Trilobites of the Late Cambrian Pterocephaliid Biomere in the Great Basin, United States

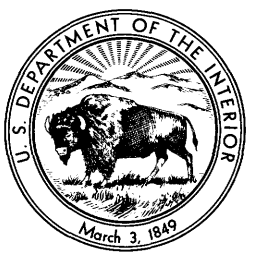
GEOLOGICAL SURVEY PROFESSIONAL PAPER 493

Trilobites of the Late Cambrian Pterocephaliid Biomere in the Great Basin, United States

By ALLISON R. PALMER

GEOLOGICAL SURVEY PROFESSIONAL PAPER 493

The content, concept, and internal zonation of a trilobite biomere in the Great Basin of Western United States are defined; 112 species representing 51 genera of ptychoparioid trilobites are described and illustrated



UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON : 1965

UNITED STATES DEPARTMENT OF THE INTERIOR

STEWART L. UDALL, *Secretary*

GEOLOGICAL SURVEY

Thomas B. Nolan, *Director*

The U.S. Geological Survey Library has cataloged this publication as follows:

Palmer, Allison Ralph, 1927–

Trilobites of the late Cambrian Pterocephaliid biomere in the Great Basin, United States. Washington, U.S. Govt. Print. Off., 1964.

iv, 106 p. illus., maps (3 fold. in pocket) diagrs. 30 cm. (U.S. Geological Survey. Professional paper 493)

Bibliography: p. 97–100.

1. Trilobites. 2. Paleontology—Cambrian. 3. Paleontology—Great Basin. I. Title. (Series)

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C. 20402

CONTENTS

ILLUSTRATIONS

[Plates 1–20 follow index; plates 21–23 are in pocket]

TRILOBITES OF THE LATE CAMBRIAN PTEROCEPHALIID BIOMERE IN THE GREAT BASIN UNITED STATES

By ALLISON R. PALMER

ABSTRACT

The Pterocephaliid biomere is a biostratigraphic unit of stage magnitude that includes the most consistently fossiliferous parts of the Upper Cambrian in the Great Basin of western conterminous United States. The thickness of strata containing faunas of this biomere generally exceeds 500 feet. This interval includes units consisting of fine-grained detrital material and of clean carbonate rocks; the carbonate rocks probably represent sediments that composed a broad carbonate bank, and the units of detrital material represent belts of predominantly land-derived detrital sediments that flanked the bank on the east and west.

The ptychoparioid trilobite fauna of the Pterocephaliid biomere consists of 112 species representing 51 genera. The sequence of faunas within the Pterocephaliid biomere is divided into five zonal assemblages that can be traced throughout the Great Basin. The assemblages are, in ascending order, the *Aphelaspis* zone, *Dicanthopyge* zone, *Prehousia* zone, *Dunderbergia* zone, and *Elvinia* zone. The first three zones, which are valid throughout the Great Basin, may correlate with beds currently assigned only to the *Aphelaspis* zone in central Texas and the southern Appalachian region.

The principal faunal elements of the Pterocephaliid biomere probably invaded the Great Basin region from oceanic regions to the west and annihilated nearly all previously existing faunas of the older Crepicephalid biomere. The invading faunas then evolved in place and were in turn annihilated by a new invading fauna, which terminated the Pterocephaliid biomere. Several possible evolutionary series are described, including one that extends through five species and two genera. Geographic distribution of contemporaneous ornamented species in several genera suggests some correlation between environment and ornamentation in some groups of trilobites.

New taxa are *Oligometopus contractus* n. sp., *Cheilocephalus brachyops* n. sp., *Cheilocephalus granulosus* n. sp., *Pseudokingstonia exotica* n. gen., n. sp., *Iddingsia intermedia* n. sp., *Apachia prima* n. sp., *Dellea? punctata* n. sp., *Dunderbergia calculosa* n. sp., *Dunderbergia brevispina* n. sp., *Elburgia intermedia* n. sp., *Irvingella transversa* n. sp., *Hardyoides mimicus* n. sp., *Aciculolenus peculiaris* n. gen., n. sp., *Xenocheilos granulosus* n. sp., *Terranovella brevis* n. sp., *Simulolenus quadrisulcatus* n. gen., n. sp., *Dicanthopyge convergens* n. gen., n. sp., *Dicanthopyge quadrata* n. sp., *Dicanthopyge reductus* n. sp. *Aphelaspis longispina* n. sp. *Olenaspella paucisegmenta* n. sp., *Litocephalus magnus* n. sp., *Stenambon megagranulus* n. gen., n. sp. *Stenambon paucigranulus* n. sp., *Parahousia subequalis* n. sp., *Prehousia diverta* n. sp., *Prehousia impolita* n. sp., *Prehousia indenta* n. sp., *Prehousia prima* n. sp., *Tumicephalus depressus* n. gen., n. sp., *Cernuolimbus laevifrons* n. sp., *Cernuolimbus granulosus* n. sp., *Strigambitus bilobus* n. gen., n. sp., *Strigambitus transversus* n. sp., *Strigambitus? blepharina* n. sp., *Pterocephalia? punctata* n. sp., *Erixanium? brachyaxis* n. sp., *Erixanium multisegmentus* n. sp., *Bromella veritas* n. gen., n. sp., *Dytremacephalus asperaxis* n. sp., *Minupeltis definita* n. sp., *Aphelotoxon limbata* n. gen., n. sp., *Aphelotoxon punctata* n. sp., *Aphelotoxon spinosus* n. sp., *Aphelotoxon marginata* n. sp., *Aphelotoxon granulosus* n. sp., *Comanchia minus* n. sp., *Anechocephalus spinosus* n. sp., *Morosa brevispina* n. sp., and *Morosa extensa* n. sp.

INTRODUCTION

During the Cambrian period, the present Great Basin in western conterminous United States (fig. 1) was almost continuously covered by generally shallow seas, and a blanket of sediments averaging more than 5,000 feet in thickness was deposited. Many complete or partial sections through this blanket are exposed in the mountain ranges of eastern Nevada, western Utah, and southeastern California. Where limestones are interbedded with shales or siltstones in these sections, trilobite remains are common in many places, whereas in uniform sequences of thick-bedded carbonates, shales, or sandstones, trilobite remains are relatively scarce.

The only part of the Cambrian that consistently yields trilobites in nearly every section in the Great Basin is the Upper Cambrian interval included between the abrupt appearance of *Aphelaspis* or its associates and the equally abrupt disappearance of *Irvingella* and its associates. This interval is a biostratigraphic unit of stage magnitude, in which the upper and lower limits are paleontologically defined. It does not conform strictly to the definition of a stage, however (see p. 4), and is called the Pterocephaliid biomere after one of the two common trilobite families that characterize the interval.

The Pterocephaliid biomere has been chosen as the first part of the Cambrian faunal sequence of the Great Basin to be comprehensively studied, because trilobites from within the biomere are among the most frequently collected fossils. It is also the only widespread Cambrian faunal unit presently known

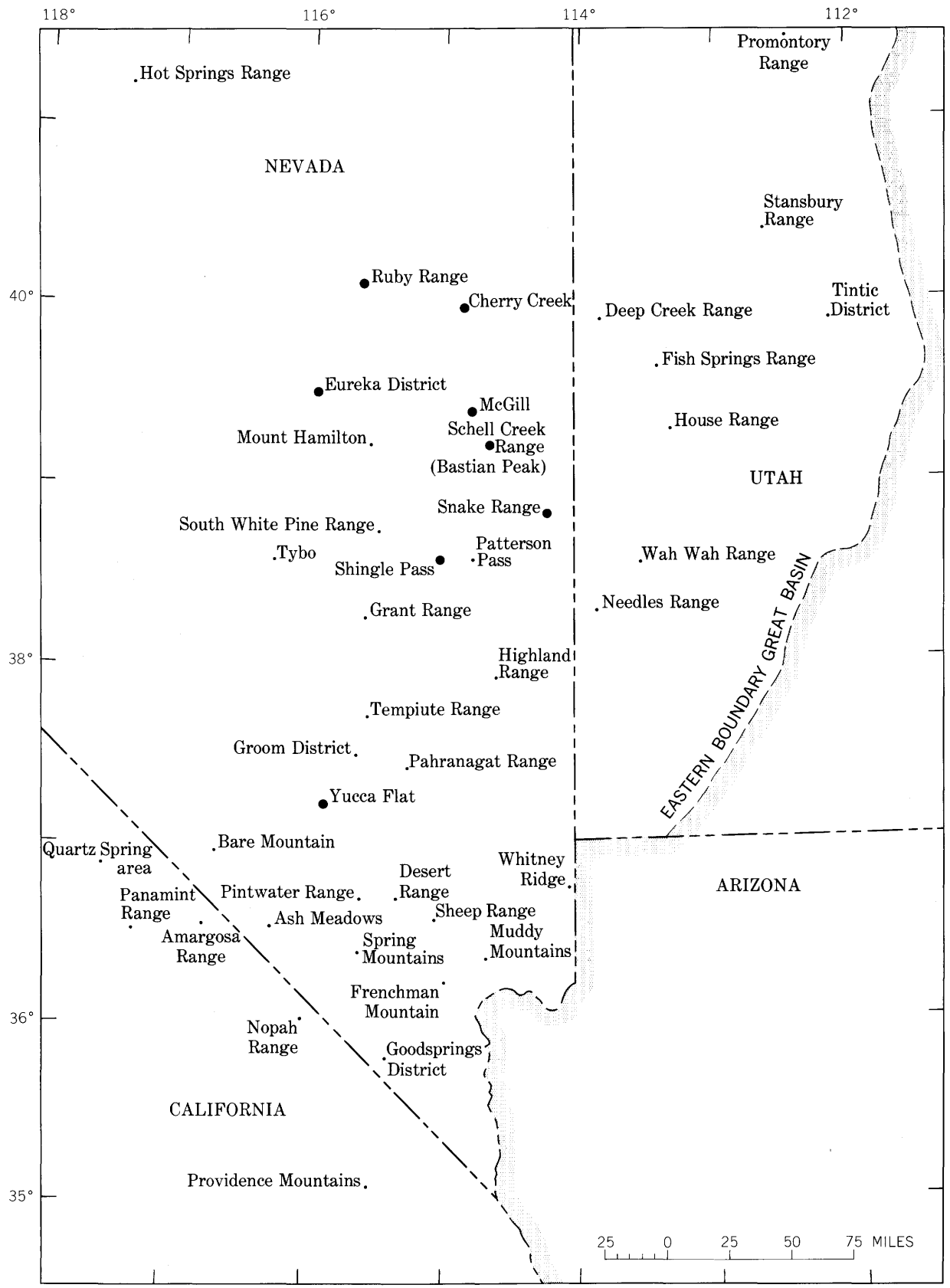


FIGURE 1.—Map showing localities of fossiliferous beds of the Pterocephaliid biomere in the Great Basin. Sections through part or all of the beds of the Pterocephaliid biomere at localities marked with a large solid circle are illustrated on plates 22 and 23.

that has clearly definable upper and lower limits. The two most completely fossiliferous sequences of beds including the Pterocephaliid biomere are at McGill and Cherry Creek, Nev. (fig. 1). These sections have been sites of intensive collecting and are the standard reference sections for the Pterocephaliid biomere in the Great Basin.

The McGill and Cherry Creek sections, together with other sections in and around White Pine County, Nev.—at Eureka, Ruby Range, Bastian Peak, Snake Range, and Shingle Pass—and in the House and Deep Creek ranges, Utah, have provided more than 200 stratigraphically controlled collections that form the principal source of material for the systematic paleontology and zonation of the Pterocephaliid biomere. More than 100 additional collections of the U.S. Geological Survey and U.S. National Museum from the Pterocephaliid biomere at all other known localities in the Great Basin have subsequently been examined. Few additional ptychoparioid trilobite species were added to the fauna from these collections; therefore the trilobites described here represent probably most of the recoverable ptychoparioid trilobite species of the Pterocephaliid biomere for the whole Great Basin. For this reason, this paper includes a dichotomous key (p. 23–28) to the identification of these trilobites.

Knowledge of the systematics of trilobites of the Pterocephaliid biomere prior to 1960 was limited to miscellaneous descriptions of species as parts of larger faunal studies, and biostratigraphic information was almost completely lacking (Hall and Whitfield, 1877; Walcott, 1884, 1916, 1924, 1925; Resser, 1935, 1936, 1937, 1942b; Kobayashi, 1938). Robison (1960) presented descriptions, illustrations, and stratigraphic information about some of the species of the biomere from sections in western Utah. No new species were described, and some of his identifications have been changed as a result of the regional study presented here. Palmer (1960a) described 47 ptychoparioid species from the *Dunderbergia* and lower *Elvinia* faunas in the Eureka district, Nev. Later (Palmer, 1962b), 7 species of the *Aphelaspis* fauna at McGill and Cherry Creek, Nev., were described. These 54 species, 8 others described by earlier workers, and 50 new species constitute the named ptychoparioid trilobites of the Pterocephaliid biomere in the Great Basin described in this paper.

The Agnostida of the Pterocephaliid biomere belong mostly to genera that range beyond the biomere limits. They represent a morphologically and perhaps ecologically distinct group of trilobites that merit separate study, as do the brachiopods and other nontrilobite fossils of the Pterocephaliid biomere. For this reason, Agnostida are not described in this paper. The interested reader can find descriptions and illustrations of most of the agnostid species found in the Pterocephaliid biomere in other papers (Palmer, 1955, 1960a, 1962b).

ACKNOWLEDGMENTS

Almost all the types and figured specimens of previously described species of the Pterocephaliid biomere in the Great Basin are in the collections of the U.S. National Museum. These and much undescribed material were available for constant study by agreement with Dr. G. A. Cooper, Curator of Geology, U.S. National Museum. In addition, the specimens illustrated by Robison from western Utah (1960) were loaned by Dr. J. Keith Rigby of Brigham Young University, Provo, Utah, and specimens illustrated by Kobayashi (1938) from British Columbia were loaned by Dr. D. J. McLaren of the Geological Survey of Canada at Ottawa.

Assistance in locating or measuring sections through the Pterocephaliid biomere was provided at various times and places between 1957 and 1960 by many geologists. I was guided to sections at Yucca Flat by Harley Barnes, at Bastian Peak by Harald Drewes, at McGill and Cherry Creek by J. C. Young, and at the Snake Range by D. H. Whitebread. R. H. Raymond assisted in measuring and collecting from all the sections discussed in this paper.

All the photographs were prepared by R. H. McKinney.

During 1961 and 1962, the National Science Foundation granted funds to the author for study of Cambrian trilobites from Australia and western Europe having American affinities. Particular thanks are here given to the National Science Foundation for its generous support, to the Smithsonian Institution for agreeing to administer the grant, and to the following paleontologists who provided access to described and undescribed specimens pertinent to this study and permitted replicas to be made of all materials of interest: Dr. A. A. Öpik, Bureau of Mineral Resources, Canberra, Australia; Dr. O. P. Singleton, University of Melbourne, Melbourne, Australia; Dr. N. V. Pokrovskaya, Geological Institute of the Academy of Sciences, Moscow, U.S.S.R.; Dr. Gunnar Henningsmoen, Paleontological Museum, Oslo, Norway; Dr. Valdar Jaanusson, Uppsala University, Uppsala, Sweden; Dr. Erik Jarvik of Riksmuseet and Miss Anne Reintamm of the Geological Survey of Sweden, Stockholm, Sweden; and Mr. Adrian Rushton, Cambridge University, Cambridge, England.

Thanks are also due to Dr. H. B. Whittington of the Museum of Comparative Zoology, Cambridge, Mass., for loan of latex molds of the Upper Cambrian trilobites from Argentina, described by Rusconi (1953).

SCOPE, CONTENT, AND CONCEPT OF THE PTEROCEPHALIID BIOMERE

The two best-known and most sharply defined faunal changes in the Upper Cambrian of the United States occur just beneath the *Aphelaspis* fauna and just above the *Elvinia* fauna. Documentation of these faunal changes in the continental interior has been provided by Lochman and Duncan (1944), Wilson (1951), and Palmer (1954). The change below the *Aphelaspis* fauna is so striking and widely recognizable that Lochman and Wilson (1958, p. 333) proposed restricting the Dresbachian stage to beds below this change. They proposed that an unnamed stage be designated in the Upper Cambrian between the Dresbachian and Franconian stages to include the *Aphelaspis* and *Dunderbergia* zones, as they defined them. This proposal is unacceptable for two principal reasons:

First, the suggested stage has no clear upper boundary. In the interior of the conterminous United States, a widespread disconformity is present between beds of the *Elvinia* zone and older beds generally assigned to the *Aphelaspis* zone. The contrast between the *Aphelaspis* and *Elvinia* faunas was the basis for originally defining the boundary between the Dresbachian and Franconian stages. However, the additional knowledge of the sequence of trilobite faunas in the Great Basin has demonstrated the evolutionary relationship and continuous gradation of forms from the latest Dresbachian to the earliest Franconian faunas (pl. 21), and any biostratigraphic boundary within the evolutionary sequence is arbitrary and probably not precisely correlatable from region to region. Thus the upper boundary of the unnamed stage—the traditional base of the Franconian stage—is hardly satisfying as a boundary for a major biostratigraphic unit in the Great Basin.

Second, and even more decisive, is the fact that the lower boundary of the proposed stage, although sharply defined, is not everywhere the same age. The lowest beds containing an *Aphelaspis* fauna at McGill, Nev., are the temporal equivalents of the highest beds containing a *Crepicephalus* fauna in the Snake Range and elsewhere to the east (Palmer, 1962b, p. 8, 9). Because the contact between the *Aphelaspis* fauna and older faunas is demonstrably time transgressive, it cannot be used as a stage boundary. Thus, the stage proposed by Lochman and Wilson would have an indefinite upper boundary and a lower boundary that is not a "time plane," and it cannot be considered as a satisfactory improvement in the nomenclature of the Upper Cambrian biostratigraphy of the United States.

A more satisfactory alternative, in the light of present knowledge, is the use of the biomere concept (Palmer, 1965). The faunal change above the *Elvinia* zone is comparable in magnitude to that below the *Aphelaspis* zone. Between these two faunal changes, the trilobite assemblages are dominated by members of the Pterocephaliidae and Elviniidae. Neither family is known from older beds in the United States, and younger trilobites that are assigned to the families, even if the assignments are correct, are not dominant elements of the younger faunas. The first representatives of these families in the American sections must have migrated into the shelf areas and have eliminated the major elements of an older faunal complex (fig. 2). The invading trilobites then evolved into a new complex, which in turn was eliminated by a later invasion. The interval between these major faunal changes therefore forms a natural biostratigraphic unit of stage magnitude having a lower boundary that is certainly time transgressive and an upper boundary that may be time transgressive. The most appropriate term for this internally related trilobite complex is a "biomere," and this complex is hereafter referred to as the Pterocephaliid biomere. The adjective "Pterocephaliid," denoting one of the characteristic family components of the biomere, the Pterocephaliidae, was proposed in an earlier paper (Palmer, 1962b) that described only the relationships at the lower boundary.

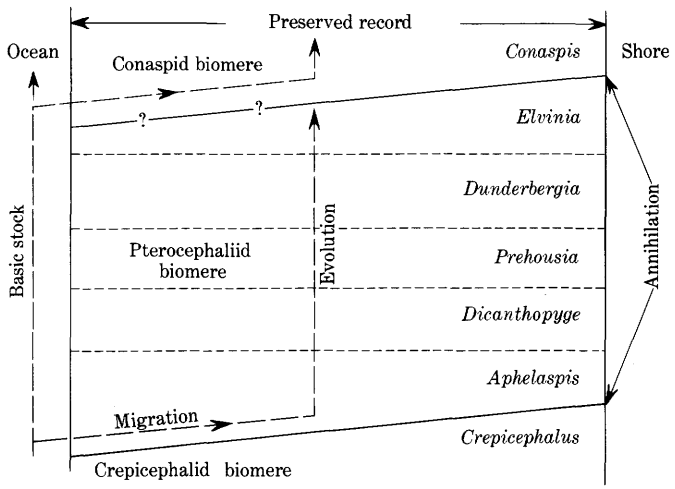


FIGURE 2.—Schematic diagram of the origin of the Pterocephaliid biomere and its relation to older and younger biomeres. Horizontal lines represent time.

Similar younger and older biomeres should be recognizable in Cambrian and perhaps younger rocks. These may ultimately prove to be more satisfactory for describing the dynamic picture of faunal relationships than is the static stage terminology that was developed before many details of the faunal sequences were known.

DIVISIONS OF THE PTEROCEPHALIID BIOMERE

Plate 21 shows the approximate range of each of the named species of the Pterocephaliid biomere in the Great Basin. This figure illustrates the gradual change of the faunal content of the biomere with time. The vertical dimension, however, is proportional to the thicknesses of the McGill and Cherry Creek sections, each of which totals about 750 feet. These two are the most completely fossiliferous sections through the Pterocephaliid biomere that are presently known. The basic data for the ranges of the species were compiled by plotting the observed ranges of the species in the two sections on a vertical scale of 1 inch equals 50 feet. The species represent about two-thirds of the total number of species of the Pterocephaliid biomere here described. The sections at Eureka and in the Snake Range section above the Lincoln Peak Formation also seem to have thicknesses comparable to correlative parts of the McGill and Cherry Creek sections, and the ranges of the species in these sections were also directly plotted on the initial compilation. The lower part of the Snake Range section is relatively thicker than comparable parts of the McGill and Cherry Creek sections, and the ranges of the species in this part were proportionately reduced before being plotted on the figure. The species identified in the McGill, Cherry Creek, Eureka, and Snake Range sections constitute nearly 90 percent of the fauna of the Pterocephaliid biomere. The ranges of the remaining species and some extensions of ranges of the species already plotted were added to the figure by interpolation of data on faunal associations found in all other collections from the Pterocephaliid biomere in the Great Basin.

In addition to showing the approximate relative ranges of the ptychoparioid trilobites of the Pterocephaliid biomere, plate 21 distinguishes relatively common species known from four or more areas (solid bars) from relatively rare species known from three or fewer areas (open bars).

On the basis of the calculated ranges of the more common species and of empirical observations of characteristic species associations, the species complex of the Pterocephaliid biomere can be divided into five successive assemblage zones, discussed in the following sections. Each assemblage zone generally has a recognizable upper and lower part. Because of the continuous gradation of the ranges of species within the biomere, the zone boundaries are arbitrarily defined by the appearance of distinctive new trilobites. The zone boundaries within the Great Basin are assumed to be approximately time parallel (fig. 2). Assemblages elsewhere may be correlated with the zones and subzones in the Great Basin, but the subdivisions of the Pterocephaliid biomere described and defined here are intended primarily for use only within the Great Basin.

APHELASPIS ZONE

The term *Aphelaspis* zone was first applied by Lochman (1938a, p. 73) to beds in the Upper Cambrian Riley Formation of central Texas that contained abundant specimens of *Aphelaspis*. The limits of the zone in the type area were first defined, however, by Palmer (1954). Beds containing fossils assigned to this zone have been reported from many areas throughout the United States, and elements of the *Aphelaspis* fauna have been described in Texas by Lochman (1938a) and Palmer (1954), in Tennessee and Virginia by Resser (1938a), in Montana by Lochman and Duncan (1944) and Lochman and Hu (1962), in Wisconsin by Nelson (1951), in Wyoming by Shaw (1956), and in Nevada by Palmer (1962b).

The limits of the *Aphelaspis* zone in the Texas area, as in the area described in this paper, were intended for use principally in the area that was studied. Beds at the base of the *Aphelaspis* zone in Texas have *Cheilocephalus brevilobus* (Walcott), *Glaphyraspis ornata* (Lochman), and the brachiopod genus *Angulotreta*, as do beds assigned to the upper part of the *Aphelaspis* zone in the Great Basin. The trilobites found below the ranges of *C. brevilobus*, *G. ornata*, and *Angulotreta* in the Great Basin apparently characterize an older *Aphelaspis* fauna not known to occur in the interior United States and found elsewhere only in central Alabama (Palmer, 1962b, p. 9).

The boundary between the *Aphelaspis* zone and the overlying post-*Aphelaspis* (subsequently *Dunderbergia*) zone in Texas cannot be precisely correlated with a boundary in the Great Basin sequence because of a lack of common diagnostic species. However, the presence of *Dytremacephalus granulosus* Palmer in the lower beds of the post-*Aphelaspis* zone indicates that the beds can probably be correlated with the lower *Dunderbergia* zone of the Great Basin, two zones above the *Aphelaspis* zone. Thus the *Aphelaspis*

zone as recognized in the Great Basin may be more restricted at the top and include more beds at the bottom than the *Aphelaspis* zone in Texas (fig. 3).

In the Great Basin, faunas assignable to the *Aphelaspis* zone are known to occur in 10 areas (fig. 4). The lower boundary of the zone is drawn at the abrupt faunal change to underlying beds of the Crepicephalid biomere. This change can be observed in the following sections, where faunas of the two biomeres are separated by the interval cited: McGill (8 in.), Cherry Creek (3 ft), Snake Range (5 ft), and Yucca Flat (4 ft). At Cherry Creek the change is associated with a probable local unconformity (Palmer, 1962b, p. 10). At McGill the change takes place at the contact between clean limestones and overlying silty limestones and siltstones, but there is no evidence at present for a disconformity. In the Snake Range and at Yucca Flat, the faunal change takes place within a sequence of almost identical and apparently conformable limestone beds. Thus the faunal change is not directly related to a consistent physical change or interruption in sedimentation, just as in Texas (Palmer, 1954, p. 715), and it must be the result of some widespread change in the marine environment. The suggestion by Lochman and Duncan (1944, p. 32) that the change in environment was a temperature change seems to be the most reasonable interpretation so far proposed. A change in temperature of the sea sufficient to bring about such a drastic change in the marine fauna throughout much of a continent, however, should probably be reflected in Cambrian sequences on other continents. If so, the change in environment could represent an important point for intercontinental correlation of Upper Cambrian rocks.

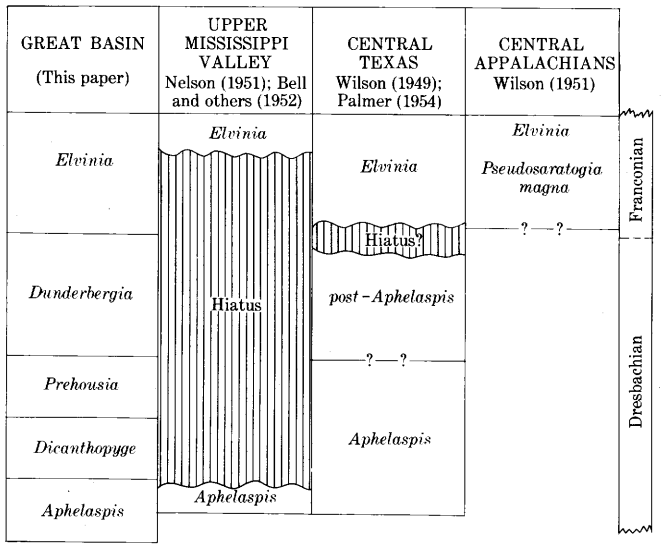


FIGURE 3.—Correlation of the zones of the Pterocephaliid biomere in the Great Basin with zonation of contemporaneous beds in the central and eastern United States.

The upper boundary of the *Aphelaspis* zone in the Great Basin is drawn at the first appearance of *Dicanthopyge quadrata* n. sp., which seems to be a direct descendant of *Aphelaspis haguei* (Hall and Whitfield) by way of *Aphelaspis longispina* n. sp. Although *A. longispina* is known from only two areas, both *A. haguei* and *D. quadrata* are widespread, and the zone boundary can be placed with reasonable precision in most sections between the occurrences of these two species.

Thirteen species are present in the *Aphelaspis* zone (pl. 21). Two of these, *Aphelaspis brachyphasis* Palmer and *Olenaspella separata* Palmer, characterize the lower subzone. The upper subzone is characterized by the association of *Aphelaspis haguei* (Hall and Whitfield), *Olenaspella regularis* Palmer, and *Aphelaspis subditus* Palmer. The last two species, however, range into the lower part of the overlying *Dicanthopyge* zone, and *A. haguei* ranges down into the upper part of the lower subzone. Four of the rarer species, *Terranovella brevis* n. sp., *Blountia bristolensis* Resser, *Hardyoides minor* Kobayashi, and *Aphelaspis longispina* n. sp., have been found only in the upper subzone. *Listroa toxoura* Palmer is the only species found in the *Aphelaspis* zone that ranges above the lower part of the overlying *Dicanthopyge* zone.

DICANTHOPYGE ZONE

The term *Dicanthopyge* zone is here proposed for the beds in the Great Basin that lie between the *Aphelaspis* and *Prehousia* zones and that contain species of *Dicanthopyge* n. gen., generally in association with *Tumicephalus depressus* n. sp. *Dicanthopyge*, the definitive genus, is not known outside the Great Basin. Beds correlative with the zone, however, may be present in central Texas if the correlation of the *Aphelaspis* zone mentioned in the foregoing section is correct. In Tennessee, *Tumicephalus tumifrons* (Resser), a species closely related to *T. depressus*, is found at many localities within the sequence of beds containing *Aphelaspis*. The description of the trilobite faunas of the Nolichucky Shale now being undertaken by Franco Rasetti (oral communication, 1963) should provide information for more precise correlation of the sequence in the southern Appalachians with that in the Great Basin.

In the Great Basin, faunas assignable to the *Dicanthopyge* zone are known from 14 areas (fig. 5). The lower boundary of the zone is placed between beds containing *Aphelaspis haguei* (Hall and Whitfield) or *A. longispina* n. sp. and beds containing their

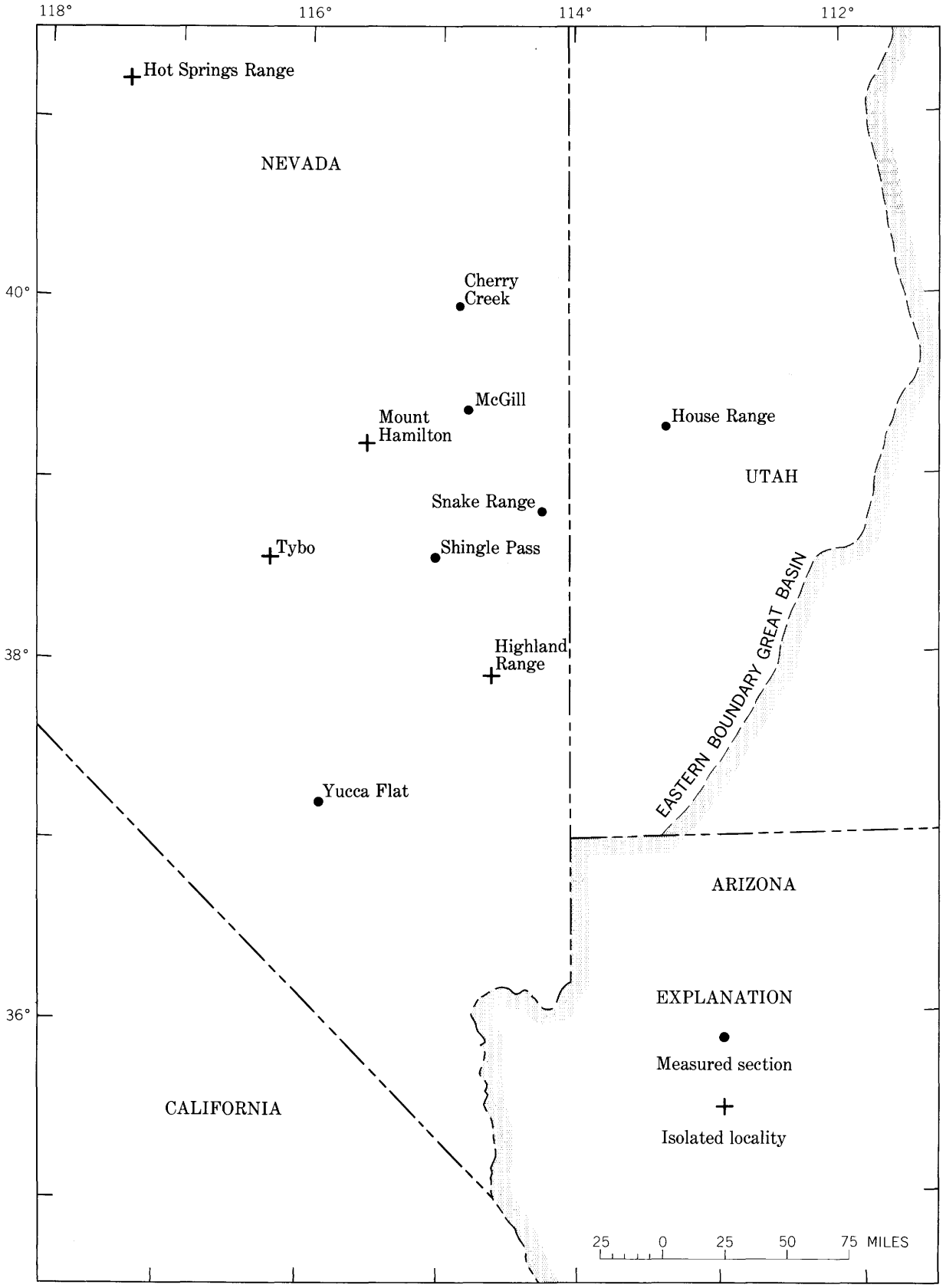


FIGURE 4.—Map showing localities containing faunas of the *Aphelaspis* zone.

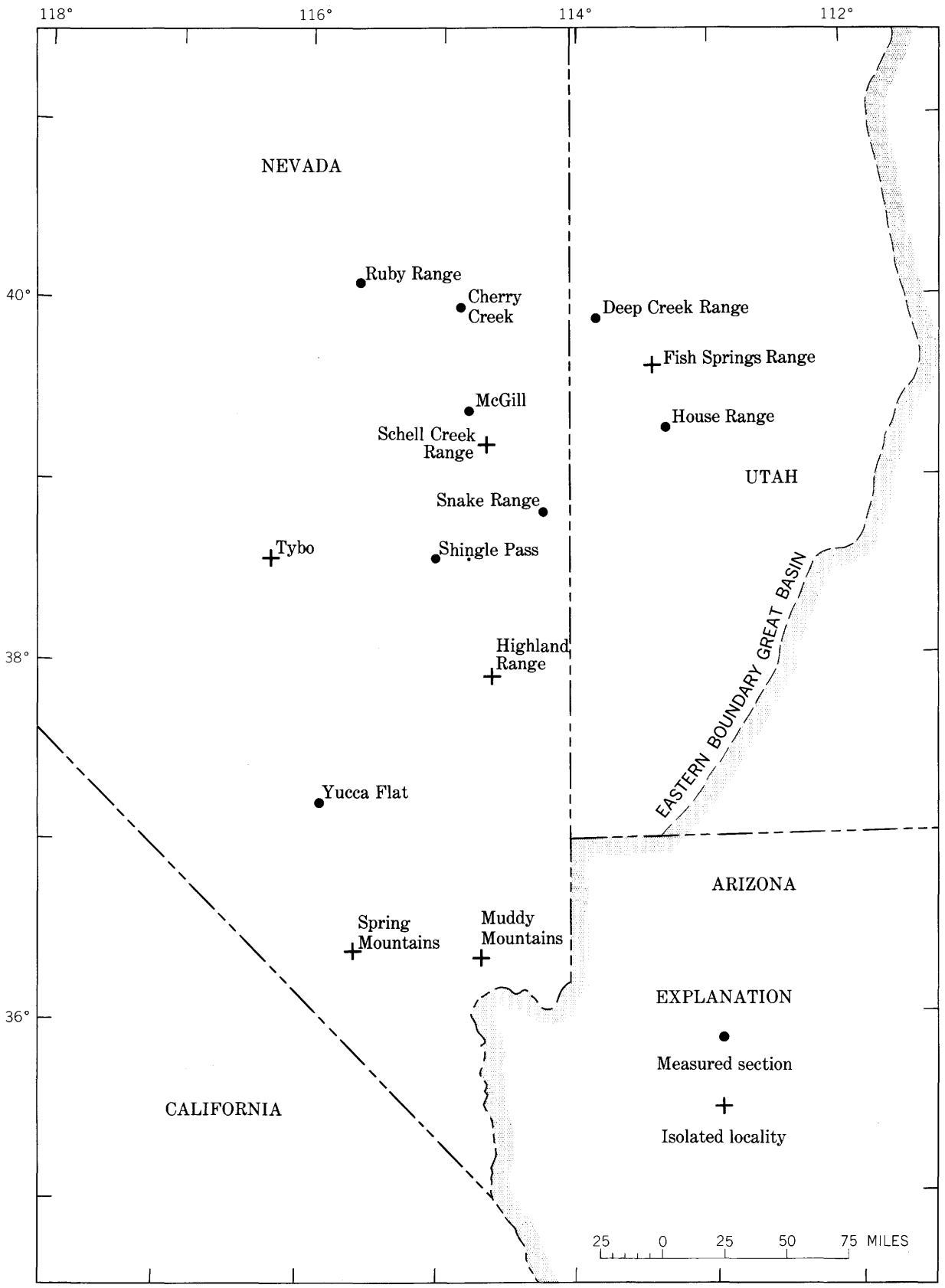


FIGURE 5.—Map showing localities containing faunas of the *Dicanthopyge* zone.

descendant, *Dicanthopyge quadrata* n. sp. The upper boundary is placed between beds containing *Prehousia prima* n. sp., *Tumicephalus depressus* n. sp., and *Dicanthopyge reductus* n. sp. and beds containing *Prehousia indenta* n. sp., a species that seems to be the direct descendant of *P. prima.*

Thirteen species have been identified in the *Dicanthopyge* zone (pl. 21). Seven of these are not known outside of the zone. The lower subzone is characterized by *Dicanthopyge quadrata* n. sp., and the upper subzone is characterized by *Dicanthopyge convergens* n. sp., *Dicanthopyge reductus* n. sp., *Dunderbergia brevispina* n. sp., *Hardyoides mimicus* n. sp., and *Prehousia prima* n. sp. *Tumicephalus depressus* n. sp., which is one of the most common trilobites in the zone, is found throughout the upper subzone and in at least the upper part of the lower subzone.

PREHOUSIA ZONE

The term *Prehousia* zone is here proposed for the beds containing a generally small fauna that lie above beds of the *Dicanthopyge* zone and below beds containing the varied assemblages of the *Dunderbergia* zone. Species of *Prehousia*, in many places occurring alone or associated with only one or two other trilobites, characterize the beds of this zone. A lower subzone is characterized by *Prehousia indenta* n. sp., and an upper subzone is characterized by *Prehousia alata* Palmer and *Prehousia impolita* n. sp. None of the elements of the *Prehousia* zone are known outside the Great Basin, but possibly correlative beds may be present in central Texas and eastern Tennessee. (See discussions of *Aphelaspis* and *Dicanthopyge* zones).

In the Great Basin, faunas assignable to the *Prehousia* zone are known from 15 areas (fig. 6). The definitive fossils for the lower boundary of the zone are *Prehousia prima* n. sp. and *Prehousia indenta* n. sp., discussed in the foregoing section in relation to the upper boundary of the *Dicanthopyge* zone. The upper boundary of the *Prehousia* zone is placed above beds that contain *Prehousia alata* Palmer and *P. impolita* n. sp., at a generally marked change in faunal content from older beds characterized by species of the Aphelaspindinae and Housiinae to younger beds characterized by species of the Elviniinae and Pterocephaliinae.

DUNDERBERGIA ZONE

The name *Dunderbergia* zone was proposed by Lochman and Wilson (1958, p. 333) for the interval formerly called the post-*Aphelaspis* zone (Palmer, 1954, p. 715) that occupies a position between beds of the *Aphelaspis* and *Elvinia* zones in central Texas. Presence of this zone in the Great Basin was also cited by Lochman and Wilson, but information about the ranges of species there had not yet been collected; therefore, details of the content and limits of the zone, which they felt should come from study of the Great Basin sequence, were not presented. The considerable increase in knowledge of the faunas of this interval since publication of the paper by Lochman and Wilson can be seen by comparing the trilobite ranges shown in plate 21 of this paper with the ranges shown in figure 12 of Lochman and Wilson (1958) which was compiled before detailed study of the faunas of the Pterocephaliid biomere in the Great Basin was undertaken. Much of the fauna of the upper part of the *Dunderbergia* zone has recently been described (Palmer, 1960a).

Beds containing elements of the *Dunderbergia* zone are known in the United States, outside of the Great Basin and central Texas, only from the vicinity of Frederick, Md. (Rasetti, 1961). In Texas, the upper boundary cannot be accurately defined because of the presence of a moderately thick unfossiliferous interval between beds bearing the *Dunderbergia* and *Elvinia* faunas. The lower boundary in the Texas sections cannot be accurately correlated with the Great Basin sequence, because of a lack of sufficient diagnostic species in common. The presence of *Dytremacephalus granulosus* in the lower *Dunderbergia* zone of both areas, however, indicates that correlation of the lower limits of the zone from Texas to the Great Basin may be approximately correct.

The faunas of the *Dunderbergia* zone are the most widespread Cambrian faunas in the Great Basin. Trilobite assemblages assignable to the zone have been collected from 34 areas (fig. 7). The lower boundary of the zone is placed above beds containing *Prehousia alata* Palmer and *Prehousia impolita* n. sp. and below the point where assemblages characterized by a dominance of trilobites assignable to the Elviniinae and Pterocephaliinae appear. The upper boundary is drawn between the last occurrence of *Elburgia quinnensis* (Resser) and the first appearance of its probable descendant, *Elvinia roemeri* (Shumard).

A total of 61 species of ptychoparioid trilobites has been identified in the *Dunderbergia* zone assemblages (pl. 21). Forty-seven of these species are known at present only from this zone. A lower subzone is characterized particularly by *Dunderbergia? anyta* (Hall and Whitfield), *Strigambitus transversus* n. sp., *Dytremacephalus granulosus* Palmer, and *Prehousia diverta* n. sp. among the common species and by six of the rarer species. An upper subzone is characterized

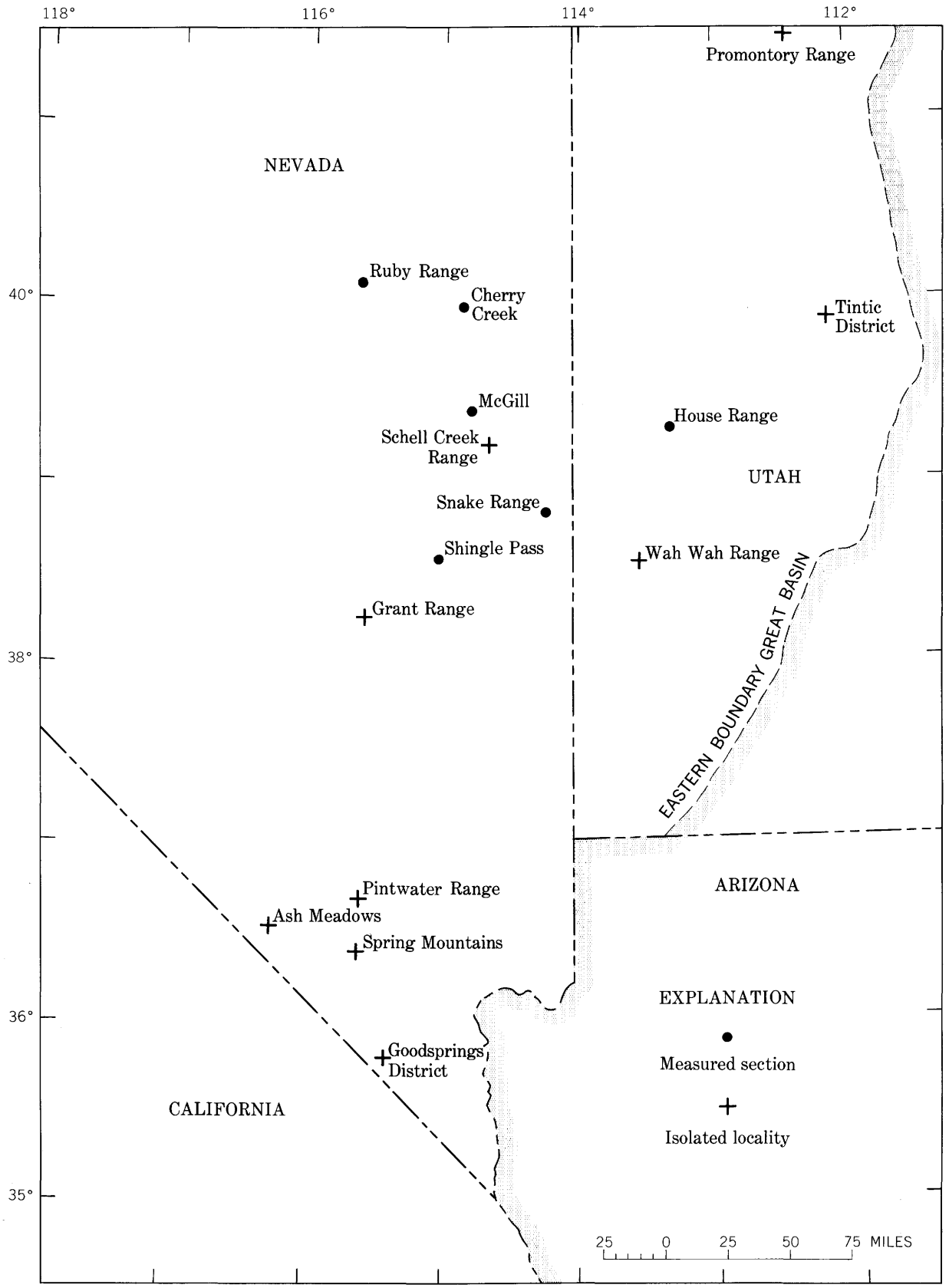


FIGURE 6.—Map showing localities containing faunas of the *Prehousia* zone.

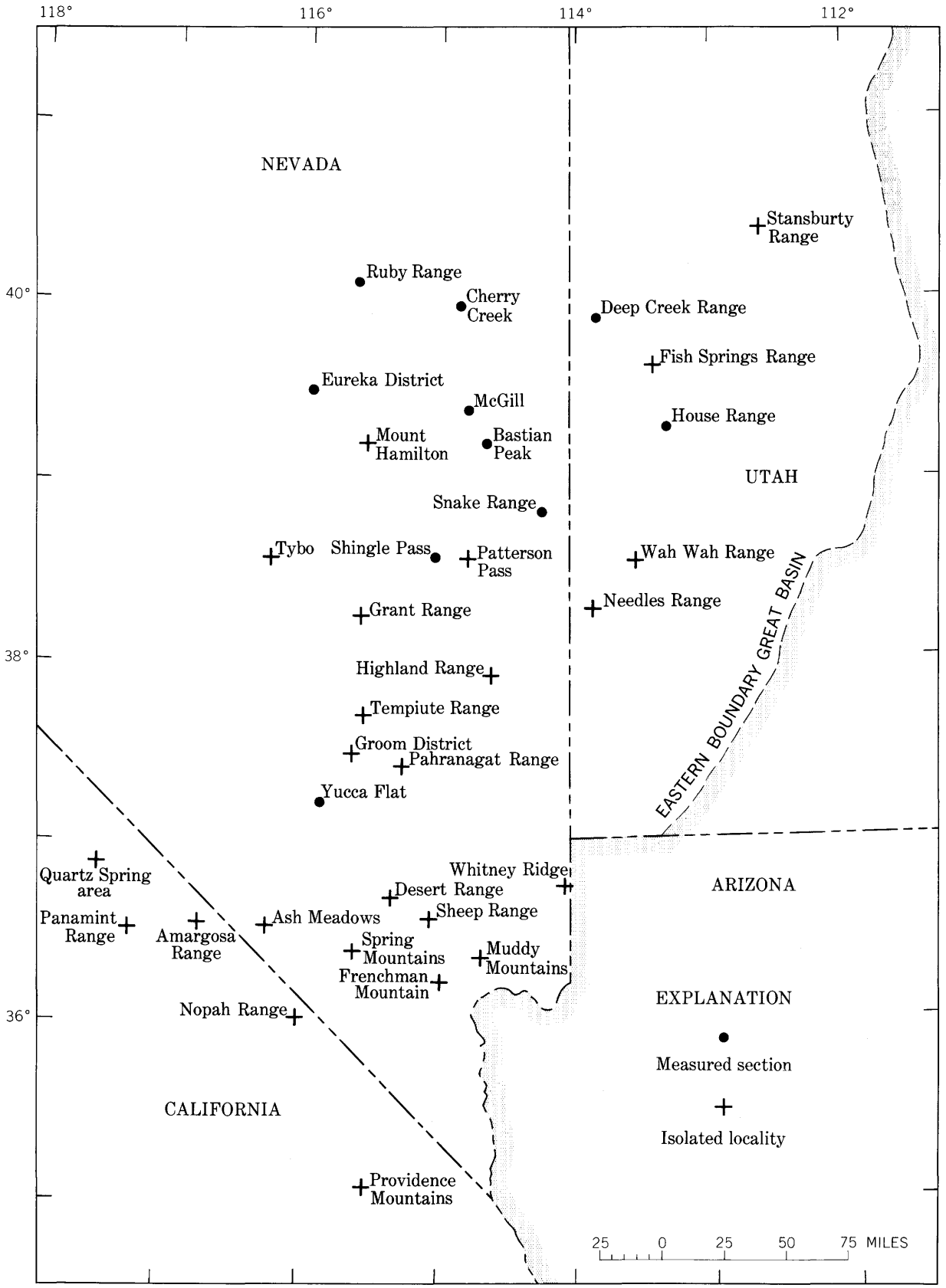


FIGURE 7.—Map showing localities containing faunas of the *Dunderbergia* zone.

by *Simulolenus wilsoni* (Henningsmoen) and *Elburgia quinnensis* (Resser) among the common species and by 17 of the less common species. The fauna of the *Dunderbergia* zone contains the greatest number of species in the Pterocephaliid biomere. The number of species in the older zones of the Pterocphaliid biomere is noticeably less, and after the peak in the upper subzone of the *Dunderbergia* zone, the number of species gradually reduces before the sudden extinction of all elements of the biomere at the end of the *Elvinia* zone.

ELVINIA ZONE

The name *Elvinia* zone was first used by Resser (1933) in a chart showing a proposed zonal sequence for the American Cambrian. No discussion was given in his paper as to the content and limits of the zone. The first reference to the content of the zone was by Mason (1938), who listed species from the Great Basin. Many of these species belong actually to the *Dunderbergia* zone as here defined. The generic content of the *Elvinia* zone and its stratigraphic position in the American Cambrian were presented by Howell and others (1944). This fauna has been one of the most fully described Upper Cambrian faunas in the United States. Studies have been made of the fauna in Texas by Bridge (in Bridge and Girty, 1937), Missouri, Texas, Oklahoma, Utah, and Nevada by Resser (1942b), Oklahoma by Frederickson (1948, 1949), Texas and Pennsylvania by Wilson (1948, 1949; 1951), Texas and Oklahoma by Wilson and Frederickson (1950), Montana by Lochman (1950), New York by Fisher and Hanson (1951), Texas by Gaines (1951), Minnesota by Bell and others (1952), Wyoming by Deland and Shaw (1956), and Nevada by Palmer (1960).

Trilobites assignable to the *Elvina* zone have been collected from 16 areas in the Great Basin (fig. 8). The lower boundary of the zone is placed at the first appearance of *Elvinia roemeri* (Shumard), which seems to be the direct descendant of *Elburgia quinnensis* (Resser), one of the characteristic species of the upper part of the *Dunderbergia* zone. The top of the *Elvinia* zone is drawn between beds carrying *Irvingella major* Ulrich and Resser and beds immediately above containing a fauna of ptychoparioid trilobites almost totally unrelated to any in the Pterocephaliid biomere. This change in fauna, like the one at the base of the Pterocephaliid biomere, seems to reflect an ecological change and is unrelated to any consistent sedimentary change or physical hiatus. Close documentation of this change was made at the following named sections, in which faunas of the Pterocephaliid biomere and the next younger biomere are separated by the distances cited: McGill (3 in.), Cherry Creek (3 in.), Yucca Flat (2 ft.), and Eureka (1 ft).

A total of 37 ptychoparioid trilobites has been identified in the *Elvinia* zone assemblages in the Great Basin (pl. 21). Twenty-five of the species are not known in older or younger beds. A lower subzone is characterized by *Bynumina globosa* (Walcott) and *Irvingella angustilimbatus* Kobayashi among the more common species and by eight of the less common species. An upper subzone is characterized by *Irvingella flohri* Resser, *Iddingsia similis* (Walcott), *Irvingella major* Ulrich and Resser, *Comanichia minus* n. sp., and *Simulolenus quadrisulcatus* n. sp. among the more common species and by eight of the less common species. The upper few feet of the upper subzone has a distinctive zonule that correlates with the *Irvingella major* faunizone of others and that includes nine species not found in older parts of the subzone. Careful examination of the content and thickness of the upper *Elvina* subzone and overlying beds at more localities in the central Great Basin may give evidence to show that the upper boundary of the Pterocephaliid biomere, like the lower boundary, is diachronous.

PHYSICAL STRATIGRAPHY OF THE PTEROCEPHALIID BIOMERE

A description of the physical stratigraphy of the Pterocephaliid biomere is a project for the future. The biostratigraphy presented in this paper provides a framework upon which physical data can now be superimposed. The ultimate integration of the physical and biological data will provide a picture of the dynamic relationships of the physical environments existing during the time represented by the Pterocephaliid biomere. A preliminary attempt to integrate some of this information has already been made (Palmer, 1960b) with regard to the area around White Pine County, Nev. Refinement of the picture presented for that area is not the purpose of this paper. Some basic information necessary to further examination of the regional stratigraphy, however, is compiled in figure 9 and plates 22 and 23. Figure 9 shows the correlation of all the named stratigraphic units of the Great Basin that include beds partly or wholly within the range of the Pterocephaliid biomere. The age shown at each formation boundary in figure 9 is the age of the formation at its type locality or in its type area.

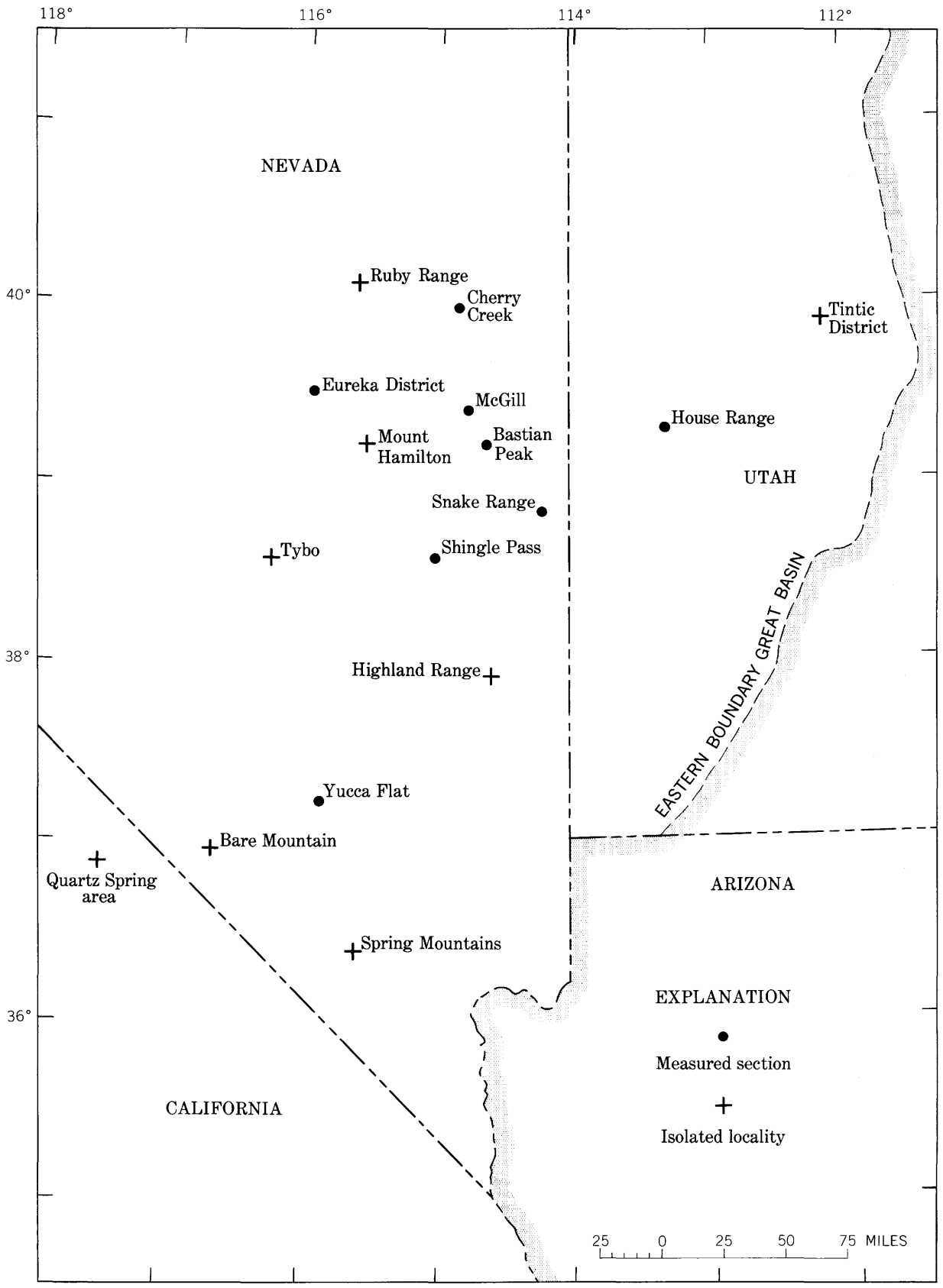


FIGURE 8.—Map showing localities containing faunas of the *Elvinia* zone.

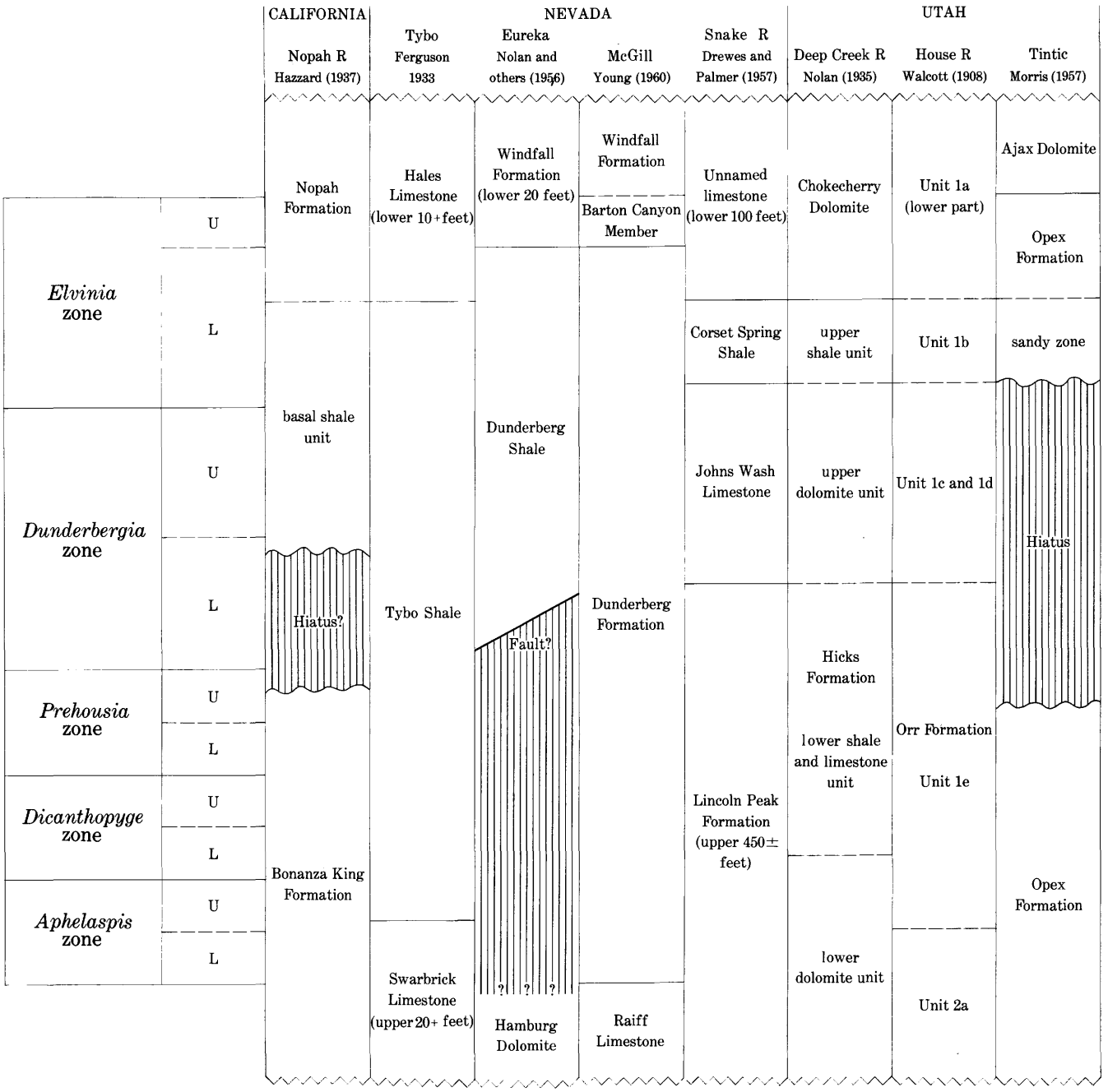


FIGURE 9.—Correlation of the formations in the Great Basin that include beds of the Pterocephaliid biomere.

EVOLUTION WITHIN THE PTEROCEPHALIID BIOMERE

The evolutionary development of most of the species of the Pterocephaliid biomere will probably never be known, but some stratigraphic series containing morphologically similar forms may represent evolutionary sequences. Several of the better documented probable evolutionary series are discussed in following paragraphs and include: *Aphelaspis haguei* (Hall and Whitfield) → *A. longispina* n. sp. → *Dicanthopyge quadrata* n. sp. → *D. convergens* n. sp. → *D. reductus* n. sp.; *Prehousia prima* n. sp. → *P. indenta* n. sp. → *P. alata* Palmer; *Elburgia quinnensis* (Resser) → *Elvinia roemeri* (Shumard); *Pterocephalia concava* Palmer → *P. sanctisabae* Roemer; and, *Elviniella laevis* Palmer → *Irvingella augustilimbatus* Kobayashi → *I. flohri* Resser → *I. major* Ulrich and Resser. None of these series show reversals in morphologic trends at different localities, even though the rock sequences indicate frequent significant shifts and repetitions of

several environments. Thus the alternative possibility that the series represent superposition of ecologic variants by progressive ecologic shift has no support.

Some of the more general relationships at the genus level are reviewed in the appropriate family discussions in the part on "Systematic paleontology" (p. 28).

APHELASPIS HAGUEI (HALL AND WHITFIELD) → DICANTHOPYGE REDUCTUS N. SP.

Although *Aphelaspis haguei* is listed as the first species in the evolutionary series *A. haguei* → *Dicanthopyge reductus* n. sp., it may have been derived from *A. brachyphasis* Palmer (fig. 11). The thoracic pleurae of both *A. brachyphasis* and *A. haguei* have short pointed tips. In the section at McGill (pl. 23), *A. brachyphasis* has been found in nearly all the fossiliferous beds of the lower *Aphelaspis* subzone. Holaspid specimens of *A. brachyphasis* in silicified suites in the lower part of the subzone vary considerably in details of pygidial shape, ranging from specimens having a narrow border to specimens having a relatively wide and slightly concave border (Palmer, 1962b, pl. 4, figs. 6–10). In the upper beds of the subzone, forms having pygidia differing only slightly from those of forms in the lower beds, which have a wide border, are associated with forms that have distinctive cranidia on which the angle between brim and border is more acute than the angle on the cranidia of *A. brachyphasis* and that have more pronounced fossulae at the anterolateral corners of the glabella than the fossulae on the associated specimens of *A. brachyphasis*. In addition, on these forms associated with *A. brachyphasis* in the upper beds of the subzone, the fixed cheeks are slightly upsloping, the glabella has a distinct ornamentation of fine pits, and the surface of the pleural parts of the pygidium is ornamented by obscure closely spaced fine granules. These specimens are here assigned to the early part of the range of *A. haguei*. On the later forms of *A. haguei*, pygidial furrows are more subdued than on earlier forms, the pleural regions are somewhat less concave, the axis is somewhat shorter, the cranidia have more pronounced fossulae at the anterolateral corners of the glabella, and a border furrow is more consistently present.

The collections from beds directly overlying the highest beds containing *A. haguei* at McGill, Nev., include a species that has many features in common with *A. haguei*. Cranidia of the two species are indistinguishable. Both species have a fine pitted ornamentation on the cranidium and fine closely-spaced granules on the pleural regions of the pygidium. The species differ in the structure of the pygidium and the thorax. The pleural tips of the thoracic segments of the new species, *A. longispina*, are long and backswept in contrast to the short and laterally directed tips of *A. haguei*. The pygidium of *A. longispina* is distinctly subquadrate in outline rather than transversely subovate as in *A. haguei*.

A form having elongate pleural tips on the thoracic segments but a transversely subovate pygidium is present in beds at the top of the range of *A. haguei* in a partial section in the Highland Range, Nev. This form is interpreted here as being evolutionally as well as morphologically transitional between *A. haguei* and *A. longispina*. Because of its pygidial shape, it is tentatively included within the hypodigm of *A. haguei*.

In both the McGill and Highland Range sections, the fossiliferous beds directly overlying the beds containing the long-spined populations of *Aphelaspis* have a species that differs from *A. longispina* only by having posterolateral spines formed on the pygidium. This species is assigned to a new genus and named *Dicanthopyge quadrata* n. sp. Two additional species of *Dicanthopyge* are found in succeeding beds at McGill and differ from *D. quadrata* only in shape of the pygidium. The oldest of these is *D. convergens* n. sp., which has distinctly convergent sides of the pygidium but moderately long posterior spines. The terminal species is *D. reductus* n. sp., which has an even more pronounced taper of the pygidial sides making the pygidium subtriangular and reducing the posterior spines to short nubs.

D. reductus has no apparent immediate descendants in the Great Basin. The only possibly related species belong to *Litocephalus*, a genus found in the *Dunderbergia* and *Elvinia* zones. These trilobites have the well-defined cranidial border and long pleural tips to the thoracic segments characteristic of *Dicanthopyge*, but they have a large pygidium that is transversely subovate and has a distinct median notch. Intermediate forms will have to be found before an evolutionary relationship between *Dicanthropyge* and *Litocephalus* can be seriously considered.

Parts of the series *A. haguei* → *D. reductus* are known from many areas of the Great Basin, and the stratigraphic succession of the individual elements of the series is always the same. This series of forms is therefore interpreted as a true example of evolution that can be traced through five successive species and two genera. The significant evolutionary changes are in the pleural parts of the thorax and pygidium of these trilobites. At this point, I cannot overemphasize the importance of searching for all parts of dissociated trilobites before attempting identification. For

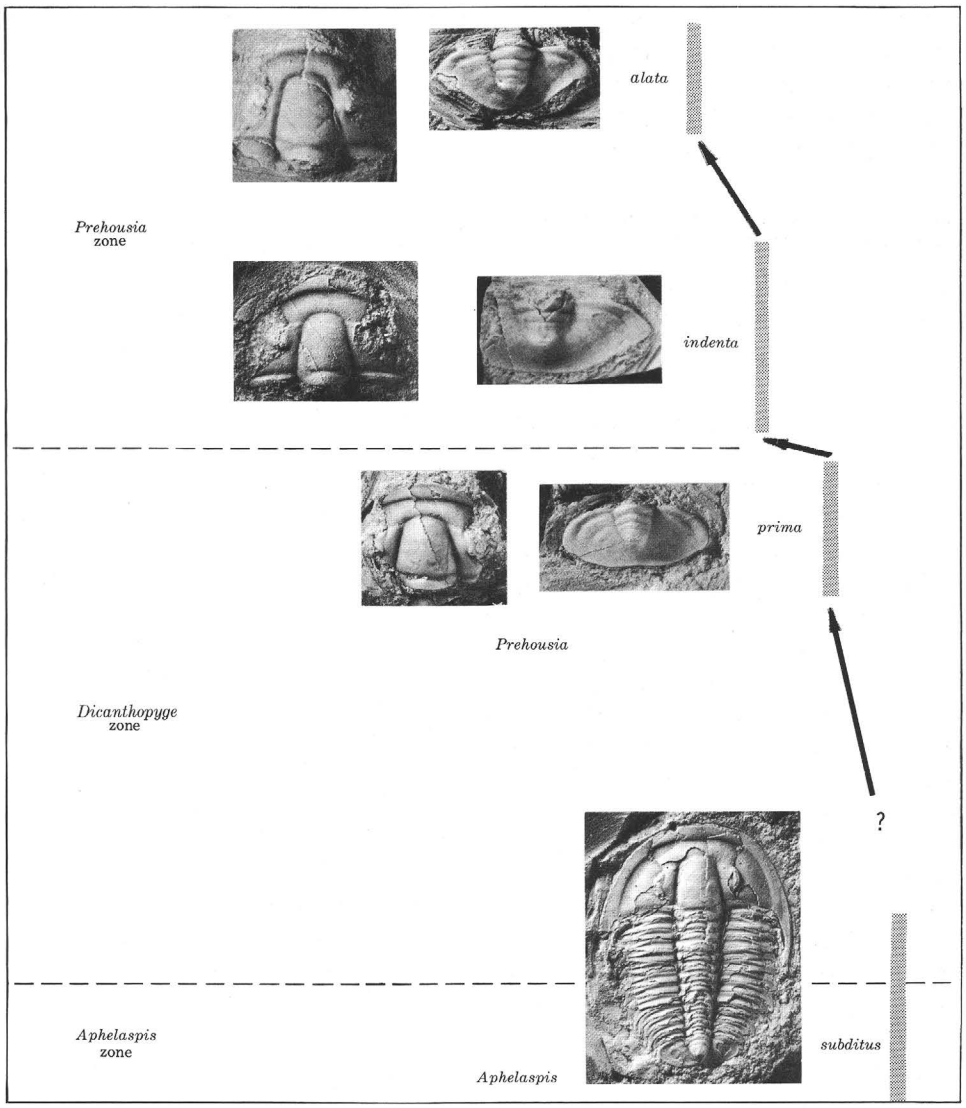


FIGURE 10.—Evolutionary relationships of *Prehousia*. Species ranges are proportional to those given in plate 21.

example, if only the cranidia of these species were known, more than two "species" probably could not have been recognized, and these would probably have been considered congeneric.

