remarks.--The description by Resser (1942b, p. 62) and Rasetti (in Harrington, et al., p. 0517) summarize the characteristics of this genus.

ELLIPSOCEPHALOIDES SILVESTRIS Resser

Ellipsocephaloides silvestris RESSER, 1942b, p. 64, pl. 11, figs. 1-3; pl. 12, fig. 7; BELL AND ELLINWOOD, 1962, p. 406, pl. 59, figs. 10-12 (synonymy to date); GRANT, 1965, p. 143, pl. 14, fig. 31.

Remarks.--Ellipsocephaloides silvestris is characterized by a frontal area divided into a convex preglabellar field and a downsloping anterior border by a faint anterior

border furrow that is slightly raised and posteriorly pointed on the axial line. This furrow is difficult to find on specimens preserved in siltstone. Because the ocular ridges in the Texas specimens range from distinct to weak, I agree with Bell and Ellinwood that E. nitela Resser, 1942b, is synonymous with E. silvestris.

Occurrence.--Rare but locally common in the Ellipsocephaloides zone at EC - 55, 60; GR - 204, 210, 214; JR - 210, 232, 233, 255; LL - 750; MC - 750; SS - 138.5.

Genus HETEROCARYLON Raymond, 1937

Heterocaryon RAYMOND, 1937, p. 1119.

Type species.--Heterocaryon platystigma RAYMOND, 1937, p. 1119, pl. 3, fig. 13.

Remarks.--The original description by Raymond (1937, p. 1119), the brief description by Rasetti (1944, p. 241), and the excellent description by Winston and Nicholls (1967, p. 76) summarize all that is known of this rather rare genus.

HETEROCARYLON cf. H. TUBERCULATUM Rasetti

Heterocaryon tuberculatum RASETTI, 1944, p. 241, pl. 36, fig. 55.

Heterocaryon cf. H. tuberculatum Rasetti, WINSTON AND NICHOLLS,

1967, p. 76, pl. 11, figs. 15, 18.

Remarks.--Because I think that Rasetti's figured holotype of Heterocaryon tuberculatum, which I have not seen, is both incomplete and partly covered with matrix, the Texas cranidia are assigned to his species with uncertainty. The taxon is represented by only three cranidia from one measured section, and it is characterized by its tumid to overhanging, anteriorly expanded glabella, the pitted anterior border furrow, coarse granular ornament, deeply notched glabellar furrows, and elevated fixigenae. H. cf. H. tuberculatum is distinguished from Bowmania pennsylvanica by its steeply down-sloping frontal area, glabella that rises vertically out of or overhangs the circumglabellar furrows, and the higher, more convex fixigenae.

Because I think this genus is closely allied to Bowmania and because I am uncertain about familial affinities of either of them, neither is assigned to a family.

Occurrence.--Rare in the Saukiella serotina subzone at TC - 1392, 1400.

Genus MONOCHEILUS Resser, 1937

Monocheilus RESSER, 1937, p. 19; BELL, FENIAK, AND KURTZ, 1952, p. 119; GRANT, 1962, p. 995.

Type species.--Conocephalites anatinus HALL, 1863, p. 153, pl. 7, figs. 34, 35.

Diagnosis.--Medium cranidium with large anteriorly rounded or truncate glabella; glabellar furrows faint to absent. Anterior border furrow very faint to absent. Fixigenae narrow. Palpebral lobes broad, arcuate, from one-half to almost the full length of the glabella. Posterior limbs narrow. Surface smooth or granulate.

Remarks.--As Nelson (1951, p. 778); Bell, Feniak, and Kurtz (1952, p. 19); and Grant (1962, p. 995) state, Monocheilus is similar to Stigmacephalus, but differs from it in having longer palpebral lobes and narrower posterior limbs. Spatially and temporally the two could be genetically related, but Grant (1962, p. 995) describes significant differences between them and between Monocheilus and most other genera of the Anomocaridae. It is interesting that, according to the Treatise, Monocheilus is the only Upper Cambrian, North American genus in the family; four other Upper Cambrian genera are from Korea, China, and Russia; the rest of the family is Middle Cambrian. Because of morphological and spatial differences from the rest of the family, I have followed Grant (1962) in not assigning Monocheilus to any family.

MONOCHEILUS TRUNCATUS Ellinwood

Monocheilus truncatus Ellinwood in BELL AND ELLINWOOD, 1962, p. 389, pl. 52, figs. 1-3.

Remarks.---This species, one of the markers for the Saukiella pyrene subzone in central Texas, is characterized by its low convexity, shallow furrows, nearly quadrate glabella with a rounded-truncate anterior end, very narrow fixigenae, and wide, arcuate palpebral lobes. There is a moderate amount of variation in the degree of truncation of the glabella and also in the degree of anterior tapering of the glabella. Because I view these differences in terms of intra-specific variation I have not segregated the few variants. Many specimens in the two collections from the Camp San Saba measured section are granulate on all parts of the cranidium except the palpebral lobes. The furrows on internal molds are deeper than on the exoskeleton.

Stitt (1968) records Monocheilus truncatus from the lower part of the Saukia zone, and a new species from the Saukiella junia subzone.

Occurrence.---Common at the base of the Saukiella pyrene subzone at BC - 23, 34, 41, 42; JR - 351, 357; MC - 915±; SPH - 87, 93, 96.5; SS - 302.5, 307.5; TC - 1233, 1237, 1268.

Genus TAENICEPHALINA Rasetti, 1945

Taenicephalina RASETTI, 1945b, p. 473; Lochman in HARRINGTON, et al., 1959, p. 0309.

Type species.--Taenicephalina lechevalieri RASETTI, 1945b, p. 473, pl. 62, figs. 6-8.

Remarks.--The descriptions by Rasetti (1945b, p. 473; 1963, p. 1012), combined with that of Lochman and Hu (1959, p. 424), summarize the characters of the genus. The indefinite familial assignment follows that of Lochman and Hu (1959).

TAENICEPHALINA GLOBULA Lochman and Hu

Taenicephalina globula LOCHMAN AND HU, 1959, p. 424, pl. 57, figs. 34-43; BELL AND ELLINWOOD, 1962, p. 406, pl. 59, figs. 13-15.

Remarks.--Fourteen small cranidia from four measured sections are assigned to this species. Between Lochman and Hu and Bell and Ellinwood, the species is well described and illustrated. The cranidia are not well enough preserved to show ornament.

Taenicephalina globula is distinguished from T. lechevalieri Rasetti (1945b, p. 473, pl. 62, figs. 6-8; 1963, p. 1012, pl. 130, figs. 1-4) by more distinct furrows and an anterior border furrow that, viewed from the front, rises to a point on T. globula but is gently arched on T. lechevalieri.

The anterior border and furrow of T. globula and T. levisensis (Rasetti) (1963, p. 1012, pl. 130, figs. 5-9) are similar, but T. globula has a longer (sag.) preglabellar field, wider fixigenae, and less distinct glabellar and circumglabellar furrows.

T. globula occurs in association with Drumaspis texana and ranges into the zone of transition from D. texana to D. idahoensis.

Occurrence.--Rare in the Idahoia zone at CR - 743-747; JR - 195.5; TC - 1009; WC - 968.

Genus WESTONASPIS Rasetti, 1945

Westonaspis RASETTI, 1945b, p. 474; in HARRINGTON, et al., 1959, p. 0521.

Type species.--Westonaspis laevifrons RASETTI, 1945b, p. 475, pl. 62, figs. 16, 17.

Remarks.--Both of Rasetti's diagnoses summarize the characteristics of this genus.

WESTONASPIS? TEXANA Longacre, n. sp.

Pl. 6, Figs. 16-18.

Description.--Cranidium wider than long, transversely convex. Glabella moderately convex, slightly tapered, slightly rounded to truncate anteriorly. Two or three pairs of faint

glabellar furrows are present; the posterior pair is short, shallow, and angles posteriorly, almost isolating triangular basal lobes; second and third pairs are shallow, broad lateral notches. Axial furrow wide and deep posteriorly, becoming shallower and narrower anteriorly; very shallow preglabellar furrow. Occipital furrow deep, with the lateral ends angled forward. Occipital ring broadest in the center, narrow and curved forward laterally. Fixigenae wider than one-half glabellar width, rise sharply out of the axial furrows, slope downward laterally. Fixigenae crossed by faint ocular ridges that merge into short, upraised palpebral lobes that are opposite or anterior to the glabellar midpoint. Preglabellar field short, moderately convex, with shallow axial groove between glabella and anterior border. Thin, convex and laterally tapered anterior border well-defined by transverse anterior border furrow that may be slightly recurved medially, making the border appear to be pointed or expanded on its posterior edge. Anterior facial sutures convergent, broadly rounded. Posterior facial sutures directed straight laterally behind palpebral lobes, defining wide (tr.), very stout posterior limbs with a length (exsag.) about one-half that of the cranidium, and a transverse width about 1.5 times the width of the occipital ring. Posterior border furrow deep, becoming broader and shallower as it gently curves backward; posterior border broadens and flattens laterally. Low

scattered granules on glabella, preglabellar field, fixigenae and posterior limbs.