PREHOUSIA PRIMA→PREHOUSIA ALATA

The sequence *Prehousia prima* → *P. alata* (fig. 10) is somewhat more subtle than the sequence of *Aphelaspis haguei* → *Dicanthopyge reductus*. *Prehousia prima*, which is first found in the McGill section in association with *D. reductus*, could be assigned to *Aphelaspis* on the basis of all characteristics except size of the palpebral lobes. The lobes are distinctly shorter than the palpebral lobes of any of the Great Basin species of the Aphelaspidinae.

In strata immediately above beds containing *P. prima*, a second species, *P. indenta*, is found, which differs from *P. prima* by having slightly narrower fixed cheeks. A third species, *P. alata*, which has still narrower fixed cheeks and, also, smaller palpebral lobes, is found in higher beds. The pygidia of the species in this series are much like the pygdium of *Aphelaspis subditus* Palmer, but they differ by having a somewhat wider border of more constant width.

The combined characteristics—narrow fixed cheeks, small palpebral lobes, and a pygidial border of nearly constant width—are features of the genus *Housia* from the *Elvinia* zone. *Prehousia diverta* n. sp. from the *Dunderbergia* zone is intermediate both morphologically and stratigraphically between the evolution-

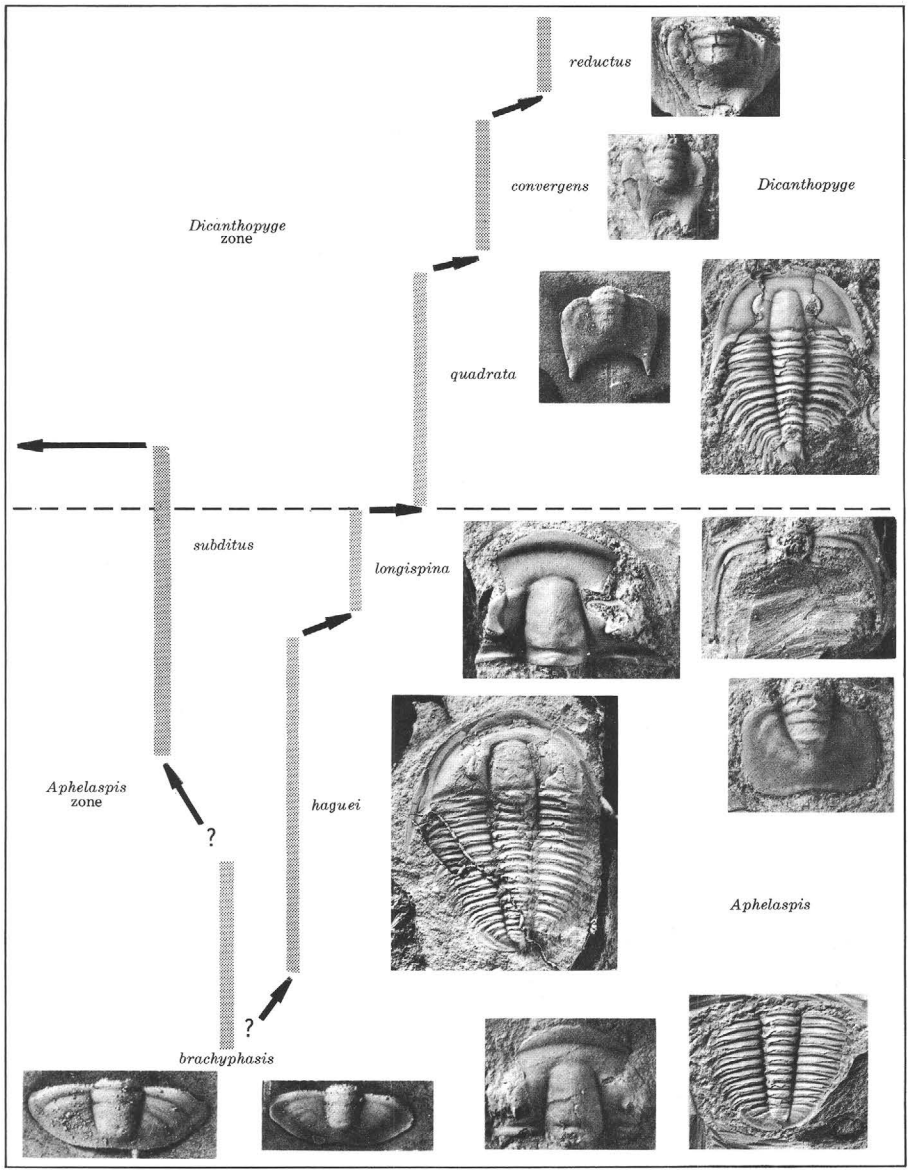


FIGURE 11.—Evolutionary relationships of *Aphelaspis* and *Dicanthopyge*.

ary sequence of *P. prima* → *P. alata* and the species of *Housia*. Although the details of the whole evolutionary sequence are not available because of lack of sufficient specimens from critical levels, the striking morphologic change of width of the fixed cheeks and size of the palpebral lobes with time is well shown by the triangular diagram in figure 12.

The great similarity of *P. prima* to earlier species of *Aphelaspis* is evidence for the probable derivation of the Housiinae from one of the species of the Aphelaspidinae, and it is the principal reason for changing the family Housiidae (Palmer, 1960a, p. 74) to a subfamily within the Pterocephaliidae.

ELBURGIA INTERMEDIA N. SP.→ELVINIA ROEMERI (SHUMARD)

Although the series *Elburgia intermedia* → *Elvinia roemeri* (fig. 13) is shown as beginning with *E. intermedia* n. sp., *Dunderbergia brevispina* n. sp. may be a still older species in the same lineage. The similarities between *Dunderbergia* and *Elburgia* are shown by the median angulation of the border and border furrow on the cranidium, the form of the pygidium, and the course of the ventral cephalic sutures. Species of both genera are found throughout the *Dunderbergia* zone; so, evidence for any common ancestry must be found in older beds. The discovery of *Dunderbergia*

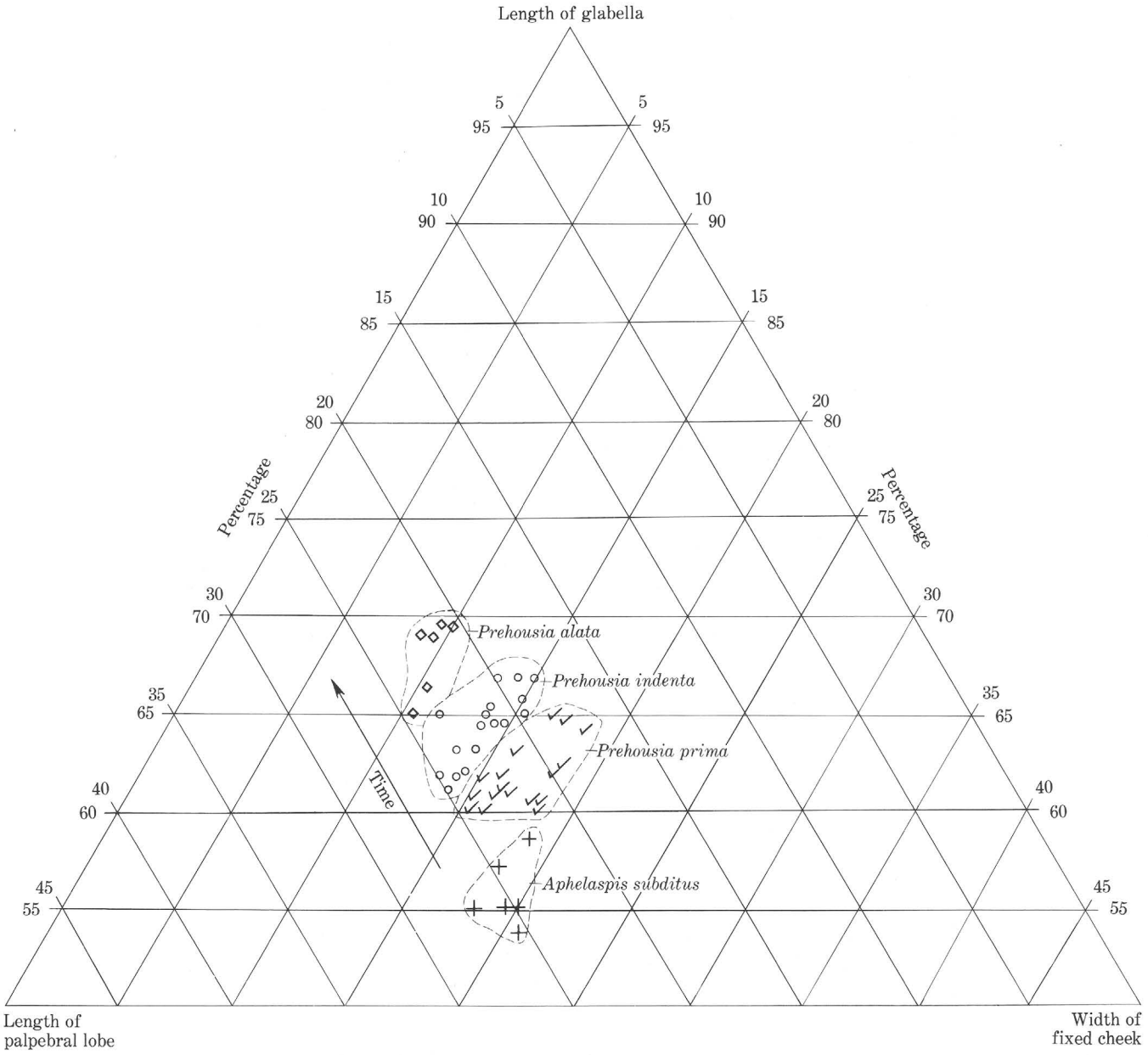


FIGURE 12.—Comparative evolution of length of palpebral lobe, width of fixed cheek, and length of glabella in *Prehousia*.

brevispina in the upper part of the *Dicanthopyge* zone provides an important possible link between the genera. The cranidium of *D. brevispina* has the prominent convex glabella characteristic of most species of *Dunderbergia*. The free cheeks have short genal spines virtually like those of all the species of *Elburgia*. Until additional intermediate forms can be found in the *Prehousia* zone, however, a direct ancestral relationship between *D. brevispina* and a species of *Elburgia* cannot be demonstrated with certainty.

Evolutionary relationships among the species of *Elburgia* are complicated by the fact that the range of *Elburgia granulosa* (Hall and Whitfield) completely overlaps that of *E. intermedia* n. sp. and overlaps the lower part of the range of *E. quinnensis* (Resser). In general, however, the granular species of *Elburgia* are found in older beds than is *E. quinnensis*, which is characterized by a smooth surface. Because *E. intermedia* lacks granules on the external surface of the glabella, and thus is morphologically intermediate between *E. granulosa* and *E. quinnensis*, and because its total range is older than the range of *E. quinnensis*, it is here considered to be the probable direct ancestor of *E. quinnensis*.

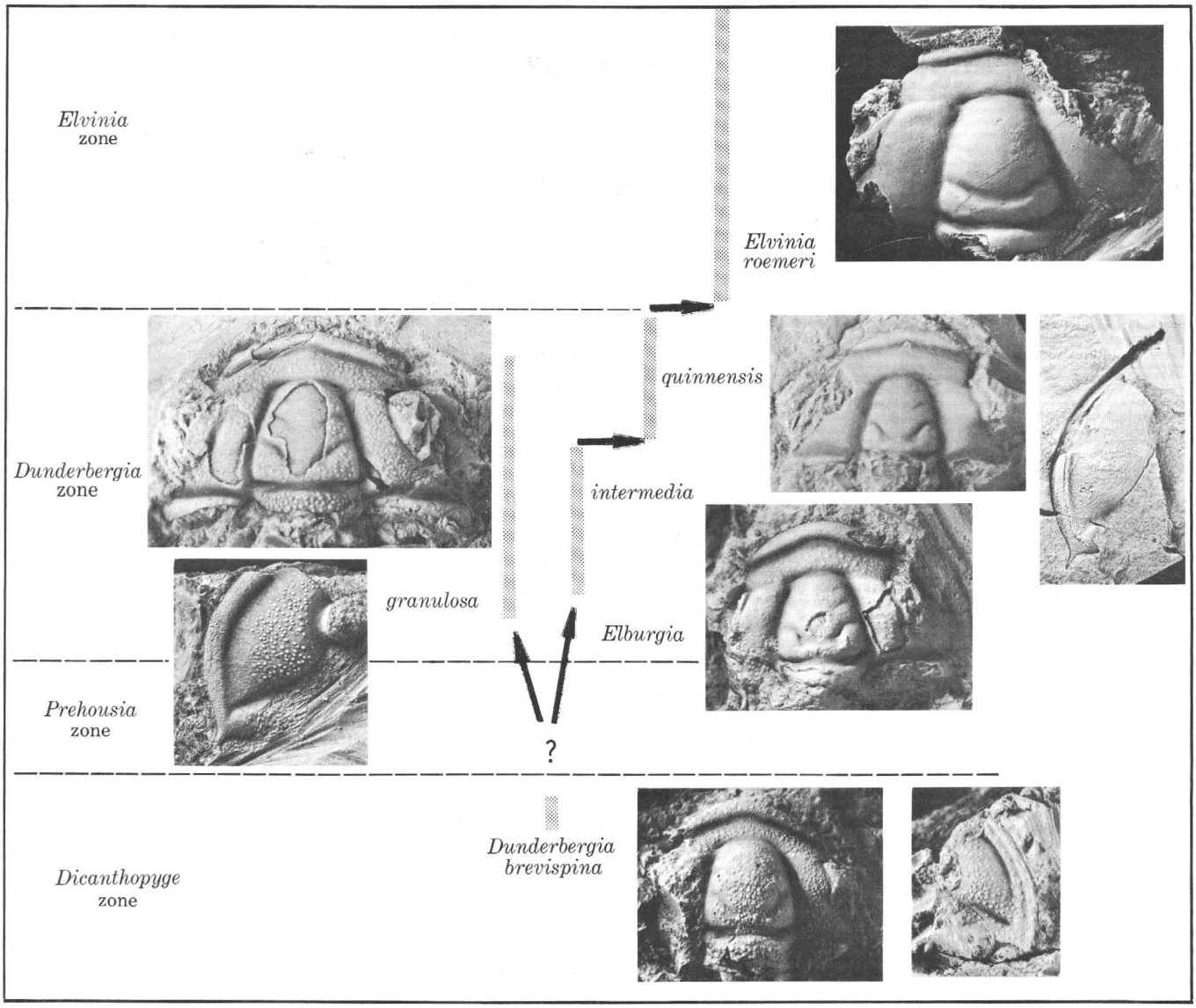


FIGURE 13.—Evolutionary relationships of *Elburgia*. Species ranges are proportional to those given in plate 21.

The differences between *E. quinnensis* and *Elvinia roemeri* (Shumard) lie entirely in the cranidium and are indicated principally the presence of an evenly curved border furrow and a shallow posterior transglabellar furrow of nearly constant depth on *E. roemeri*. The stratigraphic ranges of these common species do not overlap, further strengthening the conclusion that the younger species, *E. roemeri*, is a direct descendant of *E. quinnensis*.

PTEROCEPHALIA CONCAVA PALMER→ PTEROCEPHALIA SANCTISABAE ROEMER

Pterocephalia concava (fig. 14) is older than *P. sanctisabae* and is found in the middle and lower parts of the *Dunderbergia* zone. *P. sanctisabae* is found in the upper *Dunderbergia* zone and throughout the *Elvinia* zone. Holaspid cranidia of the two species that are longer than 10 mm are nearly indistinguishable, although *P. concava* generally has less well formed glabellar furrows. The large pygidia of *P. sanctisabae* differ from those of *P. concava* only by having one or two additional distinct ring furrows and pleural ridges. The principal differences between the species are in the early development of the holaspis (Palmer, 1960a, p. 88). The small holaspis of *P. concava* has a short frontal area on the cranidium and a relatively narrow pygidial border; these characteristics resemble those of species of *Sigmocheilus*. During holaspid development the cranidial and pygidial borders increased their breadths markedly. In contrast, small

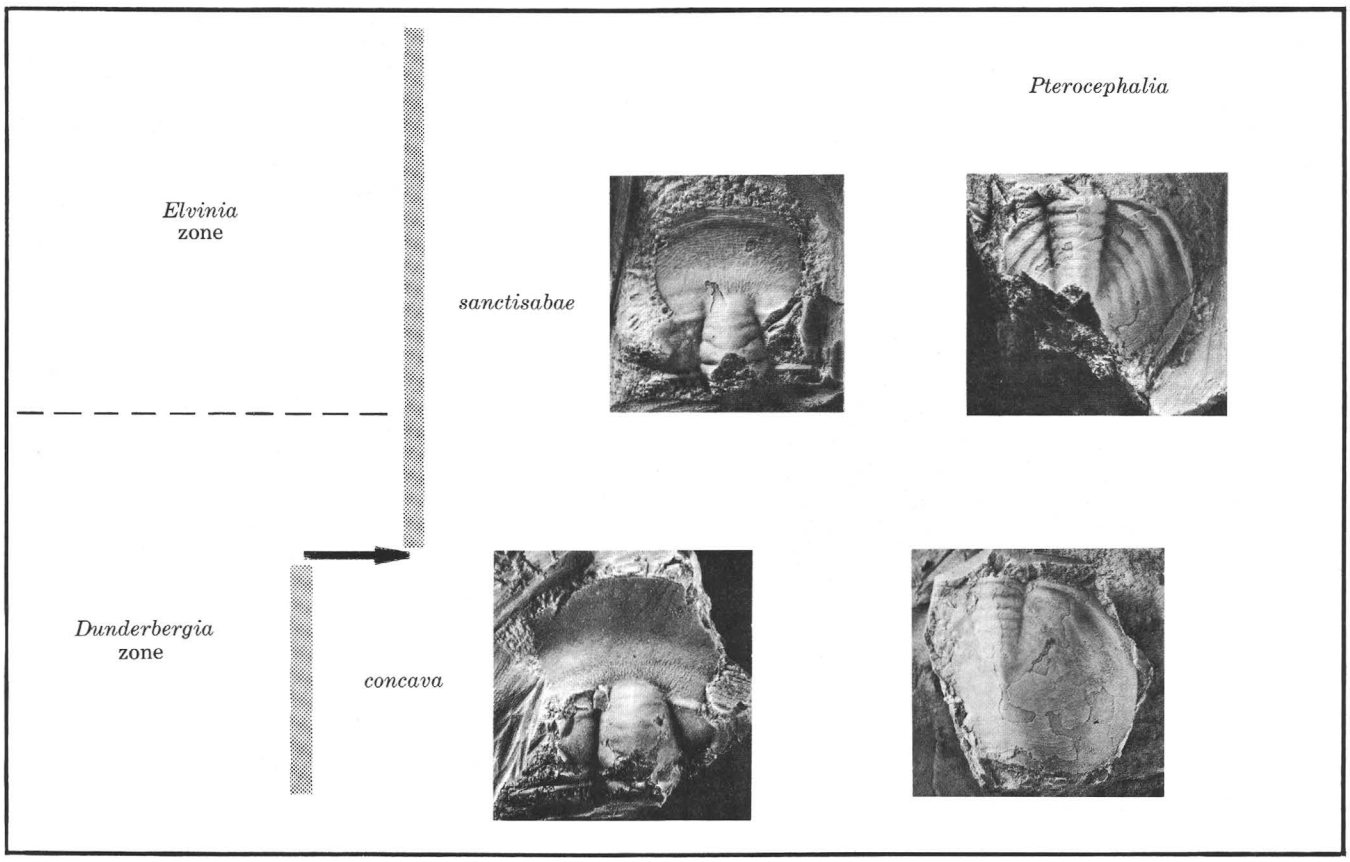


FIGURE 14.—Evolutionary relationships within *Pterocephalia*. Species ranges are proportional to those given in plate 21.

holaspids of *P. sanctisabae* already resemble the large holaspids. Thus, *P. concava* seems to be a transitional species reflecting its *Sigmocheilus*-like ancestor in the early holaspid stages and developing a different large holaspid whose characteristics became stabilized and were present throughout the holaspid development of the descendant species, *P. sanctisabae*.

ELVINIELLA LAEVIS PALMER→IRVINGELLA MAJOR ULRICH AND RESSER

The series *Elviniella laevis* → *Irvingella major* (fig. 15) has been suggested in an earlier paper (Palmer, 1960a, p. 64), but lack of data prevented adequate documentation of the series. The additional stratigraphic information collected from the regional study presented in the present paper seems to confirm the evolutionary series. A probable ancestor for *Elviniella laevis* is not found in the Great Basin region. In the *Dunderbergia* zone, however, this species is linked by two morphologically and stratigraphically intermediate species to *Irvingella major* at the top of the *Elvinia* zone. *Irvingella angustilimbatus* Kobayashi is the probable direct descendant of *Elviniella laevis*; it differs by having a parallel-sided rather than anteriorly tapered glabella and a shorter more nearly subequally divided frontal area. *I. angustilimbatus* gave rise to *I. flohri* Resser, which has a still shorter frontal area that is subdivided into a brim and border only on meraspid and small holaspid specimens. *I. major* seems to have evolved from *I. flohri* by the development of a more prominent glabella and the movement of the anterior ends of the palpebral lobes closer to the axial furrows. *I. major* does not have any apparent immediate descendants, and the evolutionary sequence probably terminates at the top of the Pterocephaliid biomere.

The foregoing evolutionary sequences are potentially useful for interregional and intercontinental correlation. Although each species, in theory, may live on after the appearance of an evolutionary offshoot, the first appearance of a species can certainly be no earlier than the time of its development from an earlier form. Whereas the first individual or even the first few generations of newly evolved species can never be determined in practice, the observed lower limits of all but the first species in the foregoing series

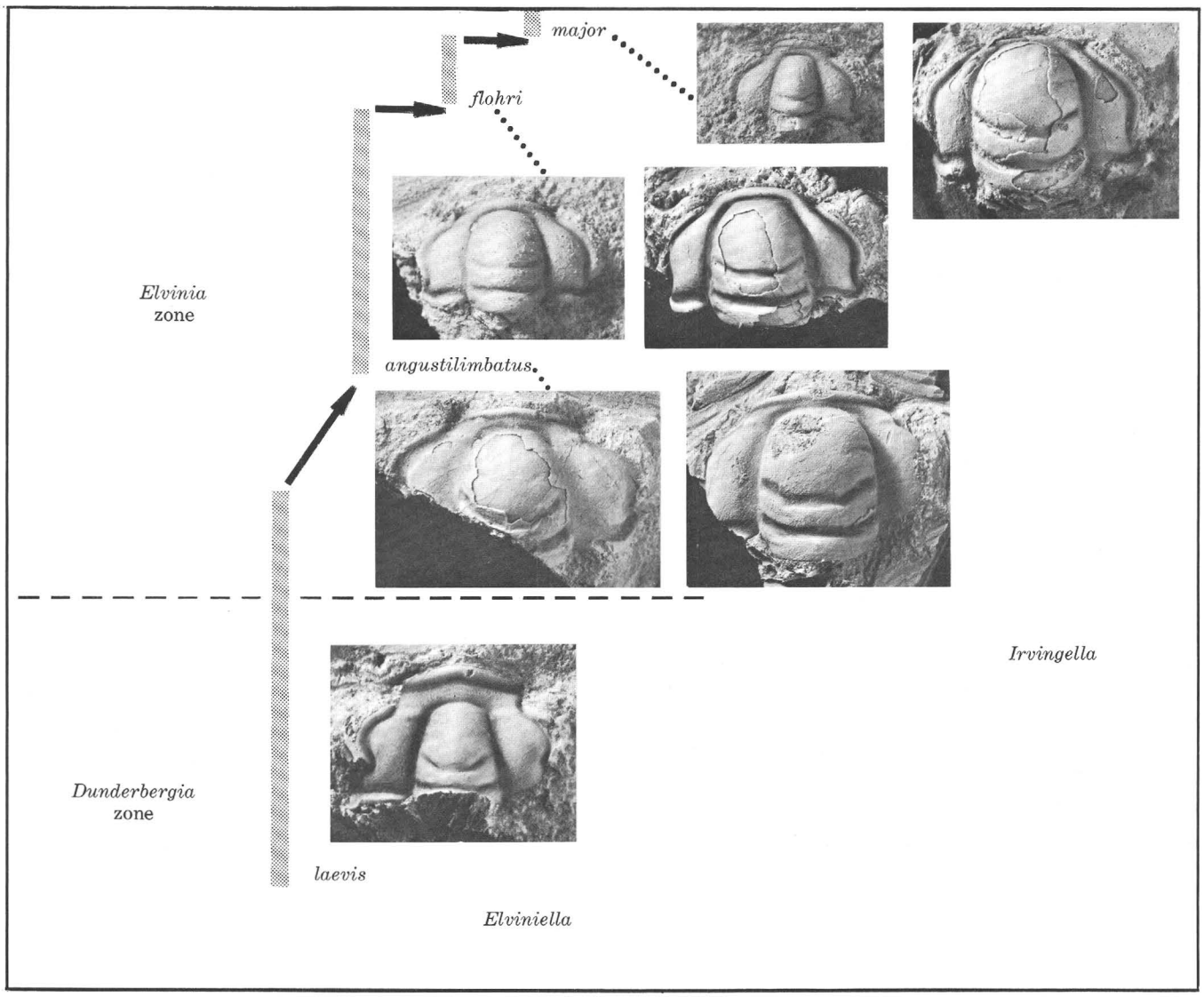


FIGURE 15.—Evolutionary relationships of *Irvingella*. Species ranges are proportional to those given in plate 21.

are probably close to the real lower limits of these species. Otherwise, examples of association of ancestor and descendant should occur, but these have generally not been seen. Also, the observed upper limits of intermediate species in a series may be close to the real upper limits. Thus, the genus *Irvingella* takes on special sratigraphic importance. Species of this genus have been reported from Australia, South America, and many localities in Europe and Asia (p. 46). Identification and evaluation of the specimens from these localities affords the best opportunity presently known for precise intercontinental correlation of regions that were widely separated during the Cambrian, particularly if more than one element in the evolutionary series is present.

SIGNIFICANCE OF ORNAMENTATION

External surfaces of trilobites of the Pterocephaliid biomere are smooth, pitted, or covered to varying degrees with one or more sizes of granules. Ornamentation is an important criterion for the identification of species of most genera of the Elviniidae and of some other genera. Discussion of the reliability of ornamentation for population differentiation has been presented in an earlier paper (Palmer, 1960a, p. 57, 58).

The regional study presented here shows that in some genera (for example, *Dunderbergia*, *Elburgia*, *Litocephalus*, *Cernuolimbus*), species whose principal identifying characteristics are their ornamentation

have partly overlapping ranges in time (pl. 21). However, these species are rarely found in the same collection. If they are found associated, only one species is common. These observations seem to indicate that contemporaneous congeneric species generally did not inhabit the same local areas.

If the whole trilobite fauna of the Pterocephaliid biomere is analyzed for stratigraphic distribution of ornamentation, a striking arrangement of forms having and lacking granular ornamentation is apparent. Whether all the trilobites or only the common species are included, the faunas below the *Dunderbergia* zone, where species lacking granular ornamentation predominate, contrast with the faunas in and above the *Dunderbergia* zone, where species having granular ornamentation predominate. If the distribution figures for the common species are broken down to each subzone, the curve constructed to show species having granular ornamentation indicates, first that less than 20 percent of the granular species occur in the *Aphelaspis* zone, and second that the proportion of granular species increases regularly to a peak of more than 80 percent of the fauna in the *Dunderbergia* zone and then decreases to less than 50 percent of the fauna at the end of the *Elvinia* zone (fig. 16). This distribution pattern is at least partly due to the fact that the Aphelaspidinae and Housiinae, which are the common trilobites in beds of the pre-*Dunderbergia* zone, include few species having granular ornamentation, whereas the Elviniidae and Pterocephaliinae, which characterize the younger beds, commonly include species having granular ornamentation. However, all the suprageneric taxa involved include both species having and species lacking granular ornamentation.

The relative abundance of species having granular ornamentation in the *Dunderbergia* zone may result from parallel evolution in several families in response to the environmental changes related to the regional shift towards more calcareous sediments at this time. Although this change might explain the distribution pattern outlined in figure 16, it provides only a partial explanation for the contemporaneous existence of congeneric ornamented species that seem to have mutually exclusive geographic distributions.

If the trilobites were naturally gregarious, and a species traveled in swarms, perhaps local abundance of particular ornamented species merely indicates temporary and random population peaks. Their distribution pattern, however, may be related to special local and as yet unresolved microenvironments. If such special conditions existed, then the strata affected by microenvironments might be recognized by their characteristic ornamented species; this relationship would be very useful in making a bed-by-bed petrographic-paleontologic analysis of paleoecology. Such a paleoecological analysis, however, is the subject for a separate study that must take into consideration not only the trilobites described here but also the agnostid trilobites, the linguloid, acrotretid, and orthoid brachiopods, and the echinoderms, conodonts, algae, sponges, molluscs, and burrowing soft-bodied organisms that formed a part of the animal communities.

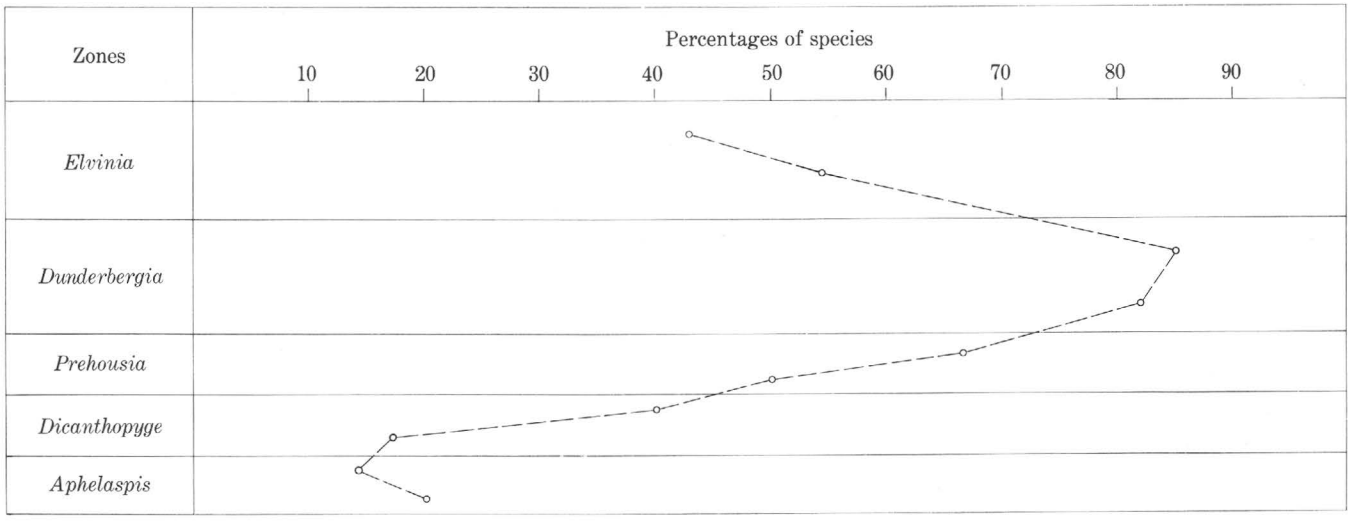


FIGURE 16.—Changes in percentage of common species having granular ornamentation during the time of the Pterocephaliid biomere.

KEY TO THE PTYCHOPARIOID TRILOBITES OF THE PTEROCEPHALIID BIOMERE IN THE GREAT BASIN

The following key is designed as an aid to the idnetification of the trilobites described in this paper. Although it may also aid in identification of trilobites at the generic level in other contemporaneous faunas, its purpose is parochial. Because of the necesssarily subjective nature of many of the characteristics used in the key, all final determinations of a species identification will require reference to illustrations and descriptive text.

The key is constructed principally on the basis of cranidial features, and pygidial features are cited only where absolutely necessary for final discrimination of species having nearly indistinguishable cranidia. Statements about details of ornamentation refer to textural features of the external surface of the exoskeleton, which are visible on many specimens only after whitening with MgO or NH_4Cl. All proportions cited were determined from measurement under a microscope containing a scale having divisions of at least one-fifth millimeter. Particular dimensions were measured as straight-line distances between furrows or from margins to furrows in the following manner:

Dimension	*Description of measurement*
Sagittal length of border	From anterior cranidial margin to middle of border furrow.
Sagittal length of brim	From middle of border furrow to middle of preglabellar furrow.
Sagittal length of frontal area	From anterior cranidial margin to middle of preglabellar furrow.
Sagittal length of glabella	From middle of preglabellar furrow to middle of occipital furrow.
Width of fixed cheeks	On line between midlengths of palpebral lobes, from middle of palpebral furrow to middle of axial furrow.
Basal glabellar width	Between midpoints of axial furrows across widest part of glabella just anterior to occipital furrow.
Distinct anterior position of palpebral lobes.	If sagittal distance from preglabellar furrow to line connecting anterior ends of palpebral lobes is about two-thirds or less of sagittal distance from occipital furrow to line connecting posterior ends of palpebral lobes.

Key No. and characteristic	*Move to key number indicated*
1. a. Frontal area on cranidium either convex and not divided or lacks indication of brim in front of glabella	9
b. Brim on craniduim indicated in front of glabella	2
2. a. Posterior glabellar furrows connected across midline of glabella	13
b. Posterior glabellar furrows not connected across midline of glabella	3
3. a. Cranidial border distinctly concave (Pterocephaliinae)	50
b. Cranidial border not distinctly concave	4
4. a. Glabella has at least one pair of moderately deep lateral glabellar furrows	15
b. Glabella has lateral furrows generally shallow, poorly formed, or absent	5
5. a. Palpebral lobes distinctly anterior to glabellar midlength	24
b. Palpebral lobes about opposite or posterior to glabella midlength	6
6. a. Cranidial border defined by distinct border furrow of approximately constant depth	31
b. Cranidial border defined by change in slope or by poorly defined shallow border furrow	7
7. a. Sagittal length of border equal to or greater than length of brim	8
b. Sagittal length of border less than length of brim	40
8. a. Sagittal length of frontal area more than one-half length of glabella	*Listroa toxoura* Palmer (pl. 11).
b. Sagittal length of frontal area less than one-half length of glabella	*Minupeltis*—114
9. a. At least one pair of deep lateral glabellar furrows present	45
b. Lateral glabellar furrows only slightly apparent	10
10. a. Glabella well defined by axial furrows	11
b. Glabella poorly defined by axial furrows	12
11. a. Distinct border furrow present	*Oligometopus*—56
b. No distinct border furrow	*Cheilocephalus*—57
12. a. Sagittal length of frontal area more than one-fourth length of glabella	*Bynumina globosa* (Walcott) (pl. 18).
b. Sagittal length of frontal area less than one-fourth length of glabella.	*Pseudokingstonia exotica* Palmer (pl. 1).
13. a. Sides of glabella subparallel, at least in posterior half.	*Irvingella angustilimbatus* Kobayashi (pl. 6).
b. Sides of glabella convergent forward	14
14. a. Ocular ridges directed slightly anterolaterally towards ends of palpebral lobes	*Elviniella laevis* Palmer (pl. 7).
b. Ocular ridges directed straight laterally or slightly posterolaterally to ends of palpebral lobes	*Elvinia*—61
15. a. Palpebral lobes distinctly anterior to glabellar midlength	46
b. Palpebral lobes about opposite or posterior to glabellar midlength	16
16. a. Width of fixed cheeks distinctly less than one-fourth basal glabellar width	17
b. Width of fixed cheeks one-fourth or more basal glabellar width	18
17. a. Sagittal length of border greater than length of brim.	*Comanchia minus* Palmer (pl. 19).
b. Sagittal length of border less than length of brim.	*Stenambon*—62
18. a. Anterior border has long anteriorly directed projection.	*Dokimocephalus pernasuta* (Walcott) (pl. 3).
b. Anterior border lacks long anterior projection	19

Key No. and characteristic	Move to key number indicated
19. a. Anterior border furrow has distinct anteriorly directed median angulation	20
b. Anterior border furrow nearly evenly curved in plan view	21
20. a. Second pair of glabellar furrows nearly as deep as posterior glabellar furrows	*Elburgia*—64
b. Second pair of glabellar furrows distinctly shallower than posterior glabellar furrows	*Dunderbergia*—73
21. a. Glabella nearly subparallel sided and squarely truncate at front	*Erixanium*—63
b. Glabella either distinctly tapered forward or rounded at front	22
22. a. Palpebral lobes small, poorly defined, having length less than one-third sagittal length of glabella.	*Glaphyraspis ornata* (Lochman) (pl. 7).
b. Palpebral lobes large, well defined, having length more than one-third sagittal glabellar length	23
23. a. Fixed cheeks nearly horizontal.	*Pseudosaratogia leptogranulata* Palmer (pl. 2).
b. Fixed cheeks distinctly upsloping; palpebral lobes distinctly posterior to glabellar midlength.	*Iddingsia*—66
c. Fixed cheeks distinctly upsloping; palpebral lobes about opposite glabellar midlength	*Kindbladia affinis* (Walcott) (pl. 3).
24. a. Palpebral lobes well defined by palpebral furrows.	*Morosa*—81
b. Palpebral lobes poorly defined by palpebral furrows	25
25. a. Axial furrows at sides of glabella noticeably downsloping anterior to palpebral lobes, in side view; brim steeply downsloping, nearly flat, wider than nearly horizontal border	*Housia*—82
b. Axial furrows at sides of glabella not noticeably downsloping anterior to palpebral lobes	26
26. a. Axial furrows at sides of glabella noticeably concave between palpebral lobes in dorsal view.	*Parahousia*—83
b. Axial furrows at sides of glabella not noticeably concave	27
27. a. Brim has distinct median swelling.	*Tumicephalus depressus* Palmer (pl. 13).
b. Brim lacks median swelling	28
28. a. Occipital furrow not apparent.	*Blountia bristolensis* Resser (pl. 1).
b. Occipital furrow apparent	29
29. a. Width of fixed cheek about one-half basal glabellar width; glabella barely tapered forward, very rounded at front	*Hardyoides*—115
b. Width of fixed cheek generally less than one-half basal glabellar width; glabella either distinctly tapered forward or bluntly rounded at front	30
30. a. Basal glabellar width slightly greater than glabellar length; if width equals length, sagittal length of cranidium less than 4 mm	*Aphelotoxon*—84
b. Basal glabellar width slightly less than glabellar length; if width equals length, sagittal length of cranidium generally exceeds 4 mm	*Prehousia*—69
31. a. Anterior margin of cranidium distinctly pointed.	*Morosa extensa* Palmer (pl. 20).
b. Anterior margin of cranidium rounded	32
32. a. Fixed cheeks strongly upsloping	*Anechocephalus*—89
b. Fixed cheeks nearly horizontal or only slightly upsloping	33
33. a. Border furrow on cranidium has indication of slight to moderate median angulation that is pointed forward	*Dunderbergia*—73
b. Border furrow lacks indication of median angulation that is pointed forward	34
34. a. Sagittal length of border greater than that of brim.	*Taenora expansa* Palmer (pl.11).
b. Sagittal length of border less than that of brim	35
35. a. Anterior end of glabella strongly rounded; junction between axial and preglabellar furrows unmarked.	*Apachia*—80
b. Anterior end of glabella bluntly rounded; distinct anterolateral corners or shallow to deep anterolateral fossulae apparent	36
36. a. External surface of cranidium strongly pitted	37
b. External surface of cranidium smooth, faintly pitted or granular	38
37. a. Border very convex in sagittal profile.	*Della? punctata* Palmer (pl.3).
b. Border flat or unevenly convex in sagittal profile.	*Prehousia prima* Palmer (pl. 13).
38. a. Pygidium has one or two pairs of border spines	43
b. Pygidium lacks border spines	39
39. a. Pygidium has distinct posterior median notch.	*Litocephalus*—92
b. Pygidium lacks notch in posterior margin	44
40. a. External surface of cranidium smooth or pitted	41
b. External surface of cranidium has strong granular ornamentation.	*Pseudosaratogia abnormis* Palmer (pl. 2).
41. a. Pygidium has one pair of marginal spines.	*Dicanthopyge*—95
b. Pygidium lacks marginal spines	42
42. a. Pygidium has median swelling behind axis.	*Erixanium? brachyaxis* Palmer (pl. 17).
b. Pygidium lacks median swelling behind axis.	*Aphelaspis*—97
43. a. Pygidial margin between border spines curved forward.	*Dicanthopyge*—95
b. Pygidial margin between border spines curved backward.	*Olenaspella*—90
44. a. Lateral border of free cheek moderately convex; cranidial length less than 6 mm.	*Bromella veritas* Palmer (pl. 18).
b. Lateral border of free cheek nearly flat; cranidial length may exceed 6 mm	*Aphelaspis*—97
45. a. Posterior furrows on glabella connected across top	*Irvingella*—59
b. Posterior furrows on glabella curved, not connected across top	*Terranovella brevis* Palmer (pl. 7).
46. a. Occipital ring has prominent occipital spine.	*Xenocheilos granulosus* Palmer (pl. 7).
b. Occipital ring lacks prominent occipital spine	47
47. a. Glabellar sides moderately to strongly convergent forward	48
b. Glabellar sides subparallel, bowed, or only slightly convergent forward	49
48. a. Sagittal length of border less than length of brim.	*Dytremacephalus*—101
b. Sagittal length of border equal to or greater than length of brim	*Aphelotoxon*—84

Key No. and characteristic	Move to key number indicated
49. a. Sagittal length of frontal area more than one-sixth length of glabella	*Simulolenus*—102
b. Sagittal length of frontal area less than one-sixth length of glabella	*Aciculolenus peculiaris* Palmer (pl. 7).
50. a. Border tapered laterally to sharp point.	*Cernuolimbus depressus* Palmer (pl. 14).
b. Border not tapered to sharp point laterally	51
51. a. Cranidial border well defined	52
b. Cranidial border poorly defined	54
52. a. Palpebral lobes poorly defined by palpebral furrow.	*Strigambitus? blepharina* Palmer (pl. 16).
b. Palpebral lobes well defined by palpebral furrow	53
53. a. Border furrow generally shallow; junction of facial suture with anterior margin not distinctly angular.	*Sigmocheilus*—104
b. Either border furrow deep and narrow, or junction of facial sutures with anterior margin distinctly angular.	*Cernuolimbus*—107
54. a. Cranidium has well-defined granular ornamentation on brim	*Strigambitus*—110
b. Cranidium has subdued or absent granular ornamentation on brim	55
55. a. External surface of cranidium finely pitted.	*Pterocephalia? punctata* Palmer (pl. 17).
b. External surface of cranidium not pitted.	*Pterocephalia*—112
56. a. Width of fixed cheeks about one-half basal glabellar width; granular ornamentation well-defined.	*Oligometopus breviceps* (Walcott) (pl. 1).
b. Width of fixed cheeks one-third or less basal glabellar width; granular ornamentation barely apparent.	*Oligometopus contractus* Palmer (pl. 1).
57. a. Frontal area short—length about one-ninth that of glabella including occipital ring; anterior margin convex, has zone of terrace lines about half sagittal length of frontal area	*Cheilocephalus brachyops* (pl. 1).
b. Frontal area nearly flat—length more than one-eighth that of glabella including occipital ring	58
58. a. External surfaces of all parts nearly smooth.	*Cheilocephalus brevilobus* (Walcott) (pl. 1).
b. External surfaces of all parts covered with closely spaced granules; zone of terrace lines on anterior margin narrow.	*Cheilocephalus granulosus* Palmer (pl. 1).
59. a. Width of fixed cheek about two-thirds basal glabellar width	*Irvingella transversa* Palmer (pl. 6).
b. Width of fixed cheek one-half or less basal glabellar width	60
60. a. Distance between palpebral furrows on line tangent to front of glabella slightly greater than basal glabellar width; transverse and longitudinal convexity of glabella moderate; second glabellar furrows generally not apparent	*Irvingella flohri* Resser (pl. 6).
b. Distance between palpebral furrows on line tangent to front of glabella slightly less than basal glabellar width; transverse and longitudinal convexity of glabella great; second pair of glabellar furrows generally distinct, especially on molds.	*Irvingella major* Ulrich and Resser (pl. 6).
61. a. Surface of cranidium smooth; sagittal length of border distinctly less than length of brim.	*Elvinia roemeri* (Shumard) (pl. 3).
b. Surface of cranidium covered with low coarse granules; sagittal length of border about equal to length of brim	*Elvinia granulata* Resser (pl. 3).
62. a. External surface obscurely ornamented; pygidium has broad, shallow median notch; axis has three distinct ring furrows behind articulating furrow.	*Stenambon paucigranulus* Palmer (pl. 11).
b. External surface conspicuously ornamented with close-spaced granules; pygidium has moderately deep median notch; axis has four distinct ring furrows posterior to articulating furrow.	*Stenambon megagranulus* (pl. 11).
63. a. Cranidial border defined by distinct shallow border furrow; axis of pygidium has two or three ring furrows; postaxial part of pygidium has distinct carina	*Erixanum carinatum* Palmer (pl. 17).
b. Cranidial border defined principally by change in slope; axis of pygidium has five or six ring furrows; postaxial part of pygidium lacks carina.	*Erixanium multisegmentus* Palmer (pl. 17).
64. a. Glabella has prominent external granular ornamentation	*Elburgia granulosa* (Hall and Whitfield) (pl. 5).
b. Glabella lacks external granular ornamntation	65
65. a. Brim has distinct coarse granular ornamentation on external surface	*Elburgia intermedia* Palmer (pl. 6).
b. Granular ornamentation lacking or only barely visible on lateral parts of brim.	*Elburgia quinnensis* (Resser) (pl. 6).
66. a. Sagittal length of border on cranidium distinctly less than length of brim; surface of mold has granules on top of glabella and fixed cheeks; lateral and posterior border furrows on free cheek joined.	*Iddingsia intermedia* Palmer (pl. 2).
b. Sagittal length of border on cranidium equal to or slightly more than sagittal length of brim; surface of mold smooth; lateral and posterior border furrows on free cheek not connected	67
67. a. External surface of cranidium smooth.	*Iddingsia utahensis* Resser (pl. 2).
b. External surface of cranidium partly or wholly granular	68
68. a. Brim and border smooth or have very fine granular ornamentation; distinct contrast between ornament on glabella and that on frontal area.	*Iddingsia similis* (Walcott) (pl. 2).
b. Brim and border have distinct granular ornamentation.	*Iddingsia robusta* (Walcott) (pl. 2).
69. a. Length of palpebral lobe on cranidium generally about one-half length of glabella.	*Prehousia semicircularis* Palmer (pl. 12).
b. Length of palpebral lobe on cranidium generally about one-third or less length of glabella	70
70. a. Sagittal profile of frontal area smoothly concave; frontal area lacks definite border furrow.	*Prehousia diverta* Palmer (pl. 12).
b. Frontal area has distinct border furrow; border flat or gently convex	71
71. a. Width of fixed cheeks on larger holaspids (length >4 mm) more than 12 percent of sum of length of glabella, width of fixed cheek, and length of palpebral lobe, surface has moderately distinct pits.	*Prehousia indenta* Palmer (pl. 13).

Key No. and characteristic	Move to key number indicated
71. b. Width of fixed cheeks on larger holaspids generally less than 12 percent of sum of length of glabella, width of fixed cheek, and length of palpebral lobe; surface smooth, faintly pitted, or roughened	72
72. a. Pygidium has poorly defined pleural furrows; posterior margin unevenly curved; width of axis nearly one-third width of pygidium; surface generally smooth or faintly pitted—*Prehousia alata* Palmer (pl. 13).	
b. Pygidium has three distinct pleural furrows extending across pleural field onto inner part of slightly concave border; posterior margin evenly rounded; width of axis about one-fourth width of pygidium; surface generally faintly roughened. *Prehousia impolita* Palmer (pl. 13).	
73. a. External surfaces of cranidium and free cheek generally smooth; pygidium has fine granular ornamentation on axis and border only. *Dunderbergia nitida* (Hall and Whitfield) (pl. 4).	
b. External surface of cranidium ornamented partly or wholly with either pits or granules; pygidium partly or wholly ornamented with closely spaced granules	74
74. a. External surfaces of cranidium and free cheek coarsely pitted—particularly top of glabella and border regions—*Dunderbergia polybothra* Palmer (pl. 4).	
b. External surface of cranidium partly or wholly granular	75
75. a. Cranidial relief low; anterolateral corners of brim generally only downsloping; free cheek has long slender genal spine; length of spine about three times length of posterior section of facial suture. *Dunderbergia anyta* (Hall and Whitfield) (pl. 4).	
b. Cranidial relief moderate to great; anterolateral corners of brim generally depressed; free cheek has short slender genal spine; length of spine about equal to or shorter than length of posterior section of facial suture	76
76. a. Ornamentation of cranidium generally consists only of scattered moderately prominent coarse granules. *Dunderbergia variagranula* Palmer (pl. 5).	
b. Ornamentation of cranidium consists either of mixture of closely spaced fine granules and scattered coarse granules or of closely spaced fine granules only	77
77. a. Cranidial ornamentation consists dominantly of closely spaced fine granules on all parts. *Dunderbergia calculosa* Palmer (pl. 5).	
b. Cranidial ornamentation consists of both closely spaced fine granules and scattered coarse granules	78
78. a. Closely spaced fine granules on cranidium generally apparent only on border, also on top of glabella and palpebral lobes of some specimens; coarse scattered granules most apparent on brim; free cheek has genal spine whose length is about equal to length of posterior section of facial suture. *Dunderbergia bigranulosa* Palmer (pl. 4).	
b. Closely spaced granules and scattered coarse granules mixed on all parts of cranidium; free cheek has genal spine whose length is about one-half length of posterior section of facial suture. *Dunderbergia brevispina* Palmer (pl. 5).	
79. a. Border of cranidium differentiated from brim only by distinct break in slope; length of border less than one-half length of brim. *Pseudosaratogia abnormis* Palmer (pl. 2).	
79. b. Border of cranidium differentiated from brim by shallow border furrow; length of border about one-half length of brim. *Pseudosaratogia leptogranulata* Palmer (pl. 2).	
80. a. Frontal area subequally divided; back of glabella rises distinctly from occipital furrow. *Apachia butlerensis* (Frederickson) (pl. 3).	
b. Sagittal length of brim about twice that of border; back of glabella does not rise distinctly from occipital furrow—*Apachia prima* Palmer (pl. 3).	
81. a. Length of genal spine about equal to length of posterior section of facial suture; terrace lines only on outer edge of border of pygidium. *Morosa brevispina* Palmer (pl. 20).	
b. Length of genal spine about twice length of posterior section of facial suture; entire border of pygidium generally covered with terrace lines. *Morosa longispina* Palmer (pl. 20).	
82. a. Free cheek has long genal spine; sagittal length of pygidium about two-thirds width. *Housia ovata* Palmer (pl. 12).	
b. Free cheek lacks genal spine; sagittal length of pygidium about one-half width. *Housia varro* (Walcott) (pl. 12).	
83. a. Sagittal length of border of cranidium nearly twice that of brim; external surface has coarse pitted ornamentation—*Parahousia constricta* Palmer (pl. 12).	
b. Sagittal length of border of cranidium only slightly greater than length of brim; external surface not distinctly pitted. *Parahousia subequalis* Palmer (pl. 12).	
84. a. Occipital ring has short median spine. *Aphelotoxon spinosus* Palmer (pl. 19).	
b. Occipital ring lacks spine	85
85. a. Anterior margin distinctly acuminate; glabella poorly defined—*Aphelotoxon acuminata* Palmer (pl. 19).	
b. Anterior margin gently curved; glabella moderately well defined	86
86. a. External surface of cranidium coarsely pitted; fixed cheeks moderately convex; sagittal length of border distinctly greater than that of brim. *Aphelotoxon punctata* Palmer (pl. 19).	
b. External surface generally either smooth or granular; fixed cheeks flat or gently convex; frontal area subequally divided	87
87. a. Width of fixed cheek nearly one-half basal glabellar width—*Aphelotoxon marginata* Palmer (pl. 19).	
b. Width of fixed cheek about one-third basal glabellar width	88
88. a. External surface covered with closely spaced fine granules—*Aphelotoxon granulosus* Palmer (pl. 19).	
b. External surface smooth. *Aphelotoxon limbata* Palmer (pl. 19).	
89. a. Sagittal length of frontal area of cranidium less than one-third glabellar length; pygidium lacks posterolateral spines—*Anechocephalus trigranulatus* Palmer (pl. 20).	
b. Sagittal length of frontal area of cranidium between one-third and one-half length of glabella; pygidium has pair of posterolateral spines. *Anechocephalus spinosus* Palmer (pl. 20).	

Key No. and characteristic	Move to key number indicated
90. a. Axis of pygidium has two ring furrows posterior to articulating furrow; border has two pairs of evenly spaced spines, each connected by low ridge to posterior band of adjacent pleural segment. *Olenaspella paucisegmenta* Palmer (pl. 10).	
b. Axis of pygidium has three or more ring furrows posterior to articulating furrow; border has one to three pairs of border spines	91
91. a. First pleural segment of pygidium has well-formed border spines; other border spines, if present, placed near anterolateral spines. *Olenaspella separata* Palmer (pl. 10).	
b. First and second pleural segments of pygidium have well-formed border spines, approximately equally spaced along posterior margin; third pair of spines, if present, placed close to and adaxially from spine of second pleural segment; each spine connected by low ridge to posterior band of adjacent pleural segment. *Olenaspella regularis* Palmer (pl. 10).	
92. a. External surface of cranidial border smooth; top of pygidial axis smooth; posterior median notch short. *Litocephalus bilobatus* (Hall and Whitfield) (p. 11).	
b. External surface of cranidial border and pygidial axis ornamented with either fine closely spaced granules or coarse granules	93
93. a. Cranidial border has scattered coarse granules; pygidial axis has pairs of granules on each of first four segments. *Litocephalus verruculapeza* Palmer (pl. 11).	
b. Cranidial border has fine closely spaced granular ornamentation	94
94. a. Granular ornamentation on cranidium confined to border; posterior median notch on pygidium short. *Litocephalus granulomarginatus* Palmer (pl. 10).	
b. Fine granular ornamentation present on most areas of cranidium, particularly on top of glabella; pygidium has long, slender median notch. *Litocephalus magnus* Palmer (pl. 10).	
95. a. Pygidium subquadrate, sides subparallel; external surfaces of pleural regions of pygidium, genal spines, and tips of thoracic segments generally covered with fine granules *Dicanthopyge quadrata* Palmer (pl. 9).	
b. Sides of pygidium conspicuously convergent posteriorly	96
96. a. Posterior border spines moderately long; surfaces of all parts of exoskeleton have shallow closely spaced pits. *Dicanthopyge convergens* Palmer (pl. 9).	
b. Posterior border spines short, close together; surfaces of pleural regions of pygidium and genal spines roughened *Dicanthopyge reductus* Palmer (pl.10).	
97. a. Pygidium subquadrate; posterior margin has slight median inbend; tips of thoracic segments long, slender, backswept *Aphelaspis longispina* Palmer (pl. 9).	
b. Pygidium transversely subovate; tips of thoracic segments short, sharp-pointed	98
98. a. Border of pygidium narrow, only slightly expanded laterally; pleural fields crossed by three or four shallow pleural furrows; border of cranidium narrow, well defined by border furrow; eye ridges distinct, directed laterally at right angles to axial line; genal spine on free cheek more than twice as long as posterior section of facial suture *Aphelaspis buttsi* (Kobayashi) (pl. 8).	
b. Border of pygidium moderately expanded laterally; pleural fields crossed by only one or two distinct pleural furrows; genal spine on free cheek less than twice as long as posterior section of facial suture	99
99. a. Fixed cheeks on cranidium slightly upsloping; anterolateral fossulae generally well formed; brim moderately to strongly convex, making distinct angle with border; sagittal length of border only slightly less than length of brim; external surface generally distinctly pitted; pleural fields on pygidium crossed by one or two moderately well defined pleural furrows; border generally slightly concave. *Aphelaspis haguei* (Hall and Whitfield) (pl. 9).	
b. Fixed cheeks on cranidium nearly horizontal; anterolateral fossulae poorly defined; sagittal length of border between one-half and three-fourths length of brim; surface generally smooth; pleural furrows on pygidium generally shallow	100
100. a. Cranidium has distinct border furrow; palpebral furrow moderately well defined; free cheek has slender genal spine; pygidium has two or three ring furrows generally apparent behind articulating furrow; only one pleural furrow generally apparent. *Aphelaspis subditus* Palmer (pl. 8).	
b. Border furrow and palpebral furrow on cranidium very slightly apparent; free cheek has short broad-based genal spine; pygidium has one or two distinct ring furrows generally apparent behind articulating furrow; two pleural furrows generally apparent. *Aphelaspis brachyphasis* Palmer (pl. 8).	
101. a. Palpebral lobes on cranidium placed slightly anterior to glabellar midlength; external surface of cranidium covered with closely spaced granules. *Dytremacephalus granulosus* Palmer (pl. 18).	
b. Palpebral lobes on cranidium opposite or slightly anterior to glabellar midlength; distinct granular ornamentation on cranidium confined to top of glabella. *Dytremacephalus asperaxis* (pl. 18).	
102. a. Sagittal length of frontal area about one-fourth glabellar length; pygidium has two distinct furrows posterior to articulating furrow and two distinct pleural furrows. *Simulolenus quadrisulcatus* (pl. 8).	
b. Sagittal length of frontal area more than one-fourth glabellar length; pygidium has one ring furrow posterior to articulating furrow and one pleural forrow	103
103. a. External surface smooth; ring furrow on pygidium poorly defined. *Simulolenus wilsoni* (Henningsmoen) (pl. 8).	
b. External surface finely granular; ring furrow on pygidium distinct *Simulolenus granulatus* (Palmer) (pl. 8).	
104. a. Pygidium has border spines; length of cranidial border generally less than twice length of brim	105
b. Pygidium lacks border spines; length of cranidial border generally more than twice length of brim	106
105. a. Pygidial border spines very short; margin of pygidium very slightly scalloped; cranidial brim strongly convex in sagittal profile; external surface of glabella covered with closely spaced coarse granules. *Sigmocheilus pogonipensis* (Resser) (pl. 15).	

Key No. and characteristic	Move to key number indicated
105. b. Pygidial border spines well defined; five or six short broad-based pairs of spines present; cranidial brim gently convex in sagittal profile; external surface of glabella has very slight fine granular ornamentation. *Sigmocheilus flabellifer* (Hall and Whitfield) (pl. 15).	
106. a. Border of pygidium flared laterally; posterior margin gently rounded, slight median inbend present in some specimens; line connecting points of greatest width passes slightly posterior to end of axis. *Sigmocheilus grata* (Resser) (pl. 15).	
b. Border of pygidium not flared laterally; posterior margin bluntly pointed on axial line; line connecting points of greatest width passes over end of axis. *Sigmocheilus notha* (Resser) (pl. 15).	
107. a. External surface of cranidium distinctly pitted. *Cernuolimbus orygmatos* Palmer (pl. 14)	
b. External surface of cranidium partly or wholly granular	108
108. a. Sagittal length of cranidial border about 1½ times length of brim *Cernuolimbus semigranulosus* Palmer (pl. 14).	
b. Sagittal length of cranidial border equal to or less than than length of brim	109
109. a. Cranidial border has granular ornamentation. *Cernuolimbus granulosus* Palmer (pl. 14).	
b. Cranidial border smooth. *Cernoulimbus laevifrons* Palmer (pl. 14).	
110. a. Pygidium transversely subovate; posterior margin gently convex backward; axis has three well defined ring furrows posterior to articulating furrow. *Strigambitus transversus* Palmer (pl. 16)	
b. Pygidium subquadrate; posterior margin has distinct median inbend; axis generally has only two distinct ring furrows posterior to articulating furrow	111
111. a. Pleural fields and axis of pygidium coarsely granular; median notch only moderately developed. *Stringambitus utahensis* (Resser) (pl. 16).	
b. Pleural fields of pygidium generally nearly smooth; granular ornamentation faint on large specimens; median notch generally deep. *Strigambitus bilobus* Palmer (pl. 16)	
112. a. Pygidium elongate, subquadrate. *Pterocephalia elongata* Palmer (pl. 17).	
b. Pygidium subovate	113
113. a. Pygidium has six or more ring furrows posterior to articulating furrow; four or five distinct pleural ridges generally present. *Pterocephalia sanctisabae* Roemer (pl. 17).	
b. Pygidium has four or five distinct ring furrows posterior to articulating furrow; two or three distinct pleural ridges generally present. *Pterocephalia concava* Palmer (pl. 17).	
114. a. Anterior end of glabella clearly defined by preglabellar furrow *Minupeltis definita* Palmer (pl. 18).	
b. Anterior end of glabella not clearly defined by preglabellar furrow. *Minupeltis conservator* Palmer (pl. 18).	
115. a. Occipital spine present. *Hardyoides mimicus* Palmer (pl. 7).	
b. Occipital spine absent. *Hardyoides minor* Kobayashi (pl. 7).	

SYSTEMATIC PALEONTOLOGY

The descriptions on the following pages are arranged alphabetically by family, subfamily within the family, genus within the family or subfamily, and species within the genus. Genera not clearly assigned to families or subfamilies are arranged alphabetically under "Unassigned trilobites" (p. 77), following the last of the described trilobites having a family assignment. A diagnosis or description is provided for each species and for most supraspecific taxa. Lack of discussion of a suprageneric taxon indicates acceptance of this taxon as it is constituted in part O of the "Treatise on Invertebrate Paleontology," (Harrington and others, 1959). The descriptive terms used here are defined or illustrated in the Treatise on pages 42, 44, 46, 47 and 117–126.

All described specimens are preserved in limestone and show little evidence of diagenetic flattening. Nearly all deformation of specimens resulted from late Paleozoic or younger tectonic activity. Silicification of the exoskeleton is found in specimens from some collections, although the quality of surface detail has been lost on many specimens. All descriptions refer to features of the external surface of the exoskeleton unless specifically stated otherwise.

Statements in the section on occurrence given with each species description are a subjective appraisal of the relative abundance of the species in the faunal assemblages in which it is found. Geographic frequency of occurrence is summarized in plate 21, in which the solid bars represent the occurrence of species known from four or more of the localities in figure 1, and the open bars represent the occurrence of species known from three or fewer of these localities.

The probability that a named fossil species approximates a neontologic species is directly related to the frequency of occurrence and abundance of specimens assigned to it. Species indicated to be common or moderately common are generally represented by enough material so that new discoveries will probably not materially alter their concept or content. Species indicated to be rare or moderately rare may have their concept or content significantly changed by new discoveries.

Family ASAPHISCIDAE Raymond

Subfamily BLOUNTIINAE Lochman

Genus BLOUNTIA Walcott

Blountia Walcott, 1916, p. 396; Shimer and Shrock, 1944, p. 619; Palmer, 1954, p. 721; 1962b, p. 22; Howell, 1959, p. 292.

Homodictya Raymond, 1937, p. 1114; Rasetti, 1946, p. 454; Shaw, 1952, p. 473; Howell, 1959, p. 292.

Stenocombus Raymond, 1937, p. 1106.

Blountia bristolensis Resser

Plate 1, figures 1, 2, 4

Blountia bristolensis Resser, 1938a, p. 65, pl. 12, fig. 24; Palmer, 1962b, p. 22, pl. 3, figs. 33, 34.
Maryvillia bristolensis Resser, 1938a, p. 87, pl. 12, fig. 38.
Maryvillia hybrida Resser (part), 1942b, p. 71, pl. 13, figs. 14, 15.
Blountia nixonensis Lochman, 1944, p. 43, pl. 4, figs. 7–12; Palmer, 1954, p. 722, pl. 79, fig. 4.

Diagnosis.—Anterior margin of cranidium evenly rounded. Width of fixed cheek about one-third basal glabellar width. Sagittal length of border slightly greater than length of brim. Free cheek narrow. Genal spine very short and sharp pointed. Pygidium subsemicircular in outline. Border furrow moderately well defined at anterolateral margin, becoming shallow towards rear, interrupted by poorly defined end of axis, which barely extends onto border.

Discussion.—This species is distinguished from other species in the genus by the form of the border furrow on the pygidium, which becomes shallower towards the rear and seems to be interrupted by the end of the axis. The specimens from Nevada and Utah do not seem to differ significantly from specimens in the *Aphelaspis* zone in Tennessee.

Occurrence. Rare, *Aphelaspis* zone: House Range, Utah; Highland Range and Yucca Flat, Nev.

Family CHEILOCEPHALIDAE Shaw

Diagnosis.—Subisopygous ptychoparioid trilobites having an unfurrowed glabella slightly tapered forward, reaching to border furrow or to short undivided frontal area. Palpebral lobes generally situated slightly anterior to glabellar midlength. Posterior limbs moderately broad exsagittally, bluntly pointed. Pygidium has moderately broad border of nearly constant breadth. Axis reaching to inner edge of border; length greater than width; width equal to or less than greatest width of pleural region.

Discussion.—Besides *Cheilocephalus*, the genera *Pseudokingstonia* n. gen. and *Oligometopus* Resser are here assigned to this formerly monotypic family. None of the species are common elements of the faunas, and their assignments to one family may only reflect a superficial similarity. *Pseudokingstonia* is probably correctly assigned, however, because, in addition to the characters in the diagnosis, it has the peculiar geniculation of the posterior limbs of the cranidium and the distally expanded band of the first pygidial segment typical of *Cheilocephalus*. The assignment of *Oligometopus* is less certain and is based principally on the presence of the large anteriorly tapered glabella that reaches to the border furrow.

Genus CHEILOCEPHALUS Berkey

Cheilocephalus Berkey, 1898, p. 289; Palmer, 1954, p. 757; Lochman, 1959, p. 312.
Pseudolisania Kobayashi, 1935, p. 162; Shimer and Shrock, 1944, p. 621.

Type species.—*Cheilocephalus st. croixensis* Berkey, 1898, p. 290, pl. 17, fig. 1; pl. 20, figs. 7, 8; pl. 21, fig. 19.

Diagnosis.—Moderately large trilobites (maximum probable length about 80 mm) having cranidium subtrapezoidal in outline. Glabella large, low, tapered forward, and bluntly rounded at front and reaches more than five-sixths cranidial length. Occipital ring well defined, has low poorly defined median node. Frontal area short sagittally and flat or slightly concave; it has poorly defined narrow border. Fixed cheeks narrow, downsloping; width, including palpebral lobes, one-third or less than one-third basal glabellar width. Palpebral lobes small, poorly defined, situated opposite anterior third of glabella. Eye ridges short and commonly mark abrupt change in slope between fixed cheek and frontal area. Posterior limbs large, subtriangular in outline; exsagittal length slightly more than one-half length of gabella. Posterior margin generally has distinct "shoulder" about at transverse midlength of limb. Posterior border furrow shallow, curved forward distally on some specimens.

Pygidium subsemicircular in outline. Axis prominent, tapers posteriorly to rounded poorly defined tip at inner edge of border; five or more shallow ring furrows generally apparent posterior to articulating furrow. Pleural regions divided by narrow border furrow into gently convex pleural fields and moderately broad concave border of nearly constant width. First pleural furrow well defined extends nearly across border and outlines broad distally expanded anterior band of first pleural segment. Remaining pleural and interpleural furrows generally shallow, close spaced; anterior furrows may extend onto border.

External surfaces of all parts are either smooth or have granular ornamentation.

Discussion.—This is a rare but distinctive genus found throughout the Pterocephaliid biomere. The small anteriorly placed palpebral lobes, narrow fixed cheeks, short frontal area, and large posterior limbs that generally have marginal "shoulders" distinguish the cranidia from those of all other trilobites in the fauna. The broad concave border of nearly constant width and the distally expanded anterior band of

the first pleural segment are the most distinctive features of the pygidium.

Specifically identifiable specimens referable to *Cheilocephalus* are present in more than a dozen collections from the Pterocephaliid biomere in the Great Basin; they occur in rocks ranging from the upper part of the *Aphelaspis* zone to the lower part of the *Elvinia* zone. The species, as recognized, seem to be long-ranging and of limited value for precise dating within the Pterocephaliid biomere.

Lochman (1953, p. 887) suppressed *Bernicella* Frederickson as a synonym of *Cheilocephalus* without any explanation. Although Frederickson (1949, p. 347) suggested the possibility that the type species of *Bernicella*, *B. minuta*, might be an immature *Cheilocephalus*, he pointed out several valid and useful distinguishing characteristics. Cranidia of *C. brachyops* n. sp. that are smaller than the cranidia of *Bernicella minuta* are almost like those of large *Cheilocephalus* cranidia. (See pl. 1, fig. 14.) The distinctions between cranidia of *Bernicella* and of *Cheilocephalus* pointed out by Frederickson, therefore, are not immature features, and *Bernicella* is here considered to be a genus separate from *Cheilocephalus* but probably synonymous with *Oligometopus* (p. 31).

Cheilocephalus brachyops n. sp.

Plate 1, figures 12–15, 17

Cheilocephalus spp., Palmer, 1960a, p. 94, pl. 10, figs. 13, 14.

Diagnosis.—Cranidium has short frontal area; marginal part convex, forms poorly defined border; sagittal length about one-ninth that of glabella, including occipital ring. Anterior margin has zone of terrace lines about one-half sagittal length of frontal area. Fixed cheeks narrow; width slightly less than one-third basal glabellar width. External surface of cranidium has closely-spaced granular ornamentation —most apparent on glabella and fixed cheeks posterior to eye ridges.

Outer part of concave border of pygidium nearly horizontal. Tops of axial rings and surface of pleural fields have low scattered poorly defined granules.

Discussion.—The short convex marginal part of the frontal area distinguishes this species from the other species of *Cheilocephalus* in the Great Basin. It differs from *C. buttsi* Resser, which occurs in the Ore Hill Limestone Member of the Gatesburg Formation in Pennsylvania, principally in having relatively broader fixed cheeks.

The pleural region on the right side of a large aberrant pygidium from USGS collection 2563-CO from Shingle Pass, Nev., (pl. 1, fig. 15) is only about two-thirds the width of the pleural region on the left. The margin of the pygidium is complete and the border is present, evidence indicating that the specimen was not broken and healed.

Occurrence. Moderately rare, lower part of *Elvinia* zone: Eureka, Shingle Pass, Snake Range, and Ash Meadows, Nev.; House Range, Utah. Rare, upper part of *Prehousia* zone: Shingle Pass, Nev.

Cheilocephalus brevilobus (Walcott)

Plate 1, figures 9–11

Lisania? *breviloba* Walcott, 1916, p. 404, pl. 66, figs. 3, 3c.
Pseudolisania breviloba (Walcott). Kobayashi, 1935, p. 162; Resser, 1938a, p. 96, pl. 16, fig. 17.
Pseudolisania raaschi Lochman, 1938a, p. 77, pl. 18, figs. 25–34.
Pseudolisania texana Lochman, 1938a, p. 80, pl. 18, figs. 35–38.
Cheilocephalus breviloba (Walcott). Palmer, 1954, p. 759, pl. 88, figs. 1–4.

Diagnosis.—Frontal area of cranidium relatively broad, nearly flat; sagittal length about one-sixth that of glabella including occipital ring. Width of fixed cheek including palpebral lobe about one-third basal glabellar width.

Lateral part of concave border of pygidium nearly horizontal; breadth of pygidium about equal to greatest breadth of pleural field.

Surfaces of all parts generally smooth. Fixed cheeks rarely have scattered granules.

Discussion.—This species is distinguished from all others in the genus except *C. minutus* Palmer and *C. omega* (Lochman and Hu) by its nearly smooth surface. It differs from *C. minutus* and *C. omega* by having a relatively broader and less downsloping pygidial border and differs further from *C. omega* by having a less sagittally convex cranidium; better definition of the axial furrows on the cranidium, and better definition of both axial and ring furrows on the pygidium.

Lochman's assignment of *C. omega* to *Maryvillia* and the accompanying attempt to justify it are not supported by any significant morphological features. Her specimens have the "elbows" on the posterior limbs of the cranidium and the distal expansions of the anterior band of the first pleural segment of the pygidium that are characteristic of *Cheilocephalus*, as are the glabellar shape, structure of the frontal area and posterior limbs, and position of the palpebral lobes. Only in the shallowness of the furrows on the outer surface of the exoskeleton do these specimens have even a superficial resemblance to *Maryvillia*. They differ most importantly from *Maryvillia* by lacking a separately identifiable brim, a characteristic

of at least generic value. The collection described by Lochman and Hu seems to be one of the uncommon examples of two congeneric species, *C. omega* and *C. granulosus*, occurring together.

Occurrence. Rare, *Aphelaspis* zone: Shingle Pass and Snake Range, Nev.; (?) upper part of *Elvinia* zone: Cherry Creek, Nev.

Cheilocephalus granulosus n. sp.

Plate 1, figures 6–8

Cheilocephalus sp., Palmer, 1962b, p. 27, pl. 3, figs. 30, 31.
Cheilocephalus brevilobus Lochman and Hu, 1962, p. 436, pl. 69, figs. 1–24.

Diagnosis.—Frontal area moderately broad, nearly flat; sagittal length between one-sixth and one-eighth length of glabella, including occipital ring. Anterior margin has narrow zone of terrace lines. Width of fixed cheeks including palpebral lobes about one-third basal glabellar width.

Outer part of concave border of pygidium nearly horizontal. Breadth of border about equal to greatest breadth of pleural field.

External surfaces of all parts, except over areas of muscle attachment on glabella, covered with fine closely spaced granules.

Discussion.—This species is intermediate in stratigraphic position between the older form *C. brevilobus* and the younger species *C. brachyops*. It differs from *C. brevilobus* principally by having a granular ornamentation and from *C. brachyops* by having a broader frontal area and a narrower marginal zone of terrace lines on the cranidium and granular ornamentation on the border of the pygidium.

The distinctive granular ornamentation of this species is also found on all the specimens identified as *Cheilocephalus brevilobus* by Lochman and Hu (1962) that have the exoskeleton preserved. Their species, therefore, is not conspecific with Walcott's specimen of *C. brevilobus*, which has a characteristically smooth external surface, but it is more probably conspecific with the forms described here as *C. granulosus* n. sp.

Occurrence. Rare, *Dicanthopyge* zone: Cherry Creek and Shingle Pass, Nev.; *Dunderbergia* zone: Highland Peak, Nev.

Genus OLIGOMETOPUS Resser

Oligometopus Resser, 1936, p. 28; Palmer, 1960a, p. 100.
Bernicella Frederickson, 1949, p. 347.

Type species.—*Ptychoparia* (*Solenopleura*?) *breviceps* Walcott, 1884, p. 49, pl. 10, fig. 9.

Description.—Small Cheilocephalidae probably not exceeding 15 mm in total length. Only cranidium known. Glabella prominent, moderately convex transversely and longitudinally, well defined by deep axial furrows, tapered forward; sides straight or slightly bowed outward, strongly rounded in front, reaching to border furrow. Glabellar furrows very slightly apparent. Occipital furrow deep, straight. Occipital ring has low, broad median node near occipital furrow. Frontal area consists only of narrow prominent convex, gently curved to nearly straight border having a strongly depressed outer part; sagittal length about one-eighth or less that of glabella. Fixed cheeks moderately convex, downsloping; width between one-fourth and one-half basal glabellar width. Palpebral lobes moderately well defined, depressed below surface of cheek, situated opposite or slightly anterior to glabellar midlength; length between one-third and one-half length of glabella. Posterior limbs short, bluntly terminated, have deep, straight border furrow; transverse length less than basal glabellar width.

Course of anterior section of facial suture slightly convergent forward from palpebral lobe to border furrow and curved across border to cut anterior margin near anterolateral corners of cranidium. Ventral course not known. Course of posterior section convex.

External surfaces of all parts except border have moderately coarse low granules. Border has well-defined terrace lines.

Discussion.—Species of this genus differ from others in the Cheilocephalidae particularly by having a prominent convex glabella, moderately broad fixed cheeks, a border clearly defined laterally, and a nearly vertical anterior margin. *Bernicella* (Frederickson, 1949, p. 347) seems to share these features with *Oligometopus* and is here considered a synonym of that genus rather than of *Cheilocephalus*, as stated by Lochman (1953a, p. 887). Only the holotype of *Bernicella minuta*, the type species, seems referable to *Oligometopus*. The figured paratype (Frederickson, 1949, pl. 68, fig. 16) is from a different collection and may be an immature specimen of a species of *Cheilocephalus*. (Compare with *C. brachyops*, pl. 1 fig. 14.)

Oligometopus contractus n. sp.

Plate 1, figure 5

Diagnosis.—Fixed cheeks relatively narrow; width about one-third or less than one-third glabellar width. Palpebral lobes situated slightly anterior to glabellar midlength. Granular ornamentation subdued, barely apparent, even on whitened specimens.

Discussion—This species has significantly narrower fixed cheeks and considerably less well-developed granular ornamentation than either *O. breviceps* (Walcott) or *O. minutus* (Frederickson).

Occurrence. Rare, upper part of *Dunderbergia* zone: Shingle Pass, Nev.; lower part of *Elvinia* zone: Snake Range, Nev.

Oligometopus breviceps (Walcott)

Plate 1, figure 3

Ptychoparia (Solenopleura?) breviceps Walcott, 1884, p. 49, pl. 10, fig. 9.
Stenelymus breviceps (Walcott). Raymond, 1937, p. 1101.
Oligometopus breviceps (Walcott). Resser, 1936, p. 29; Palmer, 1960a, p. 100, pl. 10, figs. 19, 20.

Diagnosis.—Cranidium has moderately broad convex fixed cheeks; width about one-half basal glabellar width. Palpebral lobes situated about opposite glabellar midlength. External surface has moderately coarse well-defined granular ornamentation.

Discussion.—This species is most like *O. minutus* (Frederickson), differing principally by having more convex and less downsloping fixed cheeks, more posteriorly placed palpebral lobes, and a posterior border furrow more nearly at right angles to the axial line.

Occurrence. Rare, lower part of *Elvina* zone, Eureka, Nev.

Genus PSEUDOKINGSTONIA n. gen.

Type species.—*Pseudokingstonia exotica* n. sp.

Diagnosis.—Cheilocephalidae having cranidium moderately to strongly convex transversely and longitudinally, gently rounded at front. Glabella slightly tapered forward, clearly defined only at sides by change in slope from glabella to slightly downsloping fixed cheeks; front poorly defined, reaching to border. Occipital ring smooth, not differentiated from glabella. Border narrow, low, composed of several transverse terrace lines raised above surface of anterior margin of cranidium. Fixed checks gently convex; width, including palpebral lobe, about one-third basal glabellar width. Palpebral lobes not differentiated from fixed cheek, situated opposite anterior third of glabella. Posterior limb subtriangular in outline; transverse width slightly less than basal glabellar width. Posterior border furrow broad, shallow, subparallel to posterior margin. Posterior edge of limb marked by distinct angulation or "shoulder" about midway between tip of limb and axial furrow.

Pygidium subsemicircular in outline; all features on external surfaces barely visible. Axis raised slightly above gently convex pleural fields, tapered posteriorly, reaching to inner edge of border; width less than greatest width of pleural region. Border moderately wide, barely differentiated from pleural fields, moderately convex, outer edge depressed. First pleural furrow apparent only across border, barely outlining thickened distal part of anterior band of first pleural segment.

Free cheeks and ventral features not known. External surfaces of all known parts smooth.

Discussion.—This genus is proposed for small nearly featureless trilobites in the *Elvinia* zone that superficially resemble the much older genus *Kingstonia* but differ in several important respects that show a more probable relationship to *Cheilocephalus*. The cranidium has a poorly defined glabella, narrow terrace-lined border, and small anteriorly placed palpebral lobes and the pygidium has a downturned margin; all these features conform to the general concept of *Kingstonia*. However, the glabella reaches to the inner edge of the border, the posterior border furrow is subparallel to the posterior margin, and the posterior margin has distinct "shoulders." Also, the anterior band of the first pleural segment of the pygidium seems to be thickened distally, and the pygidium has a relatively wide border. These features are not typical of *Kingstonia* and, together with the narrow fixed cheeks and anterior position of the palpebral lobes, are characteristic of *Cheilocephalus*. Because of these morphologic characteristics, *Pseudokingstonia* is here recognized as a nearly smooth genus within the Cheilocephalidae.

Pseudokingstonia exotica n. sp.

Plate 1, figures 16, 18, 19

Diagnosis.—This species is the only one known at present for the genus, and its characteristics are those of the genus.

Occurrence. Rare, *Elvinia* zone: House Range, Utah; Cherry Creek and Schell Creek Range, Nev.

Family ELVINIIDAE Kobayashi

Diagnosis.—Micropygous ptychoparioid trilobites having a prominent generally well defined glabella; border and doublure on cranidium generally narrow, of nearly constant width, subcircular in cross section except in some Dokimocephalinae having a border that is broad and flat, or modified into unusual shapes. Border and doublure of pygidium generally narrow, of nearly constant width. Axis prominent, generally having four or fewer segments; tip of axis connected to border by short, broad, poorly defined postaxial ridge. Many species have well-formed granular ornamentation.

Discussion.—This family includes here what may superficially seem to be a heterogeneous assortment of 10 dubiously related genera (pls. 2-7): *Dunderbergia*, *Elburgia*, *Elvinia*, *Elviniella*, *Irvingella*, *Apachia*,

Dokimocephalus, *Iddingsia*, *Kindbladia*, and *Pseudosaratogia*. These genera are listed among six families and four superfamilies in part O of the "Treatise on Invertebrate Paleontology" (Harrington and others, 1959). They are grouped here in one family and two subfamilies because of similarities in morphology that suggest possible genetic relationship. The possibility of such a relationship is strengthened by a similar temporal and spatial distribution within a biomere that afforded a continuum of environmental complexes on the western shelf of the North American continent; during the time of occurrence, interrelation could have logically occurred among the genera.

Interpretation of the degree of relationship of genera is still highly subjective with regard to Cambrian trilobites and may never be resolved to the satisfaction of all paleontologists. The scheme presented here seems to be the most reasonable at the present time for presenting the relationship of the Upper Cambrian trilobite genera under consideration. The differences between this scheme and that of the Treatise reflects what is perhaps the greatest deficiency in the classification of many of the Cambrian trilobites in that book—that is, the apparent reliance almost entirely on morphologic similarity at the generic level and little or no regard for spatial and temporal distribution of the forms. Thus, morphologic similarities that may indicate real genetic relationships cannot be distinguished from morphologic similarities resulting from convergence or happenstance.

If only the end members of lineages are looked at, little reason for grouping, for example, *Dokimocephalus* (pl. 3, fig. 18) and *Irvingella* (pl. 6, figs. 7–24) in the same family can be seen. However, by following the history of evolution and relationships of these genera to other trilobites backward in time, a reasonable case for their relationship can be made. *Dokimocephalus* differs from *Iddingsia* principally by modification of the cranidial border. *Iddingsia* has the posterior pair of lateral glabellar furrows commonly longer, more distinct, and more posteriorly directed than the other pairs. The glabellar structure in the oldest named species of *Iddingsia*, *I. intermedia* n. sp. (pl. 2, figs. 5, 7, 8), is not greatly different from the glabellar structure of the older species of *Dunderbergia*, *D. brevispina* n. sp. (pl. 5, figs. 11, 15) and *D. calculosa* (pl. 5, figs. 6, 8). Thus, a reasonable chain of morphologic features connects *Dunderbergia* with *Dokimocephalus* through *Iddingsia*. *Dunderbergia* differs from *Elburgia* principally by lacking well defined glabellar furrows. Both *Dunderbergia* and *Elburgia* have an anteriorly directed angulation of the border furrow as does *Elviniella*, and *Elviniella* is the probable ancestor of *Irvingella*. The pygidium of *Irvingella* is structurally little different from that of *Dunderbergia*. Thus, a real relationship seems to exist between *Dunderbergia* and *Irvingella* and, therefore, also between *Irvingella* and *Dokimocephalus*. *Pseudosaratogia* is related to *Dokimocephalus* and *Iddingsia* through the glabellar structure, as is *Apachia*, and *Apachia* has a probable common ancestor with *Kindbladia* (p. 34). *Elvinia* is the probable descendant of *Elburgia* (p. 17).

The heterogeneous assortment of genera of the Elviniidae, therefore may represent a group of trilobites logically related on the basis of stratigraphy, morphology, and biology.

Subfamily DOKIMOCEPHALINAE Kobayashi

Diagnosis.—Elviniidae having glabella generally strongly rounded at front, posterior glabellar furrows generally well defined, directed obliquely backward.

Genus APACHIA Frederickson

Apachia Frederickson, 1949, p. 346.

Type species—Apachia trigonis Frederickson, 1949, p. 346, pl. 70, figs. 14–17.

Diagnosis.—Small Dokimocephalinae, total length probably not exceeding 20 mm. Glabella prominent, strongly convex to conical transversely, moderately to strongly convex longitudinally, tapered forward, strongly rounded anteriorly, well defined by axial and preglabellar furrows. Glabellar furrows shallow or absent; posterior pair if present inclined strongly backward. Frontal area short; length between one-third and one-half that of glabella. Brim downsloping or depressed; sagittal length slightly greater than that of strongly convex border. Border furrow deep, narrow, gently to strongly curved in plan view. Fixed cheeks narrow, gently convex, horizontal or slightly upsloping; width between one-third and one-fourth basal glabellar width. Palpebral lobes narrow, well defined by gently curved palpebral furrow, situated about opposite glabellar midlength. Posterior limbs slender, tapered to point.

Course of anterior section of facial suture nearly straight forward or slightly outward from palpebral lobe to border furrow, then turned inward across border to cut anterior margin about opposite anterolateral corners of glabella. Course of posterior section, divergent and sinuous.

Border of free check narrower than ocular platform. Lateral and posterior border furrows joined at genal angle. Genal spine short; length less than length of posterior section of facial suture.

Pygidium subsemicircular. Axis broad, moderately elevated, poorly defined at sides, merged posteriorly with short broad ridge; axis reaches nearly to inner edge of narrow well-defined border of nearly constant width. One or two ring furrows present posterior to articulating furrow. Pleural fields have no furrows apparent posterior to articulating furrow.

Discussion.—The concept of this genus is here broadened to include *A. prima* n. sp. and *Dellea butlerensis* Frederckson (1949, p. 351), which differ from the type species and from *A. convexa* Deland and Shaw (1956, p. 546) by having a strongly convex rather than conical glabellar cross section and a more curved border furrow in plan view.

The oldest species of the genus, *A. prima*, shows many similarities to *Kindbladia* and differs principally in lacking distinct glabella furrows and upsloping fixed cheeks. The two genera seem to have had a common ancestry.

Apachia butlerensis (Frederickson)

Plate 3, figures 10, 13

Dellea butlerensis Frederickson, 1949, p. 351, pl. 69, figs. 16–18.

Diagnosis.—Cranidium has a very convex glabellar cross section. Posterior part of glabella rises steeply above occipital furrow. Length of border on frontal area slightly less than length of brim. Border furrow strongly bowed forward in plan view. External surface covered with closely spaced fine granules.

Other parts not known.

Discussion.—This species is most like *A. prima* n. sp. and differs by having a more nearly subequally divided frontal area and by having the posterior part of the glabella distinctly rising above the occipital furrow. The convex rather than conical cross section of the glabella distinguishes *A. butlerensis* from the other described species of the genus.

Occurrence. Rare, *Elvinia* zone: Shingle Pass, McGill, and Mount Hamilton (?), Nev.

Apachia prima n. sp.

Plate 3, figures 5–7

?*Dellea butlerensis* Wilson [not Frederickson], 1951, p. 639, pl. 91, figs. 1–3, 11.

Diagnosis.—Cranidium has strongly convex glabellar cross section. Posterior part of glabella does not rise steeply from occipital furrow. Sagittal length of brim on frontal area about twice length of border. Border furrow bowed forward abruptly in plan view. Free check and pygidium, as described for genus. External surfaces of all parts covered with closely spaced fine granules.

Discussion.—This species is most like *A. butlerensis* (Frederickson). It differs by having a relatively longer brim and by not having the posterior part of the glabella rising steeply from the occipital furrow. It also resembles species of *Kindbladia* but lacks the distinct glabellar furrows and upsloping fixed cheeks of species of that genus.

The specimens illustrated by Wilson (1951) as *Dellea butlerensis* Frederickson seem to have the relatively long brim and the lower posterior part of the glabella characteristic of *A. prima* rather than of *A. butlerensis* (Frederickson).

Occurrence. Moderately rare, upper part of ***Dunderbergia*** zone: McGill, Bastian Peak, and Ash Meadows, Nev.

Genus DOKIMOCEPHALUS Walcott

Dokimocephalus Walcott, 1924, p. 55; 1925, p. 83; Shimer and Shrock, 1944, p. 623; Frederickson, 1948, p. 800; Wilson, 1949, p. 36; Lochman, 1959, p. 281; Palmer, 1960a, p. 95.

Type species.—*Ptychoparia? pernasutus* Walcott, 1884, p. 49, pl. 10, figs. 8, 8a–b.

Diagnosis.—Dokimocephalinae having a large glabella well defined by axial and preglabellar furrows. Posterior pair of glabellar furrows generally deep, nearly straight, posterolaterally directed; second pair may be present. Occipital ring has median node or spine. Frontal area has narrow brim and broad border variously modified into pointed, spatulate, or linguiform shape; sagittal length of border more than four times that of brim. Fixed cheeks narrow, flat to moderately convex, upsloping; width less than one-half basal glabellar width. Palpebral lobes strongly arcuate, well defined by palpebral furrows, situated opposite posterior third of glabella. Posterior limbs tapered laterally to point.

Lateral and posterior border furrows on free cheeks deep, not joined, merged with base of genal spine. Genal spine moderately long, directed posterolaterally at slight angle to margin of cheek.

Outline of pygidium transversely subovate. Axis prominent, short; length about two-thirds that of pygidium; two or three ring furrows visible behind articulating furrow. Pleural fields crossed by two or three shallow pleural furrows. Border not clearly differentiated from pleural field.

External surfaces of glabella, fixed cheeks, ocular platform of free cheeks, and tops of axial rings of pygidium have coarse granular ornamentation. Brim and border of cranidium, border and genal spine of free cheek, and pleural regions of pygidium smooth

or granular. Molds of all parts have granular ornamentation similar to that on external surface.

Discussion.—The most distinctive feature of members of this genus is the structure of the cranidial border. A secondary feature of value in distinguishing imperfectly preserved cranidia from those of contemporaneous species of *Iddingsia* is the nature of the ornamentation of the mold. On all the younger species of *Iddingsia* the mold is smooth, whereas on all species of *Dokimocephalus* the mold has a granular ornamentation similar to that on the external surface.

Both Frederickson (1948) and Wilson (1949) emphasized the presence of an occipital spine as a generic feature. They were apparently unaware of the lack of an occipital spine in the type species, *D. pernasutus*.

Dokimocephalus pernasutus (Walcott)

Plate 3, figure 18

Ptychoparia? pernasutus Walcott, 1884, p. 49, pl. 10, figs. 8, 8a–b.

Dokimocephalus pernasutus (Walcott). Walcott, 1924, p. 55, pl. 11, fig. 1; 1925, p. 84, pl. 16, figs. 29–31; Palmer, 1960a, p. 95, pl. 11, figs. 18, 20.

Dokimocephalus gregori Walcott, 1925, p. 84, pl. 16, figs. 32–33; Shimer and Shrock, 1944, pl. 264, figs. 38–39.

Diagnosis.—Border of cranidium forms a pointed snout having concave sides and a tip curved down at end. Sagittal length of border four to five times that of brim. Fixed cheeks moderately convex, slightly upsloping. External surface of glabella and fixed cheeks covered with coarse scattered granules. Surfaces of brim, border, and posterior limbs smooth.

Discussion.—Discovery of an excellently preserved cranidium of this species in southern Nevada shows that the suspected synonymy of *D. gregori* from Missouri with *D. pernasutus* (Palmer, 1960a) was correct. The specimens do not differ significantly in any observable feature. Besides the obvious character of the pointed snout, this species differs from others in the genus by having a somewhat broader brim, more convex fixed cheeks, and a lack of ornamentation of the frontal area.

Occurrence. Rare, lower part of *Elvinia* zone: Eureka, Snake Range, and Yucca Flat, Nev.

Genus IDDINGSIA Walcott

Iddingsia Walcott, 1924, p. 58; 1925, p. 97; Shimer and Shrock, 1944, p. 627; Bell and others, 1952, p. 184; Lochman, 1959, p. 282; Palmer, 1960a, p. 95.

Type species.—*Ptychoparia similis Walcott*, 1884, p. 52, pl. 10, fig. 10.

Diagnosis.—Dokimocephalinae in which glabella has one or two well-defined glabellar furrows; posterior pair generally deep, arcuate. Frontal area slightly expanded anteriorly, divided into distinct brim and border by border furrow that generally has slight median angulation. Length of brim two-thirds to nearly twice that of border. Fixed cheek generally upsloping, narrow; palpebral lobes well defined, arcuate, situated slightly posterior to glabellar midlength; eye ridges generally distinct, directed posterolaterally from axial furrow. Posterior limbs short, slender, tapered to sharp point.

Free cheek has deep lateral and posterior border furrows and long posterolaterally directed cylindrical genal spine making slight angle with lateral border of cheek.

Pygidium transverse subtriangular to subovate. Axis prominent, slightly tapered, has two to four shallow ring furrows; axis reaches to or nearly to inner edge of poorly defined narrow border that is nearly absent on axial line.

Discussion.—*Iddingsia* is distinguished from the other genera in the subfamily by its relatively narrow unmodified cranidial border and generally large glabella. Its species content has been discussed in an earlier paper (Palmer, 1960a, p. 96). The statement at that time that the frontal area is "subequally divided into brim and border" must be modified. A new species, *I. intermedia*, the oldest presently recognized in the genus, has a border distinctly narrower than the brim and a frontal area more like that of *Dunderbergia*, from which it was probably derived.

The cranidial ornamentation of the three principal species, *I. intermedia*, *I. robusta* (Walcott), and *I. similis* (Walcott), seems to show evolutionary change. *I. intermedia* has a coarse granular external ornamentation on all parts, but the surface of the mold is granular only on the glabella and fixed cheeks; *I. robusta*, the next younger species, has a granular external ornamentation similar to that of *I. intermedia*, but the surface of the mold is smooth; *I. similis*, the youngest species, has a granular ornamentation on the external surfaces of the glabella and fixed cheeks only, and the surface of the mold is smooth. *I. utahensis* Resser would seem to be the natural terminal species in this series with respect to evolution of ornamentation, both because it has a smooth external surface and because its mold has a smooth surface. However at McGill, Nev., in the one collection where it has been recognized in stratigraphic context, it is found a few feet below a bed containing *I. similis*. More data about the details of distribution of the relatively rare younger species of *Iddingsia* will be

needed to properly evaluate the significance of this occurrence.

Iddingsia intermedia n. sp.

Plate 2, figures 5–8

Diagnosis.—Glabella well defined across front by preglabellar furrow; posterior glabellar furrow bigeniculate; second pair of glabellar furrows shallow; third pair apparent only on mold. Border relatively narrow, well defined by moderately deep border furrow; length about two-thirds that of brim. External surfaces of all parts except furrows have low closely-spaced coarse granules. Surface of mold has distinct granules only on top of glabella and fixed cheeks; a few scattered coarse granules occur on brim of some specimens.

A free cheek possibly belonging to this species is virtually like that of *Dunderbergia nitida* (Hall and Whitfield).

Pygidium has two distinct ring furrows posterior to articulating furrow. Pleural fields crossed by two shallow pleural furrows. Border concave, not clearly separated from pleural fields. Edge of border and tops of axial rings have low closely-spaced granules. Scattered coarse granules also present on tops of axial rings and on pleural fields.

Discussion.—The relatively narrow border and the granular cranidial mold distinguish this species from others presently assigned to the genus. It is the oldest species of *Iddingsia* known. The structure of the frontal area emphasizes the relationships of this genus to *Dunderbergia.*

Occurrence. Moderately rare, upper part of *Dunderbergia* zone and lowest part of *Elvinia* zone: McGill, Bastian Peak, Snake Range, and Schell Creek Range, Nev.

Iddingsia robusta (Walcott)

Plate 2, figures 10, 11

Ptychoparia similis robustus Walcott, 1884, p. 53, pl. 1, figs. 9, 9a.

Iddingsia robusta (Walcott). Walcott, 1925, p. 97, pl. 16, figs. 10–11; Palmer, 1960a, p. 96. pl. 11, figs. 13–16.

Iddingsia nevadensis Resser, 1942b, p. 85, pl. 16, figs. 15–17.

Diagnosis.—Preglabellar furrow generally shallow. Length of frontal area slightly greater than one-half length of glabella. Brim and border separated by abrupt change in slope. Border nearly flat, slightly downsloping; length equal to or slightly greater than length of brim. Fixed cheeks upsloping; width about one-third basal glabellar width. Occipital ring has low median node. External surface covered with closely-spaced generally small granules of several sizes. Surface of mold smooth.

Discussion.—This species differs from *I. intermedia* n. sp. by having a relatively broader border, and from *I. similis* (Walcott) and *I. utahensis* Resser by having a granular ornamentation on all parts. Exfoliated specimens cannot be distinguished with certainty from exfoliated specimens of *I. similis* and *I. utahensis.*

Occurrence. Rare, lower part of *Elvinia* zone: Eureka, Snake Range, McGill, Schell Creek Range, Nev.

Iddingsia similis (Walcott)

Plate 2, figures 1–4

Ptychoparia? similis Walcott, 1884, p. 52, pl. 10, fig. 10.

Iddingsia similis (Walcott). Walcott, 1924, p. 58, pl. 12, fig. 6; 1925, p. 97, pl. 16, figs. 8, 9; Shimer and Shrock, 1944, pl. 265, figs. 15, 16.

?*Iddingsia similis* (Walcott). Robison, 1960, p. 22, pl. 1, figs. 19, 22.

[not] *Iddingsia similis* Bell and others, 1952, p. 184, pl. 30, figs. 4a–c; pl. 31, fig. 2.

Diagnosis.—Glabella moderately defined at front by preglabellar furrow. Border flat, horizontal, or slightly downsloping, well defined by narrow border furrow; sagittal length of border about equal to or slightly greater than sagittal length of brim. Occipital ring has median node. External surfaces of fixed cheeks and glabella, exclusive of glabellar furrows, have low closely-spaced coarse granules. External surfaces of brim and border generally smooth, rarely have very fine granular ornamentation, which is visible only after whitening. Surface of mold smooth.

Lateral and posterior border furrows of free cheek discontinuous, disappearing posteriorly at base of genal spine. Genal spine long, slender, curved inward at tip.

Pygidium has tip of axis slightly anterior to border but connected to it by broad poorly defined ridge; three distinct ring furrows present posterior to articulating furrow. Border narrow, flat, slightly downsloping. Border furrow narrow, shallow.

Discussion.—This is the youngest species presently known in the genus. It is most similar to *I. robusta* (Walcott) and *I. utahensis* Resser, from which it differs primarily in cranidial ornamentation. The specimens illustrated by Bell and others (1952) have a distinct occipital spine and represent an unnamed species of *Iddingsia.* The specimens illustrated by Robison (1960) do not have a clearly preserved external surface and are not assignable with certainty to this species.

Occurrence. Moderately rare, upper part of *Elvinia* zone: Eureka, Shingle Pass, McGill, and Schell Creek Range, Nev.; House Range, Utah.

Iddingsia utahensis Resser

Plate 2, figure 9

Iddingsia utahensis Resser, 1942b, p. 85, pl. 16, figs. 18–20.

Diagnosis.—Preglabellar furrow shallow. Border gently convex, downsloping, separated from brim by abrupt change in slope; sagittal length about equal to sagittal length of brim. External surface and surface of mold smooth.

Discussion.—The smooth external surface of this species distinguishes it from all others in the genus.

Occurrence. Rare, lower *Elvinia* zone: McGill and Schell Creek Range, Nev.; Tintic, Utah.

Genus KINDBLADIA Frederickson

Kindbladia Frederickson, 1948, p. 802; Lochman, 1959, p. 283; Palmer, 1960a, p. 97.

Type Species—Berkeia wichitaensis Resser, 1942b, p. 93, pl. 15, figs. 31, 32.

Diagnosis.—Small Dokimocephalinae having total length probably not exceeding 20 mm. Glabella prominent, tapered slightly forward, strongly rounded at front, well defined by axial and preglabellar furrows; transverse convexity moderate to strong; longitudinal convexity gently to moderate, greatest at front. Posterior two pairs of glabellar furrows deep, short; posterior pair curved backward. Occipital furrow deep. Occipital ring has median node or spine. Frontal area divided into strongly convex border and moderately convex brim by narrow border furrow that is moderately to strongly curved in dorsal view. Sagittal length of border less than that of brim. Fixed cheeks narrow, gently to moderately convex, upsloping; transverse width between one-third and one-fourth basal glabellar width. Palpebral lobes small, well defined by curved palpebral furrow, situated about opposite glabellar midlength; exsagittal length between one-third and one-half that of glabella. Posterior limbs tapered laterally to a point.

Course of anterior section of facial suture slightly divergent forward from palpebral lobe to border furrow, then turned inward to cut anterior margin barely perceptibly about opposite anterolateral corners of glabella. Course of posterior section nearly straight posterolaterally from palpebral lobe to posterior margin of cranidium.

Lateral and posterior border furrows of free cheek well defined, joined at genal angle forming sharp point. Border narrower than ocular platform. Infraocular ring present. Genal spine short, sharp; length slightly less than length of posterior section of facial suture.

Pygidium subsemicircular. Axis prominent, slightly tapered posteriorly, reaches to inner edge of border, bears two or more ring furrows posterior to articulating furrow. Border flat, broad, of nearly constant width, defined at inner edge by abrupt change in slope. Pleural region crossed by two or more shallow pleural furrows extending slightly onto border.

Discussion.—The content of this genus has been discussed in an earlier paper (Palmer, 1960a, p. 97). Discovery of free cheeks and pygidia associated with *K. affinis* (Walcott) cranidia has provided the first information about the free cheek of *Kindbladia* and confirmed the assignment of the type of pygidium illustrated by Wilson (1951, pl. 92, fig. 24) to the genus. The pygidium illustrated by Frederickson (1948, pl. 123, fig. 21) has the laterally swollen anterior band of the first pleural segment and general shape characteristic of pygidia of *Cheilocephalus;* it may belong to a species of that genus rather than to *Kindbladia.*

Because of the relatvely thick exoskeleton of most specimens of *Kindbladia* and a tendency for the granular external surface to adhere to the matrix, well-preserved specimens are difficult to obtain. Unless the external surface of the cranidium and the nature of the occipital ring can be observed, specimens of *Kindbladia* are generally not identifiable to species.

Kindbladia affinis (Walcott)

Plate 3, figures 1–4

Ptychoparia (Euloma?) affinis. Walcott, 1884, p. 54, pl. 10, fig. 12.
Iddingsia affinis (Walcott). Resser, 1937, p. 14.
Berkeia affinis (Walcott). Resser, 1942a, p. 7.
Berkeia comes Resser, 1942b, p. 90, pl. 15, figs. 18–21.
Berkeia nevadensis Resser, 1942b, p. 91, pl. 15, figs. 26, 27.
Kindbladia affinis (Walcott). Palmer, 1960a, p. 97, pl. 11, figs. 17, 19, 20.

Diagnosis.—Occipital ring has median node rather than median spine. Sagittal length of border slightly less than length of brim. Length of genal spine on free cheek slightly less than length of posterior section of facial suture. Pygidium has two distinct ring furrows posterior to articulating furrow. External surfaces of cranidium and free cheek covered with closely spaced fine granules. Fine granules somewhat more scattered on external surface of pygidium. Surfaces of molds of all parts faintly pitted.

Discussion.—This species differs from *K. wichitaensis* (Resser) in its lack of an occipital spine, in its slightly narrower brim, and, if the assignment of a pygidium to *K. wichitaensis* by Wilson (1951, pl. 92, fig. 24) is correct, in the smaller number of distinct ring furrows on the pygidial axis.

Occurrence. Moderately common, lower part of *Elvinia* zone: Eureka, McGill, Shingle Pass, Bastian Peak, Cherry Creek, and Snake Range, Nev.; House Range and Tintic, Utah.

Genus PSEUDOSARATOGIA Wilson

Pseudosaratogia Wilson, 1951, p. 647; Lochman, 1959, p. 252; Palmer, 1960a, p. 101.

Type species.—Pseudosaratogia magna Wilson, 1951, p. 648, pl. 94, figs. 9–16.

Diagnosis.—Moderate-sized Dokimocephalinae, total length probably not exceeding 70 mm, generally much less. Glabella prominent, well defined by axial and preglabellar furrows, slightly tapered forward, bluntly to strongly rounded anteriorly, convexity variable. Posterior pair of glabellar furrows generally apparent, deep or shallow, at distinct angle to axial furrow. Occipital furrow deep, straight; occipital ring generally lacks spine. Frontal area flared anteriorly, has distinct brim and border separated by narrow border furrow or sharp change in slope. Sagittal length of border distinctly less than length of brim. Fixed cheek narrow; width less than one-half basal glabellar width. Palpebral lobes well defined by arcuate palpebral furrow, situated slightly posterior to glabellar midlength; exsagittal length between one-half and one-third sagittal length of glabella. Eye ridges generally apparent, make distinct angle with axial furrows. Posterior limbs slender, sharp pointed.

Course of anterior section of facial suture distinctly divergent forward from palpebral lobe to border furrow, then turned abruptly inward across border. Ventral course not known. Course of posterior section divergent sinuous.

Lateral and posterior border furrows of free cheek well defined; shallow or absent at base of genal spine. Genal spine short; length between one and two times that of posterior section of facial suture.

Pygidium subovate to subsemicircular; axis prominent, short, has two or three ring furrows posterior to articulating furrow. Pleural regions lack clearly defined border, crossed by two or three shallow pleural furrows.

External surfaces of all parts generally have distinct granular ornamentation.

Discussion.—As constituted here, this genus includes those members of the Pteropcephaliid biomere characteristically having a flared frontal area, narrow border and fixed cheeks, and prominent glabella—the posterior glabellar furrow makes a distinct angle with the axial furrow. The western species described in the following paragraphs differ from the eastern species described by Wilson (1951) by having a more convex and anteriorly rounded glabella, shallower glabellar furrows, and somewhat shorter palpebral lobes. These features may be sufficient to justify the placement of the western species in a separate genus, when more is known about the species.

Pseudosaratogia abnormis Palmer

Plate 2, figures 12–14, 16, 17

Pseudosaratogia abnormis Palmer, 1960a, p. 101, pl. 11, fig. 11.

Diagnosis.—Glabella prominent, strongly convex transversely, moderately to very convex longitudinally; front strongly rounded. Posterior pair of glabellar furrows shallow. Border narrow, separated from brim by distinct change in slope; sagittal length generally less than one-half that of brim. Length of palpebral lobe about one-third length of glabella.

Lateral and posterior border furrows of free cheek joined at genal angle, shallowest at base of genal spine. Length of genal spine slightly greater than length of posterior section of facial suture.

External surfaces of cranidium and cheek covered with closely-spaced granules; outer edges of border on cranidium and free cheek generally have narrow zone of terrace lines.

Discussion.—This species is most like *P. leptogranulata* Palmer, from which it differs principally by having a narrower cranidial border that is differentiated from the brim only by a sharp change in slope. If the free cheeks of *P. leptogranulata* are properly assigned, they differ from those of *P. abnormis* by not having the lateral and posterior border furrows connected at the genal angle.

Both this species and *P. leptogranulata* resemble *Iddingsia intermedia* n. sp. but can be distinguished by having a more flared frontal area, nearly horizontal rather than upsloping fixed cheeks, and less distinct glabellar furrows.. They are probably closely related, however, and *P. abnormis* and *P. leptogranulata* may have evolved from *I. intermedia.*

A collection from the Bastian Peak section contains several cranidia and a free cheek that may represent this species (pl. 2, figs. 16, 17). The cranidia have a well-defined external granular ornamentation characteristic of the Eureka specimens of *P. abnormis* originally described; but the molds have smooth surfaces, and they have the general proportions of *P. leptogranulata* Palmer. The free cheek has clearly disjunct border furrows. Because of lack of samples large enough to determine variability in this species, the Bastian Peak specimens are provisionally assigned to *P. abnormis.*

Occurrence. Rare, lower part of *Elvinia* zone: Eureka, Shingle Pass, McGill, and Bastian Peak(?), Nev.; Tintic, Utah.

Pseudosaratogia leptogranulata Palmer

Plate 2, figure 18

Pseudosaratogia leptogranulata Palmer, 1960a, pl. 11, fig. 10.

Diagnosis.—Glabella strongly convex transversely, moderately to strongly convex longitudinally. Posterior glabellar furrows shallow. Border furrow distinct; sagittal length of border about one-half that of brim. Length of palpebral lobe about one-third of glabella.

External surface of cranidium has distinct fine granules. Surface of mold smooth.

Discussion.—The subdued granular ornamentation and somewhat better defined cranidial border distinguish this species from *P. abnormis* Palmer.

Occurrence. Rare, lower part of *Elvinia* zone: Eureka and Ash Meadows, Nev.

Subfamily ELVINIINAE Kobayashi

Diagnosis.—Elviniidae having generally bluntly rounded or anteriorly truncated glabella. Posterior glabellar furrows of younger species continuous across glabella.

Genus DUNDERBERGIA Walcott

Dunderbergia Walcott, 1924, p. 56; 1925, p. 84; Resser, 1935, p. 23; Raymond, 1937, p. 1112; Kobayashi, 1938, p. 181; Shimer and Shrock, 1944, p. 625; Palmer, 1954, p. 760; 1960a, p. 65; Howell, 1959, p. 238.

Type species.—*Crepicephalus* (*Loganellus*) *nitidus* Hall and Whitfield, 1877, p. 212, pl. 2, fig. 8.

Diagnosis.—Elviniinae having well-defined subquadrate glabella; glabellar furrows generally not well defined. Length of palpebral lobe about one-third to one-fourth length of glabella including occipital ring. Line connecting midlengths of palpebral lobes crosses glabella just posterior to junction of second glabellar furrows with axial furrows. Anterior margin and border furrow commonly come to a blunt point on axial line instead of forming an even curve.

Free cheek has well-defined continuous lateral and posterior border furrows; posterior border furrow generally deepest. Border narrow. Ocular platform gently convex, twice or more width of border. Genal spine of variable length, from one-half to more than three times length of posterior section of facial suture.

Thorax has 13 segments. Pleural tips of anterior segments short, directed laterally; pleural tips increase in length and become increasingly backswept to 11th segment. Posterior two pleural tips relatively shorter.

Pygidium subsemicircular, widest at anterolateral corner. Border narrow, of nearly constant width. Axis prominent, subparallel sided, bluntly rounded posteriorly, generally connected to border by low broad poorly defined postaxial ridge. Pleural regions nearly flat.

Discussion.—The generally subquadrate glabella lacking well-defined glabellar furrows and the relatively small palpebral lobes are the characteristics that most easily distinguish this genus from other genera in the subfamily. Since the earlier diagnosis and description of this genus was made (Palmer, 1960a), a nearly complete individual of *D. nitida* has been collected from the Bastian Peak section. This specimen shows the nature of the thorax (pl. 4, fig. 1) and the positioning of the segments having the short and long pleural tips as described here in the revised diagnosis.

Only minor modifications in the generic description, principally in the statement about the genal spine of the free cheek, are required by the addition of three species (*D? anyta* (Hall and Whitfield), *D. brevispina* n. sp., and *D. calculosa* n. sp.) not discussed in the earlier paper. Length of the genal spine seems to be of taxonomic significance in this genus as well as in *Aphelaspis*. Most of the species have a short slender genal spine about equal in length to the posterior section of the facial suture, but *D? anyta* has a long slender genal spine about three times this length, and *D. brevispina* has a short stubby spine about half this length. In addition, *D? anyta* has a more moderate transverse and longitudinal convexity of the cranidium than other species in the genus.

Dunderbergia? anyta (Hall and Whitfield)

Plate 4, figures 8, 10, 14–16

Crepicephalus (*Loganellus*) *anytus* Hall and Whitfield, 1877, p. 219, pl. 2, figs. 19–21.
Liostracus anytus (Hall and Whitfield). Brögger, 1886, p. 202.
Dunderbergia anytus (Hall and Whitfield). Resser, 1937, p. 9.

Diagnosis.—Glabellar and cranidial convexity generally low; brim gently to moderately downsloping to depressed; frontal area distinctly flared forward.

Free cheek has long slender genal spine; length of spine about three times length of posterior section of facial suture. Lateral and posterior border furrows not clearly joined; posterior border furrow deepest, continues laterally onto base of genal spine. Anterior tip of doublure sharply rounded, indicating rostral plate has deep semiparabolic lateral notches.

Border furrow of pygidium generally shallow; border only slightly convex in cross-section. Greatest

width of axis slightly less than greatest width of pleural region.

Surfaces of all parts covered with closely-spaced fine granules. Veination of brim of cranidium generally well developed.

Discussion.—This species shows several features that are atypical of *Dunderbergia*, particularly the generally low convexity and somewhat narrower fixed cheeks of the cranidium, the long genal spine bearing the continuation of the deep posterior border furrow on the free cheek, and the relatively narrow pygidial axis. In these features it resembles *Strigambitus transversus* n. sp. (pl. 16, figs. 6–10) and differs in having narrow cranidial and pygidial borders that lack distinct terrace lines.

The differential development of the border furrows on the free cheek may not be an important distinguishing characteristic above the species level. Similar free cheeks are present on some species of other genera of the Elviniidae (pl. 2, figs. 1, 16) and also the Pterocephaliidae (pl. 12, figs. 11, 14).

The stratigraphic position of *D? anyta* within the range of *Dunderbergia*, which, however, has both older and younger species of more typical form for the genus, also raises some doubt about the degree of relationship of the species to the others of the genus.

D? anyta is tentatively assigned here to *Dunderbergia* because of its overall appearance and particularly because of the narrow cranidial border and slight median angulation of the border furrow.

The type lot of *D.? anyta* consists of counterparts of a single piece of fossiliferous limestone from near Schellbourne in the northern part of the Schell Creek range, Nev. Several cranidia, free cheeks, and a pygidium are present. The granular ornamentation of the fossils differs from that of other fossils assigned to this species by being considerably subdued and consisting of relatively larger individual granules. Because some variation in detail of granular ornamentation has been recognized in other species of *Dunderbergia*, the differences noted between the specimens in the type lot and in the more recent collections, which are otherwise indistinguishable, are not here considered to be adequate for species discrimination.

Occurrence. Moderately common, lower part of *Dunderbergia* zone: Snake Range, Ruby Range, McGill, Spring Mountains, and Schellbourne, Nev.; House Range, Deep Creek Range, and Wah Wah Range, Utah.

Dunderbergia bigranulosa Palmer

Plate 4, figures 9, 11–13

Dunderbergia bigranulosa Palmer, 1960a, p. 66, pl. 5, figs. 10–13, 15–23.

Diagnosis.—Glabella prominent, elevated. Anterolateral corners of brim generally depressed.

Free cheek has short slender genal spine; length of spine slightly greater than length of posterior section of facial suture.

Ornamentation consists of closely-spaced fine granules occurring on all specimens on the borders of the cranidium, free cheek, and pygidium and on some specimens also on axis of pygidium, top of glabella, and palpebral lobes. Pleural fields of pygidium generally have scattered or closely-spaced fine granules. Coarse scattered granules present on all specimens on brim and fixed cheeks of cranidium and ocular platforms of free cheeks; coarse granules generally less abundant or apparent on glabella and border.

Discussion.—This species seems to be in part transitional to and in part coexistent with *Dunderbergia nitida* (Hall and Whitfield). Specimens can generally be recognized by the presence of distinct fine granules on the cranidial border and moderately distinct scattered coarse granules on the brim, fixed cheeks, and perhaps other parts of the cranidium. *D. bigranulosa* is distinguished from *D. nitida* principally by the presence of granular ornamentation on the pleural fields of the pygidium and on the ocular platform of the free cheek. It differs from *D. calculosus* n. sp., which is here interpreted to be an ancestral form in the same lineage, by having better defined scattered coarse granules on the cranidium and by having the areas of closely-spaced fine granules generally confined to the border, although in some specimens they are present also on the top of the glabella and palpebral lobes. *D. variagranula* Palmer is another similar species; it generally lacks any distinct fine granular ornamentation on the cranidium and has better defined coarse granules on the glabella.

Occurrence. Moderately common, middle part of *Dunderbergia* zone: Eureka, Cherry Creek, Bastian Peak, Ruby Range, Spring Mountains, and Pahranagat Range, Nev.

Dunderbergia brevispina n. sp.

Plate 5, figures 11–13, 15

Diagnosis.—Cranidium has prominent, elevated glabella; glabellar furrows moderately distinct. Anterolateral corners of brim generally depressed.

Free cheek has short genal spine; length of spine about one-half length of posterior section of facial suture.

External surfaces of cranidium and free cheek have granules of two distinct sizes:—scattered coarse granules surrounded by closely-spaced fine granules. Entire

surface of pygidium covered with closely-spaced fine granules.

Discussion.—This species of *Dunderbergia* is the oldest presently recognized in the Great Basin. The moderately distinct glabellar furrows and short genal spines indicate a possible relationship to species of *Elburgia* and *Iddingsia* and are also the principal features distinguishing *D. brevispina* from the other granular species of *Dunderbergia*—*D. bigranulosa* Palmer, *D. variagranula* Palmer, and *D.? anyta* (Hall and Whitfield).

Occurrence. Moderately rare, *Dicanthopyge* zone: Snake Range and Shingle Pass, Nev.

Dunderbergia calculosa n. sp.

Plate 5, figures 6–10

Diagnosis.—Cranidium has prominent elevated glabella. Anterolateral corners of brim generally depressed. Posterior glabella furrows moderately distinct.

Free cheek has short slender genal spine; length of spine about equal to length of posterior section of facial suture.

External surfaces of all parts covered with closely-spaced fine granules. Few low scattered coarse granules apparent on cranidium and free cheeks of some specimens.

Discussion.—This species is intermediate in ornamentation between the older species, *D. brevispina* n. sp., and the two younger species, *D. bigranulosa* Palmer and *D. variagranula* Palmer. Its principal distinguishing characteristics are the dominance of fine granular ornamentation on all parts and the occurence of only a few scattered low coarse granules. The free cheek has a longer genal spine than does that of *D. brevispina*, and the pygidium has fine granular ornamentation on the pleural fields, which distinguishes the species from *D. bigranulosa*. The pygidium and free cheek are much like those of *D. variagranula*, which is distinguished principally by the dominance of the scattered coarse granular ornamentation and suppression or absence of associated fine granular ornamentation on the cranidium.

Dunderbergia simplex (Rasetti, 1961, p. 112, pl. 24, figs. 1–6) has a fine granular ornamentation similar to that of *D. calculosa*. However, the ornamentation lacks scattered coarse granules, the border furrow on the cranidium almost lacks the median angulation, and the free cheek has a more curved lateral margin and a much longer genal spine.

Occurrence. *?Prehousia* zone: Shingle Pass, Nev.; Lower part of *Dunderbergia* zone: McGill and Spring Mountains, Nev.; Deep Creek Range, Utah.

Dunderbergia nitida (Hall and Whitfield)

Plate 4, figures 1, 2, 5, 6

Crepicephalus (*Loganellus*) *nitidus* Hall and Whitfield, 1877, p. 212, pl. 2, fig. 8.
Crepicephalus (*Loganellus*) *simulator* Hall and Whitfield, 1877, p. 218, pl. 2, figs. 16–18.
Ptychoparia nitidus (Hall and Whitfield). Walcott, 1884, p. 57.
Dunderbergia nitida (Hall and Whitfield). Walcott, 1924, p. 56, pl. 11, fig. 2; 1925, p. 84, pl. 16, fig. 4; Shimer and Shrock, 1944, pl. 264, fig. 29; Palmer, 1960a, p. 67, pl. 4, figs. 14–21, 23, 24.
Dunderbergia simulator (Hall and Whitfield). Resser, 1935, p. 24.

Diagnosis.—Glabella prominent, elevated. Anterolateral corners of brim generally depressed.

Free cheek has short slender genal spine, length of spine about equal to length of posterior section of facial suture.

External surfaces of cranidium and free cheek generally smooth. Obscure scattered coarse granules present on brim of some specimens. Pygidium has fine closely-spaced granules on top of axis and on border. Pleural fields generally smooth.

Discussion.—The lack of any distinct cephalic ornamentation is the characteristic feature of this species. It is the most common species of *Dunderbergia* in the upper part of the *Dunderbergia* zone, although it ranges downward into the middle part of the *Dunderbergia* zone.

Occurrence. Moderately common, middle and upper parts of the *Dunderbergia* zone: Eureka, Bastian Peak, Cherry Creek, McGill, Yucca Flat, Sheep Range, Tempiute, Pahranagat Range, Mount Hamilton, and Ash Meadows, Nev.; Quartz Spring area, Calif.

Dunderbergia variagranula Palmer

Plate 5, figures 1–5

Dunderbergia variagranula Palmer, 1954, p. 761, pl. 88, fig. 7; 1960a, p. 68, pl. 4, figs. 22, 25, 26, 28, 29.

Diagnosis.—Glabella prominent, elevated. Anterolateral corners of brim depressed. Glabellar furrows obscure.

Free cheek has short genal spine; length of spine about equal to that of posterior section of facial suture.

External surfaces and molds of cranidium and free cheek contain generally prominent scattered coarse granules on all parts; external surface between coarse granules smooth or have very fine generally indistinct closely spaced granules. All parts of pygidium covered with closely spaced fine granules.

Discussion.—This somewhat variable species is characterized particularly by it cranidial ornamentation

composed of scattered generally prominent coarse granules on all parts. The most similar species are the older forms *D. brevispina* n. sp. and *D. calculosa* n. sp. The genal spine of *D. brevispina* is shorter than that of *D. variagranula*, and the fine granular ornamentation of the cranidium is more prominent. *D. calculosa* has closely spaced fine granules as its dominant ornamentation and has scattered and generally subdued coarse granules.

Some small specimens from the upper part of the *Dunderbergia* zone and the *Elvinia* zone that have an ornamentation composed of scattered coarse granules have been tentatively assigned to this species. However, larger specimens and more knowledge of the morphology and ornamentation of other parts of these trilobites are needed to confirm this identification.

Occurrence. Moderately rare, middle *Dunderbergia* zone: Eureka, Ruby Range, Sheep Range, Tempiute, Ash Meadows, and Pahranagat Range, Nev.; Panamint Range, Calif. Rare, Upper, *Dunderbergia* zone, *Elvinia* zone: Eureka and Snake Range. Nev.

Dunderbergia polybothra Palmer

Plate 4, figures 3, 4, 7

Dunderbergia polybothra Palmer, 1960a, p. 67, pl. 5, figs. 1–4, 6, 7, 9 14.

Diagnosis.—Glabella prominent, elevated. Anterolateral corners of brim generally depressed.

Free cheek has short slender genal spine; length of spine about equal to length of posterior section of facial suture.

External surfaces of all parts of cephalon coarsely pitted; pits best developed on border of cranidium and free cheeks and on top of glabella. Top of axis and border of pygidium have closely-spaced fine granules; pleural fields coarsely but faintly pitted.

Discussion.—This species is easily distinguished from others in the genus by its pitted ornamentation.

Occurrence. Moderately rare, middle part of *Dunderbergia* zone: Eureka and Yucca Flat, Nev.

Genus ELBURGIA Palmer

Elburgia Palmer, 1960a, p. 68, 69.

Type species.—*Crepicephalus* (*Loganellus*) *granulosus* Hall and Whitfield, 1877, p. 214, pl. 2, figs. 2, 3.

Diagnosis.—Elviniinae having low broad straight-sided anteriorly tapered glabella, bluntly rounded at front. Posterior two pairs of glabellar furrows generally well defined. Posterior pair deep, curved, or bigeniculate in all specimens and connected across top of glabella on molds of some specimens. Border well defined, convex, narrower than brim, has distinct median angulation. Fixed cheeks gently convex, nearly horizontal; width slightly less than one-half basal glabellar width. Palpebral lobes well defined, length about one-third length of glabella.

Free cheek has well-defined border that is narrower than ocular platform. Lateral and posterior border furrows deep, joined at genal angle. Genal spine short, sharp; length less than one-half length of posterior section of facial suture.

Pygidium short, wide, has moderately well defined narrow border. Axis prominent, broad, reaching to or nearly to border and connected to border by broad, poorly defined postaxial ridge. One or two prominent ring furrows present posterior to articulating furrow. Pleural fields crossed by one or two shallow pleural furrows extending to border furrow.

Discussion.—The distinctive generic and specific characteristics of *Elburgia* occur almost entirely in the cranidium. Isolated free cheeks cannot be distinguished from those of *Elvinia*. Isolated pygidia cannot be distinguished with certainty from those of either *Elvinia* or *Dunderbergia*. The well-defined glabellar furrows in combination with the distinct median angulation of the border and border furrow distinguish species of this genus from all others in the Elviniidae. Discrimination of species within the genus is based entirely on cranidial ornamentation.

The three species described here seem to form a morphologic series ranging from an older form having a completely granular outer surface, *E. granulosa* (Hall and Whitfield), through an intermediate form having a granular ornamentation that is reduced or lacking on the glabella and subdued on other parts, *E. intermedia* n. sp., to a nearly smooth form, *E. quinnensis* (Resser). However, specimens having a granular ornamentation that is much more concentrated than is typical of *E. granulosa* have been observed within the range of *E. quinnensis*, although they are not associated with *E. quinnensis*. Thus, a more or less similar range in time is indicated for both ornamentation types. This similarity in range provides an explanation, perhaps, for the occurrence of both granular and smooth species of *Elvinia*, which seems to be the direct descendant of *Elburgia* (p. 17).

Elburgia granulosa (Hall and Whitfield)

Plate 5, figures 14, 16–19

Crepicephalus (*Loganellus*) *granulosus* Hall and Whitfield, 1877, p. 214, pl. 2, figs. 2, 3.

Ptychoparia granulosus (Hall and Whitfield). Walcott, 1884, p. 57.

Dunderbergia granulosa (Hall and Whitfield). Resser, 1935, p. 24.

Dunderbergia (Megadunderbergia) granulosa (Hall and Whitfield). Kobayashi, 1938, p. 181.
Elburgia granulosa (Hall and Whitfield). Palmer, 1960a, p. 69, pl. 6, figs. 16, 17, 19.

Diagnosis.—External surface of cranidium, exclusive of furrows and palpebral lobes, covered with coarse granules. Intergranular distance about equal to or greater than granule diameter.

Ocular platform on free cheek has granular ornamentation as on cranidium. Lateral border, exclusive of genal spine, has more concentrated granules. Genal spine has scattered coarse pits.

Pygidium has granules on tops of axial segments, pleural ribs, and border. Granules closely-packed on border and at end of axis.

Surfaces of molds of most parts have mixture of scattered coarse granules and pits.

Discussion.—This is the oldest species in the genus and generally characterizes the earliest beds of the *Dunderbergia* zone. *E. granulosa* is distinguished from *E. intermedia* which occurs in slightly younger beds, by having a well-developed granular ornamentation on the glabella. The peculiar pitted ornamentation of the genal spine may also be a useful specific feature.

Some small cranidia, less than 3 mm long, have granular ornamentation on the palpebral lobes.

Two *Elburgia* cranidia from about the middle of the *Dunderbergia* zone have a closely-packed granular ornamentation on all parts except the furrows and may represent another species (pl. 5, fig. 18).

Occurrence. Moderately common, lower part of *Dunderbergia* zone: Cherry Creek, McGill, Eureka, Bastian Peak, Yucca Flat, Spring Mountains, and Muddy Mountains, Nev.; Deep Creek, Fish Spring, Needles, and House Ranges, Utah.

Elburgia intermedia n. sp.

Plate 6, figures 5, 6

Diagnosis.—Granular ornamentation most evident on brim; intergranular distance generally greater than granule diameter. Granules on fixed cheeks generally low, obscure. External surface of glabella generally smooth. External surface of border smooth or has fine granular ornamentation. Surface of mold has scattered coarse granules on both border and glabella in addition to brim and cheeks and abundant coarse pits.

Free cheek and pygidium not known with certainty.

Discussion.—This species occupies an intermediate position both morphologically and stratigraphically between *E. granulosa* below and *E. quinnensis* above. It differs from *E. granulosa* by lacking well-developed granular ornamentation on the glabella and from *E. quinnensis* by having well-developed granular ornamentation on the brim.

Occurrence. Moderately rare, lower part of *Dunderbergia* zone; McGill, Bastian Peak, and Grant Range, Nev.

Elburgia quinnensis (Resser)

Plate 6, figures 1–4

Taenicephalus quinnensis Resser, 1942b, p. 105, pl. 21, figs. 18, 23.
Elburgia quinnensis (Resser). Palmer, 1960a, p. 69, pl. 6, figs. 11–13, 15.

Diagnosis.—External surface of cranidium nearly smooth; some specimens finely pitted. Lateral parts of brim and of posterior limbs may have many closely spaced low granules visible only when specimen is whitened and viewed in extreme oblique lighting. Brim also may have barely visible scattered low coarse granules. Surface of mold has many fine pits that are most noticeable on brim and cheeks. Positions of coarse granules may be indicated by low elevations; terminal pits are slightly larger than those on other parts of cranidium.

Discussion.—This species is easily distinguished from others in the genus by its lack of appreciable granular ornamentation on the cranidium, even on the surface of the mold. No pygidia and free cheeks of this species have yet been found that show the external surface, although several exfoliated specimens having the typical pitted surface of the mold are known.

Ocurrence. Moderately common, middle and upper parts of *Dunderbergia* zone: Eureka, Bastian Peak, Shingle Pass, Tybo, Spring Mountains, Sheep Range, and Grant Range, Nev.; Quartz Spring area, Stovepipe Wells, and Furnace Creek quadrangle, Calif.

Genus ELVINIA Walcott

Elvinia Walcott, 1924, p. 56; 1925, p. 88; Bridge and Girty, 1937, p. 252; Kobayashi, 1938, p. 179; Shimer and Shrock, 1944, p. 625; Lochman, 1959, p. 296; Palmer, 1960a, p. 70.
Moosia Walcott, 1924, p. 59; 1925, p. 106.

Type species. Dikelocephalus roemeri Shumard, 1861, p. 220, 221.

Diagnosis.—Elviniinae having posterior glabellar furrows connected across glabella forming single arcuate furrow of nearly even depth. Other glabellar furrows rarely apparent. Palpebral lobes arcuate; length about one-half length of glabella exclusive of occipital ring on specimens having glabellar length 6 mm or less; proportionately less on larger specimens. Anterior margin of cranidium evenly curved. Border furrow appears nearly straight in dorsal view. Anterior course of facial sutures nearly straight forward from palpebral lobes.

Free cheek has short sharp genal spine diverging from general curvature of cheek margin. Ocular platform broad, separated from moderately to strongly convex border by broad deep marginal furrow; connection between lateral and posterior marginal furrows shallow.

Pygidium subsemicircular in outline, widest at anterior margin. Border narrow, of nearly constant width. Axial lobe prominent, subparallel sided, bluntly rounded posteriorly. Pleural lobes nearly flat.

Discussion.—Although this genus is widespread in the Great Basin, it is not a common trilobite. Even large collections from within the range of *Elvinia* rarely have more than a few cranidia referable to the genus. None of the collections provided any new information about the character of the genus beyond that already given in an earlier paper (Palmer, 1960a, p. 70).

Elvinia granulata Resser

Plate 3, figure 12

Elvinia granulata Resser, 1942b, p. 96, pl. 18, figs. 11, 12; Palmer, 1960a, p. 71, pl. 6, fig. 4.
Elvinia ruedemanni Resser, 1942b, p. 95, pl. 18, figs. 7–10; Fisher and Hanson, 1951, pl. 1, figs. 1, 2.
?*Parairvingella hamburgensis* Resser, 1942b, p. 27, pl. 4, figs. 23, 24.

Diagnosis.—External surface of cranidium, exclusive of furrows and palpebral lobes, covered with low granules. Brim generally flat or concave in longitudinal profile; axial length about equal to that of border.

Discussion.—The granular surface of this species is its most distinctive characteristic.

Occurrence. Rare, *Elvinia* zone; Eureka, Nev.; House Range, Utah.

Elvinia roemeri (Shumard)

Plate 3, figures 9, 11, 14, 16

Dikelocephalus roemeri Shumard, 1861, p. 220, 221.
Crepicephalus (*Loganellus*) *unisulcatus* Hall and Whitfield, 1877, p. 216, pl. 2, fig. 22.
Ptychoparia matheri Walcott, 1912, p. 268, pl. 44, figs. 15–17.
Elvinia roemeri (Shumard). Walcott, 1924, p. 56, pl. 11, fig. 3; 1925, p. 88, pl. 17, figs. 9–13; Bridge, 1933, p. 232, pl. 2, figs. 17–19; Miller, 1936, p. 30, pl. 8, fig. 36; Bridge and Girty, 1937, p. 251, pl. 69, figs. 1–22; Shimer and Shrock, 1944, pl. 264, figs. 34–37; Wilson, 1949, p. 38, pl. 10, figs. 5, 9, 10, 12, 13; Frederickson, 1949, p. 352, pl. 69, figs. 19–21; Lochman, 1950, pl. 47, figs. 21–23; Wilson, 1951, p. 642, pl. 92, figs. 18–22; Nelson, 1951, p. 775, pl. 107, fig. 8; Bell and others, 1952, p. 183, pl. 30, figs. 1a–d; Palmer, 1960a, p. 70, pl. 6, fig. 7; Robison, 1960, p. 38, pl. 4, fig. 12; Lochman and Hu, 1960, p. 814, pl. 96, figs. 38–47.
Moosia grandis Walcott, 1924, p. 59, pl. 14, fig. 9; 1925, p. 107, pl. 23, figs. 20, 21.
Elvinia tetonensis Resser, 1937, p. 12.
Elvinia texana Resser, 1938b, p. 30.
Elvinia shumardi Resser, 1938b, p. 30; Shimer and Shrock, 1944, pl. 264, figs. 41, 42.
Elvinia bridgei Resser, 1938b, p. 31; 1942b, p. 97, pl. 18, figs. 28–31; pl. 19, figs. 1–5.
Elvinia missouriensis Resser, 1938b, p. 31; 1942b, p. 96, pl. 18, figs. 13–17.
Elvinia dakotensis Resser, 1938b, p. 32.
Elvinia utahensis Resser, 1938b, p. 32; 1942b, p. 95, pl. 18, figs. 5–6.
Elvinia gregalis Resser, 1942b, p. 97, pl. 18, figs. 28–31.
Elvinia longa Resser, 1942b, p. 97, pl. 18, figs. 24–27.
Elvinia vagans Resser, 1942b, p. 98, pl. 19, figs. 6–9.
Elvinia brevifrons Resser, 1942b, p. 98, pl. 19, figs. 10–14.
Elvinia matheri (Walcott). Shimer and Shrock, 1944, pl. 264, fig. 40.
Elvinia obliquoensis Rusconi, 1953, p. 1, fig. 1.

Diagnosis.—External surface of cranidium smooth. Brim generally moderately convex. Border convex in sagittal profile; saggital length between one-half and two-thirds length of brim.

Discussion.—This widespread but relatively rare species is characterized particularly by its smooth external surface. It is distinguished from *Elburgia quinnensis* (Resser), its possible ancestor, by having the transglabellar furrow of even depth and generally longer palpebral lobes.

Replicas of Rusconi's specimens of *Elvinia obliquoensis* from Argentina (Rusconi, 1953) show that this species does not differ in any observable feature from *E. roemeri*. At present these are the only specimens referable to *Elvinia* outside North America.

Occurrence. Moderately rare, *Elvinia* zone: Eureka, McGill, Bastian Peak, Cherry Creek, Shingle Pass, Snake Range, Tybo, Ruby Range, Mount Hamilton, and Yucca Flat, Nev.; Deep Creek range, Utah.

Genus ELVINIELLA Palmer

Elviniella Palmer, 1960a, p. 71, 72.

Type species.—*Elviniella laevis* Palmer, 1960a, p. 7, pl. 6, figs. 8–10, 14.

Diagnosis.—Elviniinae having glabella tapered forward and having conspicuous posterior glabellar furrows connected across glabella; other glabellar furrows barely visible. Border and border furrow come to blunt point on axial line in many specimens. Fixed cheeks broad; width slightly greater than one-half basal glabellar width. Ocular ridges directed slightly anterolaterally to ends of palpebral lobes. Palpebral lobes long, strongly arcuate; length about one-half that of glabella including occipital ring. Anterior course of facial sutures nearly straight forward from palpebral lobes.

Free cheek has long slender genal spine directed outward at distinct angle from margin of cheek. Lateral and posterior border furrows distinct, not connected across genal angle. Width of lateral border about one-half width of ocular platform.

Pygidium, hypostome, and thoracic segments not known.

Discussion.—The discovery of free cheeks in association with cranidia assignable to *Elviniella* in USGS collection 3061-CO from the Tybo district, Nevada, has provided the new information given in the foregoing diagnosis. The relatively wide fixed cheeks and the palpebral lobes that are distinctly more than half of the glabellar length, exclusive of the occipital ring, distinguish cranidia of *Elviniella* from superficially similar small cranidia of *Elvinia roemeri* (Shumard). (Compare pl. 7, fig. 14 with pl. 3 fig. 14.) The structure of the free cheek, having the long genal spine diverging at an angle from the border, is similar to that of cheeks of *Dokimocephalus* and *Iddingsia* in the Dokimocephalinae, further emphasising the interrelationships between the Elviniinae and Dokimocephalinae (p. 33).

Elviniella laevis Palmer

Plate 7, figures 14, 18, 19

Elviniella laevis Palmer, 1960a, p. 72, pl. 6, figures 8–10, 14.

Diagnosis.—This is the only species presently recognized in the genus. The generic diagnosis is thus also a specific diagnosis. The external surfaces of the granidium and free cheeks are nearly smooth; however, whitened specimens observed in oblique lighting may show faint irregular anastomosing or reticulate markings on the posterior part of the fixed cheek and terrace lines along the anterior margin of the border.

Discussion.—Except for the discovery of a free cheek described under the genus, no significant new information has been obtained about the morphology of *E. laevis* or about possible additional species in the genus.

Occurrence. Rare, upper part of *Dunderbergia* zone: Eureka, Tybo, Ash Meadows, Pahranagat Range, and McGill, Nev.; *Elvinia* zone: Eureka, Snake Range, and Cherry Creek, Nev.

Genus IRVINGELLA Ulrich and Resser

Irvingella Ulrich and Resser (in Walcott, 1924, p. 58); Walcott and Resser, 1924, p. 10; Walcott, 1925, p. 97; Resser, 1938b, p. 33; 1942b, p. 3, 13; Shimer and Shrock, 1944, p. 627; Kobayashi, 1954, p. 34; Lochman, 1959, p. 295; Palmer, 1960a, p. 72.

Irvingella (*Parairvingella*) Kobayashi, 1938, p. 175; Palmer, 1960a, p. 73.

Irvingella (*Irvingellina*) Kobayashi, 1938, p. 175; 1954, p. 35.

Parairvingella Resser, 1942b, p. 4, 25.

Komaspis (*Parairvingella*) Kobayashi, 1954, p. 33.

Type species.—*Irvingella major* Ulrich and Resser (in Walcott, 1924, p. 58, pl. 10, fig. 3).

Diagnosis.—Elviniinae having prominent subquadrate glabella, broadly rounded anteriorly. Posterior glabellar furrows connected across glabella, forming single deep furrow; junctions of lateral parts with furrow across top generally slightly angular. Middle pair of glabellar furrows generally visible at sides of glabella. Frontal area short, less than one-fourth length of glabella including occipital ring. Fixed cheeks moderately broad; width between palpebral and dorsal furrows more than one-third width of glabella just anterior to occipital furrow. Palpebral lobes long, slender, depressed below general level of cheek; length about two-thirds length of glabella including occipital ring. Posterior limbs short, steeply depressed.