Librigena and pygidium unknown.

Available material.--3 cranidia.

Holotype.--BEG 36574, from SS - 411.

Etymology.--texana, named for its occurrence in Texas.

Remarks.--The cranidia upon which Westonaspis? texana is based are very similar to W. laevifrons Rasetti (1945a, b), except in the character of the frontal area, the wider fixigenae, the more anterior eyes, and the lesser curvature of the posterior limbs. I have assigned this species to the heretofore monotypic Westonaspis, but the assignment is tentative because of the anterior border furrow in the Texas specimens, a feature that is lacking in Rasetti's species, and because the Texas cranidia exhibit a slight axial groove across the preglabellar field.

Occurrence.--Rare in the Corbinia apopsis subzone at SS - 411.

STATISTICAL ANALYSES OF TREMPPEALEAUAN TRILOBITE RANGES

Introduction

In 1964 Alan B. Shaw published Time in Stratigraphy, a book that proposed to show 1) that because most rock units are diachronous, fossils should be used in time correlations, 2) that all of the presently used paleontologic methods are deficient in some way or another for use in time correlations, and 3) that his new correlation technique establishes an absolute chronologic basis for the use of fossils in time correlations. Shaw explains his technique in detail, its logic, statistics, graphics, and demonstrates its use by applying it to published faunal data from the Upper Cambrian Riley Formation of central Texas (Palmer, 1955a).

After carefully reading Time in Stratigraphy, particularly chapters 19 to 29, I think there is very little of logical, statistical or geologic value in his correlation technique. Despite my conclusions based on the reading, I will apply a modified version of Shaw's method to my data on Trempealeauan trilobites from the San Saba member of the Upper Cambrian Wilberns Formation of central Texas. This segment of my dissertation is designed to present Shaw's method, his statistical models, an analysis of my data using his methods, an alternate method for analysis, and to demonstrate to any reader the bases for my conclusions.

Shaw's Correlation Technique

The ultimate goal of Shaw's method is to compound faunal data from many sections into one standard of reference that is more complete and more reliable than any single contributing section, because this standard encompasses information from all the sections. This construction is called the Composite Standard (CS) and it provides the means for establishing total stratigraphic ranges of species. The Composite Standard is the basis for Shaw's time-of-flooding maps, shoreline maps, and Riley Standard Time. The following is a summary outline of Shaw's logic and technique. For an expanded explanation I refer you to Time in Stratigraphy, chapters 19 to 29.

If in two ideal sections the species-ranges are true ranges, a graphic plot of range bases and tops will yield a straight line, the slope of which is a numerical expression of the relative rates of accumulation in the two sections. Paleontologists seldom work with such ideal faunal data and sections. Because of circumstances both within and beyond control, we usually work with incomplete faunal range data. The more incomplete the range data, the higher the degree of scatter of points around the theoretical "line," and the more we must rely on estimates and/or statistical methods to find such a line. Shaw's method involves a regression analysis of

range data from two or more sections in order to find the line that best fits the data. Range values from one section can then be translated into the terms of another section, and the two sets of values compared.

The most basic and demanding requirement of this technique is a wealth of data on first and last occurrences of taxa in several measured sections. The accuracy of these data are only as high as the accuracy of the measuring of the section, the completeness of collecting, and the consistency of identification. These data are tabulated for each of the sections to be used.

From all the sections available for analysis, one must be selected as a standard for comparison. This standard section should yield the greatest amount of useful faunal information. It should include species whose ranges originate and terminate within the section, species that are common to many sections, and species that are sufficiently abundant so that the total stratigraphic ranges can be determined with reasonable accuracy (Shaw, 1964, p. 133). This standard should be the most detailed section and it should be unfaulted. To save time and work, the standard section should not produce a dog-legged pattern when graphed against other sections; such a pattern indicates a change in the relative rate of accumulation, and this would almost double the calculation time. In order to avoid negative numbers in the

calculations, the standard section either must have the oldest rocks at its base, relative to the other sections, or an arbitrary interval should be added to the base of this section.

Only one assumption is made concerning the standard section, and here Shaw begins to go astray. With respect to accumulation, he states (p. 134) that "The rate at the standard is constant by definition." By correlating all other sections with the standard, Shaw surmises that the thickness of the standard section is established as a measure of time. Using the equation

$$\text{Distance} = \text{Rate} \times \text{Time}$$

and arbitrarily setting rate at the standard section equal to unity, the equation becomes

$$\text{Distance} = \text{Time} \quad \text{or} \quad \text{Thickness} = \text{Time}.$$

Because rate is defined as constant, any increment of thickness in the standard section equals any other equal increment in that section, and they represent equal increments on the time scale (p. 131-132). He goes on to say that time is measured by the amount of time required to accumulate some increment of rock-thickness in the standard section, but that time is not measured in feet--rock units have been reduced to unit time-equivalents, and these unit time-equivalents are expressed

as "units," not in years, not in feet, but merely as units. This is his second major straying, because to me he is still saying feet of rock equal time. Setting his logic aside, let's see what can be done with his statistical method.

Once the standard section has been selected, all other sections are ranked in descending order of relative completeness of faunal data. These sections are numbered, starting with 2 for the second best section.

The first step in the statistical analysis is a graphic plotting of bases and tops of ranges of taxa common to both the standard and the second most complete section. Footages from the standard section are marked along the X-axis, and footages from the second section on the Y-axis. To graph taxon A's range, its base is plotted as a point (dot), with its stratigraphic position in the standard section as its X-coordinate, and its stratigraphic position in section 2 as its Y-coordinate. The top of the range is a point (cross), with the X-coordinate being the top of its range in the standard section and the Y-coordinate being the top of its range in section 2. All taxa common to both sections are plotted in the same manner.

After all the taxa have been plotted, certain points are eliminated from consideration for calculation. If such a point was noticeable separated from the main array, Shaw usually found some reason to discard it. Although I could find

little or no justification for most of the eliminations, I do agree that if a taxon has a unique occurrence (one collection at only one stratigraphic horizon) in both sections being compared, this taxon should not be considered in the calculation for the line of best fit.

Using the formulas that appear on following pages, Shaw calculated the regression equations (his Equation of Correlation) that fit the data, and on the graphs of bases and tops he plotted the x-dependent-on-y regression line (his Line of Correlation). He then substituted all the range-base and range-top values from section 2 into the x-on-y regression equation, and derived a series of range-base and range-top values that he calls standard equivalents--range values from section 2 that are numerically equivalent to footages in the standard section. In effect this projects the ranges from section 2 into the standard section, and does so in terms of the standard section footage numbers.

After substitutions are completed and the results tabulated, the first Composite Standard is established, CS 1-2. If a taxon occurs in one section and not the other, the Composite Standard values for range are identical to those of the section in which the taxon occurs (see taxa A and B in Table 3). This constructed CS 1-2 is the Composite Standard that is supposed to be more precise and reliable than either of the two contributing sections.

Table 3. Illustration of how the Composite Standard range values are determined from the analysis data.

Taxa	Standard Section		Section 2 Standard Equivalents		Composite Standard 1-2	
	B	T	B	T	B	T
A	1200	1350			1200	1350
B			1212	1278	1212	1278
C	1325	1400	1350	1461	1325	1461
D	1280	1400	1265	1399	1265	1400

From this point on, the Composite Standard is the reference section, and it is plotted on the X-axis when compared with another section, which is plotted on the Y-axis. Each regression analysis will modify the "old" CS and result in a "new" standard for comparison. In other words, comparison of CS 1-2 with section 3 will yield CS 1-3, and so forth, until all sections have been analyzed and have contributed to the formation of the CS 1-x.

Although the regression analyses can be treated graphically and/or statistically, only the statistical methods are used in this paper. The results of the analyses are shown in Plate 8 (pocket).