Free cheek narrow. Border broader than ocular platform except posterolateral to eye. Genal spine moderately long, forms continuous curve with border.

Course of anterior section of facial suture curved inward and forward from anterior end of palpebral lobe; cuts anterior margin of cranidium less than half the distance from anterolateral cranidial corner to axial line.

Pygidium subtrapezoidal, broadest at or near anterior margin, has prominent axis crossed by one or two deep ring furrows; length of axis about three-fifths length of pygidium. Distinct border generally present. Pleural lobes narrower than axial lobe.

Discussion.—Examination of closely spaced stratigraphically controlled collections containing *Irvingella* from Nevada shows that three common stratigraphically distinct species are present: an older species, *I. angustilimbatus* Kobayashi, an intermediate species, *I. flohri*, and a younger species, *I. major* Ulrich and Resser. A rare fourth specices, *I. transversa* n. sp., is associated with *I. major*.

A review of the historical development of the concept and content of *Irvingella* has been presented in an earlier paper (Palmer, 1960a, p. 73). The only additional change here is to discontinue recognition of *Parairvingella* as a subgenus on the basis of further study of specimens referable to its type species, *I. angustilimbatus* (p. 47).

Thirty-nine specific names have been applied to trilobites having the characteristics of *Irvingella*. Twenty-seven of these "species" are from the United States, of which 23 were described by Resser (1942b, p. 13–24). Frederickson (1949) and Gaines (1951) reviewed many of Resser's "species" from Oklahoma

and Texas, respectively, and concluded that the features cited as species features were in most instances either superficial or inaccurately reported. They recognized only one species, *I. major*, in their areas.

Examination of the typees of all the North American "species" referred to *Irvingella* during the present study has confirmed the observations of Frederickson and Gaines. Present assignments of 23 of these "species" are given in the synonymies of *I. major*, *I. flohri*, and *I. angustilimbatus*. Five additional "species" are represented by types that are not well enough preserved or illustrated to be adequately compared with species recognized here. *I. tumifrons* (Hall and Whitfield) and *I. protuberans* Kobayashi are represented by large, distorted, and exfoliated cranidia that are possibly referable to *I. major*. *I. davisensis* Resser is represented by a fragmentary cranidium possibly also referable to *I. major*, and *I. ottertailensis* Resser is represented by a mold of a cranidium so incomplete that even its generic assignment is questionable.

Most of the known specimens of foreign trilobites assigned to *Irvingella* were examined during 1961 and 1962. *I. suecica*, with its subspecies, *I. suecica marginata* (Westergard, 1947), from Sweden is a species differing from American species of *Irvingella* by having a distinct cranidial border persisting further into the holaspid stage. It differs further from *I. major* by having slightly wider fixed cheeks, a less transversely convex glabella, and less well-defined second glabellar furrows.

I. nuneatonensis (Sharman, 1886) from England may be a distinct species. It is represented by slightly compressed specimens in shale. Large cranidia differ from those of *I. major* only in having a slightly more elongate and anteriorly tapered glabella. The holotype, which is a smaller complete specimen (total length 9 mm), is not objectively distinguishable from *I. major*, but some evidence for a slight postdepositional shortening of the glabella may make the resemblance more apparent than real. This species is presently being studied (1962) by Mr. Adrian Ruston of Cambridge University.

I. jorusconii (Rusconi, 1953) from Argentina is in every respect identical with *I. major*. *I. obliquoensis* (Rusconi, 1953) may also be a synonym of *I. major*. It is represented only by large broken cranidia that have all observable characteristics correct for *I. major*, but they are inadequately preserved for accurate identification. *I. platycephala* (Rusconi, 1953) may be a separate species. One of the paratype specimens studied is a cranidium having a low transverse glabellar convexity, in which the front of the glabella obscures the border from dorsal view. However, a second one of the paratype specimens is a typical *I. major*. The holotype was not among the replicas available for study; so, correct placement of the species is not possible.

Irvingella septentrionalis (Walcott and Resser, 1924) from Novaya Zemlya is represented by a single distorted cranidium that has all the characteristics of *I. major*. However, *I.? arctica* (Walcott and Resser) (1924) is not an *Irvingella*. Although it has the posterior glabellar furrow complete across the glabella, it also possesses a large occipital node, the suggestion of a small anteriorly placed palpebral lobe, and a well-defined border that tapers laterally and is different in structure from that of species of *Irvingella* having a border. The species is represented only by one small distorted cranidium, and its correct generic assignment is not certain.

Among unnamed specimens assigned to *Irvingella* is a slightly crushed and weathered cranidium from China identified as *Irvingella?* by Troedsson (1937). The specimen lacks a preserved frontal area, and thus, although it otherwise resembles *Irvingella*, it could represent a younger genus, *Drumaspis*. Cranidia of a species of *Drumaspis* from Nevada, in a fauna containing some elements resembling those described by Troedsson from China, differ from *Irvingella* only by having facial sutures that meet on the axial line.

Irvingella tropica (Öpik, 1963) from the Pomegranate limestone in Queensland, Australia, seems to be identical in every respect with the variant of *I. angustilimbatus* from the Tybo district, Nev. (pl. 6, fig. 23), described in the following discussion.

In the collections of N. V. Pokrovskaya in Moscow are cranidia of an *Irvingella* from the northeastern part of the Siberian platform that are identical with those of *I. transversa* n. sp.

Three asiatic species seems to belong to *Irvingella*, but further comparison must await study of the specimens on which they are based. These are *I. taitzehuensis* (Lu, 1957) from China, and *Komaspis* (*Parairvingella*) *convexus* and *K.* (*P.*) *megalops* (Kobayashi, 1962) from Korea.

Irvingella angustilimbatus Kobayashi

Plate 6, figures 17, 18, 21–23

Charioccphalus? tumifrons Walcott (not Hall and Whitfield), 1884, p. 61, pl. 18, fig. 16.

Irvingella (*Parairvingella*) *angustilimbatus* Kobayashi, 1938, p. 175; Palmer, 1960a, p. 73, pl. 6, figs. 2, 3.

Parairvingella angustilimbatus (Kobayashi). Resser, 1942b, p. 26, pl. 4, figs. 18–22.

Parairvingella intermedia Resser, 1942b, p. 27, pl. 4, figs. 25–31.

Parairvingella eurekensis Resser, 1942b, p. 26, pl. 4, figs. 15–17.
Irvingella (Parairvnigella) eurekensis (Resser). Palmer, 1960a, p. 74, pl. 6, fig. 1.

Diagnosis.—Short frontal area distinctly divided into brim and border. Glabella prominent, moderately convex transversely and longitudinally; second glabellar furrows shallow. Width of fixed cheeks about one-half or less than one-half basal glabellar width.

Pygidium, free cheeks, and hypostome not known.

Discussion.—This species is the oldest representative of *Irvingella* and the only species of *Irvingella* having a well-defined cranidial border, even on large holaspids. This species was assigned to the subgenus *Parairvingella* in an earlier paper (Palmer, 1960a), when *Parairvingella eurekensis* Resser was believed to constitute a second species. The problem of adequately determining systematics from small samples, however, is indicated by the foregoing synonymy.

Parairvingella eurekensis Resser was recognized as a distinct species because the sagittal length of the frontal area on the two small known specimens is greater in comparison to glabellar length than is the sagittal length of the frontal area on larger specimens representing *I. angustilimbatus*. Generally, the sagittal length of the frontal area increases rather than decreases relative to glabellar length as size increases. A sample of *I. angustilimbatus* from Tybo, Nev., (USGS 1471–CO) has both small and large cranidia and, coupled with samples of cranidia of "*Parairvingella*" type of various sizes from other localities, shows that the holaspid growth of the frontal area of this species is uncommon. Thus, the principal distinction made between *I. angustilimbatus* and *I. eurekensis* seems to be no longer valid, and the species are here considered to be synonyms. This leaves *I. angustilimbatus* as the only recognizable American species in *Parairvingella*. The fact that *I. flohri*, *I. transversus*, and *I. major*, which lack a definite border in larger holaspids, pass through a "*Parairvingella* stage" in the meraspid and early holaspid periods (pl. 6, figs. 8, 14, 15, 19) emphasizes the close relationship of *Parairvingella* and *Irvingella*. Westergard (1947) showed a similar growth pattern for *I. suecica*, and Lochman (1953, 1959), following Westergard's suggestion, placed *Parairvingella* in synonymy with *Irvingella*. *Parairvingella* was subsequently reinstated as a subgenus (Palmer, 1960a). However, usage of the cumbersome trinomial nomenclature now seems unnecessary.

One cranidium from USGS collection 1471-CO, made at Tybo (pl. 6, fig. 23), seems to show an extreme of variation that can occur in a sample where most other cranidia are clearly conspecific with *I. angustilimbatus*. The form of this cranidium, which has a slightly tapered glabella, is much like that of *Elviniella* and emphasizes the close relationship between *Irvingella* and *Elviniella*, which is its probable ancestor (p. 20).

This cranidium cannot be objectively distinguished from the two known cranidia of *Irvingella tropica* Öpik from the Pomegranate limestone, Queensland, Australia. However, because of the small number of specimens in the Tybo collection, the variant Tybo cranidium cannot be clearly shown to represent a population specifically distinguishable from associated specimens assigned to *I. angustilimbatus*. Thus, although *I. tropica* may have existed in both Australia and America, the possibility of homeomorphy cannot be eliminated, and the Tybo specimen is recorded in the present paper as a variant of *I. angustilimbatus*.

Occurrence. Moderately rare, lower part of *Elvinia* zone: Eureka, McGill, Shingle Pass, Tybo, Yucca Flat, and Bare Mountain, Nev.

Irvingella flohri Resser

Plate 6, figures 16, 19, 20, 24

Irvingella flohri Resser, 1942b, p. 24, pl. 4, figs. 12–14.
Irvingella adamsensis Resser, 1942b, p. 24, pl. 4, figs. 7–11.
Irvingella aff. *I. flohri* Resser. Deland and Shaw, 1956, p. 556, pl. 66, figs. 10–12.

Diagnosis.—Frontal area short, undivided in larger holaspids. Sagittal convexity of glabella gentle to moderate; transverse convexity moderate. Second pair of glabellar furrows rarely apparent. Distance between palpebral furrows on line tangent to front of glabella slightly but consistently greater than basal glabellar width. Width of fixed cheeks one-half or less than one-half width of glabella.

Pygidium has axis bearing one or two ring furrows posterior to articulating furrow. Anterolateral corners generally rounded.

Discussion.—This species occurs in beds slightly older than those containing *I. major* and *I. transversa*. The foregoing distinguishing features are consistent, although minor, and are significant in the understanding of the evolution of the genus (p. 20).

Deland and Shaw (1956, p. 556) placed both *I. adamsensis* Resser and *I. richmondensis* Resser in the synonymy of *I. flohri*. The placement of *I. adamsensis* is certainly correct. *I. richmondensis* is represented by a small cranidium that could belong to either *I. major* or *I. flohri*. Because of its association with *I. transversa*, a species known only from beds containing

I. major, *I. richmondensis* is here considered to be more probably a synonym of *I. major*.

Occurrence. Moderately rare, middle part of *Elvinia* zone; Eureka, Shingle Pass, and McGill, Nev.; House Range, Utah.

Irvingella major Ulrich and Resser

Plate 6, figures 9–15

Irvingella major Ulrich and Resser, in Walcott, 1924, p. 58, pl. 10, fig. 3; Walcott, 1925, p. 98, pl. 15, figs. 26–29; Shimer and Shrock, 1944, pl. 265, fig. 25; Frederickson, 1949, p. 353–355, pl. 69, figs. 5–7; Wilson, 1951, p. 644–645, pl. 93, figs. 14, 21–23; Gaines, 1951, p. 609, pl. 1, figs. 1–32; Bell and Ellinwood, 1962, pl. 55, figs. 4, 5.
Irvingella septentrionalis Walcott and Resser, 1924, p. 10, pl. 2, figs. 32, 33.
Irvingella abrupta Resser, 1942b, p. 21, pl. 3, figs. 40–45.
Irvingella accincta Resser, 1942b, p. 21, pl. 3, figs. 37–39.
Irvingella agrestis Resser, 1942b, p. 17, pl. 3, figs. 4–6.
Irvingella alberta Resser, 1942b, p. 23, pl. 4, figs. 1–3.
Irvingella alia Resser, 1942b, p. 16, pl. 2, figs. 42–47.
Irvingella alta Resser, 1942b, p. 19, pl. 3, figs. 16–18.
Irvingella arbucklensis Resser, 1942b, p. 14, pl. 2, figs. 28–33.
Irvingella ardmorensis Resser, 1942b, p. 18, pl. 3, figs. 7–12.
Irvingella bacca Resser, 1942b, p. 20, pl. 3, figs. 34–36.
Irvingella burnetensis Resser, 1942b, p. 20, pl. 3, figs. 28–33; Wilson, 1949, p. 39, pl. 11, figs. 18, 21.
Irvingella deckeri Resser, 1942b, p. 19, pl. 3, figs. 19–27.
Irvingella gibba Miller, 1936, p. 31, pl. 8, figs. 1, 2.
Irvingella media Resser, 1942b, p. 22, pl. 3, figs. 46–54; Shimer and Shrock, 1944, pl. 265, figs. 26, 27; Wilson, 1949, p. 39, pl. 10, fig. 7; pl. 11, figs. 16, 17, 19, 20.
Irvingella mesleri Resser, 1942b, p. 15, pl. 2, figs. 34–38.
Irvingella oblonga Resser, 1942b, p. 17, pl. 3, figs. 1–3.
Irvingella plena Resser, 1942b, p. 18, pl. 3, figs. 13–15.
Irvingella recurva Resser, 1942b, p. 15, pl. 2, figs. 39–41.
Irvingella richmondensis Resser, 1942b, p. 23, pl. 4, figs. 4–6.
Irvingella silvestris Resser, 1942b, p. 13, pl. 2, figs. 22–27.
Irvingella jorusconii Rusconi, 1953, p. 2, fig. 2.
?*Irvingella obliquoensis* Rusconi, 1953, p. 2, figs. 4, 5.

Diagnosis.—Frontal area short, undivided in all but smallest holaspids. Glabella prominent, strongly convex transversely and longitudinally, has short second pair of glabellar furrows commonly most distinct on exfoliated specimens. Distance between palpebral furrows on line tangent to front of glabella generally equal to or less than basal glabellar width. Width of fixed cheeks one-half or less than one-half basal glabellar width. Anterolateral corners of pygidium on many specimens acuminate.

Discussion.—Specimens from many localities have been referred to *I. major*, and the synonymy of the species has been discussed several times. The only published description, however, is a careful and fairly complete presentation by Gaines (1951). New information derived from study of silicified specimens in USGS collection 3064—CO, Mount Hamilton district, Nev., shows that the free cheek has only a short anterior projection of the doublure beneath the cranidial border and that this species must have had a rather wide (transverse) rostral plate.

Evolutionary development within *Irvingella* is to some extent summarised in the ontogeny of *I. major*, the youngest species of the genus. Small meraspids have a distinct brim and border, as in the oldest species of *Irvingella*, *I. angustilimbatus*. Larger meraspids and perhaps small holaspids have the subdued glabellar convexity and proportionately greater distance between the anterior ends of the palpebral lobes characteristic of *I. flohri*, the immediate ancestor of *I. major*.

Occurrence. Moderately common to abundant, highest beds of *Elvinia* zone: Eureka, Snake Range, McGill, Cherry Creek, Ruby Range, Mt. Hamilton, and Yucca Flat, Nev.

Irvingella transversa n. sp.

Plate 6, figures 7, 8

Diagnosis.— Frontal area short, undivided in holaspid. Glabella prominent, moderately to strongly convex transversely and longitudinally; second glabellar furrows barely apparent. Width of fixed cheeks about two-thirds basal glabellar width. Distance between palpebral furrows on line tangent to anterior end of glabella about one-third greater than basal glabellar width.

Discussion.—This striking species is represented by both large and small cranidia and occurs in association with *I. major*. The width of the fixed cheeks and the distance between the anterior ends of the palpebral lobes relative to the basal glabellar width are far greater than the outside limits for these characteristics observed on *I. major* by Gaines (1951) and by me. Thus, this species does not seem to represent merely an extreme variation of *I. major*. The occurrence is here considered to be one of the relatively rare examples of an association of two congeneric species in the Pterocephaliid biomere.

Occurrence: Rare, upper part of the *Elvinia* zone: Eureka and Ruby Range, Nev.

Family ERIXANIIDAE Opik

This family was recently proposed (Öpik, 1963, p. 77) for trilobites having cranidia on which the border is narrow, the brim and fixed cheeks are wide, the posteriorly situated palpebral lobes are long and arcuate, and the glabella is subrectangular and has a sagittally short occipital ring. The thorax has 12 segments on which the pleural tips are long and slender. Pygidia have a short axis and, generally, a narrow border. In

addition to three new species of a single genus *Erixanium* from Australia, Öpik (1963, p. 78) noted that specimens described as Genus and species undetermined 1, 2, and 3 by Palmer (1960a, pl. 11, figs. 1–3, 5, 6) from the Dunderberg Shale also belong to *Erixanium*. These specimens together with subsequently collected material, all from the Peterocephaliid biomere, represent at least four species here assigned with varying degrees of confidence to *Erixanium*.

Genus ERIXANIUM Öpik

Erixanium Öpik, 1963, p. 77.

Type species.—*Erixanium sentum* Öpik, 1963, p. 78–81, pl. 8, figs. 1–4, 7, 8; pl. 9, figs. 1–5; text figs. 26, 27.

Diagnosis.—Because the family Erixaniidae is presently monotypic, the diagnostic features of *Erixanium* are the same as those for the family. However, *E.? brachyaxis* n. sp., which has a relatively short brim and a flat border on the cranidium and a relatively broad pygidial border, could be removed from *Erixanium* on these differential characteristics. If so, *Erixanium* could be diagnosed as follows: Erixaniidae having a narrow slightly convex cranidial border; sagittal length less than one-third that of nearly flat brim. Pygidium has narrow border; width of border less than one-half width of pleural platform.

Discussion.—Specimens of *Erixanium* are rare but widespread in the *Dunderbergia* zone of the Great Basin. Samples large enough to show infraspecific variability have not been obtained. Thus, the small differences between *E. multisegmentus* n. sp. and *E. carinatum* n. sp. and their Australian counterparts *E. alienum* Öpik and *E. sentum* Öpik may need to be reevaluated when larger samples are found.

During a visit to Dr. N. V. Pokrovskaya of the Geological Institute of the Academy of Sciences in Moscow, U.S.S.R., in May 1962, I was shown complete specimens of a species of *Erixanium* from near the mouth of the Lena River in northeastern Siberia. In that area, as well as in Australia and the United States, *Erixanium* is found in the interval between beds containing *Glyptagnostus* and those containing *Irvingella*. Thus, *Erixanium* is added to the small but growing list of geographically widespread and stratigraphically restricted Cambrian trilobite genera that are of extreme importance for accurate intercontinental correlation within the Cambrian system.

The Siberian species of *Erixanium*, which seems to be conspecific with *E. multisegmentus* n. sp. has a thorax and cephalon that are virtually the same as those of *E. sentum* Öpik. *E. sentum* differs primarily in the structure of its pygidium. Pygidial characteristics, therefore, are apparently the most significant for discrimination of species within *Erixanium*.

Erixanium carinatum n. sp.

Plate 17, figures 19–21

Diagnosis.—Cranidium has narrow convex border, defined by narrow border furrow; sagittal length between one-third and one-fourth length of brim. Glabellar furrows generally shallow. Pygidium subtriangular, has short axis, length of axis about one-half that of pygidium. Three moderately well-defined ring furrows present posterior to articulating furrow. Postaxial median carina present, connected to border. Border narrow, continuous with first pleural furrow. Anterior half of pleural fields crossed by two or three broad moderately deep pleural furrows. Shallow interpleural furrows may be present.

Discussion.—This species is most like *E. sentum*, the type species, from the Georgina and Pomegranate limestones in Australia (Öpik, 1963). The principal difference is the presence of a well-defined postaxial median carina on the pygidium. The axis has one less segment, and the posterior part of the pygidial border furrow is also better defined on the American species. The distinct postaxial carina distinguishes *E. carinatum* from all other species in the genus.

Occurrence. Rare, lower half of the *Dunderbergia* zone: Yucca Flat, Nev.; House Range?, Utah.

Erixanium multisegmentus n. sp.

Plate 17, figures 17, 18

Genus and species undetermined 1, Palmer, 1960a, p. 101, pl. 11 figs. 2, 5, 6.

Genus and species undetermined 3, Palmer, 1960a, p. 102, pl. 11, fig. 3.

Diagnosis.—Cranidium has nearly flat border separated from brim by sharp change in slope; sagittal length about one-third length of brim. Glabellar furrows distinct, moderately deep. Axis pygidium has five or six ring furrows posterior to articulating furrow; posterior end of axis poorly defined; length of axis slightly less than three-fourths length of pygidium. Border narrow, moderately well defined. Pleural fields crossed by four or five shallow pleural furrows.

Discussion.—The long many-segmented axis of the pygidium, the narrow cranidial border, the generally deep glabellar furrows, and the lack of a distinct border furrow on the cranidium distinguish this species from others in the genus.

Occurrence. Rare, middle part of *Dunderbergia* zone: Eureka and Tybo district, Nev.

Erixanium? brachyaxis n. sp.

Plate 17, figures 14–16

Diagnosis.—Cranidium has relatively broad flat border separated from brim by distinct change in slope; sagittal length nearly one-half that of brim. Glabellar furrows barely apparent. Axis pygidium short; sagittal length about one-half length of pygidium. Three or four shallow ring furrows present posterior to articulating furrow. Pleural regions have broad, flat poorly defined border; border nearly as wide as pleural fields. Pleural fields crossed by one or two shallow pleural furrows that continue onto border. Postaxial boss elongate, extended onto inner part of border.

Discussion.—This species is included in *Erixanium* because of the presence of a postaxial boss on the pygidium and the general similarity in the structure of the cranidium. It differs from other species in the genus by having a broad rather than narrow pygidial border and a broader cranidial border. The differences in pygidial structure are greater than those generally apparent between congeneric species, and *E.? brachyaxis* may represent another genus. Until more is known about these rare trilobites, the species is tentatively included in *Erixanium*, with which it has its greatest affinities.

Occurrence. Rare, middle part of *Dunderbergia* zone: McGill, Cherry Creek, and Ruby Range, Nev.

Erixanium sp.

Plate 17, figure 22

Some generally fragmentary pygidia and isolated cranidia having the generic characteristics of *Erixanium* cannot be assigned with certainty to the species of *Erixanium* named here. Some of the pygidia (pl. 17, fig. 22) may represent a species characterized by two or three pairs of well-defined pleural furrows that terminate abruptly at the border furrow and by a short axis having only four or five ring furrows posterior to the articulating furrow. Pygidia of this type are most like those of *Erixanium sentum* Öpik. They differ primarily by having the pleural furrows meeting the lateral border furrow abruptly rather than by curving backward and being continuous with it. Without more knowledge of the variability of this feature in species from either the Australian or American collections, its reliability as a discriminating factor cannot be evaluated, and the American specimens are for the present not assigned to a named species.

Occurrence. Rare, middle part of *Dunderbergia* zone: Ruby Range, Nev. and House Range, Utah.

Family LONCHOCEPHALIDAE Hupé

Genus GLAPHYRASPIS Resser

Glaphyraspis Resser, 1937, p. 12; Rasetti, 1959, p. 279; 1961, p. 112.

Raaschella Lochman, 1938a, p. 81.

Type species.—*Liostracus parvus* Walcott, 1899, p. 463, pl. 65, fig. 6.

Description.—Small Lonchocephalidae having cranidium on which glabella prominent, well defined by generally deep axial and preglabellar furrows, subparallel sided or tapered forward, bluntly rounded anteriorly. Two pairs of short deep glabellar furrows present, generally not connected to axial furrow; posterior pair generally curved. Occipital furrow deep, particularly at sides of glabella. Occipital ring generally broadest on axial line, generally lacks distinct node or spine. Frontal area short, subequally divided into convex downsloping brim and border by narrow border furrow; length one-third or less than one-third length of glabella. Fixed cheek moderately convex; width less than one-half basal glabellar width. Palpebral lobes small, narrow, situated about opposite second glabellar furrows. Narrow eye ridges generally present. Posterior limbs moderately broad exsagittally, have deep posterior border furrow and prominent convex posterior border.

Course of anterior section of facial suture slightly convergent forward from palpebral lobe to border furrow; suture curved inward across border to cut anterior margin imperceptibly near axial line and then curved backward across doublure to axial line, perhaps outlining minute triangular rostral plate. Course of posterior section of facial suture gently convex near palpebral lobe, becoming more strongly convex near posterior margin.

Lateral margin of free cheek gently curved towards front, becoming strongly curved posteriorly around genal angle. Genal spine absent. Border furrow deep near anterior end, disappears towards genal angle. Eye small, holochroal; composed of about 50 to 60 lenses. Infraocular ring absent.

Hypostome not known. Thorax has eight thoracic segments. Each segment has prominent axis equal in width or slightly narrower than pleural region. Tips of thoracic segments generally bluntly rounded.

Pygidium subtriangular. Axis prominent, tapered backward, poorly defined posteriorly, reaches nearly to posterior margin; as many as five ring furrows present posterior to articulating furrow. Pleural re-

gions nearly flat near axis; distal margins downsloping or depressed. Pleural furrows generally present. Posterior band of each pleural segment has transversely elongate node about at point where pleural region is bent ventrally. Nodes decrease in size posteriorly. No distinct border present. Doublure narrow, tapered toward axial line.

External surfaces of most parts of exoskeleton have coarse or fine granular ornamentation, particularly on cranidium and free cheeks. Smooth specimens relatively rare.

Discussion.—Glaphyraspis is particularly characterized by the prominent well-defined glabella, the short subequally divided downsloping frontal area on the cranidium, and the rounded genal angle of the free cheek. Pygidia are similar, including the nodes on the posterior bands of the pleural regions, to those of *Lonchocephalus* and *Terranovella.*

Three distinct kinds of *Glaphyraspis* species are known. The type species, *G. parva* (Walcott), is characterized by subparallel glabellar sides, generally low glabellar convexity, and a slight median indentation in the front of the glabella. It is known at present only from beds in the upper part of the *Crepicephalus* zone in Virginia (Rasetti, 1961, p. 106) and Nevada and from beds of uncertain stratigraphic position at its type locality in northwestern Wyoming. A second kind of *Glaphyraspis* is represented by forms having an anteriorly tapered moderately to strongly convex glabella and deep glabellar furrows. This is the commonest kind of *Glaphyraspis* and is found over most of the United States in the *Aphelaspis* zone. Three species are included in this group: *G. ornata* (Lochman) and *G. occidentalis* (Lochman), which are species that lack occipital spines and which were formerly placed in *Raaschella* but were shown by Rasetti (1961, p. 112) to be congeneric with *G. parva* (Walcott), and an undescribed species that has an occipital spine. *G. occidentalis* is known at present only from Montana and Wyoming (Lochman and Duncan, 1944, p. 43; Lochman and Hu, 1960, p. 815). The undescribed species is known only from southeastern Arizona. *G. ornata* seems to be the most common of these species; it occurs in many collections from the Great Basin, Texas (Lochman, 1938a, p. 82; Palmer, 1954, p. 764) and the Appalachian region. A third kind of *Glaphyraspis*, represented by *G. ovata* Rasetti, is characterized by poor definition of the glabellar furrows and is the youngest species recorded for the genus. It is found in the *Pseudosaratogia magna* fauna in Virginia (Rasetti, 1961, p. 113) in beds equivalent in age to the lower *Elvinia* zone of the Great Basin.

Glaphyraspis ornata (Lochman)

Plate 7, figures 15–17, 20–22

Raaschella ornata Lochman, 1938a, p. 82, pl. 18, figs. 6–10; Palmer, 1954, p. 764, pl. 89, figs. 7–9.

Glaphyraspis ornata (Lochman). Palmer, 1962a, p. 93, pl. 19 figs. 15–19, 26, 27, text fig. 2*C*.

Diagnosis. — Glabella tapered forward, bluntly rounded anteriorly, moderately to strongly convex transversely and longitudinally. Glabellar furrows deep. Width of fixed cheek between one-third and one-half basal glabellar width. Occipital ring lacks node or spine.

Discussion.—G. ornata is most similar to *G. occidentalis* (Lochman) from Montana and Wyoming. It differs by having relatively wider fixed cheeks and a somewhat less variable ornamentation. These features may not have actual specific significance, however. The width of the fixed cheeks of most of the cranidia in the type lot of *G. occidentalis* is about one-third the basal glabellar width; larger cranidia are nearly smooth, whereas small cranidia are distinctly granular. Most of the cranidia of *G. ornata* from USGS collection 2468-CO at McGill, Nev., have a coarse granular ornamentation on specimens of all sizes, and the width of the fixed cheeks is more nearly one-half the basal glabellar width. Trilobites in this sample are silicified, and enough specimens are available to show that the ornamentation is consistent. USGS collection 2315-CO from Shingle Pass, however, contains specimens that have wide fixed cheeks but relatively subdued granular ornamentation; USGS collection 2996-CO from the House Range, Utah, contains specimens that have a distinct granular ornamentation but have fixed cheeks intermediate in width between those typical of *G. ornata* and *G. occidentalis*. Specimens from the Highland Range have a barely apparent granular ornamentation and fixed cheeks whose width is slightly less than one-third of the basal glabellar width. All the samples seem to be of the same age. Thus, geographic variation and some intrapopulation variation seem to be present within the presently constituted species of *Glaphyraspis*. Until adequate material is obtained in stratigraphic sequence at one locality, the significance of ornamentation and cranidial proportions in the systematics of *Glaphyraspis* will remain uncertain. All the specimens from the *Aphelaspis* zone in the Great Basin are here included in *G. ornata.*

Occurrence. Moderately rare, *Aphelaspis* zone: McGill, Shingle Pass, Snake Range, and Highland Range, Nev.; House Range, Utah.

Genus TERRANOVELLA Lochman

Terranovella Lochman, 1938b, p. 473; Shimer and Shrock, 1944, p. 635; Rasetti, 1959, p. 280.

Description.—Lonchocephalidae in which the cranidium has a well-defined slightly sunken glabella surrounded by deep axial and preglabellar furrows; glabella is tapered forward, bluntly rounded at front. Two pairs of deep short lateral glabellar furrows generally present; posterior pair distinctly curved. Occipital furrow deepest at sides of glabella, narrow but well impressed across axial line. Occipital ring has moderately long posteriorly directed median spine. Frontal area convex, almost tumid, obscurely divided into brim and border; sagittal length from one-third to slightly more than one-half that of glabella. Border, when apparent, narrower than brim. Fixed cheeks moderately convex, slightly downsloping; width about one-half basal glabellar width. Palpebral lobes poorly defined, situated on line through anterior pair of glabellar furrows. Narrow eye ridges may be present. Posterior limbs broad, have deep, narrow posterior border furrow.

Course of anterior section of facial suture nearly straight forward from palpebral lobe to border, then turned inward across border to cut anterior margin imperceptibly. Ventral course not known. Course of posterior section convex.

Border of free cheek moderately to poorly defined, slightly narrower than ocular platform. Only lateral border furrow apparent. Eye prominent. Infraocular ring absent. Genal spine short, sharp.

Axis of pygidium well defined at sides, poorly defined at rear, tapered backward to inner edge of steeply depressed border region. Three or four narrow ring furrows present posterior to articulating furrow. Pleural fields crossed by several shallow pleural and interpleural furrows. Each pleural segment has low knob along outer edge of pleural field.

External surfaces either smooth, pitted, or finely granular.

Discussion.—This genus is most like *Glaphyraspis* in structure of the glabella and differs in this respect from all other trilobites of the Pterocephaliid biomere. It differs from *Glaphyraspis* by having a sunken glabella, strongly convex frontal area, and a short genal spine on the free cheek. All known species of *Terranovella* have a broad-based median occipital spine. Most species of *Glaphyraspis* lack an occipital spine.

Terranovella brevis n. sp.

Plate 7, figures 12, 13

Diagnosis.—Frontal area short; sagittal length between one-third and one-half that of glabella. External surface smooth.

Discussion.—This species is known at present only from a few cranidia from the *Aphelaspis* zone in the Highland Range, Nev. It differs from all other species in the genus by lacking any distinct ornamentation and by having a relatively short frontal area.

Occurrence. Rare, upper part of *Aphelaspis* zone: Highland Range, Nev.

Family NORWOODIIDAE Walcott

Genus HARDYOIDES Kobayashi

Hardyoides Kobayashi, 1938, p. 177.
Norwoodina Lochman, 1940a, p. 11, 48.

Type species.—*Hardyoides minor* Kobayashi, 1938, p. 177, pl. 16, fig. 29.

Diagnosis.—Norwoodiidae having subcylindrical glabella; frontal area downsloping; distinct border present; fixed cheek moderately convex, slightly downsloping; posterior fixigenal spines short. Thorax composed of eight segments; axial spines may be present on occipital ring and third, fifth, and seventh segments. Pygidium subsemicircular; border poorly defined, downsloping.

Description.—Small norwoodiid trilobites (length probably not exceeding 6 mm). Cephalon subsemicircular, gently to moderately convex transversely and longitudinally. Cranidium subtrapezoidal; width at posterior margin about twice width between anterior sections of facial sutures. Glabella prominent, subcylindrical, strongly rounded in front. Glabella furrows barely apparent. Occipital furrow deep, straight. Occipital ring has node or spine. Frontal area short, downsloping; length between one-third and one-half length of glabella. Border slightly narrower than brim, well defined by narrow curved border furrow. Fixed cheeks gently convex, slightly downsloping; width slightly more than one-half basal glabellar width. Palpebral lobes small, poorly defined, opposite anterior fourth of glabella. Narrow eye ridges generally present at right angles to axial line. Posterior limbs large; exsagittal length more than one-half that of glabella; transverse width greater than basal glabellar width. Low knobs present on many specimens adjacent to axial furrow opposite posterior end of glabella. Posterior border furrow deep near glabella, disappears laterally near base of short, stout posterior fixigenal spine.

Course of anterior section of facial suture straight forward or slightly convergent from palpebral lobe to border furrow, curved across border to cut anterior margin imperceptibly and continues diagonally backward across doublure to axial line, then abruptly turned back to form short median suture behind trans-

versely subovate rostral plate. Rostral suture nearly straight, submarginal. Course of posterior section of facial suture convex, directed outward and backward to cut lateral margin of cephalon.

Free cheek subtriangular. Border about as wide as ocular platform, poorly defined. Eye small, convex. Infraocular ring absent.

Thorax composed of eight segments. Axis distinct, convex, narrower than pleural regions. Pleural regions gently convex. Each segment has deep straight pleural furrow and blunt tip. Axial spine may be present on third, fifth, and seventh segments.

Pygidium subsemicircular. Axis prominent anteriorly, tapered backward to inner edge of poorly defined downsloping border; end not clearly marked. Two or three shallow ring furrows present posterior to articulating furrow. Pleural fields crossed by three or four pleural and interpleural furrows of more or less equal depth. Anterior width of pygidium one-half or less maximum width of cephalon.

External surfaces of all parts smooth or covered with fine even granular ornamentation.

Discussion.—The discovery of *Hardyoides minor* Kobayashi, the type species of *Hardyoides*, represented by abundant silicified and limestone individuals in the *Aphelaspis* zone of eastern Nevada, has clarified knowledge on its morphology and stratigraphic position. Earlier assignment of the species to beds of Franconia (Kobayashi, 1938) and Tremadoc (Lochman, 1959) age are incorrect. Assignment of the species to *Holcacephalus* (Shaw, 1951), the synonymy of *Norwoodina* (Lochman, 1940a) with *Holcacephalus* (Resser, 1938a) by Lochman (1940b), and the synonymy of *Levisaspis* (Rasetti, 1943) with *Hardyoides* (Kobayashi, 1938) by Shaw (1953) required that the types and relationships of these genera be reviewed.

Walcott (1916) described *Norwoodia tenera* as one of several species of early Upper Cambrian proparian trilobites assigned to a new genus *Norwoodia* and family Norwoodiidae. Lochman (1940a, p. 11) reviewed the Norwoodiidae, made *N. tenera* the type species of a new genus *Norwoodina*, and gave a careful analysis and description of the characteristics of the genus. She also cited *Holcacephalus granulatus* Resser as a synonym of *N. tenera* without explanation and failed to note that by so doing *Holcacephalus* (Resser, 1938a; type species *H. granulatus*) became a senior synonym of *Norwoodina*. This situation was quickly rectified (Lochman, 1940b), and the nomenclature seemed to be stabilized.

Earlier, however, Kobayashi (1938) described a new genus *Hardyoides* and new species *Hardyoides minor* from Upper Cambrian beds in Canada. Although he was aware of the proparian nature of *H. minor* and also of Walcott's 1916 publication, to which he referred in his text, he failed to note the resemblance of the cranidium of *H. minor* to that of *N. tenera* or even to relate his species to the Norwoodiidae. Shaw (1951, p. 106) reviewed the Norwoodiidae and suggested that *Hardyoides* represented only a subgenus of *Holcacephalus*. From his remarks in the text, it is apparent that his knowledge of *Hardyoides* came only from the poor photograph and inaccurate drawing of *H. minor* in Kobayashi (1938). He included *Hardyoides* and *Holcacephalus*, together with *Levisaspis* (Rasetti, 1943) and *Paranorwoodia* (Rasetti, 1945), in a new subfamily, Holcacephalinae of the Norwoodiidae. Shaw, later (1953, p. 145) revised his views and recognized *Holcacephalus* and *Hardyoides* as separate genera, but he placed *Levisaspis* in synonymy with *Hardyoides*. Although the Holcacephalinae was rejected by Lochman (1953, p. 892), her arrangement of the Norwoodiidae (Lochman, 1959, p. 302) was nearly that of Shaw.

Study of Kobayashi's types of *Hardyoides minor* borrowed from the National Museum of Canada, the types of *Norwoodia tenera* and *Holcacephalus granulatus* from the U. S. National Museum, Rasetti's illustrations of *Levisaspis typicalis* and the new material from Nevada has revealed the following information: *Hardyoides minor* differs from *Norwoodia tenera* principally by lacking axial spines on the occipital ring and seventh thoracic segment. There is little doubt that these species are congeneric. Both species differ from *Holcacephalus granulatus* by having a subcylindrical, virtually unfurrowed glabella instead of a subtriangular glabella having deep lateral glabellar notches. They also have a finer granular ornamentation. The structure of the glabella and the form of the granular ornamentation of *H. granulatus* are characteristic of trilobites of the Menomoniidae rather than the Norwoodiidae. *Holcacephalus*, including *H. granulatus* only, is here removed from the Norwoodiidae and considered as a proparian genus of the Menomoniidae.

Levisaspis typicalis Rasetti has a cranidium similar to that of *Hardyoides minor* and *Norwoodia tenera*, but the whole trilobite is structurally unlike these species and, although possibly related, is probably not congeneric with either form. The species has five instead of eight thoracic segments, no axial spines, and a concave, upturned pygidial border.

Most of the illustrations and statements regarding *Hardyoides*, *Holcacephalus*, *Norwoodina*, and *Levisaspis* by Lochman (1959, p. 302), based principally on the work of Shaw (1951, 1953), need to be changed.

Norwoodina is a synonym of *Hardyoides*, not of *Holcacephalus*. *Levisaspis* is not congeneric with *Hardyoides*. *Holcacephalus* belongs to a family different from that of the other three genera. The illustration of *Hardyoides* (Lochman, 1959, fig. 224–4) is actually that of *Levisaspis*. The real illustration of *Hardyoides*, although inaccurate in detail is given as part of the illustration of *Holcacephalus* (Lochman, 1959, 224–1a, 1b).

The only species recognized here as properly belonging to *Hardyoides* are *H. minor* Kobayashi, *H. mimicus* n. sp., *Norwoodia tenera* Walcott, and *Norwoodina tenera cuneifera* Lochman (1940a). *Holcacephalus* (*Hardyoides*) *glabrus* (Shaw) belongs to *Levisaspis*.

Hardyoides mimicus n. sp.

Plate 7, figure 1

Diagnosis.—Cranidium has occipital spine. Fixigenal spines short; length less than twice length of occipital ring, exclusive of occipital spine. Sagittal length of border about two-thirds that of brim.

External surface has only slightly apparent granular ornamentation, even after whitening.

Discussion.—This species occurs in beds slightly younger than those containing *H. minor* and differs by having an occipital spine and a slightly longer brim. It is most nearly like the much older species *H. tenerus* (Walcott), from which it differs principally by having shorter and more delicate fixigenal spines.

Occurrence. Rare, *Dicanthopyge* zone: Yucca Flat, Nev.

Hardyoides minor Kobayashi

Plate 7, figures 3–5, 9–11

Hardyoides minor Kobayashi, 1938, p. 177, pl. 16, fig. 29; Palmer, 1962a, p. 94, pl. 19, figs. 20–25.

Diagnosis.—Cranidium has occipital ring lacking axial spine, frontal area subequally divided into brim and border, and short posterior fixigenal spines having length less than twice sagittal length of occipital ring. Thorax has axial spines on third and fifth segments only.

External surface has moderately distinct granular ornamentation.

Discussion.—This species differs from *H. tenerus* (Walcott) by having a narrow brim and shorter posterior fixigenal spines and by lacking axial spines on the occipital ring and seventh thoracic segments. The narrow brim and absence of an occipital spine also distinguish *H. minor* from the slightly younger *H. mimicus* n. sp. *H. minor* and *H. tenerus* occur in dark limestones of the outer detrital belt (Palmer, 1960b) in the Great Basin. *H. tenerus* is found in beds equivalent to those of the *Cedaria* zone, which are at least two trilobite zones older than the beds containing *H. minor*. The occurrence of two such similar species in similar rocks at significantly different times suggests a strong environmental control on their spatial distribution.

Occurrence. Moderately rare, upper part of *Aphelaspis* zone: McGill, Nev.; House Range, Utah.

Family OLENIDAE Burmeister

Genus ACICULOLENUS n. gen.

Type species.—*Aciculolenus peculiaris* n. sp.

Description.—Small olenid(?) trilobites known only from cranidium. Glabella prominent, moderately to strongly convex transversely, gently to moderately convex longitudinally, tapered forward; sides slightly convex; anterior strongly rounded. Three pairs of deep subparallel glabellar furrows present on flanks of glabella. Occipital furrow deep at sides of glabella, displaced abruptly forward on axial line by large node or base of spine that occupies normal position of occipital furrow. Occipital ring narrow at sides, abruptly widened on axial lines. Frontal area short, concave, has upturned margin in front of glabella that is not clearly differentiated into brim and border; length of area about one-sixth or less than one-sixth length of glabella. Fixed cheeks moderately narrow, slightly downsloping; width about one-third basal glabellar width. Palpebral lobes prominent, short, convex, slightly upturned, continuous with prominent eye ridges, situated opposite second pair of glabellar furrows; length about one-third or less than one-third length of glabella. Palpebral furrow deep, continuous with moderately deep furrow at back of eye ridge. Posterior limbs subquadrate in outline; transverse width less than basal glabellar width. Posterior margin straight, directed slightly forward from base of glabella to base of border spine at genal angle; distinct backward-sloping flange present behind crest of posterior border. Border distal to posterolateral spine directed forward to intersect posterior section of facial suture about opposite base of posterior glabellar furrow. Posterior border furrow curved forward distally.

Course of anterior section of facial suture slightly convergent forward from palpebral lobe for short distance, then curved broadly and evenly inward to cut anterior margin about in front of line projected forward from base of anterior glabellar furrow. Course of posterior section concave towards glabella so that distal end just before cutting cranidial margin is at right angles to axial line.

Surface of cranidium roughened by poorly defined low granular ornamentation.

Discussion.—This trilobite has so many peculiar features that a meaningful comparison with known trilobites is difficult to make. The glabellar shape and structure of the frontal area are somewhat like those of *Acerocare tullbergi* (Moberg and Moller). (Refer to Henningsmoen, 1957, pl. 30, fig. 11.) These features plus the small prominent palpebral lobes and prominent eye ridges suggest affinities to the Olenidae, and *A. peculiaris* is tentatively assigned to that family.

Aciculolenus peculiaris n. sp.

Plate 7, figure 2

Diagnosis.—This is the only trilobite presently assigned to *Aciculolenus*, and its characteristics are those described under the genus.

Discussion.—The combination of proparian posterior limbs, concave posterior sections of the facial sutures, and a median node or spine in the normal position of the occipital furrow is unique among Late Cambrian trilobites and serves to distinguish this species from all known forms.

Occurrence. Rare, uppermost part of *Elvinia* zone: Cherry Creek and Ruby Range, Nev.

Genus SIMULOLENUS n. gen.

Type species.—*Parabolinella incerta* Wilson (not Rasetti), 1954, p. 280, pl. 26, figs. 18–22 (equal *Olenus? wilsoni* Henningsmoen, 1957, p. 112, text fig. 17).

Diagnosis.—Members of the Oleninae in which cranidium has large well-defined glabella bearing three or four pairs of glabellar furrows. Occipital ring has distinct median node. Frontal area short, has well-defined brim and border. Fixed cheeks narrow. Palpebral lobes small, situated anterior to glabellar midlength. Course of anterior section of facial suture nearly straight forward from palpebral lobe.

Free cheek has long slender genal spine. Inner spine angle slightly obtuse.

Pygidium transverse subquadrate in outline. Length about one-third width. Axis prominent, subparallel sided, bluntly terminated, has one or two ring furrows posterior to articulating furrow. One or two pleural furrows present, not crossing poorly defined border. Posterior margin smooth, has broad, shallow median indentation.

Description.—Small- to medium-sized olenid trilobites (estimated maximum length about 30 mm). Cephalon subsemicircular, has slender genal spines directed nearly straight backward. Glabella low, broad, slightly tapered forward, bluntly rounded at front. Three or four pairs of glabellar furrows generally apparent; posterior pair generally deep, narrow, makes distinct angle with axial furrow; second pair moderately deep, nearly at right angles to axial furrow; third pair shallow, short, not connected to axial furrow, distal end close to fourth pair that may form from axial furrow at back edge of moderately prominent eye ridge. Occiptal furrow narrow, has slight angulation about midway between axial furrow and top of glabella. Occipital ring broadest on median line, has distinct median node. Frontal area short; sagittal length one-third or less than one-third length of glabella. Border narrow, convex; sagittal length equal to or less than that of nearly flat slightly downsloping brim. Fixed cheek narrow, nearly flat, horizontal; width about one-fourth or less than one-fourth basal glabellar width. Palpebral lobes small, convex, semicircular, situated anterior to glabellar midlength; length between one-third and one-fourth length of glabella. Palpebral furrow straight or slightly curved. Posterior limbs tapered to sharp point laterally; transverse length less than basal glabellar width. Posterior border furrow narrow, nearly straight.

Course of anterior section of facial suture straight forward or slightly divergent outward from palpebral lobes to border furrow, then turned inward across border gradually to cut anterior margin about in front of anterolateral corners of glabella. Ventral course not known.

Middle body of hypostome undivided; contact between anterior and posterior lobes marked by shallow furrows only at sides. Lateral border well defined. No distinct posterior border. Muscle (?) areas on posterolateral parts of anterior lobe of middle body thickened.

Transverse breadth of free cheek much less than length. Lateral border narrow, well defined by lateral border furrow that connects with posterior border furrow at genal angle and continues as shallow groove onto base of genal spine. Posterior border furrow continues forward to intersect posterior section of facial suture about midway between posterior margin and palpebral lobe. Inner spine angle slightly obtuse.

Pygidium transversely subquadrate; lateral margins strongly curved; posterior margin smooth, has broad, shallow median indentation. Axis prominent, subparallel sided, bluntly terminated posteriorly, has one or two distinct ring furrows posterior to articulating furrow. Pleural regions not clearly differentiated into border and pleural platform, gently convex. One or two distally curved pleural furrows cross pleural platform but not border.

External surfaces of brim and ocular platform have distinct veination. External surfaces of all parts either smooth or finely granular.

Discussion.—The species here assigned to *Simulolenus* show their clear relationships to the Olenidae in their thin exoskeleton and the structure of the glabella, palpebral lobes, free cheeks, and hypostome. They each have a small transverse nonspinose pygidium containing only one or two ring furrows and are distinguished by this feature from all western European and eastern Canadian species of the family. The only other described olenid having such a small pygidium is *Olenus ogilviei* Öpik from early Upper Cambrian beds in Queensland, Austria (Öpik, 1963, p. 59–62). The Australian species differs from all the *Simulolenus* species, however, by having large palpebral lobes, wider fixed cheeks, and a distinct, narrow pygidial border. A species of *Bienvillia*, an olenid from younger beds in Nevada, also has a distinctive small transverse pygidium. Perhaps as more is learned of the olenid trilobites in regions bordering the Pacific ocean, an olenid stock may become apparent that can be distinguished from Atlantic forms by the possession of a small transverse pygidium.

Simulolenus granulatus (Palmer)

Plate 8, figures 9, 10

Olenus? granulatus Palmer, 1960a, p. 79, pl. 6, figs. 23–27.

Diagnosis.—Sagittal length of frontal area about one-third length of glabella. Sagittal length of border slightly more than one-half length of brim. Three pairs of furrows generally apparent on glabella. Line connecting midpoints of palpebral lobes passes through or slightly anterior to distal parts of second glabellar furrows. Width of fixed cheeks slightly more than one-fourth basal glabellar width.

Pygidium has one distinct ring furrow posterior to articulating furrow. Pleural fields crossed diagonally by one distinct pleural furrow.

External surfaces and surfaces of molds of known parts covered with low fine granules.

Discussion.—This species is most like *S. wilsoni* (Henningsmoen); it differs principally in its ornamentation and the more distinct ring furrow on the axis of the pygidium. The species have been found together in several collections. Both differ from *S. quadrisulcatus* n. sp. by lacking distinct formation of the fourth pair of glabellar furrows, by having one less axial and pleural furrow on the pygidium, and by having a slightly broader fixed cheek, slightly longer frontal area, and slightly more anteriorly placed palpebral lobes.

Occurrence. Rare, middle part of *Dunderbergia* zone: Eureka and Tybo, Nev.

Simulolenus wilsoni (Henningsmoen)

Plate 8, figures 5–8, 11, 12

Parabolinella incerta (Rasetti). Wilson, 1954, p. 280, pl. 26, figs. 18–22.

Olenus? wilsoni Henningsmoen, 1957, p. 111, text fig. 117; Palmer, 1960a, pl. 6, figs. 18, 20–22, text fig. 15.

Diagnosis.—Sagittal length of frontal area about one-third or slightly more than one-third of length of glabella. Sagittal length of border slightly greater than one-half length of brim on cranidia that are less than 2 mm long; slightly less than one-half length of brim on cranidia that are 5 mm long. Line connecting midpoints of palpebral lobes passes slightly anterior to distal ends of second glabellar furrows. Width of fixed cheek slightly less than one-third basal glabellar width. Three pairs of furrows generally apparent on glabella.

Pygidium has one poorly formed ring furrow posterior to articulating furrow. Pleural fields crossed diagonally by one pleural furrow.

External surfaces and surfaces of molds of all parts smooth.

Discussion.—This species differs from both *S. granulatus* (Palmer) and *S. quadrisulcatus* n. sp. by having a smooth rather than granular external surface. It further differs from *S. quadrisulcatus* by having broader fixed cheeks, a longer frontal area, slightly more anteriorly placed palpebral lobes, and one less axial and pleural furrow on the pygidium and by lacking a distinctly formed fourth pair of glabellar furrows.

The species shows some variability in the definition of glabellar furrows and of eye ridges. This variability is in part a function of size. The glabellar furrows and eye ridges are most prominent on smaller cranidia. (Compare pl. 8, figs. 6, 7.)

Occurrence. Moderately rare, middle part of *Dunderbergia* zone: Eureka, Tybo, Ruby Range, and Yucca Flat, Nev.

Simulolenus quadrisulcatus n. sp.

Plate 8, figures 1–4

Diagnosis.—Glabella generally has four distinct pairs of glabellar furrows. Frontal area short; sagittal length about one-fourth glabellar length. Border narrow, convex; sagittal length equal to or slightly less than that of brim. Fixed cheeks narrow; width slightly more than one-fifth basal glabellar width. Line through midpoints of palpebral lobes passes across second glabellar furrows.

Pygidium has two distinct ring furrows posterior to articulating furrow. Pleural fields crossed by two pairs of pleural furrows.

External surfaces of all parts covered with minute closely spaced granules apparent only if lightly coated with magnesium oxide and placed under low oblique lighting. Surface of mold smooth.

Discussion.—This species differs from the others assigned to the genus by its narrower fixed cheeks, shorter frontal area, slightly more posteriorly placed palpebral lobes, and generally distinct fourth pair of glabellar furrows. Its pygidium has two distinct ring and pleural furrows rather than one, as in the other species. The granular ornamentation is much finer than that of *S. granulatus* (Palmer).

A small olenid cranidium from USGS collection 2524–CO at Cherry Creek (pl. 8, fig. 3) has a granular surface, short frontal area, and four pairs of glabellar furrows suggestive of *S. quadrisulcatus;* however, the fixed cheeks are somewhat wider than those of a comparable-sized cranidium in the type lot from the Eureka district, and it may represent a different olenid species.

Occurrence. Moderately rare, uppermost part of ***Elvinia*** zone: Eureka, McGill, Ruby Range, and Cherry Creek(?), Nev.

Family PTEROCEPHALIIDAE Kobayashi

Diagnosis.—Subisopygous opisthoparian ptychoparioid trilobites having a cephalon that is generally gently to moderately convex transversely and longitudinally. Glabella tapered forward, generally well defined at sides and anterolateral corners, less well defined across front; glabellar furrows generally poorly defined; if distinct, glabellar furrows generally broad or rarely, deep and narrow. Axial furrows have tendency to develop fossulae at anterolateral corners of glabella. Occipital furrow generally present. Occipital ring of most species has median node; median occipital spine rare. Frontal area generally divided into distinct brim and border. Sagittal length of border generally greater than distance from dorsal surface of border to ventral surface of doublure. Fixed cheeks narrow, flat or slightly convex; width one-half or less than one-half basal glabellar width; position generally horizontal or slightly upsloping. Posterior limbs sharp pointed. Posterior border furrow nearly straight.

Course of anterior section of facial suture straight forward or slightly divergent from front of palpebral lobe to border, then curved inward to cut anterior margin more than one-half distance from anterolateral corners of cranidium to axial line. Rostral suture, where present, barely submarginal. Connective sutures convex towards axial line, joined to form median suture only in later members of family. Posterior section of facial suture invariably divergent sinuous, cuts posterior margin of cephalon adaxial to base of genal spine.

Hypostome has poorly differentiated median body and posterior lobe. Lateral border generally well defined, narrow. Posterior border poorly defined or absent; if present, narrow.

Rostral plate, where present, subtrapezoidal to subtriangular, has concave sides.

Border of free cheek generally well defined. Genal spine present, lateral margin of spine continuous with margin of main part of cheek. Eye surface on all known specimens separated from ocular platform by infraocular ring.

Thorax of 12 to 13 segments. Axis moderately to strongly convex transversely, generally prominent.

Pygidium has prominent posteriorly tapered axis that is moderately to strongly convex transversely and raised above pleural regions. Width of axis generally less than width of pleural region. Border generally poorly defined, on most species narrowed behind axis. Pleural field has pleural furrows, where present, broader and deeper than inter-pleural furrows.

External ornamentation generally subdued. Most species smooth or finely pitted. Granular ornamentation rare.

Discussion.—This is the dominant family in the Pterocephaliid biomere and includes about 40 percent of the described ptychoparioid species of the fauna. As stratigraphic and paleontologic study of these trilobites progressed and more was learned about the fossils from the interval between the *Aphelaspis* and *Dunderbergia* zones, it became apparent that the trilobites of the family Housiidae (Palmer, 1960a, p. 74) were intimately related through the early species of *Prehousia* to the *Aphelaspidinae* and thus that this taxon was more appropriately a subfamily within the Pterocephaliidae. The Pterocephaliidae in the Great Basin is therefore composed of three subfamilies: the Aphelaspidinae, having 15 species representing 4 genera; the Housiinae, having 10 species representing 3 genera; and the Pterocephaliinae, having 17 species representing 4 genera.

In addition, several species described in the section on "Unassigned trilobites" (p. 77) probably belong to the Pterocephaliidae. These include *Tumicephalus depressus* n. sp., n. gen., which has characteristics of both the Aphelaspidinae and Housiinae; *Listroa toxoura* Palmer, which has characteristics of the Aphelaspidinae and Pterocephaliinae; and *Taenora expansa* Palmer, which has some characteristics of the Aphela-

spidinae. Both *L. toxoura* and *T. expansa* were included in the Aphelaspidinae in an earlier paper (Palmer, 1962b, p. 31). There is some doubt, however, about the appropriateness of assigning any of these species to named subfamilies, and they are here considered as suprageneric ally unplaced genera. The genus *Morosa* has some characteristics of the Housiinae and Aphelaspidinae and may also belong in the Pterocephaliidae. Other unplaced genera having some possible affinities with the family are *Anechocephalus* and *Stenambon*. Nearly all the species having possible relationships to the Pterocephaliidae are rare elements in the fauna, and more knowledge of them and their relationships to other forms will be needed to place them confidently in suprageneric taxa.

Subfamily APHELASPIDINAE Palmer

Diagnosis.—Pterocephaliidae having generally distinct and convex border on cephalon or less commonly, flat or slightly concave border. Palpebral lobes generally located about opposite glabellar midlength. Border of pygidium generally subequal in width to greatest width of pleural platform.

Genus APHELASPIS Resser

Aphelaspis Resser, 1935, p. 11; Shimer and Shrock, 1944, p. 619; Palmer, 1954, p. 743; 1962b, p. 32; Ivshin, 1956, p. 31; Lochman, 1959, p. 256.
Proaulacopleura Kobayashi, 1936, p. 93; Howell, 1959, p. 269.
Clevelandella Resser, 1938a, p. 68.
Labiostria Palmer, 1954, p. 750; Lochman, 1959, p. 258.

Type species—*Aphelaspis walcotti* Resser, 1938a, p. 59, pl. 13, fig. 14. (See Palmer, 1953, p. 157, for discussion.)

Diagnosis.—Aphelaspidinae having border furrow on cranidium either present or absent. Glabella generally lacks well-defined glabellar furrows. If present, lateral and posterior border furrows on free cheek, join at genal angle and generally extend short distance onto base of genal spine.

Thorax has 13 segments.

Pygidium generally transversely subovate, rarely subquadrate. Axis has one to five ring furrows posterior to articulating furrow. Pleural regions have pleural furrows barely apparent on most specimens. Border poorly defined, narrowest at axial line, broadening laterally. Posterior margin is evenly curved, has very slight median inbend, or is slightly angular at posterolateral corners.

Discussion.—The statements in the description of *Aphelaspis* (Palmer, 1962b, p. 32) about the thorax—"pleural tips of each segment short, sharp,"—and the pygidium—"pygidium transversely subovate"—must be amended to read, "Pleural tips of each segment short and sharp *or long, slender*, and *backswept*," and, "Pygidium *generally* transversely subovate, *rarely subquadrate*," as a result of the discovery of *A. longispina* n. sp. Five species of *Aphelaspis* are now recognized in the central Great Basin faunas.

Prehousia is the only pterocephaliid genus that is difficult to distinguish from *Aphelaspis* if all parts are known. This difficulty is due partly to the strong probability that *Prehousia* is a direct descendant of one of the species of *Aphelaspis*, probably *A. subditus* Palmer. Species of *Prehousia* generally have smaller more anteriorly placed palpebral lobes, a narrower fixed cheek, and a pygidial border of more even width than those of species of *Aphelaspis*. The cranidial differences are indicated most clearly on a triangular diagram (fig. 12) relating length of palpebral lobe and width of fixed cheek to length of glabella. In the present area of study, beds containing *Aphelaspis* are separated from younger beds containing *Prehousia* by the beds of the *Dicanthopyge* zone. If species the *Aphelaspis-Prehousia* lineage are ever found in the *Dicanthopyge* zone, assignment of the species to either *Aphelaspis* or *Prehousia* may have to be arbitrary.

Aphelaspis brachyphasis Palmer

Plate 8, figures 13, 17–21

Aphelaspis brachyphasis Palmer, 1962b, p. 33, pl. 4, figs. 1–19.

Diagnosis.—Length of frontal area of cranidium about six-tenths length of glabella exclusive of occipital ring. Border slightly downsloping and flat or very gently convex; sagittal length variable, generally between one-half and three-fourths sagittal length of brim. Border furrow barely apparent. Palpebral lobe barely defined by palpebral furrow. Free cheek has broad-based genal spine tapered abruptly to sharp point.

Pygidium transversely subovate in outline and has sharply rounded lateral margins and slight median indentation behind axis. Axis well defined, has one or two distinct ring furrows posterior to articulating furrow. A much shallower additional ring furrow apparent on some specimens. Border poorly defined, variable in width from one-third to one-sixth that of pleural region.

Discussion.—The short, broad-based genal spines generally short frontal area, poorly defined palpebral lobes, and small number of ring furrows on the axis of the pygidium are the most distinctive features of this species. The variation observed in *A. brachyphasis* (Palmer, 1962b, p. 33) seems to polarize into characteristics of two separate species, *A. subditus* Palmer

and *A. haguei.* (Hall and Whitfield), which are often associated in the upper part of the *Aphelaspis* zone. Specimens identified as *A. haguei.* have been collected from near the top of the lower part of the *Aphelaspis* zone (pl. 9, figs. 21–23); this evidence indicates that *A. haguei* possibly represents an earlier "split" from *A. brachyphasis* than does *A. subditus.*

Occurrence. Common, lower part of *Aphelaspis* zone: McGill and Hot Springs Range, Nev.

Aphelaspis buttsi (Kobayashi)

Plate 8, figures 14–16

Olenus cf. *O. truncatus* Butts, 1926, p. 77, pl. 9, figs. 6, 7.
Proaulacopleura buttsi Kobayashi, 1936, p. 93, pl. 15, fig. 6; Resser 1938a, p. 95, pl. 16, fig. 18.
Aphelaspis buttsi (Kobayashi). Palmer, 1962b, p. 35, pl. 4, ngs. 23, 26, 31, 32.

Diagnosis.—Cephalon has long slender genal spines reaching nearly to posterior end of thorax on largest specimens; length of spines from point where posterior section of facial suture cuts cephalic margin to tip of genal spine twice or more than twice length of posterior section of facial suture. Eye ridges directed laterally at right angle to axial line. Posterior pair of lateral glabellar furrows moderately well defined, straight, inclined posteriorly. Border furrow evenly curved. Lateral and posterior border furrows of free cheek barely extend onto genal spine.

Thorax has 13 segments; each segment has short, sharp posterolaterally directed pleural spines.

Length of pygidium slightly less than one-half width. Three ring furrows present on axis posterior to articulating furrow. Pleural fields have three or four shallow pleural furrows and shallow pleural grooves between first, second, and sometimes third pleural segments. Furrows and grooves do not extend onto border. Border narrow; breadth one-sixth or less than one-sixth breadth of pleural region.

Discussion.—The long genal spines, well-defined narrow cranidial border, and moderately well defined eye ridges at nearly right angles to the axial line are the principal distinguishing characteristics of this species. *A. buttsi* resembles specimens assigned to *Olenaspella* in most features but lacks the distinctive pygidial border spines characteristic of *Olenaspella.* It occurs stratigraphically beneath the lowest known *Olenaspella*-bearing beds in Nevada and perhaps represents a divergence towards *Olenaspella* from the main *Aphelaspis* stock.

Occurrence. Rare, lowest part of *Aphelaspis* zone: McGill, Nev.

Aphelaspis haguei (Hall and Whitfield)

Plate 9, figures 19–26

Crepicephalus (*Loganellus*) *haguei* Hall and Whitfield, 1877, p. 210, pl. 2, figs. 14, 15.
Ptychoparia haguei (Hall and Whitfield) Walcott, 1884, pl. 6, fig. 6.
Elrathia haguei (Hall and Whitfield) Resser, 1935, p. 28.

Diagnosis.—Cranidium having glabella well defined by axial furrows; preglabellar furrow and prominent fossulae generally best defined in members of younger populations. Frontal area has well-defined brim and border; brim moderately to strongly convex sagittally, makes distinct angle with border; border flat or slightly convex; sagittal length slightly less than length of brim. Fixed cheeks slightly upsloping; palpebral lobes moderately defined by shallow palpebral furrow.

Free cheek has moderately broad border and slender genal spine extending posteriorly to about fifth thoracic segment. Lateral border furrow moderately to poorly formed.

Thorax composed of 12 or 13 segments. Pleural tips short, sharp, directed posterolaterally.

Pygidium has well-defined axis bearing two or three ring furrows behind articulating furrow. Pleural fields moderately convex and have one or two moderately well-defined pleural furrows. Border separated from pleural field principally by change in slope; border narrow behind axis, abruptly expanded laterally, flat or slightly concave, downsloping.

External surfaces of cranidium and free cheek, except for furrows and genal spines, generally have distinct shallow pits visible after whitening. External surfaces of pygidium and tips of genal spines have fine granular ornamentation apparent only after whitening. Surfaces of molds of all parts pitted.

Discussion.—This species is distinguished from the associated species of *Aphelaspis*, *A. brachyphasis* Palmer, or from *A. subditus* Palmer on the basis of the cranidial and pygidial features given above. Populations at opposite ends of the range of this species can generally be distinguished by minor features. Members of the geologically older populations have cranidia that lack well-defined fossulae and have pygidia on which the borders are more distinctly concave, the pleural furrows are better defined, the outline is generally less transverse, and the axis is relatively longer than on members of the younger populations.

A single collection from the Highland Range, Nev. (USGS colln. 2318-CO) contains many parts of a single species that is morphologically intermediate between *A. haguei* and *A. longispina* (pl. 9, figs. 12, 14, 18). All parts except the thoracic segments are like

those of members of younger populations of *A. haguei*, but the fragments of thoracic segments in the collection indicate the presence of long pleural tips such as those characteristic of *A. longispina*. This sample is here tentatively assigned to *A. haguei* as the terminal member of a gradually changing infraspecific complex.

The holotype of *A. haguei* is in a collection from the west side of Pogonip Ridge, Mount Hamilton, Nev., associated with *Olenaspella regularis* Palmer and *Aphelaspis subditus* Palmer. Its assignment to the Middle Cambrian genus *Elrathia* by Resser reflects the similarity of *Aphelaspis* to Middle Cambrian forms. However, the bluntly rounded glabella of *A. haguei* that has generally distinct fossulae in the axial furrows is typically that of a Pterocephaliid trilobite and unlike that of Middle Cambrian ptychoparioids.

Occurrence. Moderately rare, lower part of *Aphelaspis* zone: McGill, Nev. Moderately common, upper part of *Aphelaspis* zone: McGill, Snake Range, Highland Range, Tybo, Osgood Mountains, and Hot Springs Range, Nev.; House Range, Utah.

Aphelaspis subditus Palmer

Plate 8, figures 22–26

Aphelaspis subditus Palmer, 1962b, p. 35, pl. 4, figs. 20–22, 25.

Diagnosis.—Cranidium having lateral glabellar furrows lacking on outer surface of exoskeleton. Palpebral lobes moderately well defined by shallow palpebral furrows. Border furrow present, evenly curved. Length of border between one-half and three-fourths sagittal length of brim.

Lateral and posterior border furrows on free cheek generally well defined, joined at genal angle, very slightly extended onto genal spine. Genal spine slender, reaching to about fifth thoracic segment.

Thorax has 12 segments. Pleural tips curved slightly, pointed, directed posterolaterally.

Pygidium has two or three ring furrows on axis posterior to articulating furrow. Border barely defined, narrow, horizontal or slightly downsloping; breadth of border one-fourth to one-fifth that of pleural region. Pleural fields either have or lack distinct pleural furrows. Posterior margin has slight median indentation.

Discussion.—This species is characterized particularly by the well-defined border furrow on the cranidium and by the generally unfurrowed glabella. It is associated at many localities with *A. haguei*, from which it differs by having a less convex brim, a narrower border, a better defined border furrow on the cranidium, a generally less concave border, and less well defined pleural furrows on the pygidium. Furthermore, the external surface of *A. subditus* is generally smooth whereas that of *A. haguei* is generally pitted. Both *A. haguei* and *A. subditus* seem to have been derived from *A. brachyphasis* by polarization of the infraspecific variation observed in that species (p. 15). As a result of this close evolutionary relationship between the species, some samples are found in which the parts assignable to the two species are distinguished with difficulty. Generally, however, the foregoing features can be used satisfactorily to identify specimens belonging to either species.

Occurrence. Common, upper part of *Aphelaspis* zone: Cherry Creek, McGill, Tybo, Mount Hamilton, Highland Range, Pioche, Hot Springs Range, and Yucca Flat, Nev.

Aphelaspis longispina n. sp.

Plate 9, figures 13, 15–17

Diagnosis.—Cranidium has generally unfurrowed glabella, well defined by axial and preglabellar furrows. Frontal area divided into distinct brim and border by shallow border furrow. Brim flat, downsloping; sagittal length slightly greater than that of border. Border gently convex in sagittal profile. Fixed cheeks slightly upsloping; palpebral lobes moderately well defined by shallow arcuate palpebral furrows.

Free cheek has well-defined border. Shallow lateral border furrow and somewhat deeper posterior border furrow joined at genal angle and extended onto slender genal spine.

Thoracic segments have long backswept pleural tips.

Pygidium subquadrate. Axis prominent, defined only at sides, merged posteriorly with border, has two ring furrows behind articulating furrow; length between one-half and three-fourths that of pygidium. Pleural region has greatest breadth of border about equal to greatest breadth of pleural field. Pleural field flat or slightly convex, has two or three shallow pleural furrows extending to inner edge of border. Border flat, downsloping, broadest posterolaterally, tapered towards axial line and anteriorly. Posterior margin has slight median inbend.

External surface of cranidium—all but genal spine of free cheek and axial parts of thoracic segments and pygidium finely pitted. External surfaces of genal spines, tips of thoracic segments, and pleural regions of pygidium either roughened or very finely granular.

Discussion.—This species has been recognized in two collections from McGill, Nev. It appears to be on the direct line of evolution from *Aphelaspis* to *Dicanthopyge* and intermediate both morphologically and stratigraphically between *Aphelaspis haguei* (Hall and

Whitfield) and *Dicanthopyge quadrata* n. sp. The most distinguishing characteristic of *A. longispina* is the presence of long backswept pleural tips on the thoracic segments; supplementary characteristics are a relatively short axis, a relatively broad border, and a subquadrate shape for the pygidium.

Occurrence. Rare, uppermost part of *Aphelaspis* zone: McGill, Nev.

Genus DICANTHOPYGE n. gen.

Type species.—*Dicanthopyge quadrata* n. sp.

Diagnosis.—Aphelaspidinae in which cranidium has glabella obscurely furrowed, moderately well defined by axial and preglabellar furrows. Frontal area divided into distinct brim and border by narrow border furrow. Brim downsloping, flat; sagittal length slightly greater than that of border. Border gently to moderately convex, broadest on axial line. Fixed cheeks slightly upsloping; palpebral lobes moderately well defined by shallow arcuate palpebral furrows. Posterior limb long, slender, sharp pointed.

Free cheek has well-defined lateral and posterior border furrows of about equal depth, joined at genal angle and extended onto base of long slender genal spine.

Thorax composed of 13 segments; pleural tips increase in length and posterior deflection from front to back of thorax.

Pygidium has short prominent axis well defined at sides that has two or three ring furrows behind articulating furrow. Pleural regions nearly flat, have two or three shallow strongly curved pleural furrows. Border not differentiated from pleural field. Posterior margin has one pair of posterolateral marginal spines. Margin between spines curved forward.

Description.—Aphelaspidinae, estimated maximum length about 45 mm, having cranidium subquadrate, gently to moderately convex longitudinally, gently convex transversely. Glabella obscurely furrowed, well defined by shallow narrow axial and preglabellar furrows, straight sided, bluntly rounded at front. Occipital furrow shallow. Occipital ring gently convex, has low median node. Frontal area divided into distinct brim and border by narrow border furrow; length between one-half and two-thirds that of glabella. Brim flat, downsloping; sagittal length slightly greater than length of border. Border gently to moderately convex, slightly tapered towards anterolateral corners of cranidium. Fixed cheeks flat, slightly upsloping; width, exclusive of palpebral lobes, slightly more than one-third basal glabellar width. Palpebral lobes prominent, moderately well defined by shallow arcuate palpebral furrow; length less than one-half length of glabella. Posterior limbs long, slender, tapered to sharp point; posterior border furrow broad, moderately deep.

Free cheek has well-defined border, narrower than ocular platform. Lateral and posterior border furrows of comparable depth, joined at genal angle and extended onto base of long slender genal spine.

Course of anterior section of facial suture slightly divergent forward from palpebral lobe to border, then curved abruptly inward and continued diagonally across border to cut anterior margin just before axial line. Ventral course nearly straight backward across doublure. Course of posterior section of facial suture divergent, sinuous.

Rostral plate not known, but truncated tip of doublure of free cheek indicates plate to be probably subquadrate, longer sagittally than wide.

Thorax composed of 13 segments. Anterior segments have short sharp laterally directed pleural tips. Pleural tips on more posterior segments increase in length and become progressively more posteriorly directed.

Pygidium subquadrate to subtrapezoidal in outline; all specimens have single pair of broad-based, short posterolateral marginal spines. Axis prominent, short, generally bears two distinct ring furrows behind articulating furrow; length between one-half and three-fourths that of pygidium. Low broad poorly defined median ridge extends posteriorly from end of axis onto border. Pleural regions flat, slightly convex or slightly concave. Pleural fields not clearly differentiated from border, crossed by one or two shallow strongly curved pleural furrows that extend onto but not across border.

External surfaces of exoskeleton of cranidium, axial parts of thorax and pygidium, and free cheek except for genal spine have distinct fine pits. Pleural regions of pygidium, genal spines, and tips of thoracic segments either pitted, roughened, or covered with fine granules. Surfaces of molds of all parts pitted.

Discussion.—This genus differs from *Olenaspella* and *Nericia*, the only other Pterocephaliid trilobites having spinose pygidial margins and similar cephala, by having a pygidial axis that is short and has few segments, a border that is broader than the pleural field, and marginal spines that are not clearly associated with individual pleural segments. The cranidium differs from that of *Olenaspella* by having a broader less convex border and a slightly more tapered glabella and by lacking distinct glabellar furrows. The free cheeks differ from those of *Olenaspella* by having a truncate rather than tapered anterior tip to the doublure.

Three species are recognized here on the basis of consistent features of pygidial shape and ornamentation. These species seem to be in direct evolutionary sequence beginning with *Dicanthopyge quadrata* n. sp., which has a subparallel-sided pygidium and distinct marginal spines; followed by *D. convergens* n. sp., which has distinctly convergent pygidial sides and moderately long marginal spines; and ending with *D. reductus*, which has strongly convergent pygidial sides and short marginal spines. *D. quadrata* seems to have been derived from the immediately older species, *Aphelaspis longispina* n. sp., from which it differs principally by having marginal spines on the pygidium.

Dicanthopyge convergens n. sp.

Plate 9, figures 1, 4, 6

Diagnosis.—Pygidium has sides convergent posteriorly to outer edges of broad-based moderately long posterior marginal spines. Width of axis about equal to that of pleural regions in older populations, distinctly greater in younger populations. Surfaces of all parts of exoskeleton have shallow closely spaced pits.

Discussion.—This species is intermediate in form and stratigraphic position between *D. quadrata* n. sp. and *D. reductus* n. sp. Its pygidium has a greater posterior taper and generally wider axis than does that of *D. quadrata* and longer less closely spaced posterior marginal spines than does that of *D. reductus*. *D. convergens* differs from both species by having pitted rather than granular or roughened surfaces on the genal spines and on the pleural regions of the pygidium.

Occurrence. Moderately rare, middle part of *Dicanthopyge* zone: McGill, Shingle Pass, Ruby Range, Cherry Creek, Yucca Flat, Spring Mountains, and Muddy Mountains, Nev.; Deep Creek and House Ranges, Utah.

Dicanthopyge quadrata n. sp.

Plate 9, figures 2, 3, 5, 7–11

Aphelaspidinae, gen. and sp. undet., Palmer, 1962b, p. 40, pl. 5, figs. 22, 27, 29.

Diagnosis.—Pygidium subquadrate; sides subparallel; posterolateral marginal spines broad-based, moderately long. Width of axis about equal to or only slightly greater than width of pleural regions. External surfaces of pleural regions of pygidium, genal spines, and tips of thoracic segments generally covered with fine granules; some pygidia have fine pitted ornamentation.

Discussion.—This species is the oldest representative of *Dicanthopyge*. It seems to be a direct descendant of *Aphelaspis longispinus* n. sp., from which it differs principally by having posterolateral marginal spines on the pygidium. The subquadrate pygidial shape distinguishes *D. quadrata* from the younger species *D. convergens* n. sp. and *D. reductus* n. sp.

Occurrence. Moderately rare, lower part of *Dicanthopyge* zone: McGill, Cherry Creek, Schell Creek Range, Ruby Range, Highland Range, Mount Hamilton, Tybo, Spring Mountains, and Snake Range, Nev.; Deep Creek Range, House Range, and Fish Springs Range, Utah.

Dicanthopyge reductus n. sp.

Plate 10, figures 19, 20

Diagnosis.—Pygidium subtriangular; sides convergent posteriorly to outer edges of short closely spaced posterior marginal spines. Width of axis greater than width of pleural regions. Surfaces of pleural regions of pygidium, genal spines, and, probably, tips of thoracic segments roughened.

Discussion.—This species is the youngest presently recognized in *Dicanthopyge* and represents the culmination of the posterior taper of the pygidial sides begun in *Dicanthopyge convergens* n. sp. It differs from *D. convergens* principally in the reduced size of the posterior marginal spines and the roughened rather than pitted surfaces of the pleural regions of the pygidium and genal spines.

Occurrence. Moderately rare, upper part of *Dicanthopyge* zone: McGill and Snake Range, Nev.; House Range, Utah.

Genus LITOCEPHALUS Resser

Litocephalus Resser, 1937, p. 17; Palmer, 1956, p. 608; 1960a, p. 81.
Pterocephalina Resser, 1938b, p. 42.

Type species.—*Dicellocephalus richmondensis* Walcott, 1884, p. 41, pl. 10, fig. 7 (=*Dikellocephalus bilobatus* Hall and Whitfield, 1877, p. 226, pl. 2, fig. 36).

Diagnosis.—Aphelaspidinae in which the cephalon has border well defined by deep border furrow. Thorax has pleural spines of most segments long, slender, backwardly directed. Border of pygidium concave; posterior margin has deep median notch reaching nearly to posterior end of axis.

Discussion.—*Litocephalus* can be easily identified by its distinctive notched pygidium. Species are characterized primarily by details of external ornamentation on both the cranidium and the pygidium. This is a rare genus known principally from the more western Upper Cambrian sections. A full description based primarily on specimens from the Eureka district has

been given in an earlier paper (Palmer, 1960a). The additional specimens discovered from other areas have provided no new information. A single new species, *L. magnus* n. sp., has been identified from the *Elvinia* zone of the Tybo district, increasing the known range of the genus upward from the *Dunderbergia* zone.

Litocephalus bilobatus (Hall and Whitfield)

Plate 11, figures 13–15

Dikellocephalus bilobatus Hall and Whitfield, 1877, p. 226, pl. 2, fig. 36.
Dicellocephalus richmondensis Walcott, 1884, p. 41, pl. 10, fig. 7.
Litocephalus richmondensis (Walcott). Resser, 1937, p. 17.
Pterocephalina bilobata (Hall and Whitfield). Resser, 1942b, p. 77, pl. 14, figs. 39–43.
Litocephalus bilobatus (Hall and Whitfield). Palmer, 1956, p. 608–610, pl. 73, figs. 1–6, 8; 1960a, p. 82, pl. 7, figs. 24–27.

Diagnosis.—Cranidium and free cheek have smooth external surface of border. Sagittal length of border about three-fourths length of brim. Facial sutures cut anterior margin between point directly in front of anterolateral corners of glabella and axial line. Surface of axial rings on pygidium smooth.

Discussion.—This species is distinguished from the other species of the genus by having a smooth external surface on the cranidium. It is further distinguished from *L. verruculapeza* Palmer by lacking paired granules on each axial ring of the pygidium.

Occurrence. Common, *Dunderbergia* zone: Eureka, Nev.

Litocephalus granulomarginatus Palmer

Plate 10, figures 13, 14, 17, 18

Litocephalus granulomarginatus Palmer, 1960a, p. 82, pl. 8, figs. 14, 17, 18, 24.

Diagnosis.—Cranidium and free cheek have granular external surface of border. Sagittal length of border about three-fourths length of brim. Facial sutures cut anterior margin between point directly in front of anterolateral corners of glabella and axial line. Surface of axial rings of pygidium smooth.

Discussion.—This species is intermediate in ornamentation and stratigraphic position between *L. bilobatus*, which has a smooth cranidium, and *L. magnus* n. sp., which has a completely granular surface. It differs from *L. verruculapeza* Palmer by having smaller and more evenly distributed granules on the cranidial border and by lacking paired granules on the axial rings of the pygidium.

Occurrence. Rare, *Dunderbergia* zone: Eureka and Tybo, Nev.

Litocephalus magnus n. sp.

Plate 10, figures 12, 15, 16

Diagnosis.—External surface of cranidium and top of axis of pygidium have many low poorly defined granules. Length of palpebral lobes slightly greater than one-half length of glabella. Outline of pygidium subovate; length slightly more than two-thirds width. Axis has five or six ring furrows posterior to articulating furrow. Pleural fields crossed five or six shallow posteriorly curved pleural furrows that extend onto broad slightly concave border. Posterior median notch long, narrow.

Discussion.—This species most nearly resembles *L. granulomarginatus* Palmer in the general form of the cranidium and number of axial and pleural furrows on the pygidium. It differs by having granular ornamentation on parts of the cranidium other than the border and also on the top of the axis of the pygidium. Furthermore, the palpebral lobes of *L. magnus* are relatively larger, the pygidial border is much broader, and the median notch longer and narrower than those of *L. granulomarginatus*.

Occurrence. Moderately common, lower *Elvinia* zone: Tybo, Nev.

Litocephalus verruculapeza Palmer

Plate 11, figures 7–9

Litocephalus verruculapeza Palmer, 1960a, p. 83, pl. 8, figs. 12, 13, 15, 16, 19, 20.

Diagnosis.—Cranidium and free cheek have external surface of border smooth. Sagittal length of border about three-fourths that of brim. Facial sutures cut anterior margin between point directly in front of anterolateral corners of glabella and axial line. Surface of axial rings on pygidium smooth.

Discussion.—This species seems to be slightly divergent from the main evolutionary line of *Litocephalus;* it differs from the other species by having smaller palpebral lobes, scattered coarse granules on the cranidial border, and pairs of coarse granules on the axial rings of the pygidium.

Occurrence. Rare, *Dunderbergia* zone: Eureka and Cherry Creek, Nev.

Genus OLENASPELLA Wilson

Olenaspella Wilson, 1956, p. 1344; Palmer, 1962b, p. 36.

Type species.—Parabolinella? evansi Kobayashi, 1936, p. 92, pl. 15, figs. 7, 8, 10.

Diagnosis.—Aphelaspidinae in which border of cephalon well defined by narrow border furrow. Free cheek has lateral and posterior marginal furrows joined at genal angle, extended slightly onto base of genal spine. Pygidium transversely subovate to subsemicircular. Axis prominent, generally has two or more ring furrows posterior to articulating furrow. Pleural fields flat or gently convex transversely, have three or four broad, shallow pleural furrows. Interpleural furrows may be present between first, second, and third pleural segments. Border narrow, poorly defined; margin has one to three pairs of slender posteriorly directed spines. First pygidial segment always extended laterally as border spine.

Discussion.—This genus has been fully described in an earlier paper (Palmer, 1962b, p. 36). The only modification of the generic description required by the new species *O. paucisegmenta* is a reduction to two for the minimum number of ring furrows on the axis of the pygidium.

The well-defined straight posterior glabellar furrows on the cranidium and the narrow pygidial border having one to three pairs of border spines are the most distinctive features of species of this genus. The only other American aphelaspinid having pygidial spines is *Dicanthopyge*, which differs consistently from *Olenaspella* by lacking distinct glabellar furrows and by having generally fewer ring furrows on the pygidium, a broader pygidial axis, and no clear segmental source for the border spines.

Crepicephalus borealis Lermontova (1940) is a Siberian trilobite that represents an unnamed genus closely related to both *Olenaspella* and *Eugonocare*. Complete specimens in the collections of Dr. N. V. Pokrovskaya of the Geological Institute, Academy of Sciences, Moscow, show that the *Olenaspella*-like cranidium illustrated by Lermontova is correctly associated with a *Crepicephalus*-like pygidium. The cranidial structure of *C. borealis* demonstrates its aphelaspinid rather than crepicephalid affinities. It differs from *Olenaspella* by having the pygidial border more expanded posterolaterally and by bearing broad-based rather than slender border spines. The presence of border spines on the pygidium distinguishes the genus from *Eugonocare*.

Olenaspella paucisegmenta n. sp.

Plate 10, figures 1–3

Diagnosis.—Pygidium has two well-defined ring furrows on axis posterior to articulating furrow. Pleural regions have two or three shallow pleural furrows curved abruptly backward near inner edge of moderately to poorly defined narrow border and extended onto border. Shallow interpleural furrows apparent between first and second pleural segments near outer edge of pleural field. Margin has two pairs of spines; outer pair longest; each pair connected to posterior band of first and second pleural segment by low narrow ridge.

Discussion.—This species is closely related to *O. regularis* Palmer. It differs principally by having two rather than three or four ring furrows on the axis of the pygidium posterior to the articulating furrow. *O. evansi* (Kobayashi) has a similar short axis but bears three pairs of evenly spaced marginal spines.

The pygidial spines in this species show some variation in direction. Typical forms have the sides of the outer pair of spines subparallel to the axial line. Others (pl. 10, fig. 3) have both pairs of spines slightly convergent towards the axis. A similar kind of variation is present in the older species *O. regularis*.

Occurrence. Moderately rare, *Prehousia* zone: Ruby Range and Tybo, Nev. Rare, *Dicanthopyge* zone: Yucca Flat. Nev.

Olenaspella regularis Palmer

Plate 10, figures 4–6

Parabolinella evansi Wilson, 1954 [not Kobayashi, 1936, 1938], p. 281, pl. 25, figs. 10, 15–17.
Olenaspella regularis Palmer, 1962b, p. 38, pl. 5, figs. 1–3.

Diagnosis.—Pygidium has three or four ring furrows behind articulating furrow on axis. Pleural regions have two or three shallow pleural furrows that curve abruptly backward near inner edge of poorly defined narrow border and extend onto border. Shallow interpleural grooves apparent between first and second pleural segments near outer edge of pleural field. Margin has two or three pairs of spines. Most specimens have two pairs of spines, outer pair longest; each pair connected to posterior band of adjacent pleural segment by low narrow ridge. Third pair of spines, if present, short, adjacent to inner edge of second pair of spines.

Discussion.—Variation in this species is mostly apparent in the pygidial spines. Besides the presence of a third pair of spines adjacent to the inner spines on a few specimens, the outer pair of spines may be directed either straight backward or distinctly inward. (Compare pl. 10, figs. 5, 6.)

Occurrence. Moderately common, upper part of *Aphelaspis* zone: McGill, Cherry Creek, Hot Springs Range, and Mount Hamilton, Nev.

Olenaspella separata Palmer

Plate 10, figures 7–11

Olenaspella separata Palmer, 1962b, p. 39, pl. 5, figs. 6, 8–21, 23–26, 28, 30–32.

Diagnosis.—Length of pygidium about one-half width. Axis generally has four to five ring furrows behind articulating furrow. Pleural regions crossed by three or four shallow pleural furrows; narrow interpleural furrow present between first and second segments on some specimens. Border poorly defined. Posterior margin has one to three pairs of spines: one pair of long, slender spines formed from first pleural segment on all specimens; second pair short, formed either from second pleural segment or from border between first and second pleural segments on all specimens; third pair, if present, slightly longer than second pair, formed from second pleural segment on all specimens. Second and third pairs of spines are nearer to first pair of spines than to axial line on all specimens.

Occurrence. Moderately common, lower part of *Aphelaspis* zone: McGill, Hot Springs Range, and Mount Hamilton, Nev.

Subfamily HOUSIINAE Hupé

Diagnosis.—Pterocephaliidae having border on cephalon generally distinct and gently convex or flat. Palpebral lobes small; exsagittal length generally less than one-third sagittal glabellar length. Fixed cheeks narrow; width generally less than one-fourth basal glabellar width. Palpebral lobes situated slightly to distinctly anterior to glabellar midlength. Pygidium has poorly defined border, which is only slightly narrowed behind axis. Margin lacks spines.

Genus HOUSIA Walcott

Dolichometopus (*Housia*) Walcott, 1916, p. 374.
Housia Walcott, 1924, p. 57; 1925, p. 93; Shimer and Shrock, 1944, p. 625; Wilson, 1951, p. 642; Lochman, 1956, p. 456; Palmer, 1960a, p. 74.
Housiella Kobayashi and Ichikawa, 1955, p. 66.

Type species.—*Dolichometopus* (*Housia*) *varro* Walcott, 1916, p. 374, pl. 65, figs. 1-1e.

Diagnosis.—Housiidae having a maximum length of perhaps 60 mm; cranidium has brim and anterior part of glabella depressed. Border at a distinct angle to brim; sagittal length slightly less than length of brim. Fixed cheek composed almost completely of a flaplike palpebral lobe adjacent to dorsal furrow and anterior to midlength of glabella. Doublure of cephalon crossed by median suture.

Free cheek has moderately broad slightly convex border. Lateral and posterior marginal furrows moderately deep, not connected, disappear near base of genal spine. Genal spine short or long.

Thorax has 10-11 thoracic segments. Axial lobe prominent. Pleural spines short, posteriorly directed.

Pygidium transversely subovate in outline. Axial lobe prominent, well defined, extends to inner edge of broad poorly defined border. Border has nearly constant width.

Discussion.—This distinctive genus is most easily recognized by its characteristic cranidium that has a poorly defined glabella, downsloping brim, nearly horizontal border, and palpebral lobes situated adjacent to the axial furrow and slightly anterior to the glabellar midlength.

Another characteristic generic feature is the inconsistency with which the last thoracic segment is free. Most collections of species of *Housia* have some pygidia partly or completely ankylosed with the last thoracic segment. When the segment is completely ankylosed, the pygidium has a superficial resemblance to pygidia of members of the Ceratopygidae, which have anterolateral spines as a fundamental part. This feature led Whitehouse (1939) to consider *Housia* and *Ceratopyge* synonymous and Kobayashi and Ichikawa (1955) to place *Housia* and the Housiinae in the Ceratopygidae. The relationships of *Housia* described on page 57 show the genus to be with the Pterocephaliidae.

Kobayashi and Ichikawa (1955) also proposed a new genus *Housiella* for *Housia canadensis* (Walcott). It was distinguished from *Housia* by the presence of genal spines and by the shallowness of the axial furrows around the glabella. *Housia vacuna* (Walcott), a species having a short genal spine, would thus be assigned to *Housiella*. However, cranidia and pygidia of this species cannot be satisfactorily distinguished from those of *Housia varro*, the type species of *Housia*, and the distinctions made by Kobayashi and Ichikawa between *Housia* and *Housiella* seem to be hardly more than species differences. *Housiella* is here considered a synonym of *Housia*. This is also the opinion of Lochman (1959), who placed *Housiella* in the synonymy of *Housia* without comment.

The principal differences between species of *Housia* are the shape of the pygidium and the length of the genal spines.

Housia ovata Palmer

Plate 12, figures 8–11

Housia ovata Palmer, 1960a, p. 75, pl. 7, figs. 1–7, 9.

Diagnosis.—Free cheeks have gently curved lateral margin and long, slender genal spine. Sagittal length of pygidium about two-thirds width. External surface

of brim on cephalon, ocular platform of free cheek, and axial lobe and pleural furrows of pygidium coarsely pitted. Some small pygidia have granular surface.

Discussion.—The long slender genal spine and the relatively elongate pygidium distinguish this species from all others presently assigned to the genus.

Occurrence. Common, lower part of *Elvinia* zone; Eureka, Bastian Peak, Cherry Creek, Snake Range, Shingle Pass, Pioche, Spring Mountains, Yucca Flat, and McGill, Nev.; Quartz Spring area, Calif.

Housia varro (Walcott)

Plate 12, figures 1–7

Dolichometopus (*Housia*) *varro* Walcott, 1916, p. 374, pl. 65, figs. 1–1e.

Housia varro (Walcott). Walcott, 1924, p. 57, pl. 12, fig. 4; 1925, p. 95, pl. 18, figs. 4–8; Shimer and Shrock, 1944, pl. 265, fig. 9; Bell and others, 1952, p. 183, pl. 30, figs. 3a–d; Robison, 1960, p. 25, pl. 2, fig. 1.

?*Housia halli* (Resser). Palmer, 1960a, p. 75, pl. 7, fig. 8.

Diagnosis.—Free cheeks have sharply rounded genal angle; genal spine absent. Sagittal length of pygidium about one-half width.

Discussion.—The absence of a genal spine is the principal feature distinguishing this species from the otherwise similar species *H. vacuna* (Walcott) and *H. canadensis* (Walcott).

The type lot of *H. varro* consists of many poor specimens compressed and slightly distorted in a baked shale matrix. The discovery of better preserved specimens in limestone shows the pygidium to be somewhat shorter and wider than that of *H. ovata* and confirms the absence of genal spines on the free cheek. The free cheeks having genal spines reported (Palmer, 1960a, p. 75) from the type lot of *H. varro* have a significantly narrower doublure than those of associated cheeks of *H. varro* and probably represent a species of *Elvinia*. As far as can be determined, *H. varro* consistently lacks genal spines. *Housia halli*, which is represented only by a pygidium formerly assigned to *Dunderbergia* (Resser, 1935), may be a synonym of *H. varro*. The type pygidium does not differ significantly from well-preserved pygidia of *H. varro*, but until cranidia and free cheeks are discovered, the relationships of *H. halli* must remain uncertain.

The association of *H. varro* with *Irvingella major* and *Iddingsia similis* indicates that it comes from beds near the top of the *Elvinia* zone. *H. ovata* Palmer is found only in beds of the lower parts of the *Elvinia* zone and is evidently an older species.

Occurrence. Rare, *Irvingella major* subzone, *Elvinia* zone: House Range, Utah; Schell Creek Range, Nev.

Genus PARAHOUSIA Palmer

Parahousia Palmer, 1960a, p. 76.

Type species.—*Parahousia constricta* Palmer, 1960a, p. 77, pl. 7, figs. 16–18, text fig. 13.

Diagnosis.—Housiinae having frontal area short; length slightly less than one-half that of glabella. Border furrow shallow. Palpebral lobes prominent, barely defined by palpebral furrow, situated close to glabella and anterior to glabellar midlength. Fixed cheek narrow; width between one-fourth and one-fifth basal glabellar width.

Free cheek has conspicuous lateral and posterior border furrows that disappear near base of long slender genal spine and are not connected.

Pygidium strongly arched in transverse profile. Axis prominent, subparallel sided, extended to inner edge of poorly defined depressed border.

Discussion.—The foregoing diagnosis has been modified from that given in an earlier paper (Palmer, 1960a, p. 76) only by elimination of features now known to be specific rather than generic characteristics. This knowledge results from the addition of a second species, *P. subequalis* n. sp.

This genus is distinguished from *Housia* by the presence of a narrow fixed cheek, a shorter and less depressed frontal area, and a depressed pygidial border.

Parahousia constricta Palmer

Plate 12, figures 12, 14, 15

Parahousia constricta Palmer, 1960a, p. 77, pl. 7, figs. 16–18, text fig. 13.

Diagnosis.—Sagittal length of border nearly twice length of brim. External surfaces of most parts of cephalon coarsely pitted. External surfaces of axis and pleural fields of pygidium finely granular on small specimens, faintly pitted on large specimens. Border of free cheek, genal spine, and anterolateral corners of pygidium have prominent terrace lines.

Discussion.—This species is distinguished from *P. subequalis* principally by the pitted ornamentation and broader border of the cranidium and by lack of terrace lines on the whole of the pygidial border. In the Shingle Pass section, where both species occur, *P. constricta* appears above *P. subequalis* and is apparently a slightly younger species.

Occurrence. Moderately rare, lower *Elvinia* zone: Eureka, Shingle Pass, Cherry Creek, and Schell Creek Range, Nev.

Parahousia subequalis n. sp.

Plate 12, figures 13, 18, 19

Diagnosis.—Length of cranidial border only slightly greater than length of brim. Axial furrows have dis-

tinct pits at anterolateral corners of glabella on larger cranidia. Entire border of pygidium covered with well-defined terrace lines; external surfaces of remainder of pygidium and of cranidium smooth. Free cheek not known with certainty.

Discussion.—The lack of a distinct pitted ornamentation of the cranidium and pygidium together with the more fully ornamented pygidial border are the most striking characters that distinguish this species from *Parahousia constricta* Palmer.

Occurrence. Moderately rare, upper *Dunderbergia* zone: Snake Range and Shingle Pass, Nev.

Genus PREHOUSIA Palmer

Prehousia Palmer, 1960a, p. 77.

Type species.—*Prehousia alata* Palmer, 1960a, p. 78, pl. 7, figs. 10 ,12, 13.

Diagnosis.—Housiinae having short frontal area, sagittal length of area slightly more than one-half length of glabella. Border generally well defined, slightly convex; sagittal length between one-half and three-fourths that of brim; rarely border poorly defined. Palpebral lobes barely defined by palpebral furrow, situated anterior to glabellar midlength; exsagittal length between one-fourth and one-half that of glabella. Fixed cheeks narrow; width one-third or less than one-third basal glabellar width.

Facial sutures cut anterior margin nearly at axial line.

Free cheek has well-defined border. Lateral and posterior marginal furrows generally joined, not noticeably extended onto base of genal spine. Genal spine slender, tapered to sharp point; length about equal to length of posterior section of facial suture.

Pygidium transversely subovate; breadth generally greater than twice length. Axis prominent, tapered posteriorly, merged with inner part of border; breadth one-third to about one-fifth greatest breadth of pygidium. Border moderately broad, separated from pleural field only by gradual change in slope, has nearly constant width.

External surface smooth, pitted, roughened, or finely granular in axial region.

Discussion.—The addition of three new species to this genus has required modification of the generic diagnosis and description (Palmer, 1960a) only to the extent of allowing for trilobites having somewhat wider fixed cheeks, a narrower pygidial axis, and a roughened external surface.

The affinities of this genus to *Aphelaspis* are well shown by the two oldest species, *P. prima* n. sp. and *P. indenta* n. sp., which are distinguished principally by having slightly smaller palpebral lobes and narrower fixed cheeks on the cranidium (fig. 12).

Prehousia alata Palmer

Plate 13, figures 2, 5, 8, 9, 12, 13

Prehousia alata Palmer, 1960a, p. 78, pl. 7, figs. 10, 12, 13.

Diagnosis.—Cranidium has narrow border, moderately defined by shallow border furrow; sagittal length slightly greater than one-half length of brim. Fixed cheeks narrow; palpebral lobes short, poorly defined. Ratio of length of glabella to length of palpebral lobe to width of fixed cheek varies from 6.5:2.5:1 to 7:3:1.

Free cheek has well-defined border furrow. Genal spine moderately short; length about equal to length of posterior section of facial suture.

Pygidium has unevenly curved posterior margin; alae slightly formed at anterolateral margins on some specimens. Axis has two or three shallow ring furrows behind articulating furrow; width nearly one-third width of pygidium.

External surfaces of all parts either smooth or finely and faintly pitted.

Discussion.—This species differs from *P. prima* n. sp. and *P. indenta* n. sp. by having distinctly narrower fixed cheeks. It differs from *P. impolita* by having an unevenly curved posterior margin to the pygidium, a narrower pygidial axis, a slightly narrower cranidial border, and a smooth or pitted rather than roughened surface.

Occurrence. Upper part of *Prehousia* zone, Snake Range, Goodsprings, Wah Wah Range, Grant Range, Schell Creek Range, and Shingle Pass (?), Nev.; House Range, Utah.

Prehousia diverta n. sp.

Plate 12, figures 16, 17, 20–23

Diagnosis.—Cranidium has glabella straightsided, tapered forward, rounded anteriorly. Frontal area subequally divided into downsloping brim and slightly convex border by change in slope; distinct border furrow lacking. Fixed cheeks horizontal; width about one-fourth basal glabellar width. Palpebral lobes barely defined, short; length between one-third and one-fourth that of glabella.

Free cheek has lateral and posterior border furrows moderately well defined but becoming shallow toward genal angle. Anterior projection of doublure squarely truncated.

Thorax and hypostome not known.

Pygidium subovate. Axis prominent, bears three or four ring furrows posterior to articulating furrow; merges with moderately broad, concave poorly defined border. Width of axis between one-third and one-fourth that of pygidium. Two or three broad shallow pleural furrows cross pleural regions, turn abruptly backward at inner edge of border, and continue onto but not across border.

External surfaces of all parts of exoskeleton either smooth, finely pitted, or slightly roughened. Surfaces of internal molds pitted.

Discussion.—This species differs from all others in the genus in the structure of the frontal area of the cranidium and by the somewhat longer pygidium. The lack of a distinct border furrow and the presence of small poorly defined palpebral lobes on the cranidium are characteristics observed also on species of *Housia*. The tendency for the border furrows of the free cheek to become shallow towards the genal angle is a characteristic of both *Housia* and *Parahousia*. The width of the fixed cheek and shape of the glabella of *P. diverta* are the principal reasons for retaining this species in *Prehousia*.

Occurrence. Moderately rare, lower part of *Dunderbergia* zone: Bastian Peak, McGill, Muddy Mountains, Patterson Pass, and Spring Mountains, Nev.; House Range and Deep Creek Range, Utah.

Prehousia impolita Palmer

Plate 13, figures 1, 3, 4

Diagnosis.—Cranidium has narrow border, well defined by shallow border furrow; sagittal length between one-half and three-fourths length of brim. Fixed cheeks narrow; palpebral lobes small, poorly defined. Ratio of length of glabella to length of palpebral lobe to width of fixed cheek about 7:2:1.

Free cheek has well-defined border furrow. Genal spine moderately short; length about equal to length of posterior section of facial suture.

Pygidium subsemicircular. Axis well defined, bears two or three shallow ring furrows behind articulating furrow; width about one-fourth that of pygidium. Border broad, slightly concave, not clearly separated from pleural fields. Pleural fields crossed by three shallow pleural furrows that extend onto inner part of border.

Surfaces of nearly all parts of exoskeleton minutely granular or roughened. Ornamentation most apparent on border regions and top of glabella; visible, however, only after whitening.

Discussion—This species is most likely to be confused with *P. alata* Palmer and *P. semicircularis* Palmer. *P. alata* has a broader axis, an unevenly curved posterior margin, and poorly defined pleural furrows on the pygidium and a narrower border of the cranidium. *P. semicircularis* has a broader border, longer palpebral lobes on the cranidium, and a smooth external surface.

Occurrence. Moderately rare, upper part of *Prehousia* zone: Cherry Creek, Pintwater Range, Ash Meadows, and southern Ruby Range, Nev.

Prehousia indenta n. sp.

Plate 13, figures 6, 7, 10, 11, 14, 15

Labiostria convexiмarginata? Robison, 1960, p. 30, pl. 3, fig. 10.

Diagnosis.—Cranidium has moderately convex border; length about one-half or slightly more than one-half length of brim. Border furrow has posterior median inbend present on all specimens. Width of fixed cheek between one-fourth and one-fifth basal glabellar width.

Free cheek has moderately convex lateral border.

Pygidium has evenly curved posterior margin. Border downsloping; inner edge marked by distinct change in slope of pleural region. Width of axis between one-third and one-fifth width of pygidium.

Surfaces of all parts of exoskeleton covered with fine to moderately coarse pits.

Discussion.—This species differs from *Prehousia prima* n. sp. by having a narrower border and fixed cheeks on the cranidium and a better defined border on the pygidium. It differs from *P. alata* Palmer and *P. impolita* n. sp. by having broader fixed cheeks, from *P. alata* by lacking posterolateral alae on the pygidium, and from *P. semicircularis* Palmer by having a broader pygidial axis and broader fixed cheeks on the cranidium. The pitted ornamentation distinguishes this species from all but *P. prima*.

A cranidium probably representing this species from the Fish Springs Range, Utah, was illustrated by Robison (1960) as *Labiostria convexiмarginata*? Palmer. The palpebral lobes are small and placed slightly anteriorly, unlike those of *Labiostria* (now *Aphelaspis*) *convexiмarginata*.

Occurrence. Common, middle part of *Prehousia* zone: McGill, Snake Range, Cherry Creek, Ruby Range, and Spring Mountains, Nev.; House Range (?), Fish Spring Range, and Tintic, Utah.

Prehousia prima n. sp.

Plate 13, figures 16–18

Diagnosis.—Cranidium has flat or slightly convex border; length nearly three-fourths that of brim. Border furrow evenly curved or has slight posterior

median inbend. Width of fixed cheeks slightly less than one-third basal glabellar width.

Free cheek has nearly flat border.

Pygidium has evenly curved posterior margin. Border downsloping—continuing slope of pleural fields—not clearly differentiated. Width of axis between one-third and one-fourth that of pygidium.

Surfaces of all parts of exosekleton covered with fine to moderately coarse pits.

Discussion.—This species is intermediate in both stratigraphic position and morphology between *Aphelaspis* and more typical members of *Prehousia*. It differs from *Aphelaspis* by having smaller palpebral lobes and narrower fixed cheeks (fig. 12) and from other species of *Prehousia* by having fixed cheeks whose width is nearly one-third the basal glabellar width and a border that is nearly three-fourths the length of the brim. The most similar species is the immediately younger form, *P. indenta* n. sp., which seems to be derived from *P. prima* and differs from it by having a narrower border and fixed cheeks of the cranidium, a convex instead of flat border of the free cheek, and a pygidial border differentiated from the pleural field by a distinct change in slope.

Occurrence. Common, upper part of *Dicanthopyge* zone: McGill, Shingle Pass, and Tybo, Nev.

Prehousia semicircularis Palmer

Plate 12, figures 24–26

Prehousia semicircularis Palmer, 1960a, p. 78, pl. 7, figs. 11, 14, 15, 19.

Diagnosis.—Sagittal length of border about three-fourths length of brim, Palpebral lobes relatively large; length slightly less than one-half that of glabella; width slightly greater than width of fixed cheek. Pygidium has evenly rounded anterolateral corners; width of axial lobe slightly less than one-fourth that of pygidium. External surface smooth on all parts.

Discussion.—The large palpebral lobes of this species distinguish it from all other species in the genus. Pygidia are most like those of *P. impolita* n. sp., differing principally by lacking any noticeable ornamentation.

Occurrence. Rare, *Dunderbergia* zone: Eureka, Nev.

Subfamily PTEROCEPHALIINAE Kobayashi

Diagnosis. — Pterocephaliidae having generally broad concave border on cephalon. Palpebral lobes generally situated about opposite glabellar midlength or, less commonly, anterior to glabellar midlength. Pygidium has broad poorly defined border. Margin either has or lacks spines.

Genus CERNUOLIMBUS Palmer

Cernuolimbus Palmer, 1960a, p. 84.

Type species.—*Cernuolimbus orygmatos* Palmer, 1960a, p. 85, pl. 8, figs. 1, 3, 5, 8, 11.

Diagnosis.—Pterocephaliinae having cranidium in which brim and border are distinct; axial length of border slightly less than equal to, or slightly greater than axial length of brim; inner part of border generally downsloping. Anterior sections of facial suture cut anterior margin slightly more than three-fourths distance from anterolateral corner of cranidium to axial line.

Free cheek has long genal spine and well-defined generally concave border. Lateral border furrow continuous with posterior border furrow. Width of border at anterior margin ranges from one-fourth to slightly less than equal to greatest width of ocular platform.

Pygidium subquadrate to subsemicircular in outline; length of axis more than three-fourths total length of pygidium; axis has two to five distinct ring furrows. Pleural regions have two to four low pleural ribs extending nearly to margin. Border not clearly differentiated from pleural field, widest at anterolateral corners; border gently tapers posteriorly, narrowest on axial line.

Discussion.—The somewhat pointed anterior cranidial margin, relatively great sagittal length of the brim, and relatively long axis on the pygidium distinguish species of *Cernuolimbus* from those of *Sigmocheilus*, the most similar pterocephalinid genus. *Cernuolimbus*, represented by species in the *Prehousia* and lower *Dunderbergia* zones may be ancestral to *Sigmocheilus*, represented by species in the middle and upper *Dunderbergia* and lower *Elvinia* zones.

Cernuolimbus depressus Palmer

Plate 14, figure 9

Cernuolimbus depressus Palmer, 1960a, p. 85, pl. 8, figs. 9, 10.

Diagnosis.—External surface of cranidium coarsely pitted; border downsloping, continuing slope of brim, tapered to a point laterally. Facial sutures nearly meet on axial line, giving pointed anterior margin to cranidium. Border furrow on mold has single row of granules.

Discussion.—The downsloping, laterally tapered, pointed border of this species is its most distinguishing characteristic. It shows some morphologic similarity to *Morosa extensa* n. sp. (p. 87). However, the two species differ in the structure of the border, the position and size of the palpebral lobes, and the anterior course of the facial sutures; so, although a real

relationship between them cannot be entirely ruled out, they are here considered to be only superficially similar forms.

Occurrence. Rare, *Dunderbergia* zone: Eureka, Ruby Range, and (?) Cherry Creek, Nev.

Cernuolimbus granulosus n. sp.

Plate 14, figures 13–17

Diagnosis.—Cranidium has bluntly rounded anterior margin. Border well defined, generally sigmoid in sagittal profile; sagittal length slightly less than that of convex brim. Border furrow deep, narrow, has slight posterior median inbend. Anterior edge of border, between facial sutures, has narrow zone of terrace lines.

Free cheek has concave border, well defined by narrow border furrow; width of border at anterior margin variable from slightly less to slightly more than width of ocular platform.

Pygidium subquadrate. Axis short, prominent, has two distinct ring furrows posterior to articulating furrow. Posterior margin gently curved; posterolateral corners subangular. Pleural furrows and border poorly defined.

External surfaces of all parts, exclusive of furrows, covered with closely spaced granules. Fine-granular ornamentation visible only on many specimens after whitening.

Discussion.—This species is most easily recognized by its narrow cranidial border defined by a deep border furrow and by the granular ornamentation on all parts of the skeleton. It is most similar to *C. laevifrons* n. sp., from which it differs principally by having granular ornamentation on the borders of the cranidium and free cheeks and by having a more quadrate shape to the pygidium. The variability in the degree of granular ornamentation on the border and the median inbend of the border furrow are shown on plate 14, figures 13, 14, and 17.

Occurrence. Moderately common, lower part of *Dunderbergia* zone: Ruby Range, Spring Mountains, Yucca Flat, Tempiute, and Muddy Mountains, Nev.; Deep Creek and House Ranges, Utah; Panamint Range, Calif.

Cernuolimbus laevifrons n. sp.

Plate 14, figures 10–12, 18

Diagnosis.—Cranidium has bluntly pointed anterior margin. Frontal area subequally divided into convex brim and concave border. Border furrow has slight median inbend. External surface of border smooth except for narrow zone of terrace lines along edge between facial sutures. External surfaces of other parts of cranidium, exclusive of furrows, covered with moderately abundant low granules; granules particularly conspicuous on top of glabella and top of palpebral lobes. Some small cranidia (length, 4 mm) have granules apparent only on top of glabella, tops of palpebral lobes, and brim just anterior to eye ridges.

Free cheek has concave border; width of border at anterior margin slightly less than one-half width of ocular platform. Granular ornamentation moderately well founded on genal spine and posterior margin behind border furrow. Scattered granules apparent on ocular platform of some larger specimens.

Pygidium has prominent axis, reaching to posterior margin; axis has three distinct ring furrows posterior to articulating furrow. Pleural furrows and border poorly defined. Posterior margin moderately curved, has narrow zone of terrace lines. External surfaces of all parts covered with low granules.

Discussion.—This species is easily recognized by its bluntly pointed anterior margin, smooth cranidial border, and relatively long axis on the pygidium. It is the oldest species presently recognized in *Cernuolimbus.*

Occurrence. Moderately rare, *Prehousia* zone: Cherry Creek, Nev.

Cernuolimbus orygmatos Palmer

Plate 14, figures 1–3

Cernuolimbus orygmatos Palmer, 1960a, p. 85, pl. 8, figs. 1, 3, 5, 8, 11.

Diagnosis.—External surfaces of all parts coarsely pitted. Anterior margin of cranidium distinctly pointed. Border slightly downsloping from border furrow and nearly flat or slightly turned up at anterior margin. Pygidium subsemicircular. Axis has four ring furrows posterior to articulating furrow; each ring has pair of prominent granules.

Discussion.—The pitted ornamentation, slightly upturned anterior margin, and pairs of granules on the axial rings of the pygidium are the most distinctive features of this species. *C. depressus* Palmer, the only other species having pitted ornamentation presently known in the genus, has a more downsloping cranidial border and a more pronounced lateral taper.

Occurrence. Moderately rare, *Dunderbergia* zone: Eureka and Ruby Range (?), Nev.

Cernuolimbus semigranulosus Palmer

Plate 14, figures 4–8

Cernuolimbus semgranulosus Palmer, 1960a, p. 86, pl. 8, figs. 2, 4, 6, 7.

Diagnosis.—Facial sutures make distinct angle with anterior margin. Border flat or turned up slightly at

anterior margin, downsloping from border furrow; sagittal length nearly 1½ times that of convex brim. External surface of cranidium has distinct granular ornamentation only on tops of glabella and palpebral lobes; other areas either smooth or very finely granular.

Border of free cheek nearly as wide as ocular platform. Genal spine covered with closely spaced fine granules.

Pygidium has transversely subovate outline; axis prominent, has two ring furrows behind articulating furrow. External surface covered with fine granules visible only after whitening.

Discussion.—The wide border on the cranidium and free cheek distinguishes this species from *C. granulosus* n. sp. and *C. laevifrons* n. sp., the only other presently recognized members of *Cernuolimbus* having granular ornamentation.

Occurrence. Moderately rare, *Dunderbergia* zone: Eureka and Ash Meadows, Nev.

Genus PTEROCEPHALIA Roemer

Pterocephalia Roemer, 1849, p. 421; 1852, p. 92; Bridge, in Bridge and Girty, 1937, p. 247; Shimer and Shrock, 1944, p. 631; Palmer, 1954, p. 751; 1960a, p. 86; Lochman, 1959, p. 256.

Hederacauda Kobayashi, 1960, p. 250.

Type species.—*Pterocephalia sanctisabae* Roemer, 1849, p. 421.

Diagnosis.—Pterocephaliinae having cranidium in which border is broad, concave, scarcely differentiated from brim. Sagittal length of border greater than three times length of brim. Junction of facial sutures with anterior margin generally imperceptible. Facial sutures submarginal beneath part of anterior margin to axial line then turn abruptly backward to form median suture across doublure.

Free cheek has broad concave border, slightly raised above level of ocular platform at border furrow. A low ridge parallels entire lateral margin nearly to tip of genal spine at distance about one-fourth width of border from lateral margin. Genal spine moderately long, broad, flat at base, tapered to sharp slender point.

Thorax of 13 segments. First 12 segments have slender laterally directed pleural tips. Last segment has broad pleural tips curved distinctly backward.

Pygidium subquadrate to subovate and has well-defined axis containing four to eight ring furrows posterior to articulating furrow. Broad generally concave border not differentiated from gently convex peural fields. Three to five pleural ridges extend across pleural field and onto inner part of border. Posterior margin has slight median inbend, smooth edge.

External suface of exoskeleton generally has closely spaced fine granules in axial region. Borders of cranidium, free cheek and pygidium, and tips of pleurae of thorax generally have well-defined terrace lines.

Discussion.—The broad concave poorly defined border on the cranidium and free cheeks, which has a subsidiary ridge near its outer margin, is the most characteristic feature of *Pterocephalia.* A discussion of the content of the genus has been presented in an earlier paper (Palmer, 1960a, p. 87, 88). Three species are recognized in the Great Basin faunas and are distinguished primarily on the form and structure of the pygidium. Information about the details of thoracic structure was obtained from a complete individual of *P. sanctisabae* Roemer collected from Upper Cambrian beds in southeastern British Columbia by Mr. Thomas Thomsen of Stanford University.

Pterocephalia seems to represent the terminal genus in the evolutionary lineage of the Pterocephaliinae. No younger Cambrian genera are known that can be properly assigned to this subfamily.

Kobayashi (1960, p. 250) recently proposed a new genus *Hederacauda* having *Dikellocephalus multicinetus* Hall and Whitfield as type species. The holotype of this species is a fragmental pygidium of a specimen of *Pterocephalia sanctisabae* on which the fracturing across the pleural ribs that extend onto the border gives the broken margin a superficial appearance of having spines. The true broken nature of the border can be seen on the type but might be impossible to ascertain from the plaster cast that Kobayashi studied. The "5 spines on the margin of *Hederacauda multicinctus*" are used as the justification for excluding the species from *Pterocephalia.* These features are artifacts, however, and *Hederacauda multicinctus* is a synonym of *Pterocephalia sanctisabae.*

Pterocephalia? punctata n. sp.

Plate 17, figures 8, 12, 13

A distinctive Pterocephalinid species is associated with *Cernuolimbus granulosus* Palmer in USGS collection 2603–CO. Its cranidium is characterized by generally low relief, a bluntly pointed anterior margin, and a subequally divided frontal area having a concave border that is very slightly differentiated from the brim. The palpebral lobes are short, between one-third and one-half the glabellar length, and are situated slightly anterior to the glabellar midlength.

The free cheek has a poorly defined border and a moderately long, flat sharply pointed genal spine.

The pygidium is subovate in outline and has a prominent slender axis bearing three distinct ring

furrows posterior to the articulating furrow. A broad concave border, not clearly separated from the pleural fields, is crossed by three pleural ridges that are turned sharply backward as they cross the contact of the border and pleural field. The posterior margin is broadly rounded, and the posterolateral corners are slightly angular.

External surfaces of all parts are pitted. This ornamentation is particularly noticeable on the cranidium and free cheeks.

Discussion.—This species presents a combination of features not seen in other described Pterocephalinid genera. The cranidium and free cheek are most like those of species of *Aphelaspis* that lack a distinct border furrow, but the pygidium is totally unlike any *Aphelaspis* pygidium and is quite similar to pygidia assigned to *Sigmocheilus grata* (Resser). The species is assigned here to *Pterocephalia* with question because of the absence of a distinct border furrow, but it differs from all other species in the genus most significantly by having a subequally divided frontal area. It may represent a new genus of Pterocephaliinae. (A similar unnamed form is described on p. 92, and illustrated on pl. 16, figs. 11–13.)

Occurrence. Rare, lower part of *Dunderbergia* zone: Ruby Range and Yucca Flat, Nev.

Pterocephalia concava Palmer

Plate 17, figures 4–7

?*Pterocephalia* cf. *P. occidens* Walcott. Palmer, 1954, p. 752, pl. 86, figs. 9, 10; pl. 87, figs. 1, 2.

Pterocephalia concava Palmer, 1960a, p. 88, pl. 9, figs. 1–6, 9–12.

Pterocephalia sanctisabae Roemer. Robison, 1960, p. 31, pl. 3, figs. 4, 5, 9.

Diagnosis.—Glabellar furrows shallow. Border of cranidium and free cheek generally have low scattered coarse granules. Sagittal length of border ranges from three times length of brim on small cranidia (4–5 mm long) to more than five times on large (14 mm long) mature cranidia.

Pygidium transversely subovate in outline and has slight median inbend in posterior margin. Axis has four or five distinct ring furrows posterior to articulating furrow. Pleural fields crossed by two or three distinct pleural ridges. Breadth of border increases relative to breadth of pleural field, and border becomes more concave with increasing size.

Discussion.—This species is most like *P. sanctisabae* Roemer. It differs principally by having less conspicuous glabellar furrows, fewer distinct ring furrows and pleural ridges on the pygidium, and a strikingly different development of the mature specimens. Small mature specimens of *P. concava* have a relatively short border that increases in length relative to that of the brim during holaspid development. Small mature specimens of *P. sanctisabae*, however, are virtually like the large specimens in all observable features.

Statements made in the original diagnosis (Palmer, 1960a, p. 88) about the thoracic segments have been deleted here because the discovery of a complete specimen of *P. sanctisabae* (p. 71) shows that the macropleural segment is the last segment of the thorax, a characteristic that is probably typical of all species in the genus.

Occurrence. Moderately common, middle part of the *Dunderbergia* zone: Eureka, Bastian Peak, Cherry Creek, McGill, and Ruby Range, Nev.

Pterocephalia elongata Palmer

Plate 17, figures 9–11

Pterocephalia elongata Palmer, 1960a, p. 88, pl. 9, figs. 14–20.

Diagnosis.—Glabellar furrows shallow. Sagittal length of border between three and five times length of brim.

Pygidium has elongate subquadrate outline; greatest breadth near posterior margin; sides straight, nearly parallel, or slightly diverging posteriorly. Posterior margin nearly straight and has slight median indentation. Axis has four or five distinct ring furrows posterior to articulating furrow. Two or three distinct pleural ridges parallel lateral margin of pygidium. A narrow postaxial ridge extends across border to posterior margin.

Discussion.—The elongate subquadrate shape of the pygidium of this species distinguishes it from all others in the genus. Isolated cranidia and free cheeks cannot be distinguished with certainty from those of *P. concava* Palmer.

Occurrence. Moderately rare, middle part of *Dunderbergia* zone: Eureka and Cherry Creek, Nev.

Pterocephalia sanctisabae Roemer

Plate 17, figures 1–3

Pterocephalia sanctisabae Roemer, 1849, p. 421; 1852, p. 92, pl. 11, figs. 1 a–d; Bridge, 1933, p. 232, pl. 2, figs. 26, 27; Bridge, in Bridge and Girty, 1937, p. 246, pl. 67, figs. 1 a–d; pl. 68, figs. 7–43; Shimer and Shrock, 1944, pl. 266, figs. 35–37; Wilson, 1949, p. 42, pl. 10, figs. 1–3; Frederickson, 1949, p. 355, pl. 69, figs. 1–4; (?) Wilson, 1951, p. 647, pl. 91, fig. 24; Palmer, 1960a, p. 89, pl. 9, figs. 7, 8, 13.

Conocephalites (Pterocephalus) laticeps Hall and Whitfield, 1877, p. 221, pl. 2, figs. 4–7.

Dikellocephalus multicinctus Hall and Whitfield, 1877, p. 226, pl. 2, fig. 37.

Pterocephalia dakotensis Resser, 1938b, p. 39.

Pterocephalia bridgei Resser, 1938b, p. 40; Lochman, 1950, p. 334, pl. 47, figs. 14–18; Lochman and Hu, 1960, p. 814, pl. 96, figs. 28–33.
Pterocephalia oriens Resser, 1938b, p. 40.
Pterocephalia potosiensis Resser, 1938b, p. 40.
Pterocephalia ulrichi Resser, 1938b, p. 41.
Pterocephalia silvestris Resser, 1938b, p. 41.
Pterocephalia deckeri Resser, 1938b, p. 41.

Diagnosis.—Glabellar moderately deep. Sagittal length of border on cranidium between five and nine times length of brim on mature specimens.

Pygidium transversely subovate in outline and has at least six distinct ring furrows on axis posterior to articulating furrow and four or five distinct pleural ridges extending across pleural fields and onto border. Posterior margin has slight median indentation.

Discussion.—This species is the youngest species in the genus and the subfamily and is characterized primarily by the very wide cephalic border and the relatively large number of axial furrows and pleural ridges on the pygidium.

Occurrence. Moderately common, *Elvinia* zone: Eureka, Bastian Peak, Shingle Pass, Snake Range, Ash Meadows, Yucca Flat, and Groom District, Nev.; Tintic Utah.

Genus SIGMOCHEILUS Palmer

Sigmocheilus Palmer, 1960a, p. 89.

Type species.—*Sigmocheilus serratus* Palmer, 1960a, p. 91, pl. 10, figs. 1–3. (=*Dikellocephalus flabellifer* Hall and Whitfield, 1877, p. 227, pl. 2, figs. 29, 30.

Diagnosis.—Pterocephaliinae having generally well-defined border on cranidium. Sagittal length of border between 1½ and 4 times greater than that of brim. Border generally concave in sagittal profile and has greatest depth near its midlength. Facial sutures cut anterior margin at slight angle between point opposite anterolateral corners of glabella and axial line.

Free cheeks have long genal spines and well-defined concave border. Lateral and posterior border furrows barely connected. Lateral border furrow shallowest; posterior border furrow continues onto genal spine. Breadth of border equal to or less than greatest breadth of ocular platform.

Pygidium elongate subovate, subquadrate, or transversely subovate; greatest width about opposite or anterior to posterior end of axis. Axis prominent, bears four to six ring furrows posterior to articulating furrow, tapered to a blunt point at inner edge of border. Border and pleural field not clearly differentiated; three to five pleural ridges generally apparent, geniculated at boundary between pleural field and border, continued onto but not across border. Border concave; posterior margin evenly rounded, nearly straight, or has slight median inbend. Edge smooth or has broad spines.

Discussion.—The older species of this genus are most likely to be confused with older species of *Pterocephalia*. The principal difference between cranidia is that the border of *Sigmocheilus* is generally well marked by a border furrow, whereas a border furrow is generally not clearly marked on the external surface of *Pterocephalia*. On exfoliated cranidia of *Pterocephalia*, the border furrow is shown more clearly. On pygidia of species of *Pterocephalia* the end of the pygidial axis is generally distinctly anterior to a line passing through the points of greatest width whereas on pygidia of *Sigmocheilus*, this line passes nearly over the end of the axis or clearly anterior to the end of the axis. The length of the genal spine of *Pterocephalia* species is generally less than that of *Sigmocheilus* species. (Compare pl. 15 figs. 5, 9, pl. 17, figs. 1, 7.)

Cranidia of *Sigmocheilus* also resemble those of *Cernuolimbus* but generally have a longer concave border, the deepest part of which is at the sagittal midlength rather than anterior to the midlength. Species of this genus are common in the *Dunderbergia* zone and the lower part of the *Elvinia* zone and are discriminated principally on the shape and border features of the pygidium.

Sigmocheilus flabellifer (Hall and Whitfield)

Plate 15, figures 1, 3, 5, 6

Dikellocephalus flabellifer Hall and Whitfield, 1877, p. 227, pl. 2, figs. 29, 30.
Apatokephalus? flabellifer, Walcott, 1914, p. 350.
Parabriscoia flabellifera Resser, 1938b., p. 38.
Parabriscoia? flabellifer, Kobayashi, 1953, p. 58.
Richardsonella flabellifera, Kobayashi, 1960, p. 243, text fig. 8e.
Sigmocheilus serratus Palmer, 1960a, p. 91, pl. 10, figs. 1–3.

Diagnosis.—Sagittal length of cranidial border about 1½ times length of brim. Brim gently to moderately convex; border moderately concave. External surface of glabella has closely-spaced fine granules.

Free cheek has long slender genal spine; length of spine greater than three times that of posterior section of facial suture.

Pygidium transversely subovate. Three or four pleural ridges apparent, extend onto border. Posterior margin has five or six pairs of broad-based strongly tapered sharp border spines; pair nearest axial line generally shorter than other pairs.

Discussion.—The well-formed border spines on the pygidium are the most distinctive characteristics of this species. Cranidia resemble those of earlier species

of *Sigmocheilus* but generally have a relatively broader brim. This is the youngest species presently recognized in *Sigmocheilus*.

Hall and Whitfield's species *D. flabellifer* was based on a single imperfect pygidium (pl. 15, fig. 6) and was represented only by a slightly schematic engraving in their publication; it was vaguely located stratigraphically. Its original generic assignment presented a bias to later authors, because by 1914 *Dikellocephalus* had become restricted in concept to a group of trilobites of Trempealeau age. Thus, subsequent assignments were to genera of this age having superficially similar pygidia. The identity of *D. flabellifer* with *S. serratus* (Palmer, 1960a) was not recognized until 1961, when I found Hall and Whitfield's type specimen in the collections of the U.S. National Museum.

Occurrence. Moderately common, upper part of *Dunderbergia* zone and lower part of *Elvinia* zone: Eureka, Cherry Creek, McGill, Shingle Pass, Snake Range, Spring Mountains, Yucca Flat, and Bare Mountain, Nev.

Sigmocheilus grata (Resser)

Plate 15, figures 16–18

Pterocephalina grata Resser, 1942b, p. 78, pl. 15, figs. 3–6.
Sigmocheilus grata (Resser). Palmer, 1960a, p. 90, pl. 9, figs. 22, 23, 26, 27.

Diagnosis.—Sagittal length of border between two and three times length of brim. External surface of border smooth or covered with few scattered low coarse granules. Remainder of surface of cranidium, exclusive of furrows, covered with low fine granules.

Border of pygidium moderately flared posterolaterally; posterior margin broadly rounded or straight, has slight median indentation on some specimens. Edge smooth. Line connecting points of greatest width passes just posterior to end of axis.

Discussion.—This species differs from the closely related and apparently older species *S. notha* (Resser) by having a less pointed posterior margin and a more lateraly flared pygidial border. The absence of border spines distinguishes it from the younger species *S. pogonipensis* (Resser) and *S. serratus* Palmer.

Variability among specimens of this species is much like that of *S. notha* and is most apparent in the width and ornamentation of the cranidial border. It is perhaps the result of unstable and rapidly shifting bottom environments during the time this species was living in central Nevada.

Occurrence. Moderately common, upper part of *Dunderbergia* zone: Eureka, Cherry Creek, Spring Mountains, and Grant Range, Nev.

Sigmocheilus notha (Resser)

Plate 15, figures 7, 8, 10–15

Pterocephalina notha Resser, 1942b, p. 77, pl. 14, figs. 34–38.
Iddingsia? quinnensis Resser, 1942b, p. 88, pl. 16, figs. 39–41.

Diagnosis.—Sagittal length of cranidial border generally two to four times sagittal length of brim. Free cheek has well-defined concave border; length of genal spine between two and three times length of posterior section of facial suture. External surface of border on some specimens covered with scattered coarse granules. Other parts of cranidial exoskeleton either smooth, roughened, or very finely granular.

Posterior margin of pygidium smooth, bluntly pointed towards rear; line connecting points of greatest width pass over end of axis. Length of pygidium nearly two-thirds width. Border generally downsloping, not flared posterolaterally.

Discussion.—The relatively narrow pygidium having a bluntly pointed nonspinose posterior margin is the most distinctive part of the species. The most similar species, *S. grata* (Resser), has a less pointed posterior margin and more laterally flared border. Specimens here assigned to *S. notha* differ among themselves in sagittal length, ornamentation of the cranidial border, and to a lesser extent in details of external ornamenation of other parts of the cranidium. None of these features, however, have provided reliable means of differentiating significant taxa, and the variability is here interpreted as infraspecific. *S. notha* is common in many collections in the upper part of the Dunderberg Formation, where cyclic sedimentation is particularly conspicuous. Perhaps the morphologic variablity is a reflection of the instability of the habitat apparent preferred by this species.

Resser (1942b, p. 88) described a species, *Iddingsia? quinnensis*, on the basis of an exfoliated cranidium from the same collection as *S. notha*. It does not differ in any significant feature from *S. notha* (Compare pl. 15 figs. 8, 10) and is here considered to be a synonym of that species.

Occurrence. Common, middle and upper parts of *Dunderbergia* zone: Bastian Peak, McGill, Ruby Range, Grant Range, Quinn Canyon Range, and Cherry Creek, Nev.

Sigmocheilus pogonipensis (Resser)

Plate 15, figures 2, 4, 9

Pterocephalina pogonipensis Resser, 1942b, p. 78, pl. 15, figs. 1, 2.
Sigmocheilus pogonipensis (Resser). Palmer, 1960a, p. 91, pl. 10, figs. 4–7.

Diagnosis.—Sagittal length of cranidial border about one and one-half times that of brim. Brim

strongly arched in sagittal profile; anterior part nearly vertical. Border strongly concave. Front of glabella well defined by preglabellar furrow. External surface of cranidium, exclusive of furrows and border, covered with low coarse granules.

Free cheek has long slender genal spine; length of spine more than three times length of posterior section of facial suture.

Pygidium transverse subovate. Pleural regions crossed by four or five prominent pleural ribs that continue onto border. Border covered with well-defined terrace lines. Margin has six pairs of short asymmetrical spines.

Discussion.—The strongly convex cranidial brim and short border spines on the pygidium are the most distinctive features of this species. At Eureka and Shingle Pass, Nev., this species has been found in beds stratigraphically below those containing *S. serratus* Palmer, a species having better formed border spines on the pygidium and a less convex brim on the cranidium. *S. pogonipensis* was therefore first thought to be ancestral to *S. serratus* in an evolutionary lineage that began with species lacking border spines on the pygidium, progressed through forms having vestigial spines, and terminated with a species having well-founded spines. However, at Cherry Creek, Nev., *S. pogonipensis* and *S. serratus* are associated in two small collections, an occurrence that casts doubt on the suggested evolutionary lineage. The cranidial ornamentation of *S. pogonipensis* is very similar to that of species of *Strigambitus*, whereas the ornamentation of *S. serratus* is more like that of the other species of *Sigmocheilus*. *S. pogonipensis* may thus represent an offshoot of *Strigambitus* rather than a part of the main evolutionary lineage of *Sigmocheilus*.

Occurrence. Moderately rare, upper part of *Dunderbergia* zone: Eureka, Cherry Creek, Shingle Pass, Yucca Flat, and Pahranagat Range, Nev.

Genus STRIGAMBITUS n. gen.

Type species.—*Strigambitus transversus* n. sp.

Diagnosis.—Pterocephalinae having a well-defined glabella containing three pairs of moderately deep glabellar furrows. Frontal area subequally divided into poorly differentiated convex brim and concave border. Fixed cheeks narrow, horizontal, or slightly upsloping Palpebral lobes and eye ridges well defined. Anterior sections of facial sutures intramarginal nearly to axial line, then joined and continued ventrally across doublure as median suture.

Free cheek has well-defined lateral and posterior border furrows joined at genal angle and extended onto genal spine.

Pygidium has prominent axis bearing two or three distinct ring furrows posterior to articulating furrow. Outline transversely subovate to subquadrate. Posterior margin has or lacks median inbend. Border concave, not clearly differentiated from pleural fields.

External surfaces of border regions covered with well-defined terrace lines; all other parts covered with closely-spaced coarse granules.

Description.—Pterocephaliinae (estimated maximum length about 60 mm) having cranidium, exclusive of posterior limbs, subquadrate, moderately rounded anteriorly, gently to moderately convex transversely and longitudinally. Glabella moderately convex transversely, gently convex longitudinally, tapered forward, bluntly rounded anteriorly, well defined at sides and anterolateral corners by moderately deep axial furrows, less well defined across front. Three pairs of moderately deep glabellar furrows generally apparent; posterior pair curved broadly backward. Occipital furrow deep at sides, shallow across axial line. Occipital ring moderately wide, has low median node placed slightly anterior to midlength. Frontal area moderately long; sagittal length between two-thirds and three-fourths length of glabella. Brim and border poorly differentiated by very shallow border furrow; brim moderately convex; border concave. Sagittal length of border equal to or slightly greater than length of brim. Fixed cheeks narrow, horizontal, or slightly upsloping; width between one-third and one-fourth basal glabellar width. Palpebral lobes well defined by arcuate palpebral furrows, connected to glabella by moderately well-defined eye ridges; length about two-fifths length of glabella. Posterior limbs long, slender; posterior border furrow deep, straight.

Anterior sections of facial sutures slightly divergent forward from palpebral lobes to border furrow, then curved inward across border and intramarginal nearly to axial line, where they meet and continue backward ventrally across doublure as median suture. Posterior sections divergent and sinuous.

Free cheek has flat or concave border; width at anterior end about equal to that of ocular platform. Infraocular ring well formed. Lateral and posterior border furrows well defined, joined at genal angle and continued backward onto genal spine. Genal spine long, slender, having subcircular cross section, or short, moderately broad, having subovate cross section.

Thoracic segments and hypostome not known with certainty.

Pygidium subquadrate to transversely subovate. Axis prominent, tapered posteriorly to inner edge of border, contains two or three distinct ring furrows posterior to articulating furrow; length between one-half and

three-fourths length of pygidium; low median ridge extends from end of axis onto border. Border not clearly differentiated, variable in width. Pleural fields crossed by one or two shallow pleural furrows, generally curved abruptly backward distally and continued onto inner part of border. Posterior margin either has or lacks well-defined median inbend.

External surfaces of border regions of cranidium, free cheek, and pygidium covered with well-defined terrace lines. All other parts generally thickly covered with coarse granules.

Discussion.—The poorly defined brim and border and the well-defined glabellar furrows on the cranidium, together with the distinctive ornamentation of terrace lines on the border regions and abundant coarse granules on other parts, are the most characteristic features of species of this genus. In an earlier paper (Palmer, 1960a), *Strigambitus utahensis* (Resser) was placed in *Sigmocheilus*, but the lack of a well-defined border was atypical of *Sigmocheilus*. Discovery of additional species having cranidia like those of *S. utahensis* but having different free cheeks and pygidia indicates that these species characterize a genus distinct from *Sigmocheilus* in ornamentation and structure of the frontal area. At present, this genus is characteristic of faunas in the lower part of the *Dunderbergia* zone.

Strigambitus bilobus n. sp.

Plate 16, figures 1–3

Diagnosis.—Free cheek has short, moderately broad, flattened genal spine; length of spine only slightly greater than length of posterior section of facial suture. Pygidium subquadrate in outline, has deep rounded posterior median inbend. Width of axis at anterior margin slightly greater than anterior width of pleural region. External surface of border contains distinct terrace lines. External surface of axial rings has low coarse granules. External surface of pleural fields nearly smooth, except on large specimens, which have low scattered granules.

Discussion.—The deep median notch and relatively narrow pleural regions of the pygidium are the most distinctive features that differentiate this species from the slightly older *S. utahensis* (Resser). *S. bilobus* is the youngest species presently assigned to *Strigambitus* and occurs above *S. utahensis* in the Ruby Range section and above *S. transversus* n. sp. in the McGill section.

Occurrence. Moderately rare, lower part of *Dunderbergia* zone: Ruby Range, McGill, and Cherry Creek, Nev.

Strigambitus? blepharina n. sp.

Plate 16, figures 14–18

Diagnosis.—Glabellar furrows of larger cranidia barely apparent. Sagittal length of downsloping nearly flat brim about one-half that of moderately concave border on cranidia having a sagittal length of 15 mm or more; on cranidia 5 mm or less in length, sagittal length of brim about two-thirds or more that of border. Fixed cheeks nearly flat, horizontal. Palpebral lobes on larger cranidia barely defined on external surface; short, length between one-fourth and one-fifth that of glabella.

Free cheek has moderately broad concave border; central depression of moderate depth continues backward to intersection with posterior border furrow of comparable depth and then extends a short distance onto base of genal spine. Lateral border furrow distinct, relatively shallow, intersecting posterior border furrow at right angle. Genal spine long, slender, subcircular in cross section; length about twice length of posterior section of facial suture.

Axis of pygidium moderately to strongly tapered posteriorly; low narrow postaxial ridge extends short distance onto border. Pleural regions have broad poorly defined border. Pleural fields narrower than border, crossed by two or three narrow pleural ridges that continue more than half the distance across border.

External surface of glabella of large cranidia has closely spaced fine granules on upper parts; other parts generally smooth; smaller cranidia have fine granular ornamentation on all parts except border, which has moderately formed terrace lines. Border and genal spine of free cheek and border and tops of pleural ridges of pygidium contain moderately formed terrace lines. Top of axis of pygidium and pleural fields of small specimens have closely spaced fine granules.