Statistical Methods

SHAW'S STATISTICAL METHODS

The statistical formulas that Shaw used for his regression analysis are cumbersome when using a desk calculator (he used a digital computer) and were difficult if not impossible to find in standard statistics textbooks. He gives no source for his formulas. The only method common to our calculations is that for calculation of the correlation coefficient:

$$r = \sqrt{b_1 b_2}.$$

I did not use his regression analysis method, but his formulas are

$$\begin{aligned} Y &= a_1 + b_1 X \\ &= \bar{Y} + \frac{\sum (X - \bar{X}) (Y - \bar{Y})}{\sum (X - \bar{X})^2} (X - \bar{X}) \end{aligned}$$

$$\begin{aligned} X &= a_2 + b_2 Y \\ &= \bar{X} + \frac{\sum (X - \bar{X}) (Y - \bar{Y})}{\sum (Y - \bar{Y})^2} (Y - \bar{Y}). \end{aligned}$$

I did not use and could not find anything even remotely resembling the formulas Shaw used for Standard Error of Estimate. Allowing for a printing error, his formulas are

$$s_y = \sqrt{\frac{\sum (Y - \bar{Y})^2}{N}}$$

$$s_x = \sqrt{\frac{\sum (X - \bar{X})^2}{N}}$$

STATISTICAL METHODS USED IN THIS PAPER

The formulas used for the least squares method of line of best fit (regression analysis) can be found in Simpson, Roe and Lewontin (1960). The equations for the regression lines are

$$Y = \alpha_y + \beta_{yx} X \quad \text{or} \quad Y = a_y + b_{yx} X \quad (\text{estimators})$$

$$X = \alpha_x + \beta_{xy} Y \quad \text{or} \quad X = a_x + b_{xy} Y \quad (\text{estimators})$$

where X = standard section or Composite
Standard range values

Y = range values in the compared
section

a_x = x-intercept

a_y = y-intercept

b_{xy} = slope of line, x-dependent-on-y

b_{yx} = slope of line, y-dependent-on-x

N = size of sample

$$b_{yx} = \frac{\sum (X - \bar{X}) (Y - \bar{Y})}{\sum (X - \bar{X})^2}$$

$$= \frac{\sum XY - \frac{\sum X \sum Y}{N}}{\sum X^2 - \frac{(\sum X)^2}{N}}$$

$$b_{xy} = \frac{\sum (X - \bar{X}) (Y - \bar{Y})}{\sum (Y - \bar{Y})^2}$$

$$= \frac{\sum XY - \frac{\sum X \sum Y}{N}}{\sum Y^2 - \frac{(\sum Y)^2}{N}}$$

$$a_y = \bar{Y} - b_{yx} \bar{X}$$

$$a_x = \bar{X} - b_{xy} \bar{Y}$$

Identical results were achieved when a dummy set of data were used in Shaw's formulas and in the ones above. For the calculation of confidence intervals, Standard Error of Estimate is required, and these can be found by using

$$s_{yx}^2 = \frac{N-1}{N-2} (s_y^2 - b_{yx}^2 s_x^2) \quad s_{xy}^2 = \frac{N-1}{N-2} (s_x^2 - b_{xy}^2 s_y^2)$$

where s_x = standard deviation of range values
in standard section

s_y = standard deviation of range values
in compared section

s_{xy} = standard error of estimate of x-on-y
regression

s_{yx} = standard error of estimate of y-on-x
regression.

Confidence intervals are found by using

$$b_{yx} \pm \frac{t s_{yx}}{s_x \sqrt{N-1}}$$

$$b_{xy} \pm \frac{t s_{xy}}{s_y \sqrt{N-1}}$$

$$a_y \pm t s_{yx} \sqrt{\frac{1}{N} + \frac{x^2}{(N-1)^2 s_x^2}}$$

$$a_x \pm t s_{xy} \sqrt{\frac{1}{N} + \frac{y^2}{(N-1)^2 s_y^2}}$$

Degrees of freedom = N-2.

Analyses of Trempealeauan Trilobite Ranges

The fossil material that provides the data for the analyses are from the San Saba member of the Wilberns Formation.

Only the range data for trilobite species are used. The alphanumeric designations for collections are identical to those used in the systematic descriptions; the initials refer to a unique measured section, and the number represents footage above the base of the section.

Once the trilobites were prepared and identified, collection and occurrence data were tabulated for each measured section. Subsequently, a chart of only bases and tops of species-ranges was made for each section, and these are the basic data compiled in Appendix A. Species were arbitrarily assigned a number from 1 to 54.

Creation of the Composite Standard (CS 1-9)

Using Simpson, Roe and Lewontin's formulas for the least squares method for the line of best fit, and following Shaw's pattern for analysis, I performed a series of regression analyses on the data of Appendix A. Appendix B contains the results of the analyses that will be used in the construction of the CS 1-9, with the information and modifications from all sections included in it. Each column represents the bases of ranges (left half of Appendix) or the tops of ranges (right half) that resulted from the x-dependent-on-y regression analysis of the reference section and another section. The marginal totals represent the bases and tops of ranges in

the CS 1-9. These marginal totals will be compared with a second set of range values derived from my modification of Shaw's method.

An Alternative to Shawian Statistics

Because Shaw's pattern for analysis was beyond comprehension, and in an effort to salvage something from his method, I tried comparing only two sections at a time, and doing a regression analysis on the faunal data from the two sections. The standard section, Threadgill Creek (TC), was compared with the other eight sections individually; eight separate regression analyses yielded eight pairs of regression equations, and eight sets of modifications of Threadgill Creek-ranges were generated. Range values from the first comparison, Threadgill Creek and (Upper) James River, are identical for this technique and for the creation of CS 1-2, but results of all other two-section comparisons differ from those of the CS data. Appendix C compiles the results from the eight two-section analyses, using the same format as Appendix B. The marginal totals represent the highest top and lowest base for each species-range, selected from the range values generated by the analysis.

Comparison of the Results of the Two Techniques

Appendix D contains a tabulation of the range data from the Composite Standard 1-9 and from the two-section comparisons. These two sets of range values are illustrated on Plate 8 (pocket), along with an intuitive set of range values. Differences between the two sets of calculated range values are not great. Evident on the diagram and in the tabulated data is that generally, when they differ, the CS 1-9 bases are higher and tops are lower than those of the two-section comparisons. About 40% of the two sets of calculated range-bases and range-tops are identical; approximately 25% have differences of three feet or less, which is the size of the error that had to be built into the standard section. Differences on the order of 20 to 28 feet all came from calculations with the Camp San Saba (SS) data; when these greatly different values are compared with the intuitive ranges of Plate 8, the Shawian range value is the one out of step. I think most of the differences between the calculated range values have their roots in the basic differences between the two statistical methods.

Conclusions

There are two basic fallacies in Shaw's thinking that tend to discredit his entire effort: the rate of accumulation

in the standard section is constant, and thickness equals time, or feet-of-rock equals time.

In the first place, there is no basis for concluding that rate of accumulation at the standard section was either constant or variable. An appreciation of the interaction of processes, tectonics, and sea level changes leads to conclusions that are diametrically opposed to constant rates of accumulation.

On the other hand, in an area such as the Llano Uplift, it is possible that a significant change in rate of accumulation in one locality would be reflected in all localities. Thus the relative rates of accumulation could remain constant, and if the faunal data are plotted as Shaw suggests, no dog-legged pattern would emerge. Another point is that the more scattered the array of points, the higher the probability of not being able to detect such a pattern.

It must be understood that in order to establish an absolute chronology, Shaw had to have a constant rate of accumulation at the standard section, and equal increments of rock (feet) had to be represented by equal increments of time. Everything that he wanted to do with the Composite Standard required this. Because I cannot assume constant rates of accumulation in the standard or any other section, I cannot accept his concept and manipulations of Riley Standard Time. His assumptions are fallacious, and I think his results and

conclusions are little more than worthless.

Another point that must be made is that Shaw doesn't consider the effect of migration, or the effects of unusual local extinctions and relict faunas. He is looking for the lowest possible base and the highest possible top. First of all, let's consider the bases of ranges. I think Shaw is correct in seeking the lowest possible bases for species-ranges in an area. If the organisms appeared in most of the area at roughly the same time, the search for a low base is meaningful in terms of the species as a whole. If the organisms executed a time-transgressive migration into or across an area, to be able to demonstrate by means of Shaw's or any other method that such a relative-time-transgressive migration took place would in itself be a significant contribution.

Next, let's consider the top of a range. Although the highest possible top of a range is what Shaw sought, is this the most significant piece of information that can be derived from the data or from his technique? The highest possible top of a range could be (or be close to) the true range-top of the species, or it could be the result of an unusual local survival of a small colony after the demise or departure of the rest of the members of the species. By the same token, the lowest value for the top of a range may represent an unusually early local extinction. The question raised by these

points is "Would some sort of average of standard equivalent-range-tops (an average of all the tops projected into the reference section) be a more meaningful piece of information?" An even more basic question is, so what? The state of our knowledge about some taxa is such that, with respect to zonation, we have to forget about tops of ranges and work only with lowest occurrences. How these questions are answered depends on the individual worker and the task before him.

Setting Shaw's thinking aside, what can be learned from his technique? When two and only two sections are compared and analyzed as he proposed, a quantified measure of the relative rates of accumulation in the two sections can be determined. This can be a useful piece of information. The amount of scatter around the regression line, combined with composite range values from the two sections, can yield a measure of the completeness of collections, and can point to intervals in the sections that could be more thoroughly collected.

I doubt that Shaw's technique has any valid geological application when more than two sections are compared by means of one regression analysis. The real meaning of the composite standard escapes me when it involves three or more sections, and this is why I tried the alternate method that appears in the preceding pages.