Discussion.—*S? blepharina* is included in *Strigambitus* with question because the small palpebral lobes and relatively subdued ornamentation of larger cranidia are unlike those of other species of the genus. The affinities to *Strigambitus* are shown in the smaller cranidia, which have the characteristic ornamentation and glabellar furrows of other speices of the genus. In addition to the small palpebral lobes and modified ornamentation, this species differs from others in the genus in the unusual relation between the lateral and posterior border furrows on the free cheek.

Occurrence. Rare, *Dunderbergia* zone: Quartz Spring area and Death Valley, Calif.; Spring Mountains, Nev.

Strigambitus transversus n. sp.

Plate 16, figures 6–10

Diagnosis.—Free cheek has genal spine that is extremely long, slender, rounded in cross section; length of spine more than twice length of posterior section of facial suture. Pygidium transversely subovate; posterior margin convex backward. Axis contains three distinct ring furrows posterior to articulating furrow. Border narrower than pleural fields.

Discussion.—This seems to be the oldest of the three species here assigned to *Strigambitus* and is most easily distinguished from the others by lacking a distinct posterior median inbend in the pygidial margin.

USGS collection 1478–CO may represent a transitional assemblage between *S. transversus* and *S. utahensis*. Some pygidia having a slight median inbend in the border are present in association with pygidia definitely lacking an inbend.

Occurrence. Moderately common, lower part of *Dunderbergia* zone: McGill, Bastian Peak, Snake Range, and Spring Mountains, Nev.; House, Needles, and Deep Creek ranges, Utah.

Strigambitus utahensis (Resser)

Plate 16, figures 4, 5

Pterocephalina utahensis Resser, 1942b, p. 79, pl. 15, figs. 7–11.
Sigmocheilus utahensis (Resser). Palmer, 1960a, p. 91, pl. 9, figs. 24, 25, 28.

Diagnosis.—Free cheek has genal spine long, slender, subcircular in cross section; full length of spine not known. Pygidium subquadrate, has distinct shallow median inbend in posterior margin. External surfaces of pleural fields and axis thickly covered with coarse granules.

Discussion.—This species is morphologically and perhaps stratigraphically intermediate between *S. transversus* n. sp., a species lacking a median inbend in the pygidial margin and having well-defined pygidial ornamentation, and *S. bilobus* n. sp., which has a deep median inbend in the posterior margin and poorly defined pygidial ornamentation.

Occurrence. Moderately rare, lower part of *Dunderbergia* zone: Eureka, Spring Mountains, Muddy Mountains, and Ruby Range, Nev.; Fish Springs Range, Utah; Panamint Range, Calif.

UNASSIGNED TRILOBITES

All the trilobites described on the preceding pages are assigned with considerable confidence to their suprageneric taxa. Some of the genera and species described on the following pages may also represent suprageneric taxa described above. However, in order to distinguish between degrees of confidence in suprageneric assignment, all questionably assigned genera and their included species are described in this section and their possible affinities are indicated in either the description or the discussion following.

Genus ANECHOCEPHALUS Palmer

Anechocephalus Palmer, 1960a, p. 92.

Type species.—*Anechocephalus triganulatus* Palmer, 1960a, p. 92, pl. 8, figs. 21–23.

Description.—Small pterocephaliid(?) trilobites (estimated maximum total length 30 mm). Cranidium has glabella that is well defined at sides and anterolateral corners, less well defined in front, gently to moderately convex transversely and longitudinally, tapered slightly forward, moderately to bluntly rounded at front; glabellar furrows shallow; occipital furrow well defined, generally deep. Occipital ring gently convex, widest on axial line. Frontal area moderately short. Brim depressed, generally continuing the longitudinal convexity of glabella. Border nearly horizontal; sagittal convexity gentle to moderate. Border furrow moderately deep. Fixed cheeks upsloping to elevated; width about one-third basal glabellar width. Palpebral lobes large, arcuate, well defined by palpebral furrow, situated slightly above level of top of glabella; length slightly greater than one-half length of glabella on specimens having a glabella length of 2 mm or more; length somewhat more on smaller specimens; midlength situated slightly posterior to glabellar midlength. Posterior limbs slender, tapered laterally to sharp point; length slightly less than basal glabellar width.

Course of anterior section of facial sutures nearly straight forward or slightly bowed outward from palpebral lobe to across border furrow, then turned inward across border and marginal or submarginal nearly to axial line; ventral course not known. Posterior section at nearly right angles to axial line behind palpebral lobes, curved broadly backward to posterior margin.

Free cheek has well-defined gently convex lateral border, narrower than ocular platform. Infraocular ring present. Lateral and posterior border furrows distinct; posterior border furrow deepest; furrows join at genal angle and extend down middle of moderately long nearly flat genal spine nearly to tip.

Thoracic segments and hypostome not known.

Pygidium subquadrate. Axis prominent, tapered posteriorly, reaches to or nearly to inner edge of poorly defined border; axis contains two distinct ring furrows posterior to articulating furrow; low postaxial ridge extends for short distance behind axis.

Pleural fields not distinctly separated from border, crossed by two or three pleural furrows that are curved abruptly backward and extend onto border. Posterior margin extended either into broad short lobes or into pair of slender posteriorly directed posterolateral spines of variable length.

External surface of glabella has coarse semireticulate ornamentation that is conspicuously absent from areas of glabellar furrows. Similar ornamentation variably formed on fixed cheeks and brim. Border of cranidium covered with distinct terrace lines. Free cheek not noticeably ornamented except for terrace lines on anterior part of border and on genal spine. Pygidium generally not noticeably ornamented; poorly defined closely spaced granules on anterior part of pleural fields of some specimens.

Discussion.—This genus was originally based on only a few cranidia and pygidia from the *Dunderbergia* zone. The occurrence of at least one new species in the *Elvinia* zone represented by many specimens has provided additional information on the content and concept of *Anechocephalus*. The foregoing description is modified from that given in an earlier paper (Palmer, 1960a) on the basis of this information. The upsloping to elevated narrow fixed cheeks having large well-defined palpebral lobes and the generally short frontal area having a well-defined moderately convex border are the most distinctive characteristics of species of *Anechocephalus*.

Anechocephalus spinosus n. sp.

Plate 20, figures 1–4, 6, 7, 11, 12

Diagnosis.—Length of frontal area of cranidium between one-third and one-half length of glabella. Border furrow has slight posterior median inbend. Occipital furrow generally deepest along sides of glabella. Pygidium has pair of posterolateral spines of variable length.

Discussion.—This species, which is characterized primarily by its spine-bearing pygidium, is either unusually variable or else composed of two or more closely related forms. In three collections from the Eureka district, all taken about 16 feet below the lowest cherts of the Windfall Formation, indistinguishable cranidia and free cheeks are associated with pygidia bearing posterolateral spines of different lengths. Within each collection, the few observed pygidia are virtually the same, but a comparison between collections shows a striking difference in the length of spines on the pygidia (compare pl. 20, figs. 4, 7, 12). Because all these specimens are from the same fauna in about the same stratigraphic position in the same area and none of the samples are very large, the different pygidia are here tentatively considered to be varieties of a single species.

Occurrence. Moderately rare, uppermost part of *Elvinia* zone: Eureka, McGill, and Yucca Flat, Nev.

Anechocephalus trigranulatus Palmer

Plate 20, figures 5, 8–10, 13, 14

Anechocephalus trigranulatus Palmer, 1960a, pl. 8, figs. 21–23.

Diagnosis.—Cranidium has short frontal area; sagittal length less than one-third length of glabella. Border furrow straight, deep. Occipital furrow has nearly constant depth. Border of pygidium extended into short broad posterolateral lobes, each generally having a row of three low coarse granules paralleling posterolateral margin.

Discussion.—This species is characterized particularly by its short frontal area and lack of posterolateral pygidial spines. The occurrence of additional specimens from Cherry Creek, Nev., in the lower *Elvinia* zone increases the known stratigraphic range of the species.

Occurrence. Rare, upper *Dunderbergia* zone: Eureka and Pahranagat Range, Nev.; lower *Elvinia* zone: Cherry Creek, Nev.

Genus APHELOTOXON, n. gen.

Type species.—*Bynumiella? acuminata* Palmer, 1960a, p. 93, pl. 10, fig. 9, 10.

Description.—Small ptychopariid trilobites probably not exceeding 10 mm in total length. Cranidium subtriangular to subtrapezoidal, moderately convex transversely, gently convex longitudinally. Anterior margin straight or slightly pointed. Glabella subtriangular in outline, low, well to poorly defined by axial and preglabellar furrows. Occipital furrow moderately well defined, at least at distal ends. Occipital ring smooth or has median node or short spine. Two pairs of short glabellar furrows may be apparent; length of posterior pair about twice length of anterior pair. Frontal area short, either has or lacks well-defined convex border; sagittal length about one-fourth or less than one-fourth of glabella including occipital ring. Sagittal length of border equal to or greater than length of brim. Fixed cheek flat to moderately convex, downsloping; width between one-third and one-half glabellar width. Palpebral lobes small, poorly defined, situated opposite or slightly anterior to glabellar midlength. Ocular ridges generally not apparent. Posterior limb generally broad exsagittally, contains moderately well-defined posterior border furrow; tapered laterally to blunt point.

Course of anterior section of facial suture nearly straight forward or slightly convergent anteriorly from palpebral lobe to border, then turned inward to cross border gradually, reaching anterior margin near axial line and continuing backward ventrally across doublure as median suture. Course of posterior section divergent, sinuous.

Free cheek has moderately to strongly curved lateral margin. Border furrows poorly defined; width of border equal to or less than width of ocular platform. Genal spine short, little more than nub. Anterior part of doublure squarely truncate.

Pygidium subtriangular to subsemicircular, moderately to strongly convex transversely and longitudinally. Axis prominent, moderately well defined anteriorly, tapered backward and merged with pleural regions near posterior margin. Ring furrows well defined only on anterior part; two to four deep narrow furrows present posterior to articulating furrow. Pleural regions very slightly furrowed, sides depressed; shallow closely spaced pleural and interpleural furrows may be slightly apparent.

External surfaces of all parts smooth, coarsely pitted or finely granular.

Discussion.—The triangular glabella, generally moderate to strong cephalic convexity, and the small eyes are particularly characteristic of this genus. Several species here assigned to it are found at various levels within the *Dunderbergia* zone. The genus has no apparent relationships to any other trilobites of the Pterocephaliid biomere, but it does have some similarity to *Dresbachia*, *Menomonia*, and *Densonella* of the earlier Upper Cambrian and to *Clelandia* from the Lower Ordovician. It differs from the earlier genera by having downsloping fixed cheeks, smaller eyes, and shorter posterior limbs and from *Clelandia* by having median cephalic suture and somewhat larger eyes.

The type species, *A. acuminata* (Palmer), was first assigned with question to *Bynumiella*. Reexamination of the types and unillustrated paratypes of *B. typicalis* Resser shows that they actually belong to *Clelandia* and that *Bynumiella* is a synonym of *Clelandia*. The differences between *Clelandia* and *Aphelotoxon* are based on the observations of Ross (1951, p. 116).

An indication of evolutionary relationships within the genus is given by collections from the Ruby Range, Nev. USGS collection 2601–CO contains distinctly pitted specimens that have a well-defined glabella and border are assignable to *A. punctata* n. sp. (pl. 19, fig. 2). About 150 feet higher in the section (USGS colln. 2605–CO), specimens assignable to *A. acuminata* have a poorly defined glabella and border and a smooth surface (pl. 19, fig. 3). Specimens from a collection (USGS colln. 2603–CO) taken from strata lying midway between the strata from which the foregoing collections were taken have a poorly defined border, moderately well defined glabella, and a moderately strong surface pitting (pl. 19, fig. 7). Individuals in other collections of *A. acuminata* may have shallow pits barely apparent on the fixed sheeks and posterior limbs. Thus *A. acuminata* seems to be a direct descendant of *A. punctata*. The other species do not show such a simple relationship to *A. punctata*, which seems to be the oldest species, but part of the ornamentation on a few individuals consists of large shallow pits.

Aphelotoxon acuminata (Palmer)

Plate 19, figures 1, 3–6

Bynumiella? acuminata Palmer, 1960a, p. 93, pl. 10, figs. 9, 10; text fig. 21.

Diagnosis.—Glabella barely outlined by axial and preglabellar furrows. Glabellar furrows not apparent. Occipital furrow may be deep at distal ends. Occipital ring has median node. Frontal area downsloping, barely differentiated into narrow brim and acuminate border; sagittal length of border about twice that of brim. Posterior section of facial suture nearly straight; posterior limb subtriangular. Fixed cheeks narrow, flat, downsloping; width slightly less than one-third basal glabellar width.

Border of free cheek about one-half width of ocular platform. Lateral margin very curved.

Pygidium has two distinct ring furrows posterior to articulating furrow. External surfaces of all parts generally smooth; low granules present on occipital ring and posterior part of posterior limb on some specimens; shallow pits present on fixed cheeks and posterior limbs of some specimens.

Discussion.—This species is characterized particularly by its acuminate anterior margin and poorly defined cranidial furrows. It is most similar to *A. limbata* n. sp. and *A. marginata* n. sp., from which it differs in the features just cited.

Occurrence. Moderately common, lower half of *Dunderbergia* zone: Eureka, Bastian Peak, McGill, Cherry Creek, Ruby Range, and Yucca Flat, Nev.; Deep Creek and House Ranges, Utah.

Aphelotoxon granulosus n. sp.

Plate 19, figures 21, 22

Diagnosis.—Glabella well defined by axial furrows, less well defined across front. Two pairs of distinct short lateral glabellar furrows present. Border narrow, convex, well defined by narrow border furrow;

sagittal length slightly less than length of downsloping brim. Width of fixed cheeks about one-third basal glabellar width.

Free cheek narrow; lateral border moderately well defined.

Other parts not known. External surfaces of all known parts covered with fine closely spaced granules.

Discussion.—This species is most easily distinguished by its ornamentation from all other species in the genus. The only other species having a significant granular ornamentation is *A. marginata*, which has scattered fine granules only on the cranidium and has shallower glabellar furrows and broader fixed cheeks than *A. granulosus*.

Occurrence. Rare, *Dunderbergia* zone: Arizona Peak, Nev.

Aphelotoxon limbata n. sp.

Plate 19, figures 8, 10, 11

Diagnosis.—Glabella moderately well defined; two pairs of short glabellar furrows apparent. Frontal area subequally divided into brim and border. Anterior margin gently rounded. Occipital ring has low median node. Fixed cheeks narrow, flat, downsloping; width about one-third basal glabellar width. Palpebral lobes moderately defined on some specimens. Posterior section of facial suture moderately bowed forward; posterior limb broad.

Pygidium has three or four distinct ring furrows posterior to articulating furrow.

External surfaces of all parts smooth.

Discussion.—This species is most like *A. acuminata* (Palmer), differing in its less acute anterior margin, better defined axial and glabellar furrows, broader posterior limbs on the cranidium, and greater number of ring furrows on the axis of the pygidium.

Occurrence. Rare, lower part of *Dunderbergia* zone: McGill, Nev.; House Range, Utah.

Aphelotoxon marginata n. sp.

Plate 19, figures 14, 16

Pinctus? sp., Palmer, 1960a, p. 101, pl. 10, fig. 21.

Diagnosis.—Glabella moderately well to poorly defined by axial and preglabellar furrows. Two pairs of shallow glabellar furrows may be present. Occipital ring has median node. Border of frontal area well defined; sagittal length of border about equal to that of brim. Anterior margin gently rounded. Fixed cheeks gently convex, downsloping; width about one-half basal glabellar width. Posterior section of facial suture moderately curved forward; posterior limbs broad. External surface covered with scattered fine granules, which are apparent only after whitening.

Discussion.—The single cranidium referred with question to *Pinctus* (Palmer, 1960a.) has the characteristics of *Aphelotoxon*; it has a subtriangular glabella, short frontal area, and small anteriorly placed palpebral lobes. The nearly smooth surface, broad fixed cheeks, and lack of an occipital spine indicate its placement in *A. marqinata* n. sp.

This species is most like *A. limbata* n. sp., from which it differs principally by having significantly broader fixed cheeks. This is presently the youngest species assigned to the genus.

Occurrence. Rare, upper part of *Dunderbergia* zone: Eureka, McGill, Pahranagat Range, Spring Mountains, and Snake Range, Nev.

Aphelotoxon punctata Palmer

Plate 19, figures 2, 7

Diagnosis.—Glabella well defined by axial and preglabellar furrows; two pairs of well-defined glabellar furrows present. Border well defined by narrow border furrow on front of glabella; sagittal length about twice length of brim. Anterior margin gently rounded. Fixed cheeks moderately convex, downsloping; width about one-half basal glabellar width. Posterior section of facial stuture gently curved forward; posterior limb moderately broad. External surfaces of all known parts coarsely pitted.

Discussion.—The coarsely pitted ornamentation, well-defined glabella and glabellar furrows, and convex fixed cheeks are particularly characteristic of this species, which seems to be the oldest in the genus (p. 79).

Occurrence. Rare, lower part of *Dunderbergia* zone: Ruby Range, Nev.

Aphelotoxon spinosus n. sp.

Plate 19, figures 9, 12, 13

Diagnosis.—Glabella moderately well defined by axial and preglabellar furrows. Two pairs of distinct shallow glabellar furrows present. Occipital ring has short median spine. Frontal area has well-defined border; sagittal length of border about twice length of brim. Fixed cheeks nearly flat, downsloping; width slightly less than one-half basal glabellar width. Posterior section of facial suture gently curved; posterior limb subtriangular. Free cheek narrow; lateral margin strongly curved; width of border slightly greater than width of ocular platform.

External surfaces of all parts generally smooth or very finely pitted. Free cheek has low terrace lines on outer part of border.

Discussion.—The short occipital spine distinguishes this species from all others in the genus. The free cheek is distinctly narrower than that of *A. acuminata.*

Occurrence. Rare, lower part of *Dunderbergia* zone: House Range and Wah Wah Range, Utah.

Genus Bromella n. gen.

Type species.—*Bromella veritas* n sp.

Description.—Small ptychopariid trilobites (total length probably less than 20 mm). Glabella prominent, tapered forward, truncated anteriorly, moderately convex transversely, gently convex longitudinally, well defined by axial and preglabellar furrows. Anterolateral fossulae present on some specimens. Glabellar furrows shallow. Occipital furrow deep, nearly straight. Occipital ring has median node; short spine may also be present at posterior edge. Frontal area short, concave, divided into downsloping brim and prominent upturned border. Sagittal length of frontal area about one-half that of glabella. Sagittal length of border about one-half that of brim. Fixed cheeks narrow, horizontal, or slightly upsloping; width one-third to one-fourth basal glabellar width. Palpebral lobes well defined by moderately arcuate palpebral furrow, situated opposite or slightly anterior to glabellar midlength. Length of palpebral lobe slightly less than one-half glabellar length. Posterior limbs triangular in outline. Posterior border furrow straight, deep.

Course of anterior section of facial suture straight forward or slightly divergent anteriorly from palpebral lobe to border furrow and curved inward across border to cut anterior margin about in front of anterolateral corner of glabella. Ventral course not known. Course of posterior section of facial suture divergent, sinuous.

Lateral border of free cheek well defined by border furrow that is deep anteriorly but disappears before reaching base of genal spine. Posterior border furrow deep, extended onto base of genal spine.

Pygidium transversely subovate to subquadrate. Axis short, prominent, contains two or three ring furrows posterior to articulating furrow; anterior furrow deep; other furrows shallow. Length of axis about two-thirds that of pygidium. Pleural regions gently convex, have broad poorly defined border tapered towards axis. Pleural fields about as wide as border, crossed by one or two shallow pleural furrows.

External surfaces pitted, smooth, or finely granular.

Discussion.—This genus of small trilobites has affinities with *Aphelaspis*, *Dytremacephalus*, and *Prehousia*. It may belong in the Aphelaspidinae because of the *Aphelaspis*-like glabella and pygidium and the well-defined cranidial border, but its evolutionary relationships to the three genera it most closely resembles are obscure. It differs from *Aphelaspis* in having an upturned cranidial border and in lacking a connection of the lateral and posterior border furrows on the free cheek. Also the fixed cheeks are somewhat narrower and the palpebral lobes shorter than comparable-sized specimens of *Aphelaspis*. These features relate the genus to *Prehousia*, and the possibility that *Bromella*, which is generally associated with *Prehousia*, may merely include small holaspids of the earlier *Prehousia* species cannot be entirely eliminated. A similar degree of difference was noted in an earlier paper (Palmer, 1960a, p. 88) between small and large holaspids of early species of *Pterocephalia.* However, the prominence of the glabella and lack of connection of the lateral and posterior border furrows on the free cheeks of *Bromella*, together with its occurrence in association with *Dicanthopyge guadrata* n. sp. in one older collection, make the possibility unlikely.

The features that distinguish *Bromella* from *Prehousia* are the ones that indicate possible affinity with *Dytremacephalus.* However, the glabella of *Bromella* is less tapered anteriorly and the glabellar furrows less well defined than those of *Dytremacephalus.* The possibility that *Bromella* may be ancestral to *Dytremacephalus* is compatible with the known stratigraphic distribution of the two genera, but more information is needed before this relationship can be stressed.

Bromella veritas n. sp.

Plate 18, figures 1–9

Diagnosis.—This is the only species presently recognized in *Bromella*, and it has the characteristics of the genus.

Discussion.—More than one species may be included in *B. veritas.* Some specimens have a short occipital spine formed from the back of the occipital ring, as well as an occipital node (pl. 18, fig. 7), and have cranidia ornamented with both pits and fine granules. The reason that such specimens are not recognized as separate species is that specimens having both ornamentation types and either having or lacking the occipital spine are present in USGS collection 1439-CO from the Snake Range, Nev. Until more can be learned about this difficult little genus, all specimens referable to it are assigned to its type species.

Occurrence. Rare, *Dicanthopyge* zone: Highland Range, Nev. Moderately common, lower part of *Prehousia* zone; Snake Range, Shingle Pass, Highland Range, McGill, and Spring Mountains, Nev.; House Range, Fish Springs Range, and Promontory Range, Utah.

Genus BYNUMINA Resser

Bynumina Resser, 1942b, p. 58; Wilson, 1951, p. 628; Lochman, 1959, p. 286; Palmer, 1960a, p. 93.

Description.—Small ptychopariid trilobites (probably not exceeding 10 mm in total length). Cranidium subtrapezoidal in outline, moderately convex transversely and longitudinally, generally lacks distinct external furrows. Exfoliated specimens have well-defined anteriorly tapered glabella, slightly rounded at front. Last two pairs of glabellar furrows, if present, strongly curved posteriorly. Occipital furrow deep, straight. Occipital ring narrow, tapered laterally. Frontal area length slightly greater than one-third length of remainder of cranidium; shallow border furrow, if present, separates brim and border of nearly equal sagittal length. Fixed cheek gently convex, downsloping; width, including palpebral lobe, about one-half basal glabellar width. Palpebral lobes not differentiated from remainder of fixed cheek; length between one-third and one-fourth that of glabella including occipital ring. Posterior limbs broad exsagittally; transverse length less than that of basal glabellar width; tips bluntly rounded or pointed; border furrow apparent only near axial furrow.

Discussion.—This genus is represented in the Great Basin only by rare cranidia. A full description has been presented in an earlier paper (Palmer, 1960a, p. 93). The foregoing description of the cranidium is given only because the statements concerning the fixed cheeks and palpebral lobes were inadvertently omitted from the earlier description.

Bynumina globosa (Walcott)

Plate 18, figures 22, 23

Agraulos? globosa Walcott, 1884, p. 61, pl. 9, fig. 23.
Kingstonia globosa (Walcott). Resser, 1936, p. 24.
Bynumina globosa (Walcott). Palmer, 1960a, p. 94, pl. 10, fig. 8.

Diagnosis.—Cranidium has glabella nearly parallel sided, subquadrate in outline, moderately to strongly convex longitudinally, highest at or slightly anterior to midlength. Length of palpebral lobes about one-third of glabella including occipital ring.

Discussion.—This small smooth trilobite is a rare but persistent element of the *Elvinia* zone fauna. Its convex cranidium lacking well-defined parts but having an elevated glabellar area distinguishes it from all associated forms.

A single cranidium from the Shingle Pass section (pl. 18 fig. 23) has more slender posterior limbs and a better defined occipital ring than do most other specimens assigned to the species and may represent another form.

Occurrence. Rare, *Elvinia* zone: Eureka, Bastian Peak, Snake Range, (?) Shingle Pass, and Cherry Creek, Nev.; House Range, Utah.

Genus COMANCHIA Frederickson

Comanchia Frederickson, in Wilson and Frederickson, 1950, p. 900; Lochman, 1959, p. 252.

Type species.—*Ptychopleurites amplooculata* Frederickson, 1948, p. 802, pl. 123, fig. 9–11.

Description.—Small ptychopariid trilobites (maximum length about 30 mm). Cranidium, exclusive of posterior limbs, elongate subquadrate; anterior margin broadly rounded. Glabella elongate, well defined at sides by narrow axial furrows, tapered forward, strongly rounded at front, moderately convex transversely and longitudinally. Two or three pairs of glabellar furrows present; posterior pair most distinct, diagonal. Occipital furrow narrow, deepest at sides of glabella. Occipital ring has small low median node. Frontal area short; sagittal length about one-fourth length of glabella. Border distinct, flat or slightly convex, of nearly constant breadth; sagittal length equal to or greater than that of brim. Fixed cheeks narrow and horizontal or slightly upsloping. Palpebral lobes large, arcuate, well defined by palpebral furrow, situated about opposite glabellar midlength; breadth about equal to that of fixed cheek; length about one-half that of glabella. Width of fixed cheek, one-fifth or less than one-fifth basal glabellar width. Posterior limbs slender, have deep straight posterior border furrow.

Course of anterior section of facial suture divergent forward from palpebral lobe to border furrow, curved sharply inward and then diagonally across border to cut anterior margin about opposite anterolateral corners of glabella. Rostral suture submarginal; transverse length about equal to breadth of anterior part of glabella. Course of connective sutures and shape of rostral plate not known. Course of posterior section of facial suture divergent, sinuous.

Free cheek has narrow lateral and posterior border furrows, jointed at acute angle near base of genal spine. Lateral border flat or gently convex; breadth at anterior margin about equal to breadth of ocular platform. Ocular platform broadens posteriorly. Distinct infraocular ring present. Genal spine flat, sharp; length equal to or slightly greater than length of posterior section of facial suture.

Hypostome and thorax not known.

Pygidium subsemicircular, moderately convex transversely and longitudinally. Axis prominent, slightly tapered posteriorly to inner edge of border. Two or three ring furrows present posterior to articulating furrow. Articulating half-ring of second axial segment generally well defined. Pleural regions have gently convex downsloping pleural field crossed by two or three shallow pleural furrows. Border nearly flat, narrower than pleural fields, tapered towards axial line, well defined at inner edge by sharp change in slope.

External surfaces of all parts smooth or covered with very fine closely-spaced granules that are only very slightly visible even on whitened specimens.

Discussion.—This distinctive genus has been found in association with *Irvingella major* Ulrich and Resser in Oklahoma, Texas, Wisconsin, and Nevada. The well-defined glabella, large palpebral lobes, narrow fixed cheeks, short frontal area, and straplike posterior limbs distinguish species of *Comanchia* from all other trilobites in the Pterocephaliid biofacies. The principal new information about *Comanchia* that is presented here, concerns the free cheek, which is described for the first time, and more accurate information about the course of the anterior sections of the facial sutures based on study of some silicified specimens from Mount Hamilton, Nev.

Comanchia minus n. sp.

Plate 19, figures 15, 17–20

Diagnosis.—Sagittal length of cranidial border about twice length of brim. Pygidium has only two distinct ring furrows posterior to articulating furrow.

Discussion.—Pygidia of *Comanchia amplooculata* (Frederickson) from Wisconsin, Oklahoma, and Texas consistently have a distinct third ring furrow posterior to the articulating furrow. This is the principal feature that distinguishes them from pygidia of *C. minus*. In all other feature the species are virtually the same, except that the palpebral lobes of the Nevada specimens seem to be characteristically slightly less than one-half the glabellar length, whereas those of the specimens from Oklahoma and Texas are slightly more than one-half the glabellar length.

The relatively broad border distinguishes this species from *Comanchia prior* Kurtz (1952), which seems also to be a somewhat older species.

Occurrence. Moderately rare, uppermost part of *Elvinia* zone: Cherry Creek, McGill, Snake Range, Ruby Range, and Mount Hamilton, Nev.

Genus DELLEA Wilson

Dellea Wilson, 1949, p. 34; 1951, p. 634; Lochman, 1959, p. 306.

Type species.—*Dellea wilbernsensis* Wilson, 1949, p. 35, pl. 11, figs. 1, 2, 4–7, 12.

Diagnosis.—Small Elviniidae? probably less than 30 mm in total length. Cranidium has prominent glabella, well defined by axial and preglabellar furrows, tapered forward, bluntly rounded anteriorly. Occipital ring narrow, well defined by occipital furrow. Border of frontal area narrower than brim. Border furrow narrow, parallels curved anterior margin of cranidium. Fixed cheeks gently convex; width about one-third basal glabellar width. Palpebral lobes moderately well defined by shallow slightly curved palpebral furrow situated opposite middle third of glabella. Posterior limb moderately broad exsagittally, pointed.

Course of anterior section of facial suture straight forward or slightly divergent from palpebral lobe to border furrow, then curved inward across border to cut anterior margin about opposite anterolateral corners of glabella. Course of posterior section strongly divergent laterally from palpebral lobes, then curved backward to posterior margin.

Border of free cheek narrower than ocular platform; lateral and posterior border furrows well defined, connected at genal angle. Genal spine slender, tapered to point; length between one and two times length of posterior section of facial suture.

Pygidium has prominent axis that is tapered slightly posteriorly and reaches to inner edge of poorly defined moderately broad, slightly concave border having nearly constant width. Two or three ring furrows present posterior to articulating furrow. Pleural regions crossed by two or three shallow pleural furrows.

Discussion.—This genus includes small simple ptychopariid species from the *Elvinia* zone that are difficult to differentiate, if found out of stratigraphic context, from similar small simple ptychopariids in older and younger faunas. Specimens possibly representing *Dellea* are not common in the Great Basin faunas and have not contributed any significant new information about the genus.

Wilson (1951, p. 636) placed the type species, *D. wilbernsensis*, in synonymy with *Ptychoparia suada* Walcott (1890, p. 274), even though the holotype of *D. wilbernsensis* has a granular outer surface while that of *P. suada* has a smooth surface. Knowledge gained in the study of the Dunderberg fauna about the significance of external ornamentation indicates that in the simple trilobites such intraspecific variation is

unlikely. Although *P. suada* and *D. wilbernsensis* may be congeneric, they are probably not conspecific.

Dellea? punctata n. sp.

Plate 3, figure 8

Diagnosis.—Known only from cranidia. Glabella bluntly rounded anteriorly; distinct small pits in axial furrows at anterolateral corners of glabella. Brim downsloping; sagittal length nearly twice that of slightly convex nearly horizontal border. Fixed cheeks narrow, slightly downsloping; width between one-third and one-fourth basal glabellar width. External surface covered with moderately coarse pits.

Discussion.—This species is characterized particularly by its pitted ornamentation and the anterolateral pits adjacent to the bluntly rounded anterior end of the glabella. The generic assignment is questioned because of the glabellar outline, which is more quadrate than most species assigned to *Dellea* and more nearly like that of *Deadwoodia*. The palpebral lobes of species of *Deadwoodia* are relatively larger and more arcuate than those of *D? punctata*, however, and the species is here considered to be more likely a representative of *Dellea* than *Deadwoodia*.

Occurrence. Rare, upper part of *Elvinia* zone: Eureka and Cherry Creek, Nev.

Genus Dytremacephalus Palmer

Dytremacephalus Palmer, 1954, p. 749; Lochman, 1959, p. 258.

Type species.—*Dytremacephalus granulosus* Palmer, 1954, p. 750, pl. 85, figs. 5, 6.

Description.—Small Elviniidae(?) (total length probably not exceeding 20 mm). Cranidium has glabella well defined by deep axial furrows and somewhat shallower preglabellar furrow, moderately tapered forward, bluntly rounded anteriorly, moderately convex transversely, gently to moderately convex longitudinally. Anterolateral corners generally marked by distinct pits in axial furrows; distance between pits about one-half basal glabellar width. Two or three short deep glabellar furrows generally present. Occipital furrow straight, deep. Occipital ring has distinct median node. Frontal area strongly depressed laterally. Border well defined by narrow generally shallow border furrow, convex; sagittal length generally less than length of convex brim. Anterior margin of cranidium gently to moderately rounded. Fixed cheeks narrow, convex, horizontal or slightly upsloping; width between one-third and one-half basal glabellar width. Distinct eye ridges generally present, directed nearly at right angles to axial line. Palpebral lobes well defined by nearly straight palpebral furrows, situated opposite or slightly anterior to glabellar midlength; exsagittal length slightly more than one-half glabellar length on specimens having glabellar length less than 2 mm, slightly less than one-half glabellar length on larger specimens. Posterior limbs subtriangular, sharp pointed. Posterior border furrow deep.

Course of anterior section of facial sutures straight forward or slightly divergent from palpebral lobe to border furrow, turned inward across border to cut anterior margin about opposite anterolateral corners of glabella, then curved backward across doublure.

Rostral plate subquadrate. Transverse width greater than sagittal length. Ends indented by sharp curve to fit anterior ends of doublure of free cheek.

Lateral border furrow of free cheek shallow, disappears posteriorly before reaching base of genal spine. Posterior border furrow relatively deep, continued backward onto base of genal spine before disappearing. Genal spine short, sharp; length less than length of posterior section of facial suture.

Pygidium subsemicircular. Axis differentiated from pleural regions by sharp change in slope; axis moderately elevated anteriorly, becoming progressively lower posteriorly, reaching to inner edge of narrow poorly defined border. One or two ring furrows generally present posterior to articulating furrow. Pleural regions crossed by one or two shallow pleural furrows reaching to inner edge of border.

Thorax and hypostome not known.

Discussion.—Most of the definitive features of this genus of small trilobites and its included species are on the cranidium. The relatively large anteriorly tapered glabella having distinct glabellar furrows, the generally well-defined anterolateral pits in the axial furrows, and the well-defined narrow cranidial border are the most distinctive features.

When the genus was first proposed (Palmer, 1954), the well-defined pits in the axial furrows at the anterolateral corners of the glabella seemed to be the most distinctive feature of the genus. This characteristic taken alone may be misleading, however (see *Aphelaspis haguei*, pl. 9 fig. 24).

Dytremacephalus was first believed to be related to *Aphelaspis* (Palmer, 1954, p. 750), principally because of the similarity of *D. laevis* Palmer, known only from cranidia, to some *Aphelaspis* cranidia. Although this relationship seems to be a reasonable possibility for *D. laevis*, *D. granulosus* and *D. asperaxis* n. sp., both represented by many silicified individuals in addition to limestone specimens, seem to be related to the Elviniidae. This relationship is shown particularly

in the structure of the frontal area, which has a narrow convex border, and in the rostral plate, which is transversely subquadrate. When more is learned about the morphology of *D. laevis*, it may be removed from *Dytremacephalus*. Therefore, the genus is here tentatively related to the Elviniidae, although assignment to either of the common subfamilies, the Elviniinae or Dokimocephalinae, does not seem appropriate.

Dytremacephalus granulosus Palmer

Plate 18, figures 14, 16–19, 21

Dytremacephalus granulosus Palmer, 1954, p. 750, pl. 85, figs. 5, 6.

Diagnosis.—Cranidium has moderately convex horizontal fixed cheeks; palpebral lobes situated slightly anterior to glabellar midlength. Line connecting anterior ends of palpebral lobes passes over frontal lobe of glabella on cranidia longer than 3 mm, tangent to front of glabella on smaller specimens. External surfaces of all parts covered with closely spaced fine granules. Surfaces of molds smooth.

Discussion.—This is the oldest of the two named species from the Great Basin. It differs from *D. asperaxis*, which is probably its direct descendant, by having granular ornamentation on all parts rather than confined to the top of the glabella. Several incomplete cranidia in USGS collection 2313-CO from the *Prehousia* zone at Shingle Pass, Nev., have a granular ornamentation and seem to belong to *Dytremacephalus*. They differ from *D. granulosus* by having more posteriorly placed palpebral lobes and may represent an older species. Better material is needed before this older species can be characterized and illustrated, however.

Occurrence. Moderately common, basal part of *Dunderbergia* zone: Bastian Peak, Snake Range, Eureka(?), and Spring Mountains, Nev.; House Range, Utah.

Dytremacephalus asperaxis n. sp.

Plate 18, figures 10–13

Diagnosis.—Cranidium has moderately convex horizontal fixed cheeks. Palpebral lobes situated opposite or slightly anterior to glabellar midlength. External surface has distinct closely spaced granular ornamentation that is generally confined to top of glabella and a few scattered granules on other parts. Surface of mold smooth.

Discussion.—This species is most easily recognized by the presence of a distinct ornamentation on the top of the glabella only. On some specimens, the granules are somewhat merged so that the surface appears coarsely pitted rather than granular.

Occurrence. Moderately common, lower and middle parts of *Dunderbergia zones* Bastian Peak, McGill, Cherry Creek, Grant Range and Eureka, Nev.

Genus LISTROA Palmer

Listroa Palmer, 1962b, p. 40.

Type species.—*Listroa toxoura* Palmer, 1962b, p. 41, pl. 6, figs. 5, 8–10.

Diagnosis.—Pterocephaliinae? (total length less than 40 mm). Cranidium has obscurely furrowed well-defined glabella; border moderately broad, flat, or slightly concave; fixed cheeks nearly horizontal; eye ridges moderately well defined, directed posterolaterally from junction with dorsal furrow; anterior sections of facial sutures diverge forward from palpebral lobes and cut anterior margin at a distinct angle.

Free cheek has broad poorly defined nearly flat border. Lateral and posterior border furrows joined, extend short distance onto genal spine.

Pygidium has short prominent posteriorly tapered axis bearing two or three ring furrows posterior to articulating furrow; tip somewhat elevated. Pleural regions moderately to strongly convex. Broad poorly defined border downsloping or depressed. Posterior margin has moderate to strong median identation.

Discussion.—The slightly flared frontal area and broad flat or only slightly convex border on the cranidium combined with the downsloping border and posterior median notch of the pygidium distinguish this genus from other pterocephaliid trilobites. It is closely related to *Aphelaspis* and the Aphelaspidinae through *L. longifrons* (Palmer), but the structure of the cranidial border of *L. toxoura* Palmer is more like that of the Pterocephalinae. For these reasons *L. toxoura* is considered to be a possible ancestor for the later genera of the Pterocephaliinae.

Listroa toxoura Palmer

Plate 11, figures 1–5

Listroa toxoura Palmer, 1962b, p. 41, pl. 6, figs. 5, 8–10.

Diagnosis.—Cranidial border nearly flat, slightly downsloping, makes gentle angle with brim. Sagittal length of frontal area generally not greater than three-fourths length of glabella. Pygidium has two or three distinct ring furrows posterior to articulating furrow.

Discussion.—This species is characteristically associated with *Aphelaspis subditus* Palmer, A. *haguei* (Hall and Whitfield), and *Olenaspella regularis* Palmer in the upper part of the *Aphelaspis* zone. Rare

occurrences of the species have been noted, however, from the younger *Dicanthopyge* zone.

Variation in the degree of transverse convexity of the pygidium of this species (pl. 11 figs. 3, 4) is probably due to differential compaction. The combination of a median notch and a narrow pygidial doublure along the axis makes the axial line a line of weakness along which the pygidium was easily folded. Variable features that are not attributable to diagenetic distortion are the degree of definition of glabellar furrows and ring furrows on the pygidium.

The only other species presently assigned to *Listroa* is *L. longifrons* (Palmer 1954) from the *Aphelaspis* zone in central Texas. It differs from *L. toxoura* by having a greater angle between the brim and border, a longer frontal area, and generally one less ring furrow on the axis of the pygidium.

Occurrence. Moderately common, upper part of *Aphelaspis* zone: McGill, Cherry Creek, Tybo, Mount Hamilton district, and Highland Range, Nev. Rare, *Dicanthopyge* zone; Yucca Flat, Nev.

Genus MINUPELTIS Palmer

Minupeltis Palmer, 1960a, p. 98.

Type species. — Minupeltis conservator Palmer, 1960a, p. 98, pl. 10, figs. 11, 12.

Description.—Small trilobites (total length probably less than 10 mm). Cranidium subquadrate, gently convex transversely and longitudinally. Glabella prominent, tapered forward; axial furrows at sides bowed slightly outward. Glabellar furrows barely apparent. Occipital furrow straight, narrow. Occipital ring has low median node situated near occipital furrow. Frontal area downsloping; sagittal length slightly less than one-half that of glabella. Brim flat, downsloping. Border convex, nearly horizontal adjacent to shallow border furrow, depressed at margin. Sagittal length of border equal to or greater than length of brim. Fixed cheek gently convex, downsloping; width one-third or slightly more than one-third basal glabellar width. Palpebral lobes barely differentiated from cheek, situated about opposite glabellar midlength; length about one-third that of glabella. Posterior limbs short, bluntly pointed; transverse length about two-thirds basal glabellar width. Posterior border furrow straight, shallow.

Course of anterior section of facial suture nearly straight forward from palpebral lobe to border furrow, then curved abruptly inward across border to cut anterior margin between axial line and point opposite anterolateral corner of glabella. Posterior section nearly straight posterolaterally from palpebral lobe to border furrow, then curved backward to posterior margin.

Free cheek, hypostome, thoracic segments, and pygidium not known. External surfaces of all parts smooth.

Discussion.—This genus is characterized by its downsloping fixed cheeks and frontal area, poorly defined palpebral lobes, and short triangular posterior limbs. With the discovery of a second species, *M. definita* n. sp., the generic description has been rewritten to exclude those characteristics now known to pertain only to the type species, *M. conservator* Palmer. No other trilobite in the Peterocephaliid biomere of the Great Basin resembles this genus closely, and its suprageneric affinities remain uncertain.

Minupeltis conservator Palmer

Plate 18, figure 15

Minupeltis conservator Palmer, 1960a, p. 98, pl. 10, figs. 11, 12.

Diagnosis.—Glabella not defined at front. Frontal area has border furrow, if distinct, shallow, evenly curved, and more or less constant in depth. Sagittal length of border about equal to that of brim.

Discussion.—This species differs most distinctly from *M. definita* n. sp. in the subequal relationship of the brim and border and the poor definition of the front of the glabella.

Occurrence. Rare, middle part of *Dunderbergia* zone: Eureka and Ash Meadows, Nev.; Panamint Range, Calif.

Minupeltis definita n. sp.

Plate 18, figure 20

Diagnosis.—Glabella distinctly defined at front by shallow preglabellar furrow. Frontal area has border furrow distinctly shallower on axial line than at sides. Sagittal length of border nearly twice that of brim.

Discussion.—This species is distinguished from *M. conservator* Palmer principally by its better defined glabella and relatively broader border.

Occurrence. Rare, lower part of *Dunderbergia* zone: Cherry Creek and Spring Mountains, Nev.

Genus MOROSA Palmer

Morosa Palmer, 1960a, p. 98.

Type species.—Morosa longispina Palmer, 1960a, p. 99, pl. 10, figs. 15–17, text-fig. 22.

Diagnosis.—Pterocephaliidae? having axial length of frontal area between one-third and one-half length of glabella. Frontal area subequally divided into well-defined brim and border. Border tapered laterally to a point just before, or at, anterolateral corner of

cranidium. Anterior margin in front view nearly horizontal; course of border furrow in front view strongly bowed upward. Glabella well defined; glabellar furrows barely visible. Fixed cheeks narrow, gently convex, nearly horizontal; width between one-third and one-fourth basal glabellar width. Palpebral lobes prominent, situated about opposite or slightly anterior to glabellar midlength. Occipital ring has prominent node or short spine at posterior margin.

Free cheek has narrow border. Lateral and posterior marginal furrows moderately well defined, not joined at genal angle, disappear into base of flat slender genal spine.

Pygidium has prominent axis extending to inner edge of moderately wide slightly concave poorly defined border of nearly constant width.

External surfaces of all parts except over glabellar muscle-attachment areas distinctly and moderately coarsely pitted. Surface of mold smooth or pitted.

Discussion.—When this genus was first proposed, its affinities with the Housiidae (here a subfamily of the Pterocephaliidae) were suggested because of the anteriorly situated palpebral lobes and the even width of the pygidial border. However, the structure of the frontal area was pointed out to be distinctly atypical of the Housiidae, and *Morosa* was not assigned to a suprageneric taxon. The addition of more species, particularly *Morosa extensa*, has reaffirmed that the general glabellar structure indicates a possible relationship of the genus to the Peterocephaliidae, but no close relationship to any of the subfamilies is apparent. Cranidia of *Morosa* are best recognized by the even lateral taper of the convex anterior border that becomes nearly absent at the anterolateral cranidial corners.

Morosa brevispina n. sp.

Plate 20, figures 15, 16, 20

Diagnosis.—Crandium has glabella broad-based, moderately tapered forward; width of fixed cheeks between one-fourth and one-fifth basal glabellar width. Free cheek has lateral and posterior border furrows joined at genal angle; posterior part of ocular platform gently to moderately convex; length of genal spine about equal to length of posterior section of facial suture. Axis of pygidium slightly tapered posteriorly; border nearly flat, gently downsloping; terrace lines present only near margin.

Discussion.—This species, although comparable in size to *M. longispina* Palmer, differs by having slightly narrower fixed cheeks, a distinctly shorter genal spine, less tumid posterior part of the ocular platform on the free cheek, and a less downsloping pygidial border that has terrace lines only on its outer part. It differs from *M. extensa* n. sp. by having much narrower fixed cheeks and a much shorter genal spine on the free cheek.

Occurrence. Rare, *Dunderbergia* zone: Quartz spring area and Death Valley, Calif.; Tybo, Nev.

Morosa extensa n. sp.

Plate 20, figures 21–25

Diagnosis.—Cranidium has glabella slightly tapered forward; width of fixed cheeks about one-third basal glabellar width. Free cheek has shallow lateral and posterior border furrows; posterolateral part of ocular platform gently convex; length of genal spine about twice length of posterior section of facial suture. Pygidium has axis gently tapered posteriorly; border gently downsloping.

Discussion.—This species differs from *M. longispina* particularly by having wider fixed cheeks and by lacking a distinct hump at the posterolateral corner of the ocular platform of the free cheek. In addition, the axis of the pygidium is less tapered posteriorly, the border is less downsloping, and the distinct terrace lines characteristic of *M. longispina* are lacking. *M. extensa* is also a larger species. Cranidia have been observed that are nearly twice as large as any assigned to *M. longispina.* The small specimens of *M. extensa* illustrated show that differences between the species are not primarily those of size (refer to pl. 20, figs. 24, 25).

This species superficially resembles *Cernuolimbus depressus* Palmer (p. 69). It differs, however, by having smaller more anteriorly placed palpebral lobes, a convex rather than concave border, and less anteriorly divergent facial sutures.

Occurrence. Rare, lower part of *Dunderbergia* zone: Ruby Range and Yucca Flat, Nev.

Morosa longispina Palmer

Plate 20, figures 17–19

Morosa longispina Palmer, 1960a, p. 99, pl. 10, figs. 15–17, text figure 22.

Diagnosis.—Cranidium has glabella broad based, moderately tapered forward. Width of fixed cheeks about one-fourth basal glabellar width. Free cheek has moderately well defined lateral and posterior border furrows; posterolateral corners of ocular platform distinctly humped; length of genal spine about twice length of posterior section of facial suture. Pygidium has axis moderately tapered posteriorly. Border mod-

erately to steeply downsloping, covered with distinct terrace lines.

Discussion.—The structure of the free cheek and the ornamentation of the pygidial border are the most distinctive features of this species. Differences between *M. longispina* and *M. extensa* n. sp. are discussed under *M. extensa.*

Occurrence. Common, middle part of *Dunderbergia* zone: Eureka, Nev.

Genus STENAMBON n. gen.

Type species.—*Stenambon megagranulus* n. sp.

Diagnosis.—Aphelaspidinae? in which the cranidium has a well-defined narrow convex border; sagittal length distinctly less than length of brim. Glabella has two or three pairs of well-defined nearly straight glabellar furrows; posterior pair inclined backward at about 45° to axial furrow. Occipital furrow deep, narrow at sides of glabella, shallow on axial line. Fixed cheeks narrow, nearly horizontal; width one-third to one-fifth basal glabellar width, narrowest on large specimens. Eye ridges prominent, directed abruptly backward at about 30° to axial line. Palpebral lobes well defined, less than one-half glabellar length on larger specimens, situated slightly posterior to glabellar midlength. Posterior limbs slender, sharp-pointed.

Pygidium subovate. Axis prominent, tapered, bears three or four ring furrows posterior to articulating furrow. Pleural regions crossed by three or four well-defined pleural furrows, curved abruptly backward near outer edge of pleural field and extended straight back nearly across broad nearly flat border. Posterior margin has moderately to well formed median notch.

Description.—Small aphelaspinid? trilobites (maximum estimated length 30 mm). Cranidium, exclusive of posterior limbs, elongate and subquadrate in outline, gently convex transversely and longitudinally. Glabella well defined at sides by axial furrows, less well defined anteriorly, tapered slightly forward, bluntly rounded at front. Two or three pairs of glabellar furrows present; posterior two pairs deep, narrow, nearly straight; posterior pair inclined at about 45 degree to axial furrow. Occipital furrow deep, narrow at sides of glabella, shallow on axial line. Frontal area gently downsloping. Brim flat. Border narrow, convex, constant in width, well defined by deep narrow evenly curved border furrow; sagittal length about one-half or less than one-half length of brim; border broadest on larger specimens. Fixed cheeks narrow, nearly horizontal; width between one-third and one-fifth basal glabellar width, narrowest on larger specimens. Eye ridges well defined, directed strongly backward, makes angle of about 30 degree with axial furrow. Palpebral lobes well defined, situated slightly posterior to glabellar midlength; length slightly less than one-half glabellar length, shortest on larger specimens. Posterior limbs slender, have broad shallow medially located posterior border furrow and narrow articulating flange along posterior margin.

Anterior section of facial suture directed anterolaterally from palpebral lobe to border furrow, then curved inward across border to anterior margin near anterolateral corners of cranidium; remainder of course not known. Posterior section divergent, sinuous.

Free cheek, thoracic segments and hypostome not known.

Pygidium subovate. Axis prominent, tapered posteriorly, reaches to inner edge of border, bears three or four ring furrows posterior to articulating furrow. Slender, low postaxial ridge present. Pleural regions gently convex. Pleural fields separated from border by straight shallow furrow. Three or four pleural furrows extend laterally parallel to each other nearly to outer edge of pleural field, then curve abruptly backward and continue most of distance across border. Border broad, nearly flat; width at posterolateral margin about equal to greatest width of pleural field. Posterior margin has moderate to well-formed median notch.

External surfaces of cranidium and pygidium partly or wholly covered with closely spaced granules.

Discussion.—This genus differs from most Aphelaspidinae by having well-defined glabellar furrows, which, together with the narrow fixed cheeks and posteriorly placed palpebral lobes, are its most distinguishing characteristics. An unusual feature is the well-defined articulating flange along the posterior edge of the posterior limb (pl. 11, fig. 18).

Stenambon megagranulus n. sp.

Plate 11, figures 17, 19

Diagnosis.—Cranidium and pygidium distinctly and generally fully covered by abundant moderate to coarse closely spaced granules. Pygidium has four distinct ring furrows posterior to articulating furrow; median notch in border moderately deep.

Discussion.—This species differs from *S. paucigranulus* by having a much more distinct ornamentation and a deeper median notch on the pygidium.

Occurrence. Rare, uppermost part of *Elvinia* zone: Eureka, McGill, and Ruby Range, Nev.

Stenambon paucigranulus n. sp.

Plate 11, figures 12, 16, 18

Diagnosis.—External surfaces of cranidium and pygidium obscurely ornamented by scattered granules.

Some large cranidia have scattered large pits on glabella and cheeks, each pit having a small central granule. Pygidium has three distinct ring furrows posterior to articulating furrow. Posterior median notch broad, shallow.

Discussion.—This species is a much less highly ornamented form than is *S. megagranulus* n. sp., has one less ring furrow on the pygidial axis, and has a shallower median notch.

Occurrence. Rare, uppermost part of *Elvinia* zone: Cherry Creek and Snake Range, Nev.

Genus TAENORA Palmer

Taenora Palmer, 1960a, p. 84.

Type species.—*Taenora expansa* Palmer, 1960a, p. 84, pl. 7, figs. 20–23.

Diagnosis.—Aphelaspidinae? in which the cranidium has a well-defined flat or slightly concave border of nearly constant breadth. Fixed cheeks flat, horizontal; width less than one-third basal glabellar width. Anterior course of facial suture moderately divergent forward from palpebral lobe to marginal furrow, intramarginal along most of anterior margin; it cuts anterior margin nearly imperceptibly near axial line.

Free cheek has moderately broad and flat or slightly concave border; lateral and posterior marginal furrows joined at base of genal spine, extended for short distance onto spine. Genal spine relatively short; length less than that of ocular platform. Pygidium transversely subovate in shape and has poorly defined flat or concave border, either having or lacking slight median indentation. Axial lobe prominent, merged posteriorly with inner part of border. All furrows on pygidium shallow.

Discussion.—This is another rare genus, like *Litocephalus*, that seems to be found in only the more westerly Cambrian sections of Nevada. It is characterized by its nearly flat cranidial border of almost constant breadth and by its simple generally transverse pygidium. Besides the occurrences in the Eureka district, specifically indeterminate specimens probably representing *Taenora* have been identified in collections from the upper part of the *Dunderbergia* zone at Cherry Creek, Nev.

Taenora expansa Palmer

Plate 11, figures 6, 10, 11

Taenora expansa Palmer, 1960a, p. 84, pl. 7, figs. 20–23.

Diagnosis.—Sagittal length of border almost twice length of brim. Palpebral lobes relatively short, about one-third length of glabella. Glabella has moderately well defined glabellar furrows; posterior pair on many specimens Y-shaped. Border of free cheek moderately broad, well defined, distinctly narrowed near base of genal spine. Pygidium short, wide, has distinct median indentation.

Discussion.—*T. expansa* is a rare element of the *Dunderbergia* zone faunas that can be distinguished from associated trilobites by its characteristic cranidial border and its transverse pygidium that has a slight median notch in the posterior margin.

Occurrence. Rare, *Dunderbergia* zone: Eureka and Yucca Flat, Nev.

Genus TUMICEPHALUS n. gen.

Type species.—*Tumicephalus depressus* n. sp.

Diagnosis.—Housiinae? having tumid brim on cephalon. Lateral and posterior border furrows on free cheeks not joined at genal angle. Pygidium short, broad, subtriangular; axis prominent, broad, tapered posteriorly, reaches nearly to posterior margin. Axial preglabellar border and occipital furrows on cranidium and border furrows on cheeks and pleural furrows of thoracic segments characteristically covered with fine to coarse pitted ornamentation, at least on larger specimens.

Description. — Cranidium elongate subquadrate, moderately convex longitudinally, gently to moderately convex transversely. Glabella straight-sided, tapered forward, truncate anteriorly. Glabellar furrows not apparent on external surface. Occipital furrow deep on axial line, shallow or absent at sides of glabella. Occipital ring has low node situated slightly anterior to midlength on axial line. Frontal area divided intc brim and border by sharp change in slope, either has or lacks accompanying shallow border furrow. Brim tumid, causes border to be moderately bowed forward; length one-half or slightly less than one-half that of glabella. Border moderately convex; length between one-third and one-half length of brim. Fixed cheeks horizontal or slightly upsloping; width between one-third and one-half basal glabellar width. Palpebral lobes poorly defined, arcuate, situated slightly anterior to glabellar midlength. Eye ridges low, poorly defined. Posterior limbs subtriangular, broad-based, tapered to sharp point. Posterior border furrow broad, shallow.

Course of anterior section of facial suture slightly divergent forward from palpebral lobe to border furrow, then turned abruptly inward to cross border and cut anterior margin near axial line. Rostral suture submarginal. Connective sutures convergent backward towards axial line. Course of posterior section of facial

suture nearly straight from palpebral lobe to posterior margin of cephalon.

Free cheek has gently curved lateral margin. Genal spine moderately long, straight, slender. Lateral border furrow shallow, disappears posteriorly. Posterior border furrow broad, moderately deep, disappears laterally. Tip of anterior extension of doublure truncate.

Hypostome indistinguishable from that of *Aphelaspis*.

Thoracic segments have short, sharp posterolaterally directed tips. Pleural furrows broad, moderately deep, extended nearly to tip of segment. Number of segments not known.

Pygidium subtriangular; length slightly less than one-half width. Axis prominent, broad, tapered posteriorly, reaches nearly to posterior margin. One to three shallow ring furrows present posterior to articulating furrow, impressed only on top of axis. Pleural regions gently convex. Border poorly defined, narrow, flat. Pleural furrows shallow or absent.

External surfaces of all parts, except furrows of cephalon and thorax, generally smooth. Furrows on all parts except pygidium of many specimens covered with ornamentation of abundant fine to coarse pits. Surfaces of molds of all parts pitted.

Discussion.—This genus is tentatively assigned to the Housiinae because of the character of the border furrows of the free cheek and the poor definition and anterior placement of the palpebral lobes. These features distinguish *Tumicephalus* from all genera of the Aphelaspidinae, although the relationship of the genus to trilobites of this subfamily of the Pterocephaliidae is apparent in the shapes of the glabella and pygidium.

Tumicephalus differs most strikingly from other genera of the Housiinae by having a tumid brim. The small pygidium having a large prominent axis and a narrow border is also unlike pygidia of other genera in the subfamily.

Two species are presently recognized: *T. tumifrons* (Resser) from the southern Appalachians and *T. depressus* n. sp. from the Great Basin region.

Tumicephalus depressus n. sp.

Plate 13, figures 19–23

Diagnosis.—Axial furrows along sides of glabella well defined, deepest opposite palpebral lobes. Preglabellar furrow moderately deep. Fixed cheeks consistently upsloping. Lateral border furrow of free cheek moderately well defined. Pygidium has axis bearing only one shallow ring furrow posterior to articulating furrow; pleural regions lack apparent pleural or border furrows.

Discussion.—This species differs from *T. tumifrons* (Resser) in all the foregoing features. In addition, the pitted ornamentation of the furrows is generally better defined, when present, than it is on the eastern species.

T. depressus is characteristically associated with species of *Dicanthopyge* throughout the Great Basin region.

Occurrence. Common, *Dicanthopyge* zone: Snake Range, McGill, Cherry Creek, Shingle Pass, Ruby Range, and Muddy Mountains, Nev.; Deep Creek and House Ranges, Utah.

Genus XENOCHEILOS Wilson

Xenocheilos Wilson, 1949, p. 43; Lochman, 1959, p. 283.

Type species.—*Xenocheilos minutum* Wilson, 1949, p. 44, pl. 9, figs. 11–13.

Description.—Menomoniidae? having prominent glabella well defined by axial and preglabellar furrows, subparallel sided or tapered slightly forward, generally appearing sunken below adjacent parts of fixed cheeks and frontal area. Two or three pairs of short glabellar furrows may be present adjacent to axial furrows; anterior pair only very slightly apparent on all specimens; posterior pairs shallow or deep. Occipital ring well defined, has median node or spine. Frontal area gently to strongly convex in sagittal profile, divided into distinct brim and border; sagittal length one-half or more than one-half length of glabella. Sagittal length of border less than length of brim. Fixed cheek gently convex, horizontal, or slightly upsloping and one-half or more than one-half basal glabellar width. Distinct eye ridges generally present. Palpebral lobes small, convex, prominent, well defined in posterior part only, situated on line through second pair of glabellar furrows. Posterior limbs long, slender, directed straight laterally or backswept; transverse length greater than basal glabellar width. Posterior border furrow deep. Course of anterior section of facial suture nearly straight forward or slightly convergent from palpebral lobe onto border, then turned inward across border to cut anterior margin about in front of anterolateral corners of glabella. Ventral course not known. Course of posterior section nearly straight posterolaterally, slightly curved backward distally.

Free cheek has well-defined lateral and posterior border furrows joined at genal angle and extended onto base of long slender genal spine. Border convex; width about one-third width of ocular platform at anterior margin. Infraocular ring large, prominent; breadth nearly equal to height of surface of eye. Length of genal spine slightly less than twice length of posterior section of facial suture.

External surfaces of most parts either smooth or have scattered coarse granules. Border of cranidium and free cheek may have distinct terrace lines.

Discussion.—The glabellas of *X. granulosus* n. sp. and *X. minutus* Wilson, the type species, taper slightly forward and have short deep lateral furrows adjacent to the axial furrows; this form is characteristic of many genera of the Menomoniidae and is the reason for tentatively placing *Xenocheilos* in the family.

Xenocheilos is unlike any other genus in the Pterocephaliid biomere. It is most similar to *Bolaspidella*, a Middle Cambrian genus that is one of the less specialized forms in the Menomoniidae. *Xenocheilos* differs from *Bolaspidella* most significantly in having a glabella slightly depressed below the inner parts of the brim and fixed cheeks and in having a wholly different course for the posterior section of the facial suture. In *Bolaspidella*, the posterior section of the facial suture curves around the tip of the posterior limb so that it is directed inward, where it cuts the posterior margin of the cephalon, resulting in a broad rounded notch in the free cheek.

Xenocheilos granulosus n. sp.

Plate 7, figures 6–8

Diagnosis.—Glabella tapered forward, slightly flared at base, has two deep short pairs of glabellar furrows adjacent to axial furrow. Occipital ring has well defined median spine curved upward and backward; length of spine slightly less than length of glabella. Fixed cheeks relatively narrow, slightly upsloping; width about one-half basal glabellar width. Brim strongly convex in sagittal profile; anterior part nearly vertical. Border moderately convex, at right angles to brim in sagittal profile; sagittal length about one-half length of brim. Posterior limb slender, tapered to sharp point, not backswept.

Free cheek, as described for genus.

External surfaces of most parts have scattered low coarse granules. Border on cranidium and free cheek has distinct terrace lines.

Discussion.—This species is most like *X. minutum* Wilson in general appearance. It differs by having an occipital spine, granular external ornamentation, narrower fixed cheeks, and posterior limbs that are not distinctly backswept. Wilson (1951, p. 649) reported that V. E. Kurtz found free cheeks of *Xenocheilos* in Missouri that have long slender genal spines. Kurtz' specimens have not yet been illustrated, and comparison with specimens of *X. granulosus* cannot be made. Wilson's report, indicates, however, that free cheeks of the general type described here for *Xenocheilos* on the basis of specimens associated with *X. granulosus* are probably characteristic of other species in the genus.

Occurrence. Rare, upper part of *Elvinia* zone: Eureka and Shingle Pass, Nev.

Genus and species undetermined 1

Plate 2, figure 15

Description.—Cranidium has prominent glabella moderately to strongly convex transversely, moderately convex longitudinally, well defined at sides by deep axial furrows and across front by slightly less deep preglabellar furrow. Two or three pairs of moderately deep lateral glabellar furrows present; posterior pair deepest and at distinct angle to axial furrow. Occipital furrow broad, deep; occipital ring moderately convex, has distinct median node. Frontal area subequally divided into gently convex brim and moderately convex border by moderately deep nearly straight border furrow; sagittal length about one half that of glabella. Fixed cheeks moderately convex; width about one-half basal glabellar width. Palpebral lobes well defined by arcuate palpebral furrow, situated about opposite glabellar midlength; length about three-eighths that of glabella. Surfaces of all parts of mold covered with scattered coarse granules.

Discussion.—This species is known from only a few incomplete exfoliated cranidia in two collections from the *Aphelaspis* zone. It seems to be most closely related to the Elviniidae, particularly the Dokimocephalinae, in the form of the glabellar furrows fixed cheeks and border, and the ornamentation. Its presence in the *Aphelaspis* zone is further evidence that the Elviniidae was already a separate evolutionary stock from the Pterocephaliidae by the time the trilobites of the Pterocephaliid biomere first appeared in the Great Basin area.

Occurrence. Rare, *Aphelaspis* zone: Tybo, Nev.

Genus and species undetermined 2

Plate 3, figure 15

Description.—Pygidium subsemicircular, moderately convex transversely and longitudinally. Axis prominent, tapered strongly backward, bears two distinct rings and a distinct terminal piece of about equal sagittal length; sagittal length of axis about three-fourths length of pygidium. Pleural regions convex, about equal in width to axis, crossed by two moderately deep pleural furrows and two shallower interpleural furrows that disappear before reaching margin; margin nearly vertical. No distinct border. Surface covered with scattered coarse granules.

Discussion.—This distinctive pygidium cannot be associated with certainty with any identified trilobites. It is known from two collections of about the same age that lack any common species of granular trilobites. However, one collection has *Apachia butlerensis* (Frederickson) and the other has *Pseudosaratogia leptogranulata*? Palmer, both granular forms representing the Dokimocephalinae.

Occurrence. Rare, uppermost part of *Dunderbergia* zone: Bastian Peak and Shingle Pass, Nev.

Genus and species undetermined 3

Plate 3, figure 17

Description.—Cranidium, excluding posterior limbs, subquadrate; sagittal length only about two-thirds width at palpebral lobes. Glabella prominent, tapered forward, well defined by axial and preglabellar furrows, has three moderately distinct pairs of lateral glabellar furrows. Occipital furrow deep. Occipital ring has distinct median node. Frontal area short; sagittal length slightly less than half length of glabella; area subequally divided into gently convex brim and strongly convex, nearly straight border. Border furrow deep, nearly straight. Fixed cheeks broad, moderately convex, nearly horizontal; width about two-thirds basal glabellar width. Palpebral lobes situated about opposite glabellar midlength; form not known. Distinct straight ocular ridges present. Surface of mold covered with closely spaced moderately coarse granules.

Discussion.—This species is represented by a single cranidium that differs from all others in the fauna by being much wider than long. *Deckera* (Frederickson, 1949) is a genus of somewhat similar trilobites that differ from the form described here by having steeply upsloping fixed cheeks and palpebral lobes that are situated opposite the posterior part of the glabella.

Occurrence. Rare, *Dunderbergia* zone: Bastian Peak, Nev.

Genus and species undetermined 4

Plate 16, figures 11–13

Description.—Cranidium, excluding posterior limb, elongate, subquadrate, gently convex transversely and longitudinally; anterior margin broadly rounded. Glabella low, tapered forward, bluntly rounded anteriorly, moderately defined by axial and preglabellar furrows. Lateral glabellar furrows barely apparent. Occipital furrow distinct, shallow. Occipital ring has median node. Frontal area moderately long, has poorly defined concave border about equal in sagittal length to length of gently convex brim; sagittal length between two-thirds and three-fourths length of glabella. Fixed cheeks narrow, horizontal; width slightly less than one-third basal glabellar width. Palpebral lobes poorly defined by palpebral furrow, short, situated slightly anterior to glabellar midlength.

Pygidium has slender axis bearing two or three ring furrows posterior to articulating furrow. Length of axis slightly more than one-half sagittal length of pygidium. Pleural region broad. Border concave, wider than pleural field, not clearly defined. Posterior margin has distinct median inbend.

External surfaces of all known parts covered with distinct pitted ornamentation.

Discussion.—This species is the oldest unequivocal representative of the Pterocephalinae in the Peterocephaliid biomere. It is most similar to *Pterocephalid*? *punctata* n. sp. (pl. 17, figs. 8, 12, 13), from which it differs by having a broadly rounded rather than pointed anterior cranidial margin and a median notch in the pygidium.

Occurrence. Rare, *Prehousia* zone: Ruby Range, Nev.

Genus and species undetermined 5

Plate 16, figure 19

Description.—Cranidium, exclusive of posterior limbs, elongate subquadrate; width between palpebral furrows less than three-fourths total cranidial length; anterior margin moderately rounded. Glabella elongate, slightly tapered forward, bluntly rounded anteriorly, bears two pairs of shallow lateral glabellar furrows. Occipital furrow distinct. Occipital ring has median node. Frontal area has broad concave border having sagittal length slightly more than three times that of nearly flat downsloping brim. Fixed cheeks slightly upsloping, narrow; width between one-half and one-third basal glabellar width. Palpebral lobes long, well defined by arcuate palpebral furrows, situated slightly posterior to glabellar midlength; length almost two-thirds that of glabella; width about two-thirds that of fixed cheek. Posterior limbs long, slender.

Surfaces of all parts of cranidium except palpebral lobe and border covered with fine closely spaced granules; granules apparent only after whitening. Border covered with fine transverse terrace lines.

Discussion.—This is a distinctive species of the Pterocephalinae(?) represented by only a single cranidium. It differs from all others in the subfamily by having an extremely narrow cranidium that has steeply upsloping fixed cheeks and large palpebral lobes. The most similar described species belong to

Sigmocheilus, but more must be learned about the associated parts of this species before it can be confidently assigned to that genus.

Occurrence. Rare, *Dunderbergia* zone: Ruby Range, Nev.

Genus and species undetermined 6

Plate 18, figure 24

Description.—Cranidium small, moderately convex transversely and longitudinally. Glabella prominent, tapered forward, bluntly rounded anteriorly, well defined by deep axial furrows and moderately deep preglabellar furrow. Deep narrow anterolateral fossulae present. Glabellar furrows not apparent. Occipital furrow deep. Occipital ring has median node. Frontal area downsloping; border slightly narrower than brim; border furrow shallow distally, almost absent on axial line. Fixed cheeks convex, slightly upsloping, narrow; width about one-third basal glabellar width. Palpebral lobes small, barely defined by palpebral furrow, situated about opposite glabellar midlength.

External surface smooth.

Discussion.—This small trilobite is characterized particularly by the deep anterolateral fossulae in front of the glabella. Otherwise it is similar to other small generally nondescript forms that appear in the upper part of the Pterocephaliid biomere. Specimens assigned to this species are present in two collections.

Occurrence. Rare, *Elvinia* zone: Eureka, Nev.

STRATIGRAPHIC DATA AND LOCALITY REGISTER

This paper discusses only a part of the total fauna of the Pterocephaliid biomere. The agnostids and brachiopods, particularly, should be reviewed and described at some later date, and much can be learned about details of the stratigraphy of the carbonate facies of the Upper Cambrian using the biostratigraphic framework provided by study of the faunas. Some of this data has already been used for a preliminary synthesis of the more general aspects of the regional Upper Cambrian stratigraphy in White Pine County and vicinity, Nev. (Palmer, 1960b). However, this synthesis is only a beginning, and it is hoped that the data presented on the following pages can serve for continued intensive study of this important Upper Cambrian unit.

Plates 22 and 23 summarize the rock successions of the principal measured sections from which trilobites were obtained for this study (fig. 1) and show the positions of all collections in these sections and the ranges of all identified trilobites. Locality data for additional collections from which illustrated specimens were obtained are also listed.

BASTIAN PEAK SECTION

Location.—Connors Pass quadrangle, White Pine County, Nev. Center of sec. 30 (unsurveyed), T. 15 N., R. 66 E. Measured southwestward along crest of prominent spur 2 miles south of Bastian Peak. (See pl. 22.)

Remarks.—The Bastian Peak section is only a partial section in a badly faulted area. It begins in the uppermost beds of the Lincoln Peak Formation and continues through a varied sequence of limestones that correlate with the Johns Wash Limestone and Corset Spring Shale of the Snake Range.

The Johns Wash Limestone in the Snake Range southeast of the Bastian Peak area is a cliff-forming unit consisting generally of thick-bedded limestones. In the Bastian Peak area, the lower part of the unit temporally correlated with the Johns Wash Limestone is composed of alternations of thick-bedded ledge-forming limestones and thinner bedded less resistant limestones. Further north at McGill, the entire Johns Wash interval is represented by an interbedded sequence of siltstones, shales, and thin-bedded to massive-bedded limestones that characterize the upper part of the Dunderberg Formation. Thus the relatively clean carbonate sediments represented by the Johns Wash Limestone are replaced to the northwest by more argillaceous sediments. The distribution of fossiliferous beds indicates that the argillaceous sediments provided a more favorable environment for the faunas of the time than did the clean carbonate sediments.

The more massive part of the Johns Wash equivalent in the Bastian Peak section is badly fractured, and a reliable thickness could not be obtained. However, above these beds a unit of thin-bedded rubbly weathering limestones correlates with the Corset Spring Shale of the Snake Range. Fine muds that resulted from the erosion of areas east of the present Wasatch Range in Utah after a major Upper Cambrian regression now constitute the Corset Spring Shale. These muds reached the Bastian Peak area probably in insufficient quantity to do more than dilute the carbonate sediment and form the less-resistant rock unit from which collection 3018-CO was obtained.

CHERRY CREEK SECTION

Location.—Unsurveyed area on the east side of the Cherry Creek Range north of the community of Cherry Creek, White Pine County, Nev. (See pl. 23.) The section can be reached by driving 7.1 miles west of U.S. Highway 93 on a paved road leading to Cherry Creek, then turning north on a graded road

for 4.0 miles to a jeep trail leading up a canyon to the west. Rocks of the Pterocephaliid biomere strike across the canyon about 1 mile west of the end of the jeep trail. The section was measured in the canyon bottom from the top of the Hamburg Limestone through the Dunderberg Formation and the Barton Canyon Limestone Member of Young (1960) of the overlying Windfall Formation.

Remarks.—The Cherry Creek section is one of the best exposed sections of the Dunderberg Formation in east-central Nevada. The formation can be divided here into two members of approximately equal thickness that are also recognizable at McGill. The lower member is a slope-forming unit consisting of siltstones and grey fine-grained silty limestone in the form of numerous lenses and thin beds. The member is lithologically little different from contemporaneous parts of the Lincoln Peak Formation in the Snake Range and at Bastian Peak. The upper member is characterized by interbedded siltstone and nodular or massive ledge-forming limestone having a slightly lighter color and less silt than the underlying limestones. The varied lithologies come in consistent cyclic sequences, indicating frequent fluctuation of conditions between clean-carbonate and silty mud deposition. An ideal cycle begins with siltstone, which is followed by siltstone containing lenses of gray silty limestone; nodular argillaceous limestone occurs next and is overlain by a thick bed of relatively clean limestone containing only fine argillaceous partings. Many partial cycles are shown in the limestone ledges, where the upper and lower parts are formed of the limestone containing argillaceous partings and the middle part is formed of nodular limestone. Trilobites are most common in the more argillaceous limestones.

The Barton Canyon Limestone Member of Young (1960) of the Windfall Formation is a distinctive cliff-forming nearly pure limestone that weathers nearly white; it represents a brief return of stable clean-carbonate sedimentation to the region. Its upper contact with thin-bedded grey silty and cherty limestones nearly coincides with the sudden annihilation of most of the elements of the Pterocephaliid biomere by a new invading fauna. Only the lower few inches of these darker limestones contain the distinctive *Irvingella major* fauna that is the terminal fauna of the Pterocephaliid biomere.

EUREKA SECTION

Location.—Eureka Mining district, Eureka County, Nev. The section (pl. 23) was measured eastward across the Dunderberg and lower part of the Windfall Formation on a low spur between the road fork in Windfall Canyon and mine shafts numbered 68 and 69, shown on the south part of the geologic map of the Eureka mining district (Nolan, 1962, pl. 1).

Remarks.—The illustration given here shows only the locations of faunas found in the basal unit of the Windfall Formation that overlies the Dunderberg Shale. This basal unit is a distinctive thick-bedded noncherty limestone about 28 feet thick that is overlain by thin-bedded dark-grey cherty limestones. The lower 18 feet of this unit contains a large fauna of the *Elvinia* zone. The upper 10 feet contains at least two different younger trilobite faunas unrelated to any of the faunas of the Pterocephaliid biomere.

Exposures of the Dunderberg Shale are generally poor throughout the Eureka district, and the sequence of faunas that has been determined is given in an earlier paper (Palmer, 1960a, p. 57).

The formation at Eureka contains considerably fewer interbedded limestones than occur in correlative parts of the formation at Cherry Creek and McGill. The limestones are mostly concentrated in an interval about 60 feet thick that is present about 100 feet below the top of the principal shale unit. The contact of the Dunderberg Shale with the underlying Hamburg Dolomite is a zone of disturbance throughout the area. The amount of section missing, if any, is uncertain because of lack of information about the age of the uppermost beds of the Hamburg Dolomite.

McGILL SECTION

Location.—Ely quadrangle, White Pine County, Nev. The McGill section (pl. 23) was measured on the top and east flanks of prominent north-trending spur on the west side of the Duck Creek Range; the locality is reached by driving 1.35 miles north of McGill Post Office, turning right onto abandoned section of U.S. Highway 93, continuing 0.6 mile to jeep trail leading up slope to the east, crossing a large pipeline, and continuing into a small canyon. White limestones at mouth of canyon are the Barton Canyon Limestone Member of Young (1960) of the Windfall Formation. The beds of the underlying Dunderberg Formation are exposed further up the canyon to the west of the road before the first switchback.

Remarks.—Although the McGill section is broken into two parts by faults, it is still one of the stratigraphically most important and most fossiliferous sections of the Pterocephaliid biomere. The lower part contains a considerable thickness of the *Aphelaspis* zone and includes trilobites from the basal 40 feet that are known elsewhere only at Mount Hamilton and the Osgood Mountains, Nev., and Cedar

Bluff, Ala., where structural complications prevent description of a section. These lower beds are probably the temporal equivalents of the upper beds of the Crepicephalid biomere of the southern and eastern Great Basin (Palmer, 1962b, p. 8, 9). The remainder of the section is faunally and lithically comparable to the less faulted section at Cherry Creek. The absence of the lower beds of the *Aphelaspis* zone in the otherwise comparable section at Cerry Creek may be related to a possible topographic high point on the carbonate sediments of the older Hamburg Limestone (Palmer, 1962b, p. 10). In addition to the unusual occurrence of the *Aphelaspis* zone in the McGill section, the evolutionary sequence of five species, from *Aphelaspis haguei* (Hall and Whitfield) to *Dicanthopyge reductus* n. sp. (p. 15), can be documented from specimens occurring here.

RUBY RANGE SECTION

Location.—Jiggs quadrangle, White Pine County, Nev. The Ruby Range section (pl. 22) was measured upslope on the west side of the southern Ruby Range along a spur in the SW¼ sec. 36, T. 26 N., R. 56 E., beginning at the lowest limestone bed east of a saddle about half a mile east-southeast of hill 8093 and about 4 miles east of the headquarters of the Juaristi Ranch.

Remarks.—The Ruby Range section is cut off in the *Dunderbergia* zone by a fault. Most of the upper beds of the Pterocephaliid biomere are exposed about half a mile north of the measured section, where a succession of nodular and crinkly bedded limestones is capped by a unit of thin-bedded, grey laminated limestones containing the *Irvingella major* fauna (USGS colln. 2587–CO) in the lower part. No other fossils were found in this upper segment.

The lower part of this section is the most significant for regional stratigraphy. Below the limestones containing *Dicanthopyge* at the base of the measured part of the section is an apparently continuous unfossiliferous sequence of siltstones and shales more than 1,000 feet thick, which appear to be conformable on the fossiliferous late Middle Cambrian limestones that form the crest of hill 8093. In the nearest known Cambrian sections of Eureka and Cherry Creek, contemporaneous beds of comparable thickness are clean carbonates of the Hamburg Dolomite or Limestone.

SHINGLE PASS SECTION

Location.—West side of Egan Range about 1 mile south of road crossing Shingle Pass, SE¼, sec. 26, T. 8 N., R. 62 E. The Shingle Pass section (pl. 22) was measured up the lower part of prominent west-facing limestone outcrops, beginning where the lower massive cliff intersects the alluvium.

Remarks.—The Shingle Pass section shows the magnitude of some of the facies changes in the central Great Basin during the time of the Pterocephaliid biomere. A similar section is present at Patterson Pass in the Schell Creek Range about 13 miles to the east. Almost the entire interval of deposits of the Pterocephaliid biomere is composed of clean carbonate sediments of many types. Small stromatolites, having a preserved algal microstructure, are present at several levels. The limestones between the beds from which USGS collections 2561–CO and 2313–CO were made are nearly all strongly crossbedded echinodermal calcarenites. Crossbedded oolitic limestones are also common. Beds in the Snake Range, McGill, Cherry Creek, and Ruby Range sections and those at Mount Hamilton and Tybo that are contemporaneous with the lower 500–600 feet of the Shingle Pass section are dominantly silstones interbedded with silty limestones. Carbonate sediments similar to those in the Shingle Pass section are found in the Johns Wash Limestone of the Snake Range, which is contemporaneous only with the limestones just below the Corset Spring Shale in the Shingle Pass section. Thus the Johns Wash Limestone increases greatly in thickness between the Snake Range and Shingle Pass sections owing to the lateral shift in facies from silty sediments of the upper part of the Lincoln Peak Formation to clean carbonate sediments.

The uppermost beds of the Shingle Pass section are also significant for regional stratigraphy. USGS collections 2566–CO and 2567–CO come from thin limestones interbedded with chert just above the Corset Spring Shale. Throughout the Great Basin, the limestones in the lower part of the Windfall Formation and its correlatives are characterized by abundant beds and lenses of chert. Generally, this is the first appearance of significant amounts of chert in the entire Cambrian section. However, the evidence in the Shingle Pass section indicates that the cherts do not appear at the same time over the central Great Basin region. In the Shingle Pass section, chert beds are present in the upper part of the *Elvinia* zone. At Eureka, chert appears first associated with trilobites that are at least two zones younger.

SNAKE RANGE SECTION

Location.—Wheeler Peak quadrangle, Lincoln County, Nev. The Snake Range section (pl. 22) was measured up the south side of Lincoln Canyon at the head of Johns Wash, about 1 mile southwest of Lincoln Peak on the west side of the Snake Range.

Remarks.—The Snake Range section is the type section for the Lincoln Peak Formation, Johns Wash

Limestone and Corset Spring Shale (Drewes and Palmer, 1957). Supplemental faunal data for the lower part of the Corset Spring Shale is provided from USGS collections 3109-CO, 3110-CO, and 3114-CO, which come from a section comparable to the type section on the steep slope just east of Lincoln Peak.

YUCCA FLAT SECTION

Location.—Tippipah Spring NE quadrangle, Nye County, Nev. The Yucca Flat section (pl. 23) was measured in the saddle between the Bonanza King and Windfall Formations on the east side of Banded Mountain, east of Yucca Flat (Nevada grid square 690–868).

Remarks.—The Yucca Flat section is one of the most fossiliferous sections of the Pterocephaliid biomere in southern Nevada. The general stratigraphy of the interval is characteristic for most localities in Nye and Clark Counties, Nev., and in the Death Valley region of California. The section contrasts markedly in thickness with the sections in White Pine County and vicinity. The *Dunderbergia* and *Elvinia* zones at Yucca Flat are only slightly thinner than in the central Great Basin. However, the *Aphelaspis* and *Dicanthopyge* zones are compressed into 35 feet of clean carbonate sediments at the top of the Bonanza King Formation, and no beds of the *Prehousia* zone have been found between the top of the Bonanza King Formation and the first limestone bed containing trilobites of the *Dunderbergia* zone, 25 feet above the base of the Dunderberg Formation. Trilobites of the *Prehousia* zone have been found, however, at localities in the Spring Mountains and Muddy Mountains in Clark County.

The interval between the *Dunderbergia* zone and the base of the *Aphelaspis* zone is only 60 feet in the Yucca Flat section compared with more than 200 feet in the silty sequences of the McGill and Cherry Creek sections and more than 500 feet in the clean carbonate section at Shingle Pass. More work is needed on critical sections between White Pine County and southern Nevada to determine the events causing the contrasts in stratigraphy of the two regions.

MISCELLANEOUS COLLECTIONS THAT YIELDED ILLUSTRATED SPECIMENS

USGS collection	*Locality description and collector*
756–CO	California, Inyo County, Ubehebe Peak quadrangle, lower Nopah Formation. Last Chance foothills, 2.8 miles S. 79° W. of Quartz Spring. J. F. McAllister, 1950.
795–CO	Nevada, Eureka County, Pinto Summit quadrangle, Dunderberg Shale. On road to Catlin shaft, about 250 ft from New York Canyon road. About 760 ft S. 29° E. of the Catlin shaft. Josiah Bridge, 1939.
809–CO	Nevada, Eureka County, Pinto Summit quadrangle, Dunderberg Shale. Southwest slope of Hoosac Mountain, east of high pinnacle of Hamburg Dolomite. East of spring in tributary of Secret Canyon. About 4,980 ft S. 5° E. of the Windfall shaft. Josiah Bridge, 1939.
825–CO	Nevada, Eureka County, Eureka quadrangle, basal Windfall Formation. Hill northeast of Richmond shaft, just above old railroad grade, 760 ft N. 40° E. of Richmond shaft. Josiah Bridge, 1939.
864–CO	Nevada, Eureka County, Eureka quadrangle, Dunderberg Shale. North side of Widewest Canyon. About 900 ft N. 55° E. of Cyanide shaft. Josiah Bridge, 1939.
872–CO	Nevada, Eureka County, Eureka quadrangle, Dunderberg Shale. Dump of prospect 1,350 ft N. 64° W. of U.S. Mineral Marker 10, near Bullwhacker mine (northern 1 of 2 prospects close together). Josiah Bridge, 1939.
873–CO	Nevada, Eureka County, Eureka quadrangle, Dunderberg Shale. Dump of prospect 1,300 ft S. 74° W. of U.S. Mineral Marker 10. Josiah Bridge, 1939.
1268–CO	California, Inyo County, Ballarat quadrangle, basal Nopah Formation. North slopes of deep saddle at south end of the first long north-trending ridge west of the Quartz Springs fork of the Lippincotts road. Death Valley National Monument. J. F. McAllister, 1948.
1271–CO	California, Inyo County, Ballarat quadrangle, basal Nopah Formation. From shales in sharp gully about 1,000 ft northwest of collection 1268–CO locality and about 2,000 ft almost due north of BM 5330. J. F. McAllister, 1948.
1297–CO	Nevada, Eureka County, Pinto Summit quadrangle, Dunderberg Shale. East side of Ratto canyon; first baked shale outcrop seen after entering from south. Josiah Bridge, 1939.
1471–CO	Nevada, Nye County, Tybo district, Hales Limestone. About 10 ft above base of Hales Limestone north of road to Hales mine. A. R. Palmer, 1953.
1478–CO	Utah, Tooele County, Gold Hill quadrangle, Hicks Formation. NW¼, sec. 33, T. 9 S, R. 18 W.; highest limestone coquina just below white-weathering dolomite. Alt. about 8,125 ft. A. R. Palmer, 1953.
1479–CO	Utah, Tooele County, Gold Hill quadrangle, Hicks Formation. NW¼, sec. 33, T. 9 S., R. 18 W., lower beds of 70-ft limestone unit. A. R. Palmer, 1953.
1993–CO	Nevada, Clark County, Las Vegas quadrangle, Dunderberg Formation. South side of Macks Canyon, SE¼ sec. 27, T. 18 S., R. 56 E. C. R. Longwell, 1954.
2316–CO	Nevada, Lincoln County, Highland Peak quadrangle, Mendha Formation. On northeast side of main road, southwest of Arizona Peak, SE¼, NE¼ sec. 22, T. 1 N., R. 66 E. A. R. Palmer, 1957.

USGS collection	*Locality description and collector*
2318–CO	Nevada, Lincoln County, Highland Peak quadrangle. North side of Anderson Canyon about 25 ft above road, NW¼, NE¼, sec. 34, T. 1 N., R. 66 E. A. R. Palmer, 1957.
2432–CO	Nevada, Lincoln County, Highland Range, Mendha Formation. West side of middle row of hills in Highland Range about 5 miles north of U.S. Highway 93. C. M. Tschanz, 1957.
2457–CO	Nevada, Nye County, Ash Meadows quadrangle, basal Nopah Formation. Lowest outcrop on east side of hill 2¾ miles N. 20° W. from Devils Hole. Harald Drewes, 1958.
2612–CO	Utah, Tooele County, unsurveyed part of Deep Creek Range, Hicks Formation. North side of Goshute Canyon on crest of ridge, about 20 ft below thin sandy interval at top of Hicks Formation. A. R. Palmer, 1958.
2977–CO	Utah, Millard County, House Range, Orr Formation. North side of Granite Canyon; thin limestone in upper shaly member of Orr Formation. A. R. Palmer, 1959.
2996–CO	Utah, Millard County, House Range, Orr Formation. South side of unnamed canyon just south of Weeks Canyon, about 20 ft above algal stromatolites at top of lower limestone member of Orr Formation. A. R. Palmer, 1959.
2997–CO	Utah, Millard County, House Range, Orr Formation. Same locality as for 2996–CO, about 100 ft below top of middle silty limestone and siltstone member of Orr Formation. A. R. Palmer, 1959.
2998–CO	Utah, Millard County, House Range, Orr Formation. Same locality as for 2996–CO, about 20 ft below top of middle silty limestone member of Orr Formation.
2999–CO	Utah, Millard County, House Range, Orr Formation. Same locality as for 2996–CO, about 5 ft below top of middle silty limestone member of Orr Formation. A. R. Palmer, 1959.
3000–CO	Nevada, White Pine County, Schell Peaks quadrangle, Lincoln Peak Formation. Float on west slope of small knob just west of Cleve Creek, about 1.6 miles east-southeast of Kolcheck mine. A. R. Palmer, 1959.
3057–CO	Nevada, Nye County, Tybo district, Swarbrick Formation. From upper 10 ft of Swarbrick Formation at east end of exposures, east side of gully entering Tybo Canyon about 350 ft north of Tybo Canyon road. A. R. Palmer, 1959.
3060–CO	Nevada, Nye County, Tybo district, Tybo Shale. In eastern belt of Tybo Shale exposures, about middle of formation. Limestone bed near top of low shale knob about 1,000 ft north of Tybo Canyon road. A. R. Palmer, 1959.
3061–CO	Nevada, Nye County, Tybo district, Tybo Shale. Same locality as for 3060–CO, about 300 ft to west. A. R. Palmer, 1959.
3081–CO	Utah, Millard County, House Range, Orr Formation. E½, sec. 33, T. 19 S., R. 14 W., 2 miles south-southwest of Notch Peak. Upper shale member of Orr Formation. R. K. Hose, 1959.
3412–CO	Utah, Millard County, House Range, Orr Formation. Same locality as for 3081–CO. Upper 6 ft of middle silty limestone and shale member of Orr Formation. R. K. Hose, 1959.
3473–CO	Utah, Millard County, House Range, Orr Formation. Twenty feet below top of middle silty limestone member of Orr Formation. Same locality as for 3081. L. F. Hintze, 1960.
3820–CO	Nevada, White Pine County, Jiggs quadrangle, unnamed formation. Walker Creek area, near Ruby Range section. R. P. Sharp, 1942.
7j	Nevada, Nye County, Quinn Canyon Range, Dunderberg(?) Shale. One mile northwest of the Italian Ranch foothills. J. E. Spurr, 1899.
33d	Utah, Juab County, Fish Springs Range, Orr Formation. Thin-bedded blue limestone at the base of the first high point southwest of the J. J. Thomas ranch, east side of Fish Springs Range. L. D. Burling, 1905.
60	Nevada, Eureka County, Eureka quadrangle, Dunderberg(?) Shale. Limestone across the canyon from the dump of the old Richmond mine shaft. C. D. Walcott, 1880.
61	Nevada, Eureka County, Pinto Summit quadrangle, Dunderberg Shale. A little south of the Hamburg mine. C. D. Walcott, 1882.
62	Nevada, Eureka County, Eureka quadrangle, Dunderberg Shale. In canyon just north of Adams Hill. C. D. Walcott, 1880.
63	Nevada, Eureka County, Eureka quadrangle, Dunderberg(?) Shale. At the base of the Pogonip Group northeast of Adams Hill. Arnold Hague and J. P. Iddings, 1880.

REFERENCES

Bell, W. C., and Ellinwood, H. L., 1962, Upper Franconian and Lower Trempealeauan Cambrian trilobites and brachiopods, Wilberns formation, central Texas: Jour. Paleontology, v. 36, no. 3, p. 385–423.

Bell, W. C., and others, 1952, Trilobites of the Franconia formation, southeast Minnesota: Jour. Paleontology, v. 26, no. 2, p. 175–198.

Berkey, C. P., 1898, Geology of the St. Croix Dalles: Am. Geologist, v. 21, p. 270–294.

Bridge, Josiah, 1933, *in* Sellards, E. H., Adkins, W. S., and Plummer, F. B., Stratigraphy v. 1 of The geology of Texas: Texas Univ. Bull. 3232, p. 231–234.

Bridge, Josiah, and Girty, G. H., 1937, A redescription of Ferdinand Roemer's Paleozoic types from Texas: U.S. Geol. Survey Prof. Paper 186–M, p. 239–271.

Butts, Charles, 1926, The Paleozoic rocks, *in* Adams, G. I., and others, Geology of Alabama: Alabama Geol. Survey Spec. Rept. 14, p. 41–230.

Deland, C. R., and Shaw, A. B., 1956, Upper Cambrian trilobites from western Wyoming: Jour. Paleontology, v. 30, no. 3, p. 542–562.

Drewes, Harold, and Palmer, A. R., 1957, Cambrian rocks of southern Snake Range, Nevada: Am. Assoc. Petroleum Geologists Bull., v. 41, no. 1, p. 104–120.

Ferguson, H. G., 1933, Geology of the Tybo district, Nevada: Nevada Univ. Bull., v. 27, no. 3, 61 p.

Fisher, D. W., and Hanson, G. F., 1951, Revisions in the geology of Saratoga Springs, New York, and vicinity: Am. Jour. Sci., v. 249, p. 795–814.

Frederickson, E. A., 1948, Upper Cambrian trilobites from Oklahoma: Jour. Paleontology, v. 22, no. 6, p. 798–803.

———1949, Trilobite fauna of the Upper Cambrian Honey Creek formation: Jour. Paleontology, v. 23, no. 4, p. 341–363.

Gaines, R. B., 1951, Statistical study of *Irvingella*, Upper Cambrian trilobite: Texas Jour. Sci., v. 3, no. 4, p. 606–615.

Hall, James, and Whitfield, R. P., 1877, Paleontology: fossils of the Potsdam Group: U.S. Geol. Explor. 40th Parallel (King), v. 4, p. 199–231.

Harrington, H. J., and others, 1959, Treatise on invertebrate paleontology, part O, Arthropoda 1: New York and Lawrence, Kans., Geol. Soc. America and Univ. Kansas Press, 560 p., 415 text figs.

Hazzard, J. C., 1937, Paleozoic section in the Nopah and Resting Springs Mountains, Inyo County, California: California Jour. Mines and Geology, v. 33, p. 273–339.

Henningsmoen, Gunnar, 1957, The trilobite family Olenidae: Norske vidensk.-akad. Oslo Skr., no. 1, 303 p.

Howell, B. F., 1959, *in* Harrington, H. J., and others, 1959.

Howell, B. F., and others, 1944, Correlation of the Cambrian formations of North America (chart 1): Geol. Soc. America Bull., v. 55, no. 8, p. 993–1003.

Ivshin, N. K., 1956, Verkhnekembriyskiy trilobity Kazakhstana, chast' I: Akad. Nauk Kazakhskoy SSR, Inst. Geol. Nauk, Alma-Ata, 119 p.

Kobayashi, Teiichi, 1935, The Cambro-Ordovician formations and faunas of south Chosen; Palaeontology, pt. 3; Tokyo Univ. Fac. Sci. Jour., sec. 2, v. 4, p. 49–344.

———1936, On the *Parabolinella* fauna from province Jujuy, Argentina with a note on the Olenidae: Japanese Jour. Geology and Geography, v. 13, no. 1–2, p. 85–102.

———1938, Upper Cambrian fossils from British Columbia with a discussion on the isolated occurrence of the so-called *Olenus* beds of Mt. Jubilee: Japanese Jour. Geology and Geography, v. 15, no. 3–4, p. 151–192.

———1953, On the Kainellidae: Japanese Jour. Geology and Geography, v. 23, p. 37–61.

———1954, On the Komaspidae: Japanese Jour. Geology and Geography, v. 24, p. 23–44.

———1960, The Cambro-Ordovician formations and faunas of south Korea; pt. 6, Palaeontology V: Tokyo Univ. Fac. Sci. Jour., sec. 2, v. 12, pt. 2, p. 217–275.

———1962, The Cambro-Ordovician formations and faunas of south Korea; pt. 9, Palaeontology VIII: Tokyo Univ. Fac. Sci. Jour., sec. 2, v. 14, pt. 1, p. 1–152.

Kobayashi, Teiichi, and Ichikawa, Takeo, 1955, Discovery of *Proceratopyge* in the *Chuangia* zone in Manchuria, with a note on the Ceratopygidae: Paleont. Soc. Japan Trans. and Proc., new ser., no. 19, p. 65–72.

Kurtz, V. E., 1952, *in* Bell, W. C., and others, 1952.

Lermontova, E. V., 1940, *in* Vologdin, A. G., and others, Cambrian, v. 1 *of* Atlas of the leading forms of the fossil faunas of the U.S.S.R.: Moscow, All-Union Sci. and Prosp. Inst., Geol. Comm., 194 p.

Lochman, Christina, 1938a, Upper Cambrian faunas of the Cap Mountain formation of Texas: Jour. Paleontology, v. 12, no. 1, p. 72–85.

———1938b, Middle and Upper Cambrian faunas from western Newfoundland: Jour. Paleontology, v. 12, no. 5, p. 461–477.

———1940a, Fauna of the basal Bonneterre dolomite (Upper Cambrian) of southeastern Missouri: Jour. Paleontology, v. 14, no. 1, p. 1–53.

———1940b, Corrections to the basal Bonneterre fauna: Jour. Paleontology, v. 14, no. 5, p. 515.

———1950, Upper Cambrian faunas of the Little Rocky Mountains, Montana: Jour. Paleontology, v. 24, no. 3, p. 322–349.

———1953a, Notes on Cambrian trilobites—homonyms and synonyms: Jour. Paleontology, v. 27, no. 6, p. 886–889.

———1953b, Analysis and discussion of nine Cambrian trilobite families: Jour. Paleontology, v. 27, no. 6, p. 889–896.

———1956, The evolution of some Upper Cambrian and Lower Ordovician trilobite families: Jour. Paleontology, v. 30, no. 3, p. 445–462.

———1959, *in* Harrington, H. J., and others, 1959.

Lochman, Christina, and Duncan, Donald, 1944, Early Upper Cambrian faunas of central Montana: Geol. Soc. America Spec. Paper 54, 179 p.

Lochman, Christina, and Hu, C. H., 1960, Pt. 1 *of* Upper Cambrian faunas from the northwest Wind River mountains, Wyoming: Jour. Paleontology, v. 34, no. 5, p. 793–834.

———1962, An *Aphelaspis* zone faunule from Logan, Montana: Jour. Paleontology v. 36, no. 3, p. 431–441.

Lochman, Christina, and Wilson, J. L., 1958, Cambrian biostratigraphy in North America: Jour. Paleontology, v. 32, no. 2, p. 312–350.

Lu, Y. H., 1957, Pt. 3 *of* Index fossils of China, Invertebrate: Peking, Acad. Sinica, Inst. Paleontology, Geol. Press, p. 249–294.

Mason, J. F., 1938, Cambrian faunal succession in Nevada and California: Jour. Paleontology, v. 12, no. 3, p. 287–294.

Miller, B. M., 1936, Cambrian trilobites from northwestern Wyoming: Jour. Paleontology, v. 10, no. 1, p. 23–34.

Morris, H. T., 1957, General geology of the East Tintic Mountains, Utah, *in* Utah Geol. Soc., Guidebook to the geology of Utah: no. 12, p. 1–56.

Nelson, C. A., 1951, Cambrian trilobites from the St. Croix Valley: Jour. Paleontology, v. 25, no. 6, p. 765–784.

Nolan, T. B., 1935, The Gold Hill mining district, Utah: U.S. Geol. Survey Prof. Paper 177, 172 p.

———1962, The Eureka mining district, Nevada: U.S. Geol. Survey Prof. Paper 406, 78 p.

Nolan, T. B., and others, 1956, The stratigraphic section in the vicinity of Eureka, Nevada: U.S. Geol. Survey Prof. Paper 276, 77 p.

Öpik, A. A., 1961, Alimentary caeca of agnostids and other trilobites: Palaeontology, v. 3, no. 4, p. 410–438.

———1963, Early Upper Cambrian fossils from Queensland: Australia, Bur. Mineral Resources, Geology and Geophysics, Bull. 64, 124 p.

Öpik, A. A., and Pritchard, P. W., 1960, Cambrian and Ordovician, *in* Hill, Dorothy, and Denmead, A. K., eds., The geology of Queensland: Geol. Soc. Australia Jour., v. 7, p. 89–114.

Palmer, A. R., 1953, *Aphelaspis* Resser and its genotype: Jour. Paleontology, v. 27, no. 1, p. 157.

———1954, The faunas of the Riley formation in central Texas: Jour. Paleontology, v. 28, no. 6, p. 709–786.

———1955, Upper Cambrian Agnostidae of the Eureka district, Nevada: Jour. Paleontology, v. 29, no. 1, p. 86–101.

———1956, The type species of *Litocephalus* Resser, 1937 (Trilobita): Jour. Paleontology, v. 30, no. 3, p. 608–610

Palmer, A. R., 1960a, Trilobites of the Upper Cambrian Dunderberg shale in the Eureka district, Nevada: U.S. Geol. Survey Prof. Paper 334–C, p. 53–109.

———1960b, Some aspects of the early Upper Cambrian stratigraphy of White Pine County, Nevada, and vicinity, *in* Intermountain Assoc. Petroleum Geologists, Guidebook to the geology of east central Nevada: Salt Lake City, Utah, p. 53–58.

———1962a, Comparative ontogeny of some opisthoparian, gonatoparian, and proparian Upper Cambrian trilobites: Jour. Paleontology, v. 36, no. 1, p. 87–96.

———1962b, *Glyptagnostus* and associated trilobites in the United States: U. S. Geol. Survey Prof. Paper 374–F, 49 p.

———1965, The biomere—a new kind of biostratigraphic unit: Jour. Paleontology, v. 39, no. 1. [In press.]

Rasetti, Franco, 1943, New Lower Ordovician trilobites from Levis, Quebec: Jour. Paleontology, v. 17, no. 1, p. 101–104.

———1945, New Upper Cambrian trilobites from the Levis conglomerate: Jour. Paleontology, v. 19, no. 5, p. 462–478.

———1946, Early Upper Cambrian trilobites from western Gaspe [Quebec]: Jour. Paleontology, v. 20, no. 5, p. 442–462.

———1959, *in* Harrington, H. J., and others, 1959.

———1961, Dresbachian and Franconian trilobites of the Conococheague and Frederick limestones of the central Appalachians: Jour. Paleontology, v. 35, no. 1, p. 104–124.

Raymond, P. E., 1937, Upper Cambrian and Lower Ordovician Trilobita and Ostracoda from Vermont: Geol. Soc. America Bull., v. 48, no. 8, p. 1079–1146.

Resser, C. E., 1933, Preliminary generalized Cambrian time scale: Geol. Soc. America Bull., vol. 44, no. 4, p. 735–756.

———1935, Nomenclature of some Cambrian trilobites: Smithsonian Misc. Colln., v. 93, no. 5, 46 p.

———1936, Second contribution to nomenclature of Cambrian trilobites: Smtihsonian Misc. Colln., v. 95, no. 4, 29 p.

———1937, Third contribution to nomenclature of Cambrian trilobites: Smithsonian Misc. Colln., v. 95, no. 22, 29 p.

———1938a, Cambrian system (restricted) of the southern Appalachians: Geol. Soc. America Spec. Paper 15, 140 p.

———1938b, Fourth contribution to nomenclature of Cambrian fossils: Smithsonian Misc. Colln., v. 97, no. 10, 43 p.

———1942a, Fifth contribution to nomenclature of Cambrian fossils: Smithsonian Misc. Colln., v. 101, no. 15, 58 p.

———1942b, New Upper Cambrian trilobites: Smithsonian Misc. Colln., v. 103, no. 5, 136 p.

Robison, R. A., 1960, Some Dresbachian and Franconian trilobites of western Utah: Brigham Young Univ. Research Studies, Geology Ser., v. 7, no. 3, 59 p.

Roemer, Ferdinand, 1849, Texas, mit besondered Rucksicht auf deutsche Auswanderung und die physischen Verhaltnisse des Landes: Bonn, 464 p.

———1852, Die Kreidebildungen von Texas ihre organischen Einschlusse: Bonn, 100 p.

Ross, R. J., Jr., 1951, Stratigraphy of the Garden City formation in northeastern Utah, and its trilobite faunas: Yale Univ., Peabody Mus. Nat. History Bull. 6, 155 p.

Rusconi, Carlos, 1953, Trilobitas Ordovicios y Cambricos de Mendoza: Bol. Paleontologico de Buenos Aires, no. 25, 8 p.

Sharman, George, 1886, On the new species *Olenus nuneatonensis* and *Obolella granulata* from the Lower Silurian ('Cambrian,' Lapworth), near Nuneaton: Geol. Mag., new ser., decade 3, v. 3, p. 565–566.

Shaw, A. B., 1951, New Late Cambrian trilobites, pt. 1 *of* The paleontology of northwestern Vermont: Jour. Paleontology, v. 25, no. 1, p. 97–114.

———1952, Fauna of the Upper Cambrian Rockledge conglomerate near. St. Albans, pt. 2 *of* Paleontology of northwestern Vermont: Jour. Paleontology, v. 26, no. 3, p. 458–483.

———1953, Miscellaneous Cambrian fossils, pt. 3 *of* Paleontology of northwestern Vermont: Jour. Paleontology, v. 27, no. 1. p. 137–146.

———1956, A Cambrian *Aphelaspis* fauna from Steele Butte, near Boulder, Wyoming: Jour. Paleontology, v. 30, no. 1, p. 48–52.

Shimer, H. W., and Shrock, R. R., 1944, Index fossils of North America: New York, John Wiley, 837 p.

Shumard, B. F., 1861, The primordial zone of Texas, with descriptions of new fossils: Am. Jour. Sci., 2d ser., v. 32, p. 213–221.

Troedsson, G. T., 1937, On the Cambro-Ordovician faunas of western Qurug Tagh, eastern Tien-shan: Paleontologica Sinica, new ser. B, no. 2, whole ser. no. 106, 74 p.

Walcott, C. D., 1884,, Paleontology of the Eureka district: U.S. Geol. Survey Mon. 8, 298 p.

———1899, Cambrian fossils of the Yellowstone National Park: U.S. Geol. Survey Mon. 32, p. 440–478.

———1908, Cambrian sections of the Cordilleran area: Smithsonian Misc. Colln., v. 53, p. 167–230.

———1912, New York Potsdam-Hoyt fauna: Smithsonian Misc. Colln., v. 57, no. 9, p. 251–304.

———1914, *Dikelocephalus* and other genera of the Dikelocephalinae: Smithsonian Misc. Colln., v. 57, no. 13, p. 345–412.

———1916, Cambrian trilobites: Smithsonian Misc. Colln., v. 64, no. 5, p. 303–456.

———1924, Cambrian and Lower Ozarkian trilobites, pt. 5, no. 2 *of* Cambrian geology and paleontology: Smithsonian Misc. Colln., v. 75, no. 2, p. 53–60.

———1925, Cambrian and Ozarkian trilobites, pt. 5, no. 3 *of* Cambrian geology and paleontology: Smithsonian Misc. Colln., v. 75, no. 3, p. 61–146.

Walcott, C. D., and Resser, C. E., 1924, Trilobites from the Ozarkian sandstones of the island of Novaya Zemlya: Kristiana [Olso], A. W. Brøggers, 14 p. (Report of the scientific results of the Norwegian expedition to Novaya Zemlya 1921, no. 24. Pub. by Videnskapsselskapet i Kristiania.)

Westergard, A. H., 1947, Supplementary notes on the Upper Cambrian trilobites of Sweden: Sveriges Geol. Undersökning, ser. C, no. 489, p. 1–34.

Whitehouse, F. W., 1939, The polymerid trilobites, pt. 3 *of* The Cambrian faunas of northeastern Australia: Queensland Mus. Mem., v. 11, p. 179–282.

Wilson, J. L., 1948, Two Upper Cambrian *Elvinia* zone trilobite genera: Jour. Paleontology, v. 22, no. 1, p. 30–34.

———1949, The trilobite fauna of the *Elvinia* zone in the basal Wilberns limestone of Texas: Jour. Paleontology, v. 23, no. 1, p. 25–44.

———1951, Franconian trilobites of the central Appalachians: Jour. Paleontology, v. 25, no. 5, p. 617–654.

———1954, Late Cambrian and Early Ordovician trilobites from the Marathon uplift, Texas: Jour. Paleontology, v. 28, no. 3, p. 249–285.

Wilson, J. L., 1956, Revisions in nomenclature and new species of Cambro-Ordovician trilobites from the Marathon uplift, West Texas: Jour. Paleontology, v. 30, p. 1341–1349.

Wilson, J. L., and Frederickson, E. A., 1950, The *Irvingella major* (*"Ptypchopleurites"*) faunizone of the Upper Cambrian: Am. Jour. Sci., v. 248, p. 891–902.

Young, J. C., 1960, Structure and stratigraphy in north central Schell Creek range [Nevada], *in* Intermountain Assoc. Petroleum Geologists, Guidebook to the geology of east central Nevada, 1960: Salt Lake City, Utah, p. 158–172.

INDEX

[Italic page numbers indicate major references]

PLATES 1–20

PLATE 1

FIGURES 1, 2, 4. *Blountia bristolensis* Resser (p. 29), × 4.
1. Free cheek, USNM 141504.
2. Cranidium, USNM 141505.
4. Pygidium, USNM 141506.
All from USGS colln. 2432–CO, *Aphelaspis* zone, Highland Range, Nev.

3. *Oligometopus breviceps* (Walcott) (p. 32), × 4.
Stereogram of holotype cranidium, USNM 24577, USNM loc. 62, *Elvinia* zone, Eureka, Nev.

5. *Oligometopus contractus* n. sp. (p. 31), × 10.
Holotype cranidium, USNM 141507, USGS colln. 2563–CO, *Dunderbergia* zone, Shingle Pass, Nev.

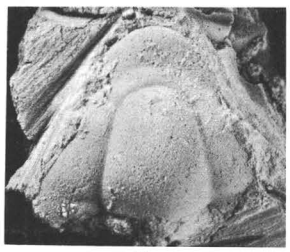
6–8. *Cheilocephalus granulosus* n. sp. (p. 31).
6. Holotype cranidium, × 4, USNM 141508, USGS colln. 2535–CO, Cherry Creek, Nev.
7. Pygidium, × 3, questionably assigned, USNM 141509, USGS colln. 2561–CO, Shingle Pass, Nev.
8. Small pygidium, × 6, USNM 141510, USGS colln. 2535–CO, Cherry Creek, Nev.
All from *Dicanthopyge* zone.

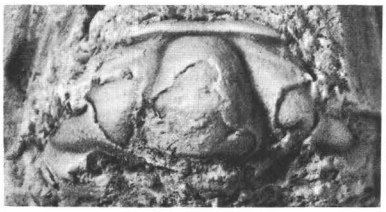
9–11. *Cheilocephalus brevilobus* (Walcott) (p. 30).
9. Cranidium, × 2, questionably assigned, USNM 141511, USGS colln. 2557–CO, *Elvinia* zone, Cherry Creek, Nev.
10. Stereogram of typical cranidium, × 3, USNM 141512.
11. Pygidium × 3, USNM 141513.
10 and 11 from USGS colln. 2315–CO, *Aphelaspis* zone, Shingle Pass, Nev.

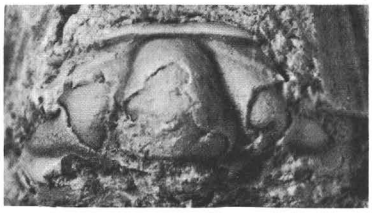
12–15, 17. *Cheilocephalus brachyops* n. sp. (p. 30).
12. Stereogram of holotype cranidium, × 4, USNM 141514.
13. Stereogram of associated pygidium, × 3, USNM 141515.
14. Small cranidium, × 10, USNM 141516.
15. Pygidium, × 1, having incompletely formed right pleural region, USNM 141517.
17. Pygidium, × 3, USNM 141518.
All from USGS colln. 2563–CO, highest part of *Dunderbergia* zone, Shingle Pass, Nev.

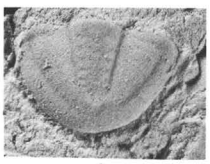
16, 18, 19. *Pseudokingstonia exotica* n. gen., n. sp. (p. 32).
16. Stereogram of holotype cranidium, × 10, USNM 141519.
18. Cranidium, × 10, front oblique view showing narrow striated border, USNM 141520.
19. Stereogram of pygidium, × 4, USNM 141521.
All from USGS colln. 2977–CO, *Elvinia* zone, House Range, Utah.

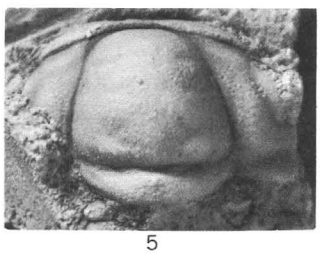

1


2

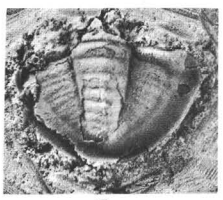

3




4

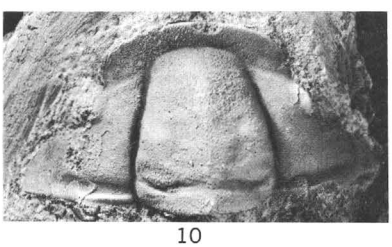

5

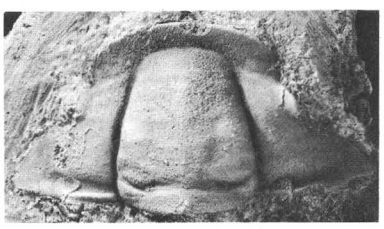

6


7

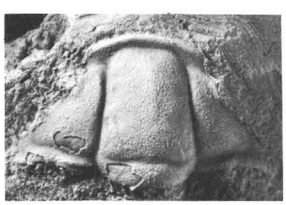

8

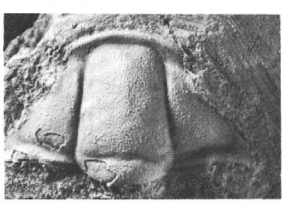

9

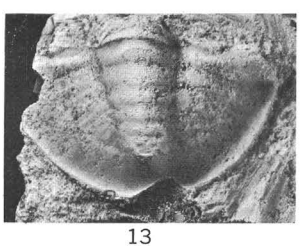

10

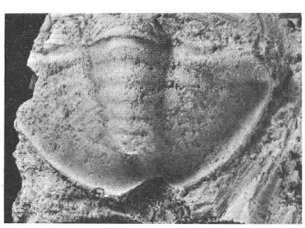


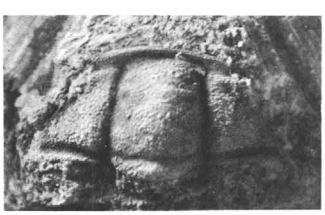

11


12

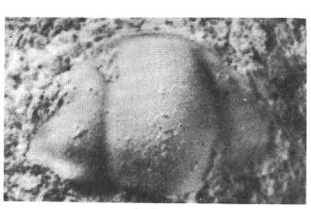


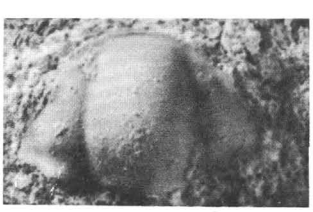


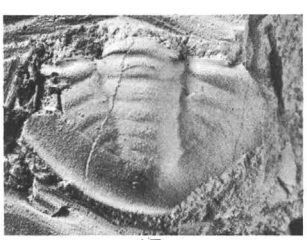

13


14

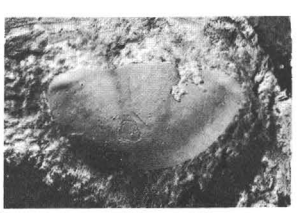

15

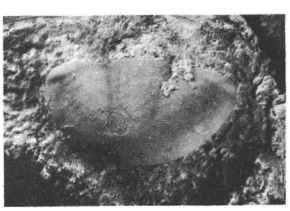



16


17


18




19

ASAPHISCIDAE AND CHEILOCEPHALIDAE

PLATE 2

FIGURES 1–4. *Iddingsia similis* (Walcott) (p. 36).

1. Latex cast of free cheek, × 2, USNM 141522.
2. Cranidium, × 2, USNM 141523.
3. Pygidium, × 1, USNM 141524.

All from USGS colln. 2579–CO, *Elvinia* zone, Eureka, Nev.

4. Stereogram of holotype cranidium, × 1, USNM 24641, USNM loc. 60, *Elvinia* zone, Eureka, Nev.

5–8. *Iddingsia intermedia* n. sp. (p. 36).

5. Stereogram of holotype cranidium, × 4, USNM 141525, USGS colln. 3027–CO, *Dunderbergia* zone, McGill, Nev.
6. Exfoliated free cheek, × 2, USNM 141526.
7. Exfoliated cranidium, × 4, USNM 141527.
8. Pygidium, × 2, USNM 141528.

All from USGS colln. 3033–CO, *Dunderbergia* zone, McGill, Nev.

9. *Iddingsia utahensis* Resser (p. 37), × 1.5.

Cranidium, USNM 141529, USGS colln. 2513–CO, *Elvinia* zone, McGill, Nev.

10–11. *Iddingsia robusta* (Walcott) (p. 36).

10. Stereogram of holotype cranidium, × 2, USNM 24609, USNM loc. 61, *Elvinia* zone, Eureka, Nev.
11. Fragmentary cranidium, × 3, showing characteristic ornamentation, USNM 141530, USGS colln. 3109–CO, *Elvinia* zone, Snake Range, Nev.

12–14, 16, 17. *Pseudosaratogia abnormis* Palmer (p. 38).

12. Stereogram of holotype cranidium, × 5, USNM 136923, USGS colln. 955–CO, *Elvinia* zone, Eureka, Nev.
13. Cranidium, × 4, USNM 141531.
14. Free cheek, × 6, USNM 141532.

Both from USGS colln. 2312–CO, *Elvinia* zone, Shingle Pass, Nev.

16. Free cheek, × 4, USNM 141533.
17. Cranidium, × 4, USNM 141534.

Both specimens questionably assigned from USGS colln. 3018–CO, *Elvinia* zone, Bastian Peak, Nev.

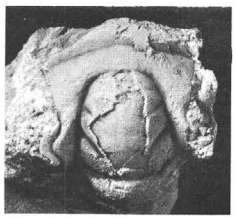
15. Genus and species undetermined 1 (p. 92), × 5.

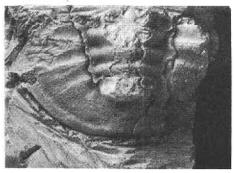
Exfoliated cranidium, USNM 141535, USGS colln. 3057–CO, *Aphelaspis* zone, Tybo, Nev.

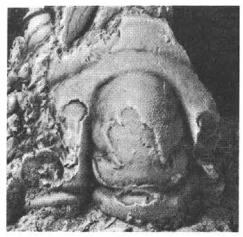
18. *Pseudosaratogia leptogranulata* Palmer (p. 39), × 3.

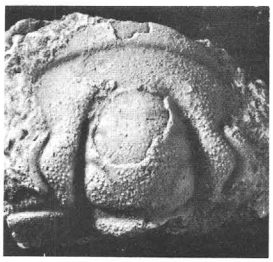
Stereogram of holotype cranidium, USNM 136922, USGS colln. 954–CO, *Dunderbergia* zone, Eureka, Nev.

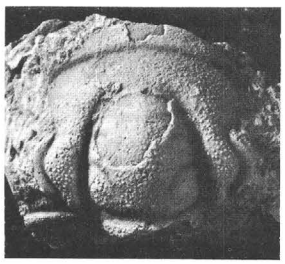

1

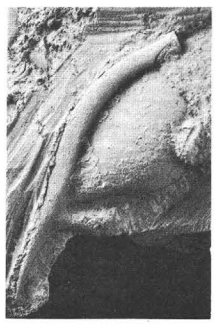

2


3


4

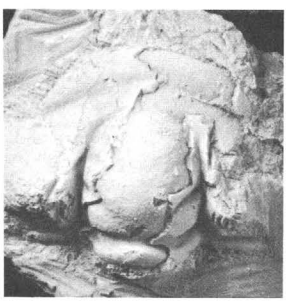

5

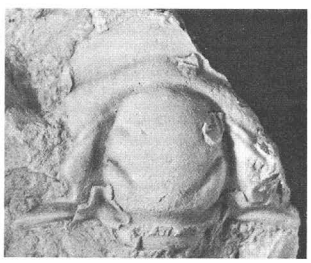


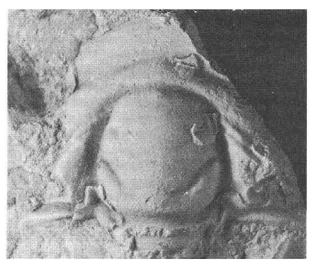

6

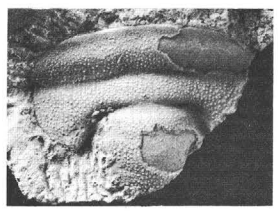

7

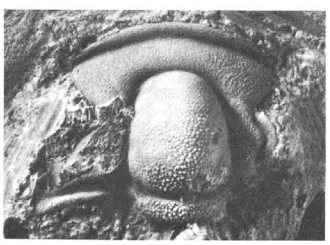

8

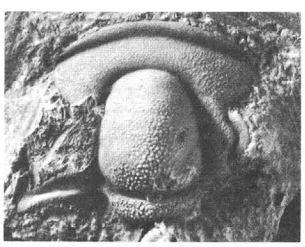

9

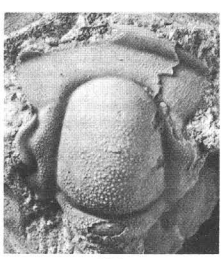

10

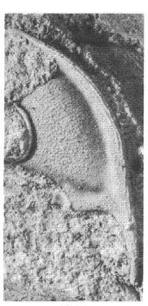


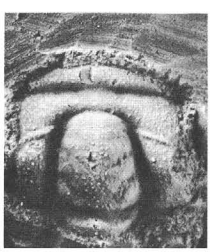

11


12

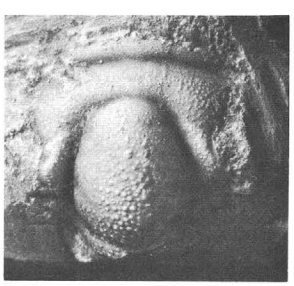


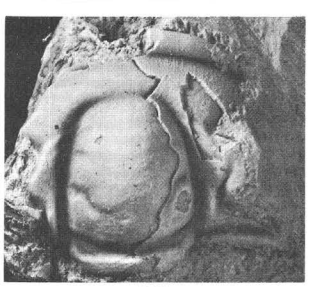

13

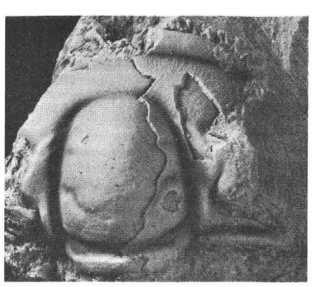

14


15


16


17


18



DOKIMOCEPHALINAE

PLATE 3

FIGURES 1–4. *Kindbladia affinis* (Walcott) (p. 37).

1. Free cheek, × 10, USNM 141536.
2. Stereogram of cranidium, × 4, USNM 141537.

Both from USGS colln. 2556–CO, *Elvinia* zone, Cherry Creek, Nev.

3. Cranidium, × 5, showing characteristic ornamentation, USNM 141538, USGS colln. 2565–CO, *Elvinia* zone, Shingle Pass, Nev.
4. Pygidium, × 6, USNM 141539, USGS colln. 3109–CO, *Elvinia* zone, Snake Range, Nev.

5–7. *Apachia prima* n. sp. (p. 34).

5. Stereogram of holotype cranidium, × 4, USNM 141540.
6. Pygidium, × 6, USNM 141541.
7. Free cheek, × 6, USNM 141542.

All from USGS colln. 3031–CO, *Dunderbergia* zone, McGill, Nev.

8. *Dellea? punctata* n. sp. (p. 84), × 8.

Holotype cranidium, USNM 141543, USGS colln. 2580–CO, *Elvinia* zone, Eureka, Nev.

9, 11, 14, 16. *Elvinia roemeri* (Shumard) (p. 44).

9. Stereogram of typical cranidium, × 2, USNM 141544, USNM colln. 2552–CO, *Elvinia* zone, Cherry Creek, Nev.
11. Cranidium, × 3, USNM 141545.
14. Small cranidium, × 6, showing characteristic relatively greater length of palpebral lobes, USNM 141546.

Both from USGS colln. 2580–CO, *Elvinia* zone, Eureka, Nev.

16. Immature cranidium, × 8, USNM 141547, USGS colln. 2564–CO, *Elvinia* zone, Shingle Pass, Nev.

10, 13. *Apachia butlerensis* (Freckerickson) (p. 34), × 4.

10. Stereogram of cranidium, USNM 141548, USGS colln. 3034–CO, *Dunderbergia* zone, McGill, Nev.
13. Cranidium, showing fine granular ornamentation, USNM 141549, USGS colln. 2563–CO, *Dunderbergia* zone, Shingle Pass, Nev.

12. *Elvinia granulata* Resser (p. 44), × 3.

Stereogram of holotype cranidium, USNM 108815, USNM loc. 63, *Elvinia* zone, Eureka, Nev.

15. Genus and species undetermined 2 (p. 91), × 5.

Pygidium USNM 141550, USGS colln. 3018–CO, *Elvinia* zone, Bastian Peak, Nev.

17. Genus and species undetermined 3 (p. 92), × 4.

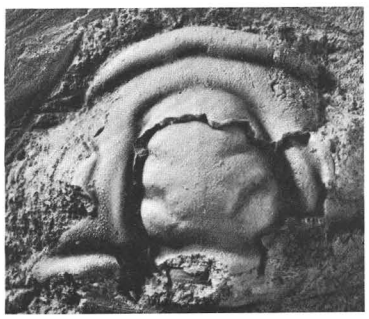
Exfoliated cranidium, USNM 141551, USGS colln. 3009–CO, *Dunderbergia* zone, Bastian Peak, Nev.

18. *Dokimocephalus pernasutus* (Walcott) (p. 35), × 1.

Stereogram of best known cranidium; anterior part is latex cast, USNM 141552, USGS colln. 3537–CO, *Elvinia* zone, Yucca Flat, Nev.

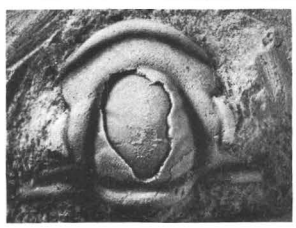
1

2

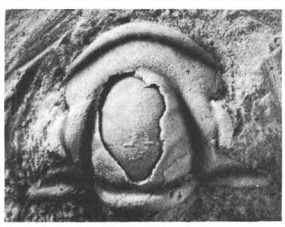


3

4

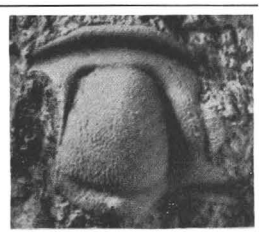


5

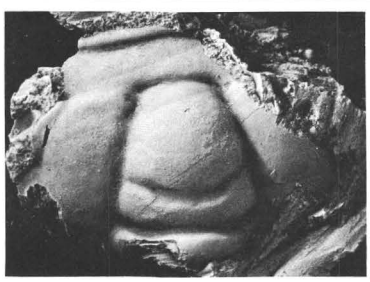


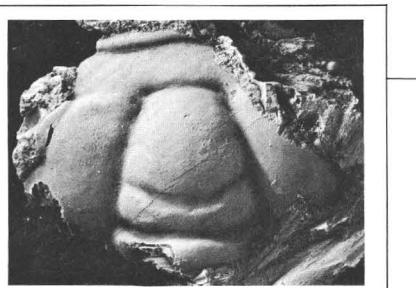
6

7

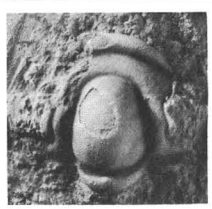


8



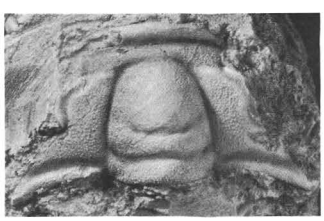


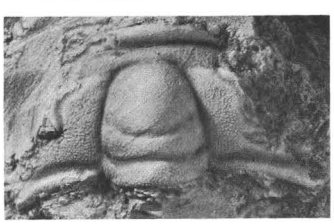
9



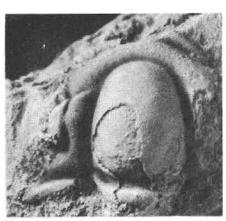
10

11





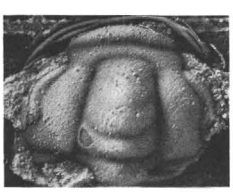
12



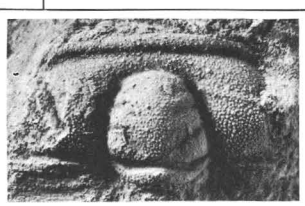
13

14

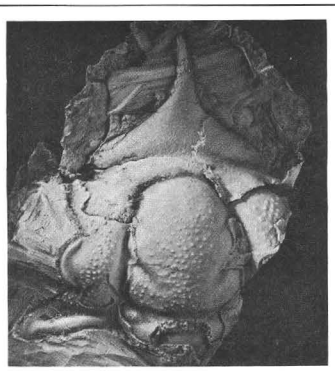
15

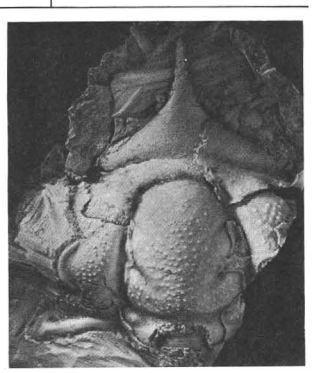


16



17





18

DOKIMOCEPHALINAE, ELVINIINAE

PLATE 4

FIGURES 1, 2, 5, 6. *Dunderbergia nitida* (Hall and Whitfield) (p. 41).

1. Stereogram of latex cast of nearly complete specimen, × 1, USNM 141553, USGS colln. 3011–CO, *Dunderbergia* zone, Bastian Peak, Nev.
2. Pygidium, × 5, USNM 136838a.
5. Stereogram of cranidium, × 4, USNM 136838c.
6. Free cheek, × 4, USNM 136838f.

All from USGS colln. 2300–CO, *Dunderbergia* zone, Eureka, Nev.

3, 4, 7. *Dunderbergia polybothra* Palmer (p. 42).

3. Stereogram of holotype cranidium, × 4, USNM 136845.
4. Pygidium, × 3, USNM 136844f.
7. Free cheek, × 4, USNM 136844b.

All from USGS colln. 2296–CO, *Dunderbergia* zone, Eureka, Nev.

8, 10, 14–16. *Dunderbergia*? *anyta* (Hall and Whitfield) (p. 39).

8. Stereogram of cranidium, × 4, USNM 141554.
10. Stereogram of pygidium, × 3, USNM 141555.
15. Free cheek, × 3, USNM 141556.
16. Doublure of free cheek, × 2, showing course of connective suture, USNM 141557.

All from USGS colln. 2998–CO, *Dunderbergia* zone, House Range, Utah.

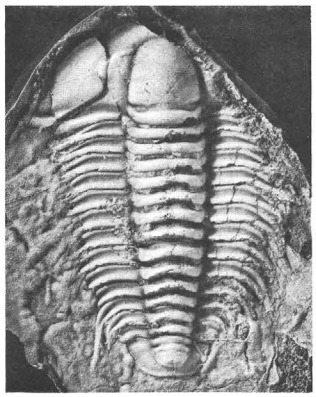
14. Stereogram of latex cast of counterpart of holotype, × 2, USNM 24576, from *Dunderbergia* zone, Schellbourne, Nev.

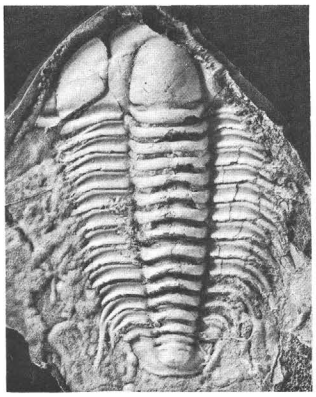
9, 11–13. *Dunderbergia bigranulosa* Palmer (p. 40).

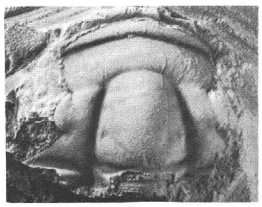
9. Stereogram of cranidium, × 4, USNM 136848a.
11. Pygidium, × 4, USNM 136848c.
12. Free cheek, × 4, USNM 136848b.

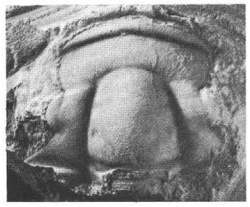
All from USGS colln. 2295–CO, *Dunderbergia* zone, Eureka, Nev.

13. Closeup of cranidial ornamentation, × 10, USNM 136849b, USGS colln. 2294–CO, *Dunderbergia* zone, Eureka, Nev.


1

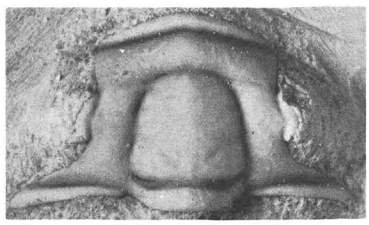


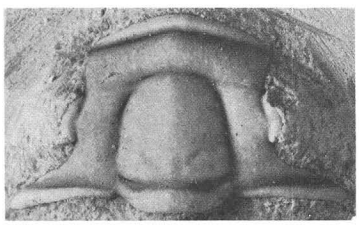

3



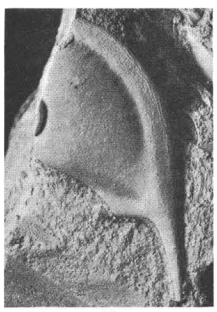

2

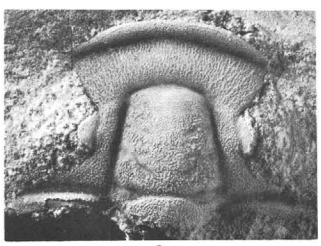

4

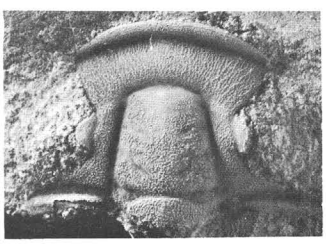

5

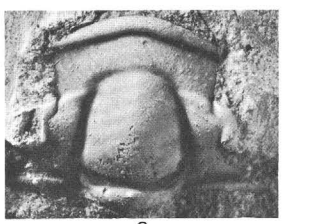


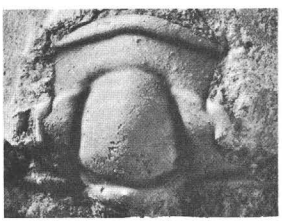

6


7

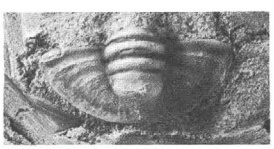

8

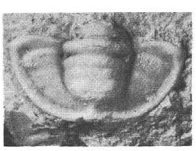



9



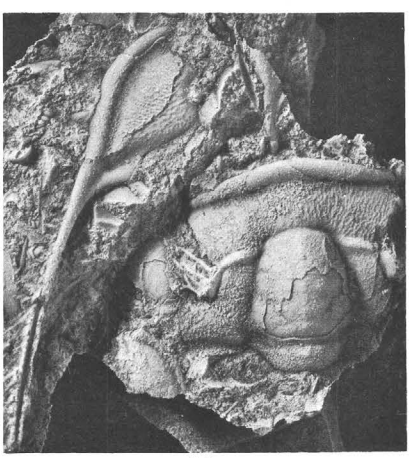

10

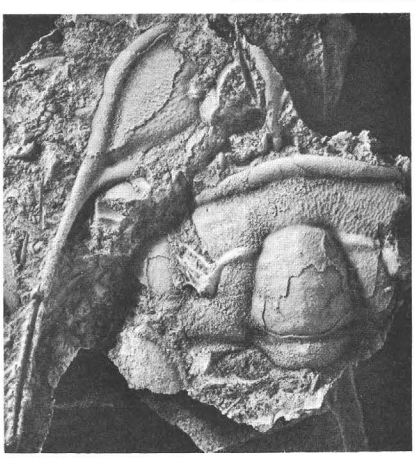



11


12


13


14




15


16

ELVINIINAE

PLATE 5

FIGURES 1–5. *Dunderbergia variagranula* Palmer (p. 41).

1. Stereogram of cranidium, × 4, USNM 136840a.
2. Free cheek, × 4, USNM 136840b.

Both from USGS colln. 2297–CO, *Dunderbergia* zone, Eureka, Nev.

3. Stereogram of pygidium, × 4, USNM 136843, USGS colln. 809–CO, *Dunderbergia* zone, Eureka, Nev.
4. Cranidium, × 3, USNM 141558.
5. Free cheek, × 3, USNM 141559.

Both from USGS colln. 2457–CO, *Dunderbergia* zone, Ash Meadows, Nev.

6–10. *Dunderbergia calculosa* n. sp. (p. 41).

6. Cranidium, × 3, USNM 141560, USGS colln. 3024–CO, *Dunderbergia* zone, McGill, Nev.
7. Closeup of anterolateral part of holotype cranidium, × 8, showing ornamentation, USNM 141561.
8. Stereogram of holotype cranidium, × 3.
9. Free cheek, × 5, USNM 141562.
10. Stereogram of pygidium, × 5, USNM 141563.

All from USGS colln. 2313–CO, *Prehousia* zone, Shingle Pass, Nev.

11–13, 15. *Dunderbergia brevispina* n. sp. (p. 40).

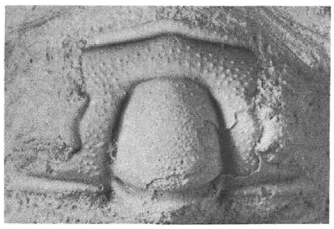
11. Stereogram of holotype cranidium, × 5, USNM 141564.
13. Stereogram of pygidium, × 5, USNM 141565.
15. Closeup of latex cast of cranidium, × 8, showing ornamentation, USNM 141566.

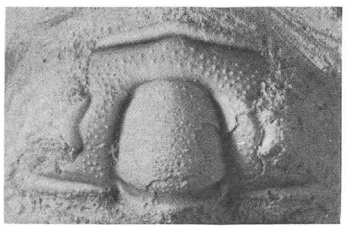
All from USGS colln. 2559–CO, *Dicanthopyge* zone, Shingle Pass, Nev.

12. Free cheek, × 5, USNM 141567, USGS colln. 2314–CO, *Dicanthopyge* zone, Shingle Pass, Nev.

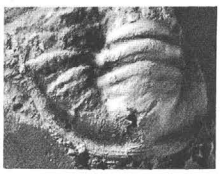
14, 16–19. *Elburgia granulosa* (Hall and Whitfield) (p. 42).

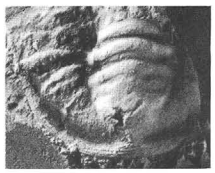
14. Stereogram of holotype cranidium, × 3, USNM 24573, *Dunderbergia* zone, Eureka, Nev.
16. Cranidium, × 2, USNM 141568, USGS colln. 2612–CO, *Dunderbergia* zone, Deep Creek Range, Utah.
17. Free cheek, × 2, USNM 141569, USGS colln. 3412–CO, *Dunderbergia* zone, House Range, Utah.
18. Cranidium, × 3, questionably assigned, USNM 141570, USGS colln. 2548–CO, *Dunderbergia* zone, Cherry Creek, Nev.
19. Pygidium, × 3, USNM 141571, USGS colln. 2612–CO, *Dunderbergia* zone, Deep Creek Range, Nev.