In all honesty I must say that although either method

may in some way be useful, both are intuitively unsatisfactory. In the first place, the analyses all but duplicated work that I had already done. During the processes of preparation and identification of the trilobites, an intuitive range chart was generated in much the same manner as the quantitative charts were; ranges and associates in the sections were compared and projected into the one or two best sections available. The statistical manipulations of numbers did not noticeably improve the intuitive chart. Conversely, the methods could be used as the initial basis for a range chart of an assemblage or fauna for which there is no composite range data. I would like to see the results from the application of the technique to recent Foraminifera from deep-sea cores; if the method will ever be of any valid use, I think it must be successfully applied to pelagic foraminifers.

A second and more broadly-based reason for being wary of these analytical methods is that I do not like to see partial information blanketed with an aura of precision merely by the application of numbers. There is an overwhelming tendency today to give more credence to work that involves numbers, statistics, and use of the computer. And, analytical methods are used on data that often don't warrant such manipulation. I certainly do not advocate that applications of statistical and numerical analyses be abandoned in

geological work, but I do suggest that the bases for the analyses and the analytical methods be examined before reliance is placed on the results.

APPENDICES

APPENDIX A - BASIC DATA

RANGE BASIS IN MEASURED SECTIONS

RANGE TOPS IN MEASURED SECTIONS

Species	No.	9	8	7	6	5	4	3	2	1	No.	1	2	3	4	5	6	7	8	9	No.
<i>Monochellus truncatus</i>	1	87	--	302.5	--	--	23	--	351	1233	1	1268	357	--	42	--	--	307.5	--	96.5	1
<i>Illiaenurus quadratus</i>	2	87	--	--	--	--	23	--	347	--	2	--	--	--	23	--	--	--	--	114.5	2
<i>Rasettia magna</i>	3	--	--	--	--	--	--	--	--	1233	3	1244	--	--	--	--	--	--	--	--	3
<i>Saukiella fallax</i>	4	--	--	--	--	--	--	--	351	--	4	--	354	--	--	--	--	307.5	--	--	4
<i>Eurythaspis frontalis</i>	5	140	--	302.5	--	--	36	--	369.5	1237	5	1238	369.5	--	42	--	--	307.5	--	140	5
<i>Keithiella scapane</i>	6	93	--	--	--	--	23	--	369.5	1237	6	1263	394	--	42	--	--	307.5	--	93	6
<i>Bayfieldia binodosa</i>	7	93	--	--	--	--	23	--	357	1237	7	1307.5	459	--	70	--	--	356	--	140	7
<i>Eurythaspis typicalis</i>	8	--	12.6	345	--	--	109.5	--	479	1301	8	1307.5	481	--	109.5	--	--	372.5	12.6	--	8
<i>Eurekia granulosa</i>	9	91	--	--	--	--	23	--	354	1244	9	1291	374.5	--	42	--	--	--	--	110	9
<i>Saukiella pyrene</i>	10	86	--	--	--	--	34	--	394	1286	10	1287	406.5	--	42	--	--	--	--	140	10
<i>Keithiella retula</i>	11	--	54	409	--	--	--	35.6	453	1286	11	1400	536	44	--	--	--	409	61.8	--	11
<i>Saukiella levinensis</i>	12	--	--	--	--	--	--	--	436	1291	12	1293	460	--	70	--	--	--	--	--	12
<i>Saukiella lunia</i> var. B	13	--	--	--	--	--	70	--	479	1301	13	1337.5	479	--	--	--	--	370	--	--	13
<i>Eurythaspis lugalis</i>	14	--	--	--	--	--	27	--	357	1303	14	1395	536	32.4	--	27	--	--	--	--	14
<i>Saukia tumida</i>	15	--	--	--	--	--	27	--	481	1307.5	15	1322.5	481	--	--	--	--	360.5	--	--	15
<i>Stenopilus latus</i>	16	--	12.6	356	--	--	58.2	109.5	460	1322.5	16	1400	529	43	109.5	61	--	370	--	--	16
<i>Saukiella lunia</i> var. A	17	--	--	--	--	--	--	--	--	1343.5	17	1343.5	--	--	--	--	--	360.5	--	--	17
<i>Eurythaspis kirki</i>	18	--	52	398	--	--	58.2	--	521	1371	18	1400	536	54	--	63	--	409	71	--	18
<i>Eurekia eos</i>	19	--	52	375	32	63	149	109.5	529	1349	19	1395	532	54	149	63	32	398	65.5	--	19
<i>Bayfieldia sinuata</i>	20	--	12.6	356	32	27	109.5	11	481	1360	20	1400	536	45.4	149	58.2	32	398	65.5	--	20
<i>Calvinella procera</i>	21	--	52	383	--	--	--	--	--	1360	21	1371	--	--	--	--	--	383	55	--	21
<i>Calvinella tenuisculpta</i>	22	--	--	375	--	--	58.2	--	519	--	22	--	521.5	45	--	--	--	375	--	--	22
<i>Saukia imperatrix</i>	23	--	12.6	--	--	--	--	--	484	--	23	--	492	--	109.5	61	--	--	12.6	--	23
<i>Idiomus intermedius</i>	24	--	54	375	--	--	61	109.5	521.5	1382	24	1400	540	55.5	149	67	--	411	61.8	--	24
<i>Saukiella serotina</i>	25	--	52	409	32	58	58	--	521.5	1382	25	1400	536	54	--	63	48.8	411	61.8	--	25
<i>Briscoia llanensis</i>	26	--	59.3	--	--	--	58.2	--	521.5	1382	26	1400	532	53	--	63	--	409	65.5	--	26
<i>Macronoda prima</i>	27	--	--	--	--	--	61	--	529	1388	27	1400	529	53	--	63	--	--	--	--	27
<i>Calvinella prethoparia</i>	28	--	59.3	--	--	--	--	--	--	1392	28	1400	536	53	--	63	--	--	--	--	28
<i>Bowmania sagitta</i>	29	--	--	--	--	--	--	--	--	1343.5	29	1400	--	--	--	--	--	--	--	--	29
<i>Briscoia hariti</i>	30	--	--	--	--	--	--	--	--	1392	30	1400	--	--	--	--	--	372.5	--	--	30
<i>Heterostylon cf. H. tuberculatum</i>	31	--	--	--	--	--	--	--	529	--	31	1400	--	--	--	--	--	--	--	--	31
<i>Plectonocopus convergens</i>	32	--	52.6	302.5	--	--	61	36	--	1400	32	--	532	45	70	61	--	302.5	61.8	--	32
<i>Saukiella pinata</i>	33	--	61.5	--	--	--	61	--	--	1400	33	1400	--	53	--	61	--	302.5	61.8	--	33
<i>Leiodontella leonensis</i>	34	--	72	411	48	67	67	--	539	1402	34	1402	543	55.5	--	67	48	411	72	--	34
<i>Corbina spolia</i>	35	--	72	411	48	67	67	--	538	1402	35	1409	545	56	--	69.5	48	416	72	--	35
<i>Achelopta masonensis</i>	36	--	72	411	48	67	67	--	538	1402	36	1409	540	55.5	--	69.5	48	411	72	--	36
<i>Triarthropsis nitida</i>	37	--	72	--	--	--	67	--	540	--	37	--	540	55.5	--	67	--	411	72	--	37
<i>Triarthropsis cf. T. limbata</i>	38	--	--	--	--	--	67	--	539	--	38	--	540	--	--	67	--	--	--	--	38
<i>Prosaikia remora</i>	39	--	55	--	--	--	--	--	--	--	39	--	--	45	--	--	--	--	55	--	39
<i>Theodenisia brevis</i>	40	--	54	--	--	--	--	--	--	--	40	--	--	54	--	--	--	--	54	--	40
<i>Triarthropsis pinettonensis</i>	41	--	72	--	--	--	67	--	45	--	41	--	--	55.5	--	67	--	--	72	--	41
<i>Leiocoryphe occipitalis</i>	42	--	302.5	--	--	--	--	55.5	--	--	42	--	--	--	--	--	--	307.5	--	--	42
<i>Apatekopaloides clivovus</i>	43	--	72	411	48	67	67	--	--	--	43	--	--	55	--	67	48	--	72	--	43
<i>Bowmania americana</i>	44	--	52	--	--	--	63	--	369.5	--	44	--	--	45.8	--	63	--	--	61.8	--	44
<i>Idiomus levinensis</i>	45	85.5	--	--	--	--	--	--	351	--	45	--	460	--	42	--	--	--	--	85.5	45
<i>Keithia cf. K. connexa</i>	46	--	--	--	--	--	41	40	--	--	46	--	351	40	--	--	--	--	--	--	46
<i>Bowmania pennsylvanica</i>	47	--	--	--	--	--	58.2	--	--	--	47	--	--	--	--	--	--	--	--	--	47
<i>Keithiella scrupulosa</i>	48	--	--	302.5	--	--	--	--	--	--	48	--	--	--	42	--	--	307.5	--	--	48
<i>Gragrostus? insolitus</i>	49	--	--	--	--	--	34	--	--	--	49	--	--	--	--	--	--	--	--	--	49
<i>Westonaspis? texana</i>	50	--	--	--	--	--	--	--	--	--	50	--	--	--	--	--	--	411	--	--	50
<i>Plectonocopus obtusus</i>	51	--	--	411	--	--	--	--	539	1400	51	1400	540	55.5	--	--	48	411	--	--	51
<i>Leiocoryphe cf. L. longiceps</i>	52	--	--	--	--	--	61	--	--	--	52	--	--	--	--	--	--	411	--	--	52
<i>Stenopilus pronus</i>	53	--	--	315	--	--	--	--	--	--	53	--	--	--	--	--	--	315	--	--	53
<i>Rasettia wickitensis</i>	54	--	52	--	--	--	--	--	--	--	54	--	--	--	--	--	--	--	52	--	54

MEASURED SECTIONS

- 1 = TC = Threadgill Creek
 2 = JR = Upper James River
 3 = LCS = Leon Creek (Winston)
 4 = BC = Bluff Creek
 5 = CC = Calif Creek
 6 = LC = Leon Creek (Ellinwood)
 7 = SS = Camp San Saba
 8 = SH = Spring Hollow
 9 = SPI = Sheep Pen Hollow

A P P E N D I X B

COMPOSITE STANDARD RANGE VALUES

COMPOSITE STANDARD RANGE BASES										COMPOSITE STANDARD RANGE TOPS											
No.	CS-BASE	CS 1-9	CS 1-8	CS 1-7	CS 1-6	CS 1-5	CS 1-4	CS 1-3	CS 1-2	No.	CS 1-2	CS 1-3	CS 1-4	CS 1-5	CS 1-6	CS 1-7	CS 1-8	CS 1-9	CS-TOP	No.	
1	1233	1233	--	1233	--	--	1233	--	1268	1	1268	--	1286	--	--	1286	--	1286	1286	1	
2	1233	1233	--	1233	--	--	1233	--	1256	2	1256	--	1268	--	--	--	--	1273	1273	2	
3	1233	--	--	--	--	--	1233	--	1256	3	1256	--	--	--	--	--	--	--	--	3	
4	1237	--	--	1237	--	--	1237	--	1239	4	1239	--	--	--	--	1272	--	--	1272	4	
5	1237	1237	--	1237	--	--	1237	--	1252	5	1252	--	1286	--	--	1286	--	1286	1286	5	
6	1237	1237	--	--	--	--	1237	--	1273	6	1273	--	1286	--	--	1286	--	1286	1286	6	
7	1237	1237	--	1237	--	--	1237	--	1327	7	1327	--	1327	--	--	1330	--	1330	1330	7	
8	1301	--	1301	--	--	--	1301	--	1346	8	1346	--	1347	--	--	1350	--	1350	1350	8	
9	1239	1239	--	1239	--	--	1239	--	1291	9	1291	--	1291	--	--	1291	--	1291	1291	9	
10	1260	1260	--	--	--	--	1273	--	1287	10	1287	--	1287	--	--	--	--	1287	1287	10	
11	1286	--	1286	--	--	--	1286	--	1400	11	1400	--	--	--	--	1400	--	1400	1400	11	
12	1291	--	--	--	--	--	1291	--	1328	12	1328	--	1328	--	--	--	--	--	1328	12	
13	1301	--	--	1301	--	--	1301	--	1344	13	1344	--	--	1344	--	1347	--	--	1347	13	
14	1242	--	--	--	--	--	1242	--	1395	14	1395	--	--	1395	--	--	--	--	1395	14	
15	1308	--	--	1308	--	--	1308	--	1346	15	1346	--	--	--	--	1346	--	--	1346	15	
16	1323	--	1323	--	--	--	1323	--	1400	16	1400	--	1400	--	--	1400	--	--	1400	16	
17	1344	--	--	--	--	--	--	--	1344	17	1344	--	--	--	--	--	--	--	1344	17	
18	1351	--	1351	--	--	--	1359	--	1400	18	1400	--	--	--	--	1400	--	--	1400	18	
19	1349	--	1349	--	1349	--	1349	--	1395	19	1395	--	1398	1398	1398	1398	1398	1398	1398	19	
20	1320	--	1320	--	1320	--	1320	--	1400	20	1400	--	1400	1400	1400	1400	1400	1400	1400	20	
21	1359	--	1359	--	--	--	1359	--	1371	21	1371	--	1396	1396	1396	1396	1396	1396	1396	21	
22	1353	--	1353	--	--	--	1360	--	1380	22	1380	--	1380	--	--	1380	--	--	1380	22	
23	1335	--	1335	--	--	--	1348	--	1355	23	1355	--	1355	--	--	1380	--	--	1380	23	
24	1347	--	1347	--	1347	--	1347	--	1400	24	1400	--	1401	1401	1401	1401	1401	1401	1401	24	
25	1358	--	1358	--	1358	--	1358	--	1400	25	1400	--	1400	1400	1400	1400	1400	1400	1400	25	
26	1373	--	1373	--	1373	--	1373	--	1400	26	1400	--	--	1400	--	--	--	--	1400	26	
27	1380	--	--	--	--	--	--	--	1400	27	1400	--	--	--	--	1400	--	--	1400	27	
28	1380	--	--	--	--	--	--	--	1400	28	1400	--	--	--	--	1400	--	--	1400	28	
29	1379	--	1379	--	--	--	1382	--	1400	29	1400	--	--	--	--	1400	--	--	1400	29	
30	1344	--	--	1344	--	--	1344	--	1344	30	1344	--	--	--	--	1350	--	--	1350	30	
31	1392	--	--	--	--	--	1392	--	1400	31	1400	--	--	--	--	--	--	--	1400	31	
32	1266	--	1266	--	--	--	1359	--	1388	32	1388	--	1388	1388	1388	1388	1388	1388	1388	32	
33	1380	--	1380	--	--	--	1380	--	1400	33	1400	--	1400	1400	1400	1400	1400	1400	1400	33	
34	1390	--	1390	--	1390	--	1394	--	1402	34	1402	--	--	1402	--	1402	--	--	1402	34	
35	1390	--	1390	--	1390	--	1393	--	1409	35	1409	--	1409	1409	1409	1409	1409	1409	1409	35	
36	1380	--	1380	--	1380	--	1380	--	1409	36	1409	--	1409	1409	1409	1409	1409	1409	1409	36	
37	1390	--	1390	--	--	--	1395	--	1401	37	1401	--	1401	1401	1401	1401	1401	1401	1401	37	
38	1390	--	1390	--	--	--	1390	--	1395	38	1395	--	--	1395	--	--	--	--	1395	38	
39	1360	--	1360	--	--	--	1360	--	1382	39	1382	--	--	--	--	--	--	--	1382	39	
40	1374	--	1374	--	--	--	1382	--	1398	40	1398	--	--	--	--	--	--	--	1398	40	
41	1390	--	1390	--	--	--	1401	--	1401	41	1401	--	--	--	--	--	--	--	1401	41	
42	1266	--	--	1266	--	--	--	--	--	42	--	--	--	--	--	1272	--	--	1272	42	
43	1390	--	1390	--	1390	--	1396	--	1400	43	1400	--	--	1400	--	1400	--	--	1400	43	
44	1373	--	1373	--	1373	--	1373	--	1383	44	1383	--	--	1383	--	1383	--	--	1383	44	
45	1252	1252	--	--	--	--	1252	--	1328	45	1328	--	1328	--	--	--	--	1328	1328	45	
46	1236	--	--	--	--	--	1236	--	1236	46	1236	--	1285	--	--	--	--	--	1285	46	
47	1373	--	--	--	--	1373	1373	--	1373	47	1373	--	--	1383	--	--	--	--	1383	47	
48	1266	--	--	--	--	--	--	--	--	48	--	--	--	--	--	1272	--	--	1272	48	
49	1278	--	--	--	--	--	1278	--	--	49	--	--	1286	--	--	--	--	--	1286	49	
50	1397	--	--	1397	--	--	--	--	--	50	--	--	--	--	--	1397	--	--	1397	50	
51	1394	--	--	1394	--	--	--	1394	1400	51	1400	--	--	--	1401	--	--	--	1401	51	
52	1380	--	--	--	1380	--	--	--	--	52	--	--	--	1380	--	--	--	--	1380	52	
53	1281	--	--	1281	--	--	--	--	--	53	--	--	--	--	--	1281	--	--	1281	53	
54	1373	--	1373	--	--	--	--	--	--	54	--	--	--	--	--	--	1373	--	--	1373	54