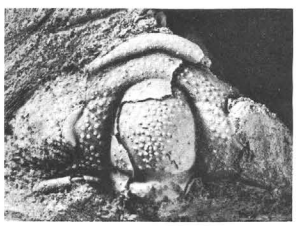

1



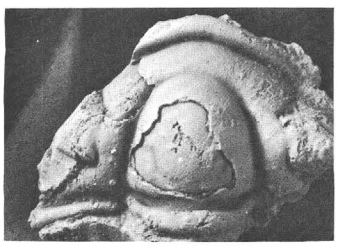

2

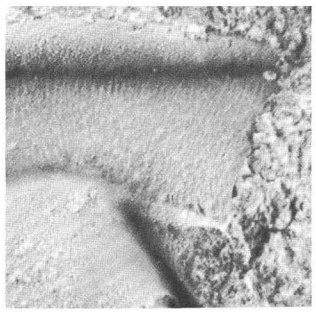

3

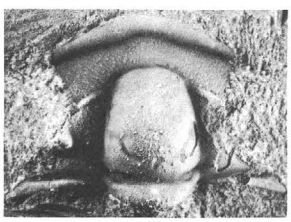


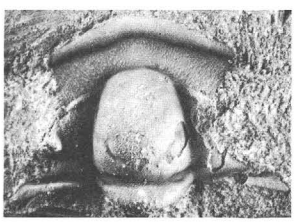

4


5


6


7


8



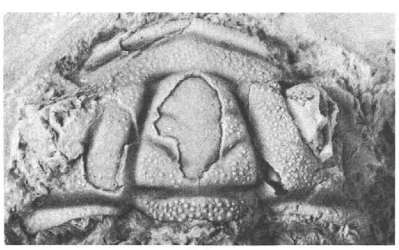

9

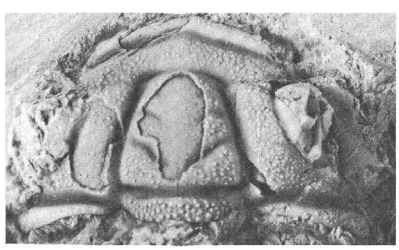

10

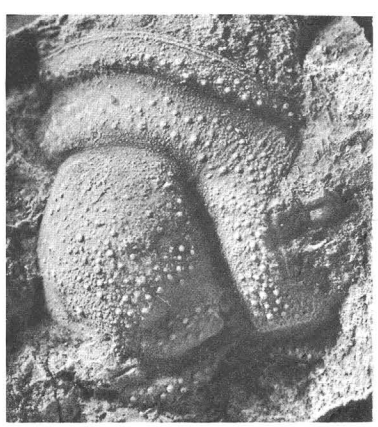

11

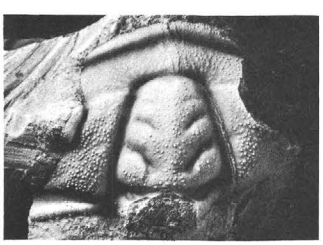

12

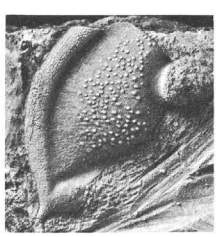

13

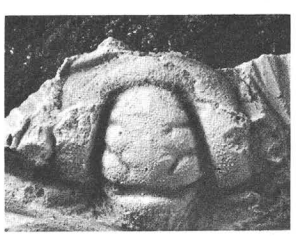

14




15


16


17


18


19

ELVINIINAE

735-610 O-65-11

PLATE 6

FIGURES 1–4. *Elburgia quinnensis* (Resser) (p. 43).

1. Exfoliated free cheek, × 2, USNM 141572 USGS colln. 1271–CO, *Dunderbergia* zone, Quartz Spring area, Calif.
2. Cranidium, × 2, USNM 141573, USGS colln. 3011–CO.
3. Stereogram of latex cast of cranidium, × 2, USNM 141574, USGS colln. 3016–CO.

Both from *Dunderbergia* zone, Bastian Peak, Nev.

4. Holotype, exfoliated cranidium, × 3, USNM 108838a, USNM loc. 7j, *Dunderbergia* zone, Quinn Canyon Range, Nev.

5, 6. *Elburgia intermedia* n. sp. (p. 43).

5. Cranidium, × 5, USNM 141575, USGS colln. 3028–CO, *Dunderbergia* zone, McGill, Nev.
6. Stereogram of holotype cranidium, × 3, USNM 141576, USGS colln. 3003–CO, *Dunderbergia* zone, Bastian Peak, Nev.

7, 8. *Irvingella transversa* n. sp. (p. 48).

7. Stereogram of holotype cranidium, × 2, USNM 141577.
8. Small cranidium, × 6, note faint border, USNM 141578.

Both from USGS colln. 2587–CO, *Elvinia* zone, Ruby Range, Nev.

9–15. *Irvingella major* Ulrich and Resser (p. 48).

9. Pygidium, × 6, USNM 141579.
10. Stereogram of characteristic cranidium, × 4, USNM 141580.
11. Stereogram of pygidium, × 4, note assymetry of pleural regions, USNM 141581.
12. Free cheek, × 3, USNM 141582.
13. Metaprotaspid, × 15, USNM 141583.
14. Meraspid cranidium, × 10, note well-defined border, USNM 141584.
15. Meraspid cranidium, × 8, note well-defined border, USNM 141585.

All from USGS colln. 2587–CO, *Elvinia* zone, Ruby Range, Nev.

16, 19, 20, 24. *Irvingella flohri* Resser (p. 47).

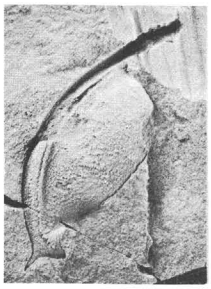
16. Stereogram of holotype cranidium, × 3, USNM 108667, USNM loc. 60, *Elvinia* zone, Eureka, Nev.
19. Small cranidium, × 6, note faint border, USNM 141586.
20. Cranidium, × 5, USNM 141587.
24. Pygidium, × 5, USNM 141588.

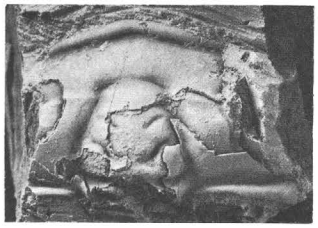
All from USGS colln. 2579–CO, *Elvinia* zone, Eureka, Nev.

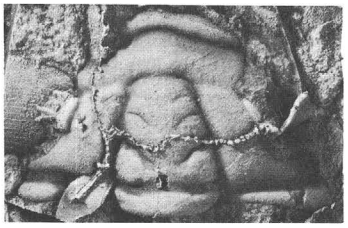
17, 18, 21–23. *Irvingella angustilimbatus* Kobayashi (p. 46).

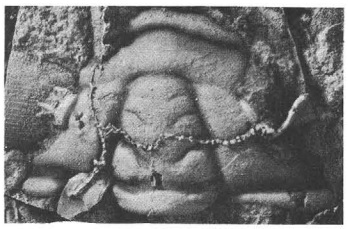
17. Stereogram of cranidium, × 3, holotype of *Parairvingella eurekensis* Resser, USNM 108668, USNM loc. 61, *Elvinia* zone, Eureka, Nev.
18. Cranidium, × 4, USNM 141589, USGS colln. 1471–CO, *Elvinia* zone, Tybo, Nev.
21. Holotype cranidium, × 2, USNM 24643, USNM loc. 62, *Elvinia* zone, Eureka, Nev.
22. Cranidium, × 2, USNM 141590.
23. Variant cranidium, × 3 (=*Irvingella tropica* Öpik?) USNM 141591.

Both from USGS colln. 1471–CO, *Elvinia* zone, Tybo, Nev.

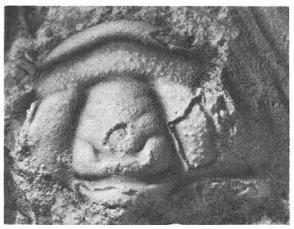

1

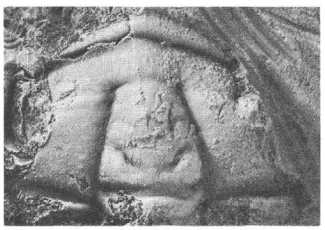

2

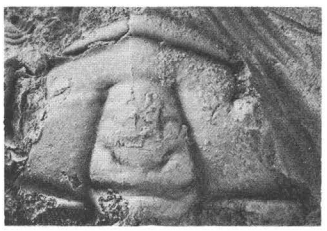

3

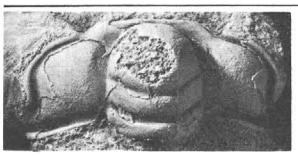


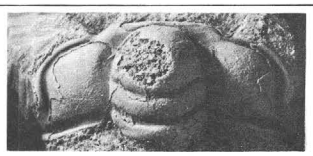

4

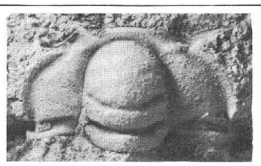

5

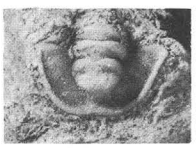

6



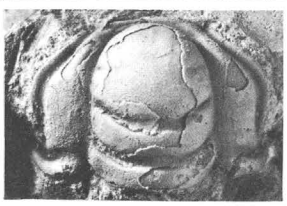

7

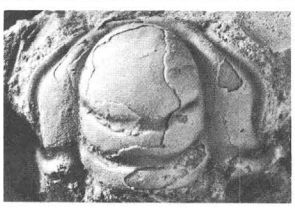


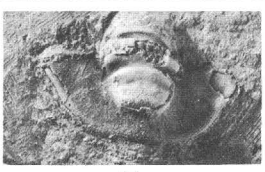

8

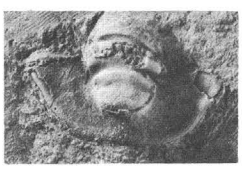

9

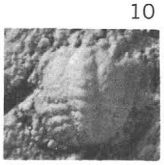

12


10

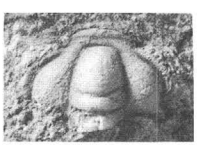


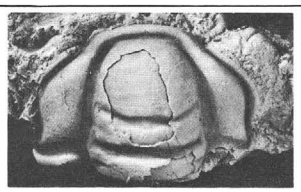

11

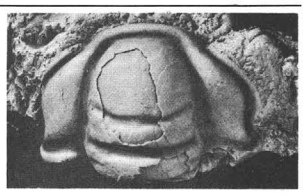


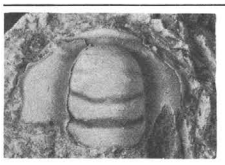

13

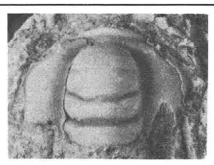

14

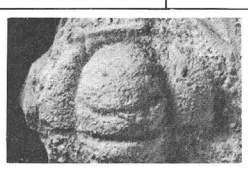

15

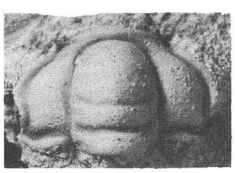

16

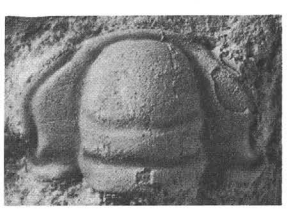


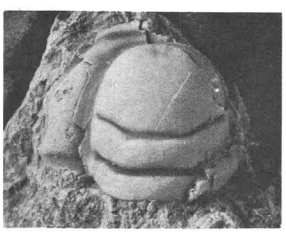

17

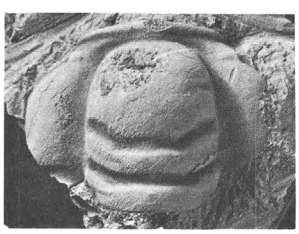


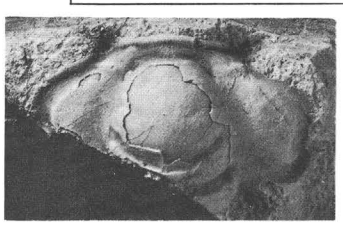

18

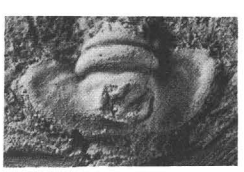

19


20


21


22


23


24

ELVINIINAE

PLATE 7

FIGURE 1. *Hardyoides mimicus* n. sp. (p. 54), × 10.
Stereogram of holotype cranidium, USNM 141592, USGS colln. 1996–CO, *Dicanthopyge* zone, Yucca Flat, Nev.

2. *Aciculolenus peculiaris* n. gen., n. sp. (p. 55), × 10.
Stereogram of holotype cranidium, USNM 141593, USGS colln. 2524–CO, topmost *Elvinia* zone, Cherry Creek, Nev.

3–5, 9–11. *Hardyoides minor* Kobayashi (p. 54), × 15.
3–5, 9. Silicified cranidium, free cheek, pygidium, and partially complete specimen, USNM 141594, 141595, 141596, 141597, USGS colln. 2486–CO, *Aphelaspis* zone, McGill, Nev.
10. Cranidium, USNM 141598, USGS colln. 2510–CO, *Aphelaspis* zone, McGill, Nev.
11. Paratype cranidium NMC 11941, *Aphelaspis* zone, Mt. Jubilee, British Columbia, Canada.

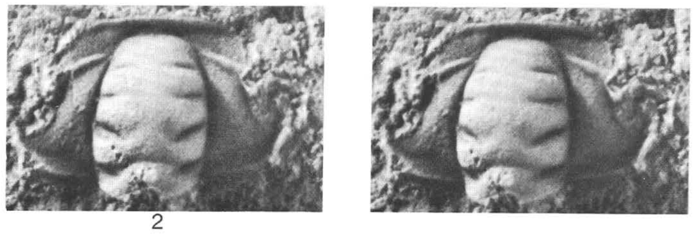
6–8. *Xenocheilos granulosus* n. sp. (p. 91), × 10.
6, 8. Free cheeks, USNM 141599, 141600.
7. Stereogram of holotype cranidium, USNM 141601.
All from USGS colln. 2566–CO, *Elvinia* zone, Shingle Pass, Nev.

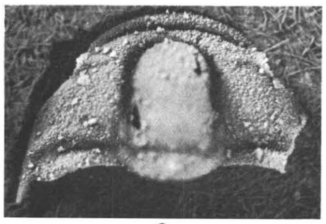
12, 13. *Terranovella brevis* n. sp. (p. 52).
12. Stereogram of holotype cranidium, × 10, USNM 141602.
13. Cranidium, × 15, USNM 141603.
Both from USGS colln. 2432–CO, *Aphelaspis* zone, Highland Range, Nev.

14, 18, 19. *Elviniella laevis* Palmer (p. 45).
14. Stereogram of holotype cranidium, × 5, USNM 136854a, USGS colln. 952–CO, *Dunderbergia* zone, Eureka, Nev.
18. Latex cast of free cheek, × 3, USNM 141604.
19. Latex cast of cranidium, × 4, USNM 141605.
Both from USGS colln. 3061–CO, *Dunderbergia* zone, Tybo, Nev.

15–17, 20–22. *Glaphyraspis ornata* (Lochman) (p. 51).
15. Cranidium, × 10, USNM 141606, USGS colln. 2315–CO, *Aphelaspis* zone, Shingle Pass, Nev.
16, 20, 21. Silicified cranidium, free cheek, and pygidium, × 15, USNM 141607, 141608, 141609, USGS colln. 2468–CO, *Aphelaspis* zone, McGill, Nev.
17. Cranidium, × 15, USNM 141610, USGS colln. 2996–CO, *Aphelaspis* zone, House Range, Utah.
22. Cranidium, × 15, USNM 141611, USGS colln. 2432–CO, *Aphelaspis* zone, Highland Range, Nev.


1

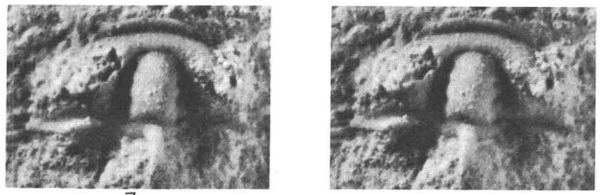

2


3

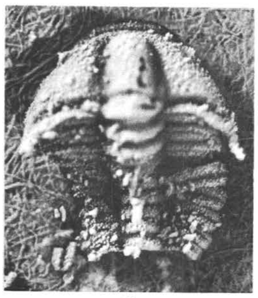

4

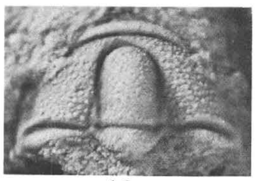

5

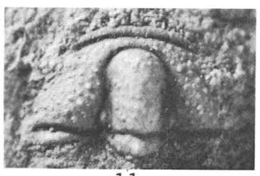

6

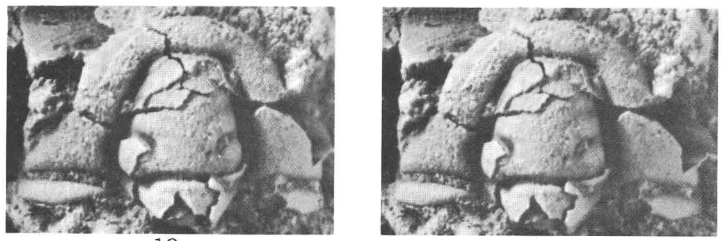

7

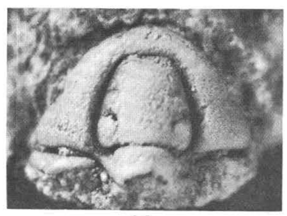

8

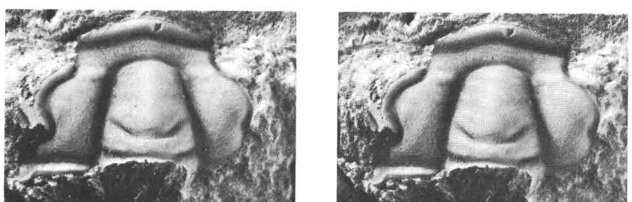

9

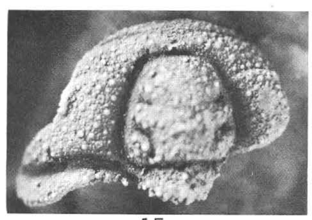

10


11

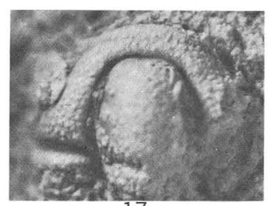

12


13


14

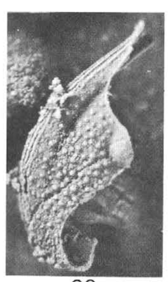

15

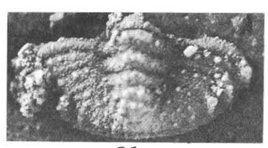

16

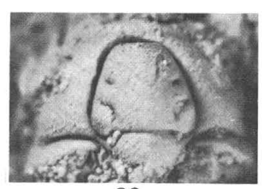

17


18


19


20


21


22

ELVINIINAE, LONCHOCEPHALIDAE, NORWOODIILAE, OLENIDAE

PLATE 8

FIGURES 1–4. *Simuloenus quadrisulcatus* n. sp. (p. 56).

1. Free cheek, × 6, USNM 141612.
2. Stereogram of holotype cranidium, × 5, USNM 141613.
4. Pygidium, × 5, USNM 141614.

All from USGS colln. 2576–CO, *Elvinia* zone, Eureka, Nev.

3. Small cranidium, × 10, questionably assigned, USNM 141615, USGS colln. 2524–CO, Cherry Creek, Nev.

5–8, 11, 12. *Simulolenus wilsoni* (Henningsmoen) (p. 56).

5. Hypostome, × 10, USNM 141616.
6. Cranidium, × 6, USNM 141617.
7. Cranidium, × 10, USNM 141618.
8. Free cheek, × 6, USNM 141619.

All from USGS colln. 3060–CO, *Dunderbergia* zone, Tybo, Nev.

11. Crandium, × 6, USNM 141620.
12. Pygidium, × 10, USNM 141621.

Both from USGS colln. 3061–CO, *Dundergia* zone, Tybo, Nev.

9, 10. *Simulolenus granulatus* Palmer (p. 56), × 10.

9. Holotype cranidium, USNM 136861, USGS colln. 2300–CO.
10. Pygidium, USNM 136860, USGS colln. 2299–CO.

Both from *Dunderbergia* zone, Eureka, Nev.

13, 17–21. *Aphelaspis brachyphasis* Palmer (p. 58).

13. Thorax and pygidium, × 2, USNM 143171, USGS colln. 2479–CO, *Aphelaspis* zone, McGill, Nev.
17. Silicified free cheek, × 6, USNM 143169m.
18. Stereogram of silicified holotype cranidium, × 6, USNM 143168.
19, 20. Silicified pygidia, × 8, showing range of variation, USNM 143169 i, e.
21. Silicified hypostome, × 6, USNM 143169k.

All from USGS colln. 2466–CO, *Aphelaspis* zone, McGill, Nev.

14–16. *Aphelaspis buttsi* (Kobayashi) (p. 59).

14. Stereogram of cranidium, × 4, USNM 143176a.
15. Pygidium, × 3, USNM 143176b.
16. Free cheek, × 3, USNM 143176c.

All from USGS colln. 2476–CO, *Aphelaspis* zone, McGill, Nev.

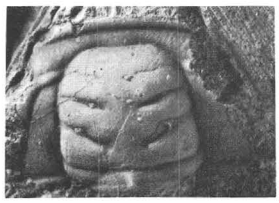
22–26. *Aphelaspis subditus* Palmer (p. 60).

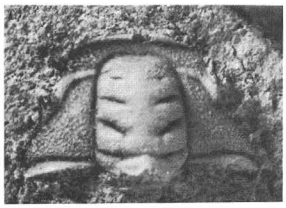
22. Stereogram of cranidium, × 4, USNM 141622, USGS colln. 2510–CO, *Aphelaspis* zone, McGill, Nev.
23. Complete specimen, × 3, USNM 143175, *Aphelaspis* zone, Mt. Hamilton, Nev.
24. Silicified free cheek, × 4, USNM 141623.
25. Silicified cranidium, ×4, USNM 141624.
26. Silicified pygidium, × 4, USNM 141625.

All from USGS colln. 2506–CO, *Aphelaspis* zone, McGill, Nev.

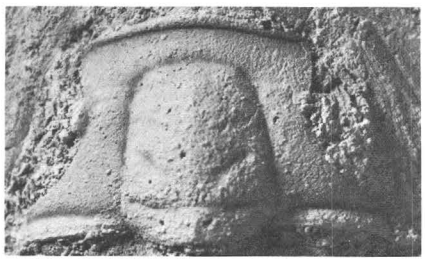

1

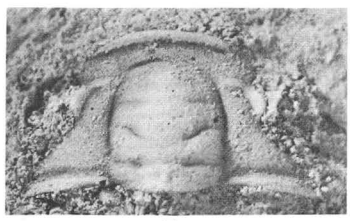

2


3

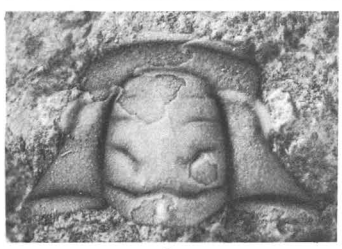

4


5

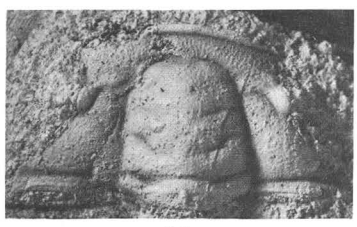

6


7

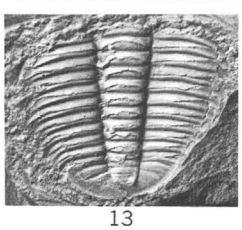

8

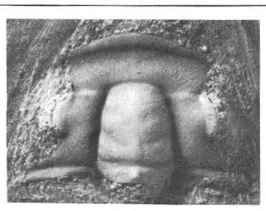

9

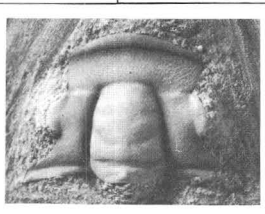

10

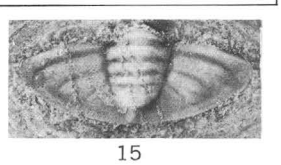

11

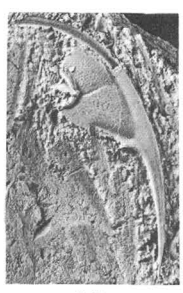

12

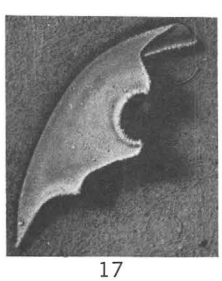

13

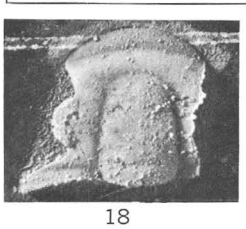

14

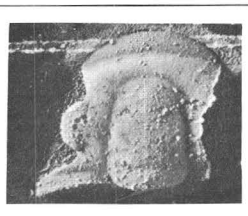


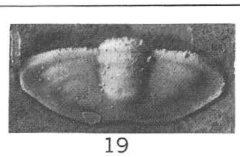

15

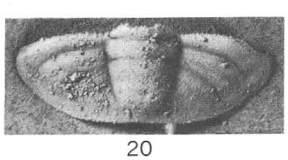

16


17

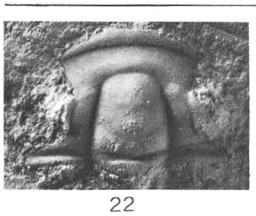

18

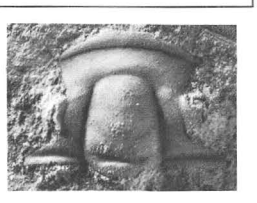


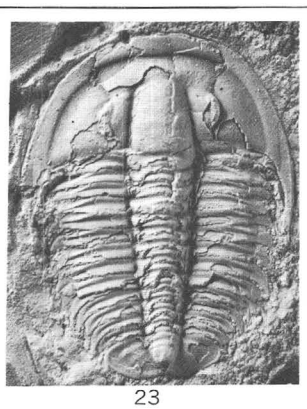

19

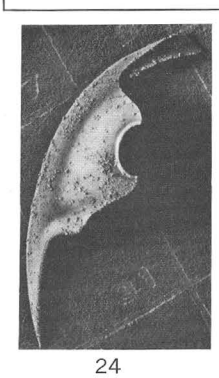

20

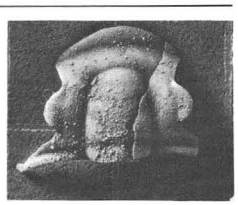

21

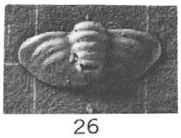

22




23


24


25


26

OLENIDAE, APHELASPIDINAE

PLATE 9

FIGURES 1, 4, 6. *Dicanthopyge convergens* n. gen., n. sp. (p. 62).

1. Stereogram of cranidium, × 4, USNM 141626.
4. Stereogram of holotype pygidium, × 4, USNM 141627.
6. Small pygidium, × 6, USNM 141628.

All from USGS colln. 2496–CO, *Dicanthopyge* zone, McGill, Nev.

2, 3, 5, 7–11. *Dicanthopyge quadrata* n. gen., n. sp. (p. 62).

2. Nearly complete specimen, × 4, USNM 141629, USGS colln. 3820–CO, *Dicanthopyge* zone, Ruby Range, Nev.
3. Stereogram of silicified cranidium, × 4, USNM 141630.
5. Stereogram of silicified holotype pygidium, × 4, USNM 141631.
7. Silicified immature holaspid pygidium, × 6, USNM 141632.
8, 9. Small silicified pygidia, × 4, USNM 141633, 141634.
10. Free cheek, × 5, USNM 141635.
11. Pathologic free cheek, × 6, USNM 141636.

All from USGS colln. 3000–CO, *Dicanthopyge* zone, Schell Creek Range, Nev.

12, 14, 18. ?*Aphelaspis haquei* (Hall and Whitfield) (p. 59).

12. Cranidium, × 3, USNM 141637.
14. Pygidium, × 4, USNM 141638.
18. Free cheek, × 3, USNM 141639.

All from USGS colln. 2318–CO, *Aphelaspis* zone, Highland Range, Nev.

13, 15–17. *Aphelaspis longispina* n. sp. (p. 60).

13. Stereogram of cranidium, × 4, USNM 141640.
15. Stereogram of holotype pygidium, × 4, USNM 141641.
16. Thoracic segment, × 3, USNM 141642.
17. Free cheek, × 4, USNM 141643.

All from USGS colln. 2491–CO *Aphelaspis* zone, McGill, Nev.

19–26. *Aphelaspis haguei* (Hall and Whitfield) (p. 59).

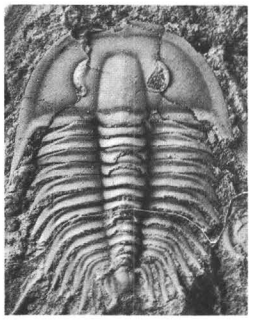
19. Pygidium, × 3, and associated pygidium of *A. subditus*, USNM 141644, USGS colln. 2486–CO, upper part of *Aphelaspis* zone, McGill, Nev.
20. Latex cast of counterpart of holotype, × 2, USNM 24660, *Aphelaspis* zone, Mt. Hamilton, Nev.
21. Pygidium, × 3, USNM 141645.
22. Free cheek, × 4, USNM 141646.
23. Cranidium × 3, USNM 141647.

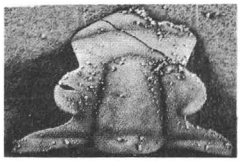
All from USGS colln. 2478–CO, lower part of *Aphelaspis* zone, McGill, Nev.

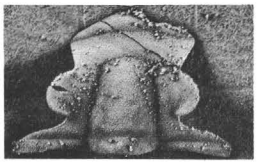
24. Stereogram of cranidium, × 4, USNM 141648, USGS colln. 2486–CO, upper part of *Aphelaspis* zone, McGill, Nev.
25. Stereogram of cranidium, × 3, USNM 141649.
26. Free cheek, × 2, USNM 141650.

Both from USGS colln. 2510–CO, upper part of *Aphelaspis* zone, McGill, Nev.

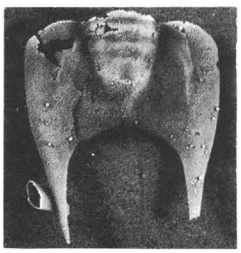

1

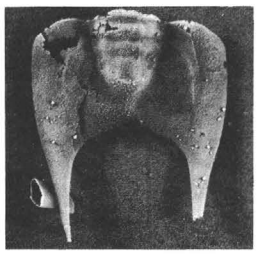

2


3




4


5



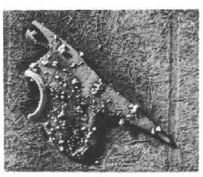

6

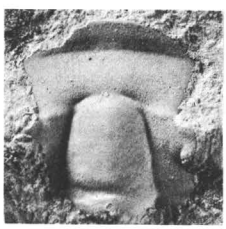

7

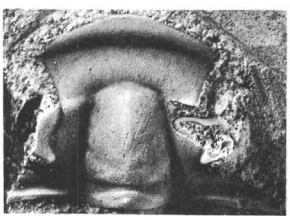

8

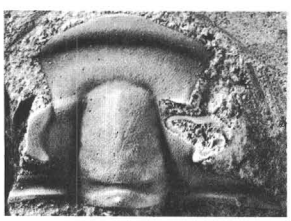

9


10


11


12


13



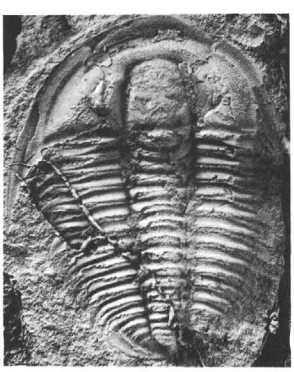

16

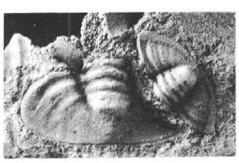

17


14


15

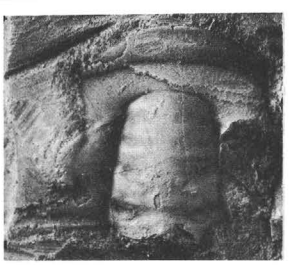

18

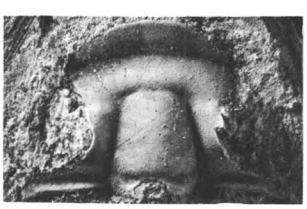

20

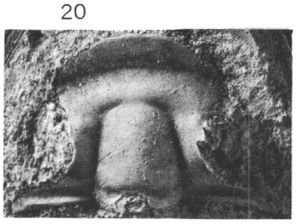

19

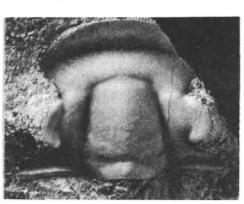

21

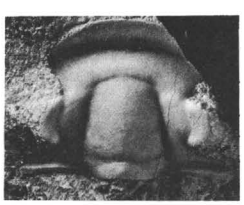

22


23


24




25




26

APHELASPIDINAE

PLATE 10

FIGURES 1–3. *Olenaspella paucisegmenta* n. sp. (p 64).

1. Stereogram of cranidium, × 4, USNM 141651.
2. Stereogram of holotype pygidium, × 4, USNM 141652.

Both from USGS colln. 2598–CO, *Prehousia* zone, Ruby Range, Nev.

3. Pygidium, × 5, USNM 141653, USGS colln. 1996–CO, *Dicanthopyge* zone, Yucca Flat, Nev.

4–6. *Olenaspella regularis* Palmer (p. 64), × 4.

4. Cranidium, USNM 141654.
5. Pygidium, USNM 141655.

Both from USGS colln. 2510–CO, *Aphelaspis* zone, McGill, Nev.

6. Pygidium, USNM 141656, USGS colln. 2536–CO, *Dicanthopyge* zone, Cherry Creek, Nev.

7–11. *Olenaspella separata* Palmer (p. 65).

7. Holotype, × 2, USNM 143182, USGS colln. 3039–CO, *Aphelaspis* zone, McGill, Nev.
8. Small silicified cranidium, × 6, USNM 143185h.
9. Silicified pygidium, × 4, USNM 143185d.
10. Large silicified pygidium, × 4, USNM 143185f.
11. Free cheek, × 6, USNM 143185g.

All from USGS colln. 2466–CO, *Aphelaspis* zone, McGill, Nev.

12, 15, 16. *Litocephalus magnus* n. sp. (p. 63), × 3.

12. Stereogram of cranidium, USNM 141657.
15. Stereogram of holotype pygidium, USNM 141658.
16. Free cheek, USNM 141659.

All from USGS colln. 1471–CO, *Elvinia* zone, Tybo, Nev.

13, 14, 17, 18. *Litocephalus granulomarginatus* Palmer (p. 63).

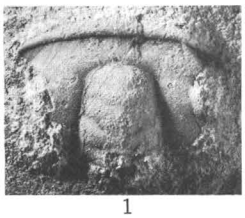
13. Holotype cranidium, × 2, USNM 136883, USGS colln. 795–CO, *Dunderbergia* zone, Eureka, Nev.
14. Detail of left anterolateral corner of holotype, × 5.
17. Free cheek, × 2, USNM 136884b.
18. Pygidium, × 2, USNM 136884a.

Both from USGS colln. 2300–CO, *Dunderbergia* zone, Eureka, Nev.

19, 20. *Dicanthopyge reductus* n. sp. (p. 62), × 2.

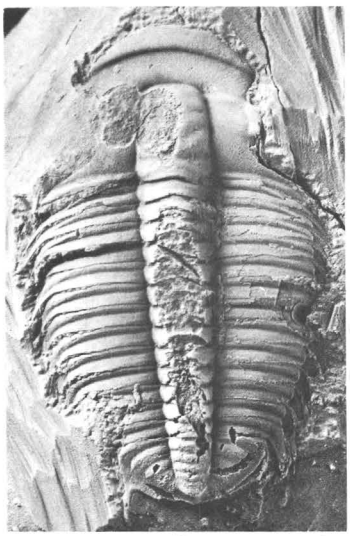
19. Stereogram of cranidium, USNM 141660.
20. Stereogram of holotype pygidium, USNM 141661.

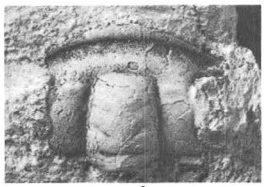
Both from USGS colln. 1438–CO, *Dicanthopyge* zone, Snake Range, Nev.

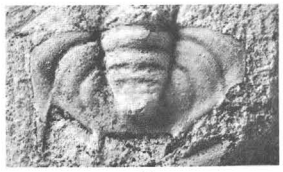

1

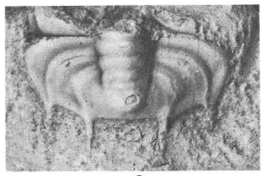

2

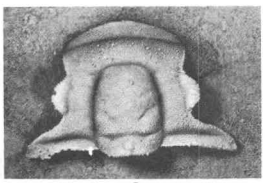

3

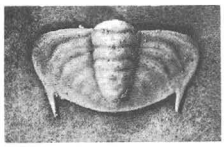

7

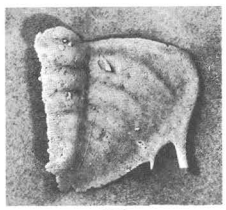

4


5

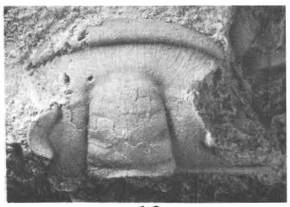

6

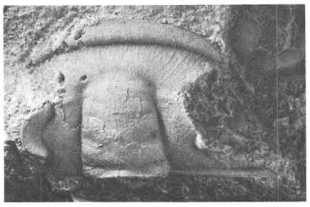

8

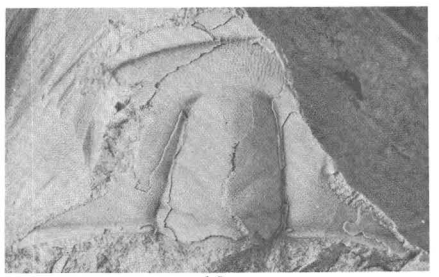

9

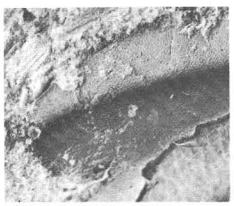

10

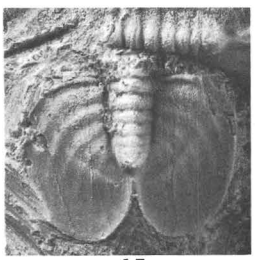

11

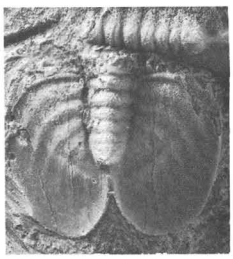

12




13

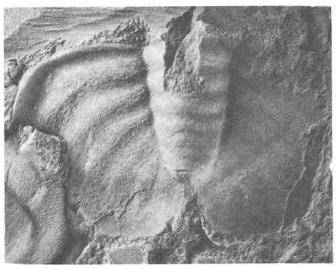

14


15

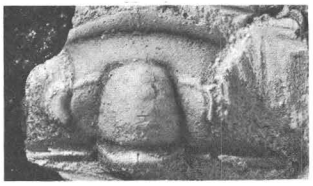



16


17


18


19




20

APHELASPIDINAE

PLATE 11

FIGURES 1–5. *Listroa toxoura* Palmer (p. 85).

1. Stereogram of cranidium × 5, USNM 141662.
2. Pygidium, × 5, showing variation in ring furrows; compare with fig. 3; USNM 141663.
3. Stereogram of small pygidium, × 5; compare transverse convexity with fig. 4; USNM 141664.
4. Stereogram of pygidium, × 4, USNM 141665.
5. Cranidium, × 5; note lack of glabellar furrows compared with specimen in fig. 1; USNM 141666.

All from USGS colln. 2510–CO, *Aphelaspis* zone, McGill, Nev.

6, 10, 11. *Taenora expansa* Palmer (p. 89).

6. Stereogram of holotype cranidium, × 3, USNM 136872.
10. Pygidium, × 2, USNM 136874.

Both from USGS colln. 954–CO, *Dunderbergia* zone, Eureka, Nev.

11. Free cheek, × 2, USNM 136873a, USGS colln, 2301–CO, *Dunderbergia* zone, Eureka, Nev.

7–9. *Litocephalus verruculopeza* Palmer (p. 63), × 3.

7. Free cheek, USNM 136882c.
8. Latex cast of cranidium, USNM 136882a.
9. Pygidium, USNM 136882d.

All from USGS colln. 2299–CO, *Dunderbergia* zone, Eureka, Nev.

12, 16, 18. *Stenambon paucigranulus* n. gen., n. sp. (p. 88).

12. Pygidium, × 4, USNM 141667.
16. Stereogram of holotype cranidium, × 2, USNM 141668.
18. Detail of ornamentation and of structure of posterior limb of holotype, × 10.

All from USGS colln. 2524–CO, *Elvinia* zone, Cherry Creek, Nev.

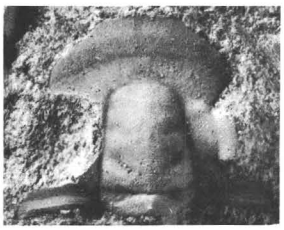
13–15. *Litocephalus bilobatus* (Hall and Whitfield) (p. 63), × 2.

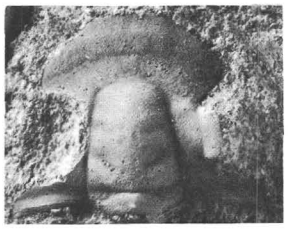
13. Free cheek, USNM 128324b.
14. Cranidium, USNM 128324a.
15. Pygidium, USNM 128324d.

All from USGS colln. 1297–CO, *Dunderbergia* zone, Eureka, Nev.

17, 19. *Stenambon megagranulus* n. gen., n. sp. (p. 88).

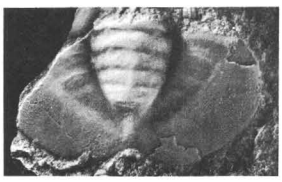
17. Stereogram of holotype cranidium, × 4, USNM 141669, USGS colln. 2576–CO, *Elvinia* zone, Eureka, Nev.
19. Stereogram of pygidium, × 3, USNM 141670, USGS colln. 825–CO, *Elvinia* zone, Eureka, Nev.

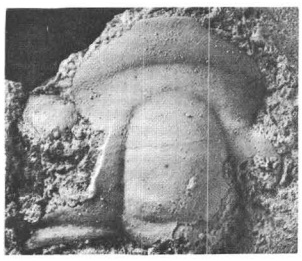

1

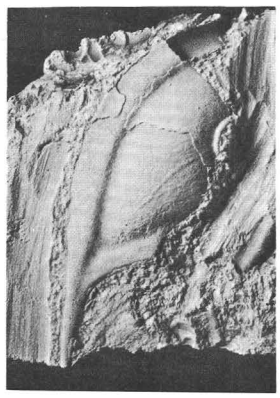


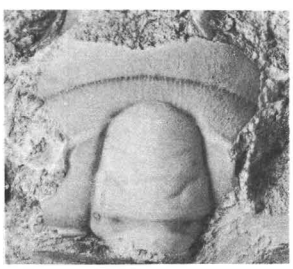

2

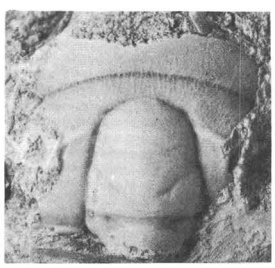

3

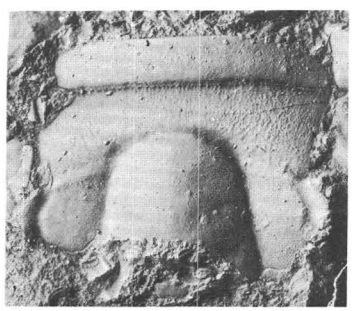

4

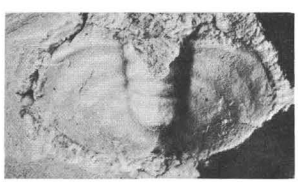

5


8

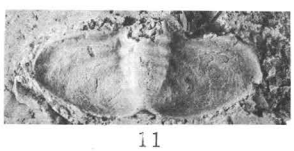

6

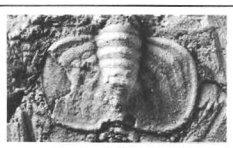



7

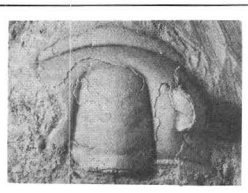

9

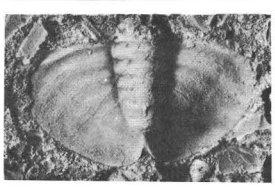

10

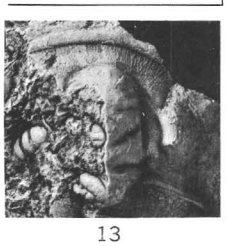

11

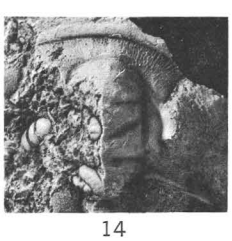

12

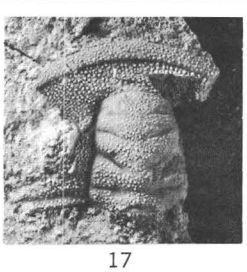

15


16

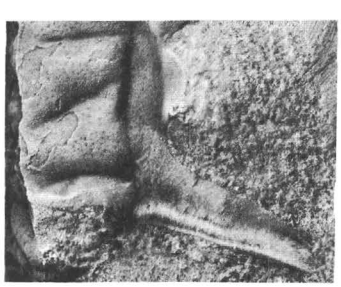


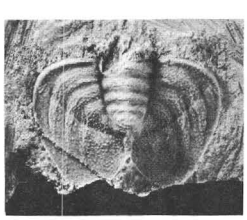

13

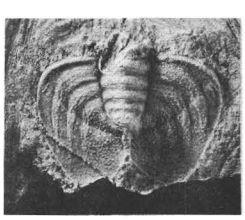

14


17


18




19



APHELASPIDINAE, UNASSIGNED PTEROCEPHALIIDAE

PLATE 12

FIGURES 1–7. *Housia varro* (Walcott) (p. 66).

1. Free cheek, × 6, USNM 141671.
2. Fragmentary cranidium, × 6, USNM 141672.
3. Holaspid pygidium, × 6, USNM 141673.
4–7. Meraspid pygidia, degrees 9, 8, and 6, showing macropleural last thoracic segment, × 10, USNM 141674, 141675, 141676, 141677.

All from USGS colln. 3081–CO, *Elvinia* zone, House Range, Utah.

8–11. *Housia ovata* Palmer (p. 65).

8. Exfoliated cranidium, × 1, showing glabellar muscle scars, USNM 141678, USGS colln. 1194–CO, *Elvinia* zone, Snake Range, Nev.
9. Exfoliated pygidium, × 2, USNM 136864b.
10. Stereogram of holotype cranidium, × 2, USNM 136863.
11. Free cheek, × 1,USNM 136864a.

All from USGS colln. 872–CO, *Elvinia* zone, Eureka, Nev.

12, 14, 15. *Parahousia constricta* Palmer (p. 66), × 4.

12. Stereogram of holotype cranidium, USNM 136870.
14. Pygidium, USNM 136871b.
15. Free cheek, USNM 136871a.

All from USGS colln. 955–CO, *Elvinia* zone, Eureka, Nev.

13, 18, 19. *Parahousia subequalis* n. sp. (p. 67), × 5.

13. Stereogram of holotype cranidium, USNM 141679.
18. Pygidium, USNM 141680.
19. Cranidium, showing variability in appearance of anterolateral fossulae, USM 141681.

All from USGS colln. 2563–CO, *Dunderbergia* zone, Shingle Pass, Nev.

16, 17, 20–23. *Prehousia diverta* n. sp. (p. 67).

16. Cranidium, × 3, USNM 141682.
17. Pygidium, × 3, USNM 141683.
21. Latex cast of free cheek, × 3, USNM 141684.

All from USGS colln. 1478–CO, *Dunderbergia* zone, Deep Creek Range, Utah.

20. Stereogram of holotype cranidium, × 2, USNM 141685.
22. Stereogram of exfoliated pygidium, × 3, USNM 141686.
23. Free cheek, × 2, USNM 141687.

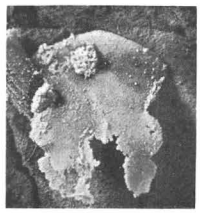
All from USGS colln. 3001–CO, *Dunderbergia* zone Bastian Peak, Nev.

24–26. *Prehousia semicircularis* Palmer (p. 69).

24. Stereogram of holotype cranidium, × 8, USNM 136868.
25. Pygidium, × 3, USNM 136869a.
26. Free cheek, × 4, USNM 136869b.

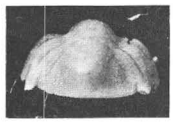
All from USGS colln. 2294–CO, *Dunderbergia* zone, Eureka, Nev.


1


2


3

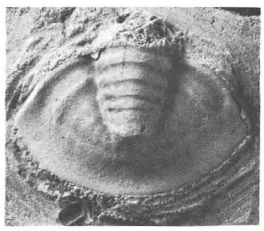

4

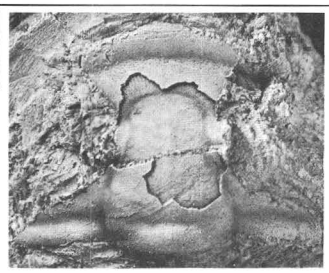

5

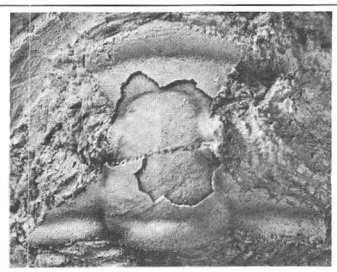

6


7

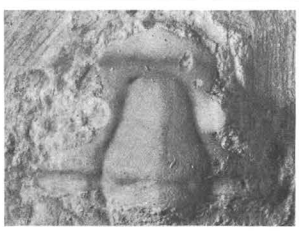

8

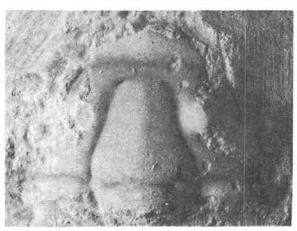

9

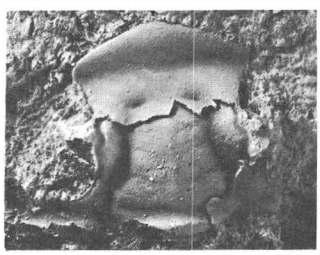

10

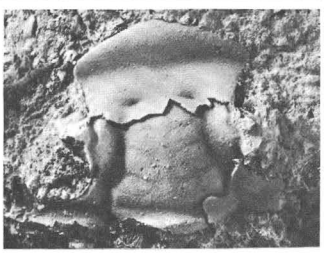



11


12

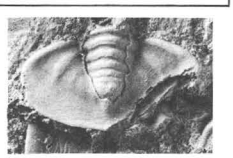


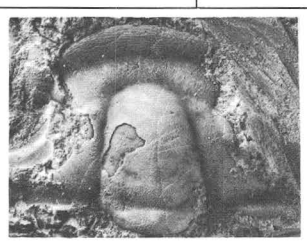

13

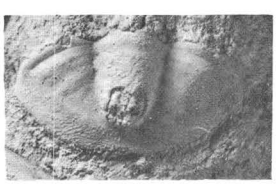



14

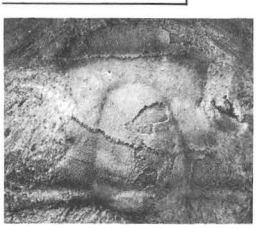

15

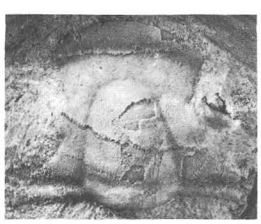

16


17

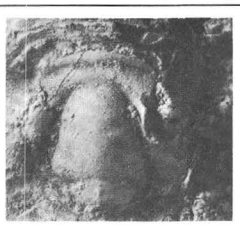

18

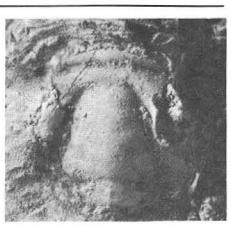

19

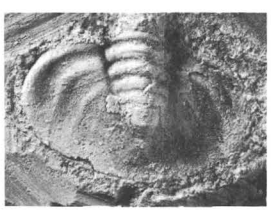

20



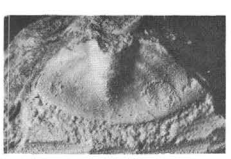

21


24




22


23


25


26

HOUSIINAE

PLATE 13

FIGURES 1, 3, 4. *Prehousia impolita* n. sp. (p. 68).

1. Stereogram of holotype cranidium, × 4, USNM 141688.
3. Stereogram of pygidium, × 2, USNM 141689.
4. Free cheek, × 2, USNM 141690.

All from USGS colln. 2540–CO, *Prehousia* zone, Cherry Creek, Nev.

2, 5, 8, 9, 12, 13. *Prehousia alata* Palmer (p. 67).

2. Stereogram of holotype cranidium, × 3, USNM 136866.
5. Stereogram of pygidium, × 2, USNM 136876b.

Both from USGS colln. 1441–CO, *Prehousia* zone, Snake Range, Nev.

8. Silicified pygidium, × 3, USNM 141691.
9. Ventral view of silicified pygidium, × 4, USNM 141692.
12. Silicified free cheek, × 6, showing doublure, USNM 141693.
13. Partially reconstructed cephalon, × 5, USNM 141694.

All from USGS colln. 1436–CO, *Prehousia* zone, Snake Range, Nev.

6, 7, 10, 11, 14, 15. *Prehousia indenta* n. sp. (p. 68).

6. Stereogram of holotype cranidium, × 2, USNM 141695.
10. Stereogram of pygidium, × 2, USNM 141696.
14. Free cheek, × 2, USNM 141697.

All from USGS colln. 2505–CO, *Prehousia* zone, McGill, Nev.

7. Cranidium, × 3, USNM 141698.
11. Pygidium, × 1.5, USNM 141699.
15. Closeup of surface of pygidium shown in fig. 11, × 6, showing pitted ornamentation.

All from USGS colln. 1440–CO, *Prehousia* zone, Snake Range, Nev.

16–18. *Prehousia prima* n. sp. (p. 68), × 3.

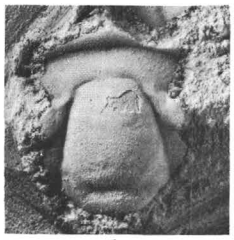
16. Stereogram of holotype cranidium, USNM 141700.
17. Stereogram of pygidium, USNM 141701.
18. Free cheek and pygidium, USNM 141702.

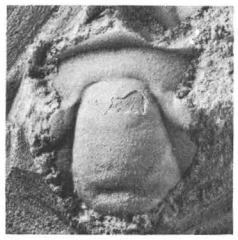
All from USGS colln. 2503–CO, *Dicanthopyge* zone, McGill, Nev.

19–23. *Tumicephalus depressus* n. gen., n. sp. (p. 90), × 4.

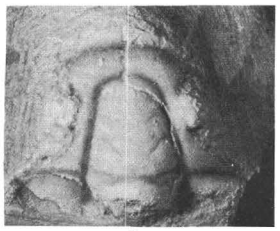
19. Free cheek, USNM 141703.
20. Thoracic segment, USNM 141704.
21. Stereogram of holotype cranidium, USNM 141705.
22. Pygidium, USNM 141706.
23. Hypostome, USNM 141707.

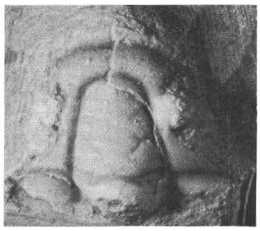
All from USGS colln. 1479–CO, *Dicanthopyge* zone, Deep Creek Range, Utah.


1

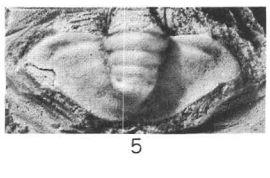


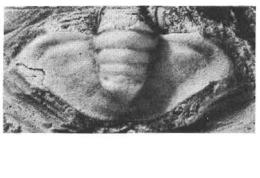

4

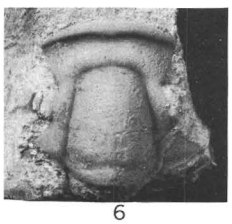

2

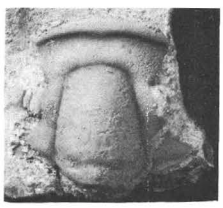


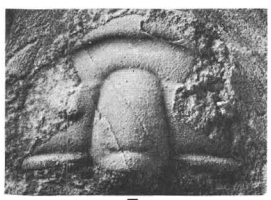

3

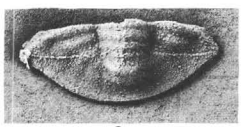

5

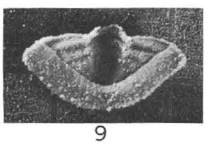



6

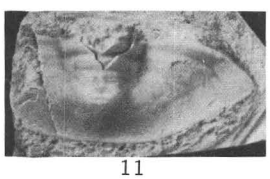



7

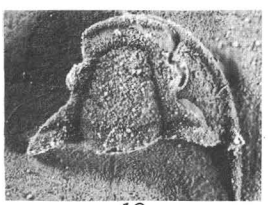

8


9


10

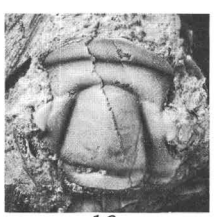

11

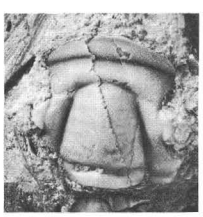

12

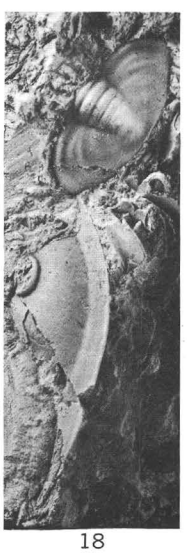

13

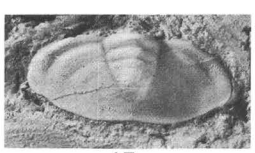

14


15


16

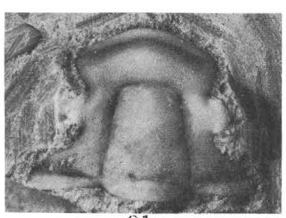


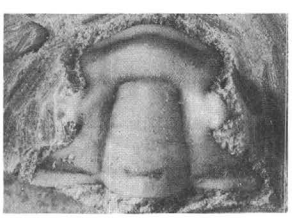

18


17


19


20


21




22


23

HOUSIINAE

PLATE 14

FIGURES 1–3. *Cernuolimbus orygmatos* Palmer (p. 70).

1. Stereogram of pygidium, × 3, USNM 136876c.
2. Stereogram of holotype cranidium, × 2, USNM 136875.
3. Free cheek, × 2, USNM 136876b.

All from USGS colln. 2295–CO, *Dunderbergia* zone, Eureka, Nev.

4–8. *Cernuolimbus semigranulosus* Palmer (p. 70).

4. Stereogram of holotype cranidium, × 3, USNM 136877.
5. Stereogram of pygidium, × 3, USNM 136878a.
8. Free cheek, × 3, USNM 136878b.

All from USGS colln. 2294–CO, *Dunderbergia* zone, Eureka, Nev.

6. Free cheek, × 3, USNM 141708.
7. Cranidium, × 2, USNM 141709.

Both from USGS colln. 2457–CO, *Dunderbergia* zone, Ash Meadows, Nev.

9. *Cernuolimbus depressus* Palmer (p. 69), × 5.

Stereogram of holotype cranidium, × 5, USNM 136879, USGS colln. 2297–CO, *Dunderbergia* zone, Eureka, Nev.

10–12, 18. *Cernuolimbus laevifrons* n. sp. (p. 70).

10. Stereogram of holotype cranidium, × 3, USNM 141710.
11. Cranidium, × 2; note assymetry of front margin; USNM 141711.
12. Stereogram of pygidium, × 3, USNM 141712.
18. Free cheek, × 3, USNM 141713.

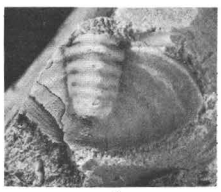
All from USGS colln. 2540–CO, *Prehousia* zone, Cherry Creek, Nev.

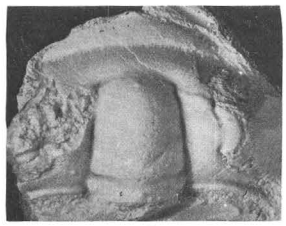
13–17. *Cernuolimbus granulosus* n. sp. (p. 70).

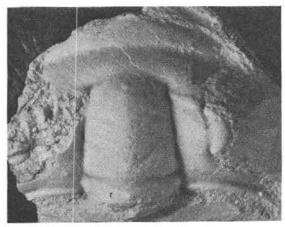
13. Free cheek, × 5, 141714.
14. Stereogram of holotype cranidium, × 5, USNM 141715.
15. Cranidium, showing inbend of border furrow, × 5, USNM 141716.
16. Stereogram of pygidium, × 5, USNM 141717.

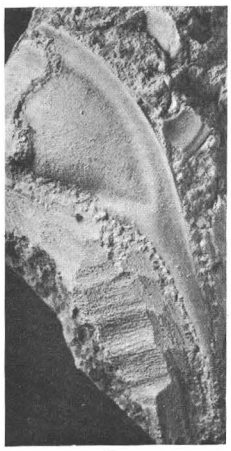
All from USGS colln. 2998–CO, *Dunderbergia* zone, House Range, Utah.

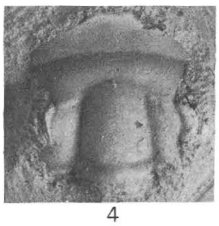
17. Cranidium, × 4, questionably assigned, having extensive granular ornamentation, USNM 141718, USGS colln. 1993–CO, *Dunderbergia* zone, Spring Mountains, Nev.

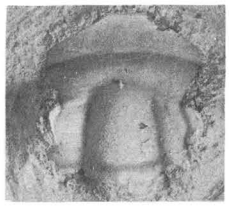

1


2

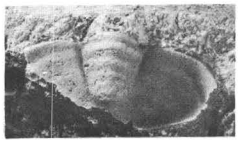


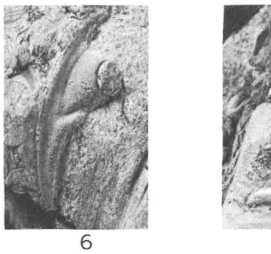

3

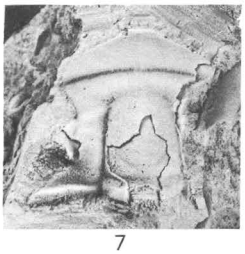

4



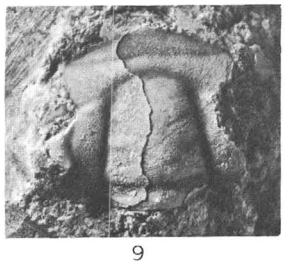

5



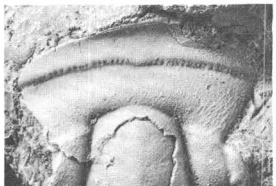

6


7


8

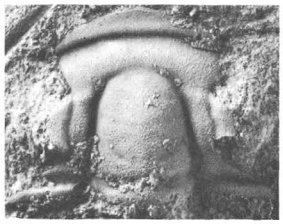

9

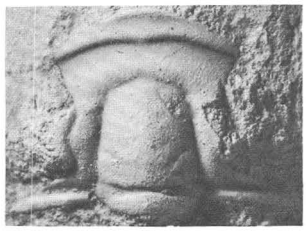

10

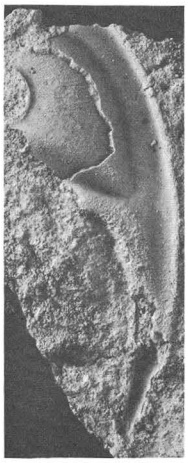

11


12

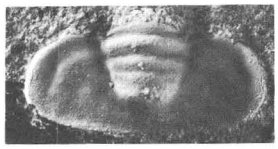

15


13


14


18


16




17

PTEROCEPHALIINAE

PLATE 15

FIGURES 1, 3, 5, 6. *Sigmocheilus flabellifer* (Hall and Whitfield) (p. 15).

1. Stereogram of cranidium, × 3, USNM 136898a.
3. Stereogram of pygidium, × 3, USNM 136898b.

Both from USGS colln. 955–CO, *Elvinia* zone, Eureka, Nev.

5. Free cheek, × 3, USNM 136899, USGS colln. 864–CO, *Elvinia* zone, Eureka, Nev.
6. Holotype pygidium, × 2, USNM 24569, *Elvinia* zone, Mt. Hamilton, Nev.

2, 4, 9. *Sigmocheilus pogonipensis* (Resser) (p. 74).

2. Stereogram of cranidium, × 3, USNM 136900a.
4. Stereogram of latex cast of pygidium, × 3, USNM 136900b.
9. Free cheek, × 3, USNM 136900c.

All from USGS colln. 2301–CO, *Dunderbergia* zone, Eureka, Nev.

7, 8, 10–15. *Sigmocheilus notha* (Resser) (p. 74).

7. Variant cranidium, × 5, nasute border having scattered granules, USNM 141719, USGS colln. 3007–CO, *Dunderbergia* zone, Bastian Peak, Nev.
8. Cranidium, × 2, holotype of *Iddingsia? quinnensis* Resser, USNM 108802a, USNM loc. 7j, Quinn Canyon Range, Nev.
10. Stereogram of cranidium, × 4, USNM 141720.
11. Free cheek, × 4, USNM 141721.
12. Stereogram of pygidium, × 4, USNM 141722.
14. Latex cast of pygidium, × 2, USNM 141723.
15. Pygidium, × 5, USNM 141724.

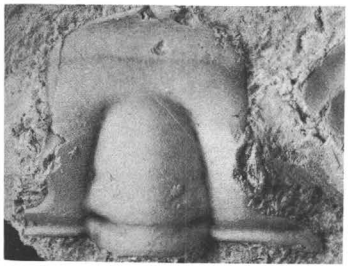
All from USGS colln. 3031–CO, *Dunderbergia* zone, McGill, Nev.

13. Holotype cranidium and associated pygidium, × 2, USNM 108781a, USNM loc. 7j, Quinn Canyon Range, Nev.

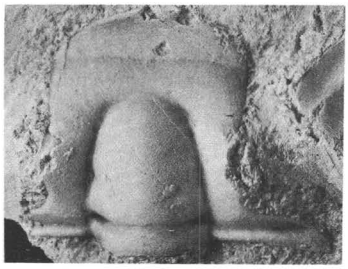
16–18. *Sigmocheilus grata* (Resser) (p. 74), × 3.

16. Stereogram of cranidium, USNM 136895c.
17. Free cheek, USNM 136895b.
18. Stereogram of latex cast of pygidium, USNM 136895a.

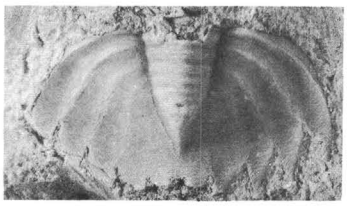
All from USGS colln. 2299–CO, *Dunderbergia* zone, Eureka. Nev.

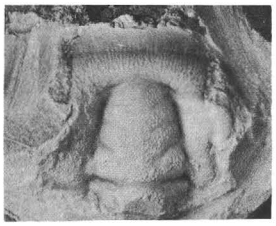


1

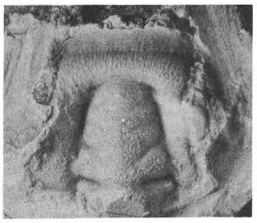


3





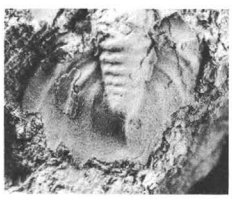
2



4

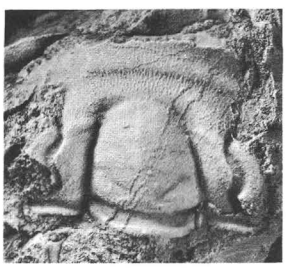
9

5

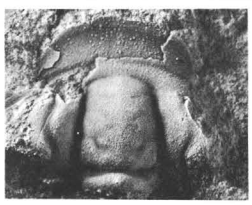


6

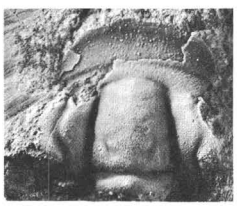
7



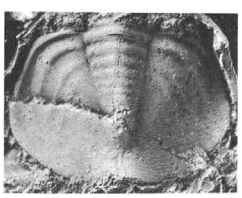
8



10



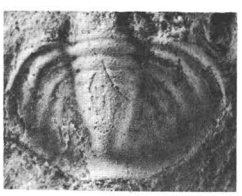
13



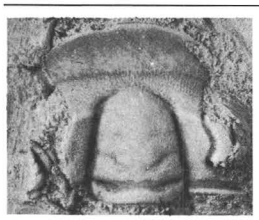
14

11

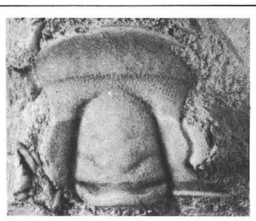