APPENDIX C

TWO-SECTION COMPARISON RANGE VALUES

TWO-SECTION COMPARISONS, RANGE BASES										TWO-SECTION COMPARISONS, RANGE TOPS											
No.	BASE	1, 9	1, 8	1, 7	1, 6	1, 5	1, 4	1, 3	1, 2	No.	1, 2	1, 3	1, 4	1, 5	1, 6	1, 7	1, 8	1, 9	TOP	No.	
1	1233	1233	--	1233	--	--	1233	--	1233	1	1233	--	1277	--	--	1268	--	1268	1277	1	
2	1233	1251	--	--	--	--	1233	--	1233	2	1233	--	1258	--	--	--	--	1276	1276	2	
3	1233	--	--	--	--	--	1233	--	1233	3	1233	--	--	--	--	--	--	--	1244	1244	3
4	1236	--	--	1238	--	--	1236	--	1236	4	1236	--	--	--	--	1245	--	--	1245	1245	4
5	1237	1237	--	1237	--	--	1237	--	1237	5	1237	--	--	--	--	1245	--	--	1300	1277	5
6	1237	1237	--	1237	--	--	1237	--	1237	6	1237	--	1277	--	--	1263	--	--	1263	1277	6
7	1237	1237	--	1237	--	--	1237	--	1237	7	1237	--	1308	--	--	1319	1329	1308	1327	1308	7
8	1301	--	1301	1301	--	--	1301	--	1301	8	1301	--	1346	--	--	1344	--	--	1346	1346	8
9	1239	1244	--	--	--	--	1244	--	1239	9	1239	--	1291	--	--	1344	--	--	1291	1291	9
10	1250	1250	--	--	--	--	1250	--	1273	10	1273	--	1287	--	--	--	--	1300	1300	10	
11	1286	--	1286	1286	--	--	1286	--	1400	11	1400	--	--	--	--	1400	--	--	1400	1400	11
12	1291	--	--	1301	--	--	1291	--	1328	12	1328	--	1306	--	--	1340	--	--	1328	1328	12
13	1301	--	--	--	--	1301	1301	--	1344	13	1344	--	--	1338	--	--	--	--	1344	1344	13
14	1242	--	--	--	--	1303	1242	--	1395	14	1395	--	--	1395	--	--	--	--	1395	1395	14
15	1308	--	--	1308	--	--	1308	--	1346	15	1346	--	--	1400	--	1326	--	--	1346	1346	15
16	1319	--	--	1319	--	--	1323	--	1400	16	1400	--	1400	--	--	1400	--	--	1400	1400	16
17	1344	--	--	1344	--	--	1344	--	1344	17	1344	--	--	--	--	--	--	--	1400	1400	17
18	1346	--	--	1371	--	--	1354	--	1400	18	1400	--	1400	--	--	1400	--	--	1402	1402	18
19	1348	--	--	1348	--	--	1349	--	1395	19	1395	--	1395	--	1395	1395	--	--	1400	1400	19
20	1309	--	--	1319	--	--	1346	--	1400	20	1400	--	1400	--	1400	1400	--	--	1400	1400	20
21	1354	--	--	1360	--	--	1360	--	1371	21	1371	--	1397	--	--	1371	--	--	1397	1397	21
22	1348	--	--	1348	--	--	1354	--	1380	22	1380	--	1380	--	--	1348	--	--	1380	1380	22
23	1329	--	--	1329	--	--	1346	--	1355	23	1355	--	1346	--	--	1329	--	--	1388	1388	23
24	1346	--	--	1382	--	--	1346	--	1380	24	1380	--	1400	--	--	1403	--	--	1403	1403	24
25	1355	--	--	1382	--	--	1355	--	1400	25	1400	--	1400	--	1405	1400	--	--	1405	1405	25
26	1370	--	--	1382	--	--	1370	--	1400	26	1400	--	1400	--	--	1400	--	--	1400	1400	26
27	1380	--	--	1380	--	--	1380	--	1400	27	1400	--	1400	--	--	1400	--	--	1400	1400	27
28	1378	--	--	--	--	1388	1378	--	1400	28	1400	--	1400	--	--	--	--	--	1400	1400	28
29	1360	--	--	1344	--	--	1392	--	1400	29	1400	--	1400	--	--	1400	--	--	1400	1400	29
30	1344	--	--	1344	--	--	1344	--	1344	30	1344	--	--	--	--	1344	--	--	1400	1400	30
31	1392	--	--	--	--	--	1392	--	1400	31	1400	--	--	--	--	--	--	--	1400	1400	31
32	1238	--	--	1238	--	--	1271	--	1388	32	1388	--	1306	--	--	1238	--	--	1390	1390	32
33	1378	--	--	1390	--	--	1378	--	1400	33	1400	--	1400	--	--	1400	--	--	1400	1400	33
34	1394	--	--	1402	--	--	1397	--	1394	34	1402	--	1402	--	1404	1403	--	--	1404	1404	34
35	1393	--	--	1402	--	--	1397	--	1393	35	1409	--	1409	--	1409	1410	--	--	1410	1410	35
36	1388	--	--	1402	--	--	1397	--	1393	36	1409	--	1409	--	1409	1409	--	--	1409	1409	36
37	1395	--	--	1403	--	--	1397	--	1395	37	1395	--	1403	--	1397	1403	--	--	1403	1403	37
38	1394	--	--	--	--	--	1394	--	1395	38	1395	--	1380	--	--	--	--	--	1397	1397	38
39	1355	--	--	1382	--	--	1355	--	1395	39	1395	--	1380	--	--	--	--	--	1382	1382	39
40	1360	--	--	1381	--	--	1380	--	--	40	--	--	1399	--	--	--	--	--	1381	1381	40
41	1397	--	--	1403	--	--	1397	--	1403	41	1403	--	1403	--	--	1403	--	--	1403	1403	41
42	1238	--	--	1238	--	--	--	--	--	42	--	--	--	--	--	1245	--	--	1245	1245	42
43	1397	--	--	1403	--	--	1397	--	1401	43	1401	--	1401	--	1404	1403	--	--	1404	1404	43
44	1370	--	--	1378	--	--	1370	--	1382	44	1382	--	1277	--	--	1391	--	--	1391	1391	44
45	1249	1249	--	--	--	--	1249	--	1328	45	1328	--	1276	--	--	1249	--	--	1276	1276	45
46	1236	--	--	1236	--	--	1236	--	1236	46	1236	--	--	--	--	--	--	--	1276	1276	46
47	1370	--	--	--	--	--	1370	--	1370	47	1370	--	--	--	--	--	--	--	1391	1391	47
48	1238	--	--	1238	--	--	1238	--	1370	48	1370	--	--	--	--	1245	--	--	1245	1245	48
49	1269	--	--	1269	--	--	1269	--	1403	49	1403	--	1277	--	--	--	--	--	1277	1277	49
50	1403	--	--	1403	--	--	1403	--	1400	50	1400	--	--	--	1404	1403	--	--	1403	1403	50
51	1394	--	--	1400	--	--	1394	--	1400	51	1400	--	--	--	1404	1403	--	--	1404	1404	51
52	1368	--	--	--	--	1388	1368	--	--	52	--	--	--	--	--	--	--	--	1368	1368	52
53	1257	--	--	1257	--	--	1257	--	--	53	--	--	--	--	--	1257	--	--	1257	1257	53
54	1378	--	--	1378	--	--	1378	--	--	54	--	--	--	--	--	--	--	--	1378	1378	54

APPENDIX D

TABULATION OF CALCULATED RANGE VALUES

RANGE BASES		RANGE TOPS		
Composite Standard 1-9	Lowest Base-- 2-Section Comparison	No.	Highest Top-- 2-Section Comparison	Composite Standard 1-9
1233	1233	1	1277	1286
1233	1233	2	1276	1273
1233	1233	3	1244	1244
1237	1236	4	1245	1272
1237	1237	5	1300	1286
1237	1237	6	1277	1286
1237	1237	7	1327	1330
1301	1301	8	1346	1350
1239	1239	9	1291	1291
1260	1250	10	1300	1287
1286	1286	11	1400	1400
1291	1291	12	1328	1328
1301	1301	13	1344	1347
1242	1242	14	1395	1395
1308	1308	15	1346	1346
1323	1319	16	1400	1400
1344	1344	17	1344	1344
1351	1346	18	1402	1400
1349	1348	19	1400	1395
1320	1309	20	1400	1400
1359	1354	21	1397	1396
1353	1348	22	1380	1380
1347	1329	23	1388	1380
1347	1346	24	1403	1401
1358	1355	25	1405	1400
1373	1370	26	1400	1400
1380	1380	27	1400	1400
1380	1378	28	1400	1400
1379	1380	29	1400	1400
1344	1344	30	1344	1350
1392	1392	31	1400	1400
1266	1238	32	1390	1388
1380	1378	33	1400	1400
1390	1394	34	1404	1402
1390	1393	35	1410	1409
1380	1388	36	1409	1409
1390	1395	37	1403	1401
1390	1394	38	1397	1395
1360	1355	39	1382	1382
1374	1380	40	1399	1398
1390	1397	41	1403	1401
1266	1238	42	1245	1272
1390	1397	43	1404	1400
1373	1370	44	1391	1383
1252	1249	45	1328	1328
1236	1236	46	1276	1285
1373	1370	47	1391	1383
1266	1238	48	1245	1272
1278	1269	49	1277	1286
1397	1403	50	1403	1397
1394	1394	51	1404	1401
1380	1388	52	1388	1380
1281	1257	53	1257	1281
1373	1378	54	1378	1373

PLATES

Explanation of Plate 1

Figure

- 1 Dellea? punctata Palmer. Partly exfoliated cranidium, X2 (BEG 36461) from LL - 671.8.
- 2-6 Parabolinoides contractus Frederickson. 2, Unexfoliated medium cranidium, with smooth test, X2.5 (BEG 36462) from JR - 122. 3, Unexfoliated small cranidium, showing ornament, X2 (BEG 36463) from CO - 124. 4, Internal mold of large cranidium, showing upturned anterior border and puckered anterior border furrow, X2 (BEG 36464) from TC - 935.25. 5, Internal mold of medium cranidium, showing low granules in anterior border furrow, X2.5 (BEG 36465) from JR - 121. 6, Internal mold of small cranidium, showing ornamented frontal area, X2.5 (BEG 36466) from SS - 47.
- 7-10 Orygmaspis llanoensis (Walcott), var. A Longacre, n. var. 7, Unexfoliated medium cranidium, showing strong anterior border furrow, upturned anterior border, and large eyes, X2 (BEG 36467) from JR - 124. 8-10, All from GR - 120 (as are 11, 12), Partly exfoliated small cranidia, showing large eyes, variation in depth of anterior border furrow, and topography of frontal area that can occur in one collection, X4 (BEG 36468), X2.5 (BEG 36469), X3 (BEG 36470).
- 11-16 Orygmaspis llanoensis (Walcott). 11, 12, Partly exfoliated medium cranidia, showing internal and external ornament, shallow furrows, and topography of frontal area, both from GR - 120 (as are figs. 8-10), X3 (BEG 36471), X2.5 (BEG 36472). 13, Partly exfoliated large cranidium, showing ridge on external surface dividing frontal area into brim and border, and also showing transverse ridge across posterior border, X1.5 (BEG 36473) from LL - 676. 14, Partly exfoliated medium cranidium, showing maximum development of ornament on the internal mold, X2 (BEG 36474) from B - 316. 15, 16, Partly and almost completely exfoliated pygidia, showing slender and stout marginal spines, X1 (BEG 36475) from JR - 132, X1.5 (BEG 36476) from CO - 129.
- 17, 18 Conaspis testudinatus Ellinwood. Partly exfoliated cranidia, showing pustulose test and internal mold, both X5 (BEG 36477) from TA - 10, (BEG 36478) from LL - 682.

PLATE I

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Explanation of Plate 1 (Continued)

Figure

- 19-21 Conaspis leptoholcus Longacre, n. sp. 19, Unexfoliated large cranidium, showing smooth surface and shallow preglabellar furrow, X5 (BEG 36479, holotype) from B - 316. 20, Internal mold of medium cranidium, showing shallow preglabellar furrow, X6 (BEG 36480) from SU - 61. 21, Unexfoliated medium cranidium, X7 (BEG 36481) from PK - 888.

Explanation of Plate 2

Figure

- 1, 2 Taenicephalus sp. Bell and Ellinwood. 1, Internal mold of small cranidium, showing straight anterior border furrow and medially expanded anterior border, X6 (BEG 36482) from CO - 143. 2, Unexfoliated small cranidium, showing anterior and posterior expansion of the anterior border along the axial line, X5 (BEG 36483) from GM - 575.
- 3 Conaspis parvafrons Kurtz. Internal mold of small cranidium, X4 (BEG 36484) from SS - 90.
- 4, 5 Ptychaspis bullasa Lochman and Hu. 4, Partly exfoliated small cranidium, showing equidimensional glabella common to specimens from high in the range, X5 (BEG 36485) from GR - 195. 5, Partly exfoliated large cranidium, showing granulate occipital ring, X1.5 (BEG 36486) from WC - 968.
- 6, 7 Drumaspis texana Resser. Unexfoliated medium cranidia, showing ornament and glabellar shape common to the Texas cranidia, both from E - 917, X3 (BEG 36487) and X2 (BEG 36488).
- 8-10 Drumaspis idahoensis Resser. All X3. 8, Internal mold of medium cranidium, (BEG 36489) from CO - 219. 9, 10, Partly and almost completely exfoliated medium cranidia, from high in the range, showing wide fixigenae and possible affinities to Dartonaspsis, both from TC - 1100 (approx.), (BEG 36490), (BEG 36491).
- 11 Dartonaspsis wichitaensis (Resser). Partly exfoliated medium cranidium, showing pitted fixigenae, X5 (BEG 36492) from MC - 844.
- 12-14 Ptychaspis sp. 12, Internal mold of medium cranidium, showing elevated fixigenae and ornament, X3 (BEG 36493) from TC - 1095. 13, Internal mold of small cranidium, X3 (BEG 36494) from TC - 1105. 14, Almost exfoliated large cranidium, X1.5 (BEG 36495) from WC - 1060-1075.
- 15-19 Idiomesus infimus Longacre, n. sp. 15, Internal mold of large cranidium, showing deep and narrow axial furrow, X6 (BEG 36496) from JR - 284.5. 16, Partly

PLATE II

Explanation of Plate 2 (Continued)

Figure

exfoliated large cranidium, showing large granules on interior edge of fixigenae, X 7 (BEG 36497, holotype) from TC - 1242. 17, 18, Internal molds of medium cranidia, showing relatively wide and deep axial furrows, both from JR - 284.5, X5 (BEG 36498), X6 (BEG 36499). 19, Fragment of a partly exfoliated cranidium, showing inflated occipital ring with node, X6 (BEG 36500) from MC - 862.

- 20, 21 Keithia cf. K. connexa Rasetti. Internal molds of large and small cranidia, showing granular ornament, X5 (BEG 36501) from JR - 351, X8 (BEG 36502) from BC - 41.

Explanation of Plate 3

Figure

- 1 Rasettia magna Ellinwood. Internal mold of small pygidium, showing smooth curvature of anterior edge of pleural field and the bi-noded terminal piece, X1 (BEG 36503) from TC - 1258.
- 2-5 Euptychaspis frontalis Longacre, n. sp. 2, Unexfoliated small cranidium, showing ornament and preglabellar field, X7 (BEG 36504, holotype) from JR - 369.5. 3, Internal mold of small cranidium, showing that internal mold can be smooth, X5 (BEG 36505) from TC - 1237. 4, Partly exfoliated small cranidium, showing ornament and no preglabellar field, X6 (BEG 36506) from BC - 42. 5, Partly exfoliated small cranidium, showing large occipital spine, X8 (BEG 36507) from BC - 41.
- 6, 7 Idiomesus levisensis (Rasetti). 6, Internal mold of small cranidium, showing low fixigenae, glabellar shape, and pitted fixigenae, X7 (BEG 36508) from BC - 41. 7, Almost exfoliated large cranidium, showing pitted fixigenae and depression on the front of the glabella, X4 (BEG 36509) from BC - 41.
- 8-10 Keithiella scapane Longacre, n. sp. 8, Internal mold of large cranidium, showing greatly expanded anterior border, X1.5 (BEG 36510, holotype) from BC - 32. 9, Internal mold of medium cranidium, X1.5 (BEG 36511) from JR - 369.5. 10, Almost exfoliated small cranidium, showing reduced curvature of anterior border furrow, X3 (BEG 36512) from BC - 41.
- 11, 12 Plethometopus convergens (Raymond). 11, Partly exfoliated large cranidium, X2 (BEG 36513) from JR - 532. 12, Internal mold of medium cranidium, X2.5 (BEG 36514) from JR - 529.
- 13, 14 Bayfieldia binodosa (Hall). Partly exfoliated medium and large cranidia, showing granular and smooth surface ornament, laterally bifurcate occipital furrow, and recurved anterior border furrow, X2 (BEG 36515) from JR - 369.5, X1 (BEG 36516) from JR - 357.
- 15-17 Eurekia granulosa Walcott. 15, Internal mold of small cranidium, showing wide anterior fixigenae, X2

PLATE III

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Explanation of Plate 3 (Continued)

Figure

(BEG 36517) from BC - 41. 16, Partly exfoliated medium cranidium, showing anteriorly rounded glabella, X2 (BEG 36518) from BC - 23. 17, Internal mold of large cranidium, showing divergent anterior facial sutures and glabellar shape of specimens from high in the range, X2 (BEG 36519) from SPH - 110.

18 Euptychaspis jugalis Winston and Nicholls. Partly exfoliated large cranidium, showing ornament, X5 (BEG 36520) from CC - 27.

19-21 Geragnostus? insolitus Grant. 19, 20, Partly exfoliated cranidium and pygidium, both X8, both from BC - 41 (BEG 36521), (BEG 36522). 21, Internal mold of small pygidium, X10 (BEG 36523) from BC - 42.

Explanation of Plate 4

Figure

- 1,2,4,5 Plethopeltis saratogensis (Walcott). 1, Internal mold of large cranidium, X1.5 (USNM 58558, holotype). 2, Partly exfoliated medium cranidium, X2 (MCZ 1730, holotype of P. walcotti Raymond). 4, Partly exfoliated medium pygidium, X2 (USNM 58560, paratype). 5, Partly exfoliated medium pygidium, X2 (MCZ 1731, paratype pygidium of P. walcotti Raymond). All from Hoyt's Quarry, 4 miles west of Saratoga Springs, New York.
- 3, 6 Plethopeltis granulosa Resser. 3, Unexfoliated medium cranidium, showing granulo-striate ornament; originally figured by Walcott (1912) as P. saratogensis, later made holotype of P. granulosa, X3 (USNM 58561). 4, Internal mold of medium pygidium, X2 (USNM 58565, paratype). Both from Hoyt's Quarry, 4 miles west of Saratoga Springs, New York.
- 7, 8 Plethopeltis sp. Both X3, from MC - 1065. 7, Partly exfoliated medium cranidium (BEG 36524). 8, Internal mold of medium cranidium, showing terrace lines on the anterior border, and granular ornament (BEG 36525).
- 9 Euptychaspis typicalis Ulrich. Internal mold of large cranidium, showing the shelf-like anterior border and striations across the preglabellar field, X4 (BEG 36526) from SS - 345±.
- 10, 11 Saukia tumida Ulrich and Resser. Internal molds of large cranidium and librigena, showing ornament, both X1, from JR - 481 (BEG 36527), (BEG 36528).
- 12 Bayfieldia simata Winston and Nicholls. Internal mold of medium cranidium, showing recurved anterior border furrow, X1.5 (BEG 36529) from SS - 360.5.
- 13, 14 Idiomesus intermedius Rasetti. Partly exfoliated medium cranidia, showing Bertillion ornament on fixigenae and frontal area, X5 (BEG 36530) from LCS - 32.4, X4 (BEG 36531) from CC - 61.
- 15 Eurekia eos (Hall). Internal mold of large pygidium, showing unusual marginal spines and pitted surface,

PLATE IV

Explanation of Plate 4 (Continued)

Figure

X2 (BEG 36532) from SS - 409.

- 16 Calvinella procera Winston and Nicholls. Partly exfoliated large cranidium, showing delicate vermiform ridge ornament on test, X1.5 (BEG 36533) from TC - 1368-1374.
- 17 Calvinella tenuisculpta Walcott. Partly exfoliated small cranidium, showing transverse ridges on the test fragments of the anterior border, and the ridges on the occipital ring fragment, X3 (BEG 36534) from LCS - 33.
- 18 Rasettia wichitaensis (Resser). Partly exfoliated pygidium, X1.5 (BEG 36535) from SH - 52.
- 19-21 Prosaukia remora Longacre, n. sp. 19, Internal mold of medium cranidium, X5 (BEG 36536, holotype) from LCS - 40. 20, Partly exfoliated cranidium, showing granular ornament, X3 (BEG 36537) from LCS - 33. 21, Internal mold of medium cranidium, X6 (BEG 36538) from LCS - 45.

Explanation of Plate 5

Figure

- 1-3 Saukiella fallax (Walcott). 1, Partly exfoliated medium cranidium, X3.5 (BEG 36539) from SS - 307.5. 2, Partly exfoliated medium pygidium, X2 (BEG 36540) from JR - 354. 3, Internal mold of large cranidium, X2 (BEG 36541) from JR - 354.
- 4-8 Saukiella pyrene (Walcott). 4-7, Internal molds of small to large cranidia, showing variation in glabellar shape and frontal area topography, X5 (BEG 36542) from JR - 394, X3.75 (BEG 36543) from JR - 394, X2.5 (BEG 36544) from SPH - 140, X2 (BEG 36545) from SPH - 140. 8, Internal mold of medium pygidium, X2.5 (BEG 36546) from SPH - 140.
- 9-11 Saukiella pepinensis (Owen). 9, Internal mold of large cranidium, showing spectacular ornament, X1.5 (BEG 36547) from TC - 1293. 10, Partly exfoliated medium cranidium, showing ornament, and crisp anterior border furrow, X2 (BEG 36548) from JR - 460. 11, Internal mold of large cranidium, showing vague Bertillion ornament on the glabella, deep glabellar furrows, and crisp anterior border furrow, X1.5 (BEG 36549) from TC - 1291.
- 12-18 Saukiella junia (Walcott), var. B, Winston and Nicholls. 12, 13, Small partly exfoliated and medium completely exfoliated cranidia from the base of the range of the species, showing shallower furrows and close affinities to S. pepinensis, X3 (BEG 36550) from TC - 1301, X1 (BEG 36551) from TC - 1303. 14, 15, Internal molds of medium and large cranidia from low in the range of the species, showing reduced convexity, shallower furrows, and longer frontal areas than figs. 12 and 13, both from TC - 1305, X2 (BEG 36552), (BEG 36553). 16, Internal mold of medium cranidium, from the middle of the range of the species, X2 (BEG 36554) from TC - 1310-1315. 17, Unexfoliated large cranidium from the middle of the range of the species, showing ornament on the occipital ring, X1 (BEG 36555) from TC - 1310-1315. 18, Partly exfoliated medium pygidium from low in the range of the species, X1.5 (BEG 36556) from TC - 1305-1310.
- 19-21 Saukiella junia (Walcott), var. A, Winston and

PLATE V

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Explanation of Plate 5 (Continued)

Figure

Nicholls. All from TC - 1341-1346. 19, 20, Internal molds of small and large cranidia, X2.5 (BEG 36557), X1 (BEG 36558). 21, Partly exfoliated large pygidium, showing almost equally divided pleurae, X0.5 (BEG 36559).

Explanation of Plate 6

Figure

- 1-3 Saukiella serotina Longacre, n. sp. 1, Partly exfoliated medium cranidium, showing spectacular ornament, and large palpebral areas of the fixigenae, X2 (BEG 36560, holotype) from CC - 61. 2, Internal mold of medium cranidium, X2.5 (BEG 36561) from SH - 61.5. 3, Partly exfoliated medium cranidium, X2 (BEG 36562) from JR - 521.5.
- 4, 5 Bowmania pennsylvanica Rasetti. Internal molds of large and medium cranidia, showing anteriorly expanded glabellas, and ornament, X2.5 (BEG 36563), X4 (BEG 36564), both from LCS - 40.
- 6 Macronoda prima Lochman. Partly exfoliated large cranidium, showing granular ornament, squared anterior end of the glabella, and posterior glabellar flattening, X2.5 (BEG 36565) from TC - 1388.
- 7-12 Calvinella prethoparia Longacre, n. sp. 7, Internal mold of large cranidium, showing ornament, wide fixigenae, and pointed anterior border, X1 (UT 12589, holotype, figured by Winston and Nicholls, 1967, pl. 11, fig. 5), from TC - 1400. 8, Partly exfoliated large cranidium, showing ornament patterns, X1.5 (BEG 36566) from LCS - 53. 9, Internal mold of medium cranidium, showing long occipital spine, X1.5 (BEG 36567) from LCS - 45.8. 10, Internal mold of small cranidium, showing wide fixigenae and ornament, X2.5 (BEG 36568) from CC - 61. 11, Partly exfoliated juvenile cranidium, showing very wide fixigenae, X8 (BEG 36569) from JR - 529. 12, Partly exfoliated medium pygidium, showing unequal division of the pleurae, and delicate granular and ridge ornament, X1 (BEG 36570) from LCS - 53.
- 13 Leiocoryphe cf. L. longiceps Rasetti. Internal mold of very small cranidium, X10 (BEG 36571) from CC - 61.
- 14, 15 Plethometopus obtusus Rasetti. Partly exfoliated small and medium cranidia, X5 (BEG 36572) from LCS - 53.3, X3 (BEG 36573) from LC - 48.
- 16-18 Westonaspis? texana Longacre, n. sp. All from SS -

PLATE VI

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Explanation of Plate 6 (Continued)

Figure

411. Internal molds of small cranidia, showing the medially recurved anterior border furrow, the anterior border, and long (exsag.) posterior limbs, X4 (BEG 36574, holotype), X6 (BEG 36575), X7 (BEG 36576).
- 19 Acheilops masonensis Winston and Nicholls. Unexfoliated large cranidium, showing occipital spine and granular ornament, X5 (BEG 36577) from SS - 411.
- 20 Triarthropsis cf. T. limbata Rasetti. Internal mold of large cranidium, showing wide anterior fixigenae, X4 (BEG 36578) from JR - 540.
- 21 Triarthropsis nitida Ulrich. Unexfoliated large cranidium, showing rounded glabella, and divergent anterior facial sutures, X4 (BEG 36579) from LCS - 55.5.

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COMPOSITE RANGES OF TRILOBITES OF THE PTYCHASPID BIOMERE, WILBERNS FORMATION, CENTRAL TEXAS

Longacre, S. 1968
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COMPARISON OF CALCULATED RANGE VALUES WITH INTUITIVE RANGE VALUES OF SAUKIA-ZONE TAXA

Longacre, S. 1968
UT Austin PhD

FOOTAGE ABOVE BASE OF
STANDARD SECTION
(THREADGILL CREEK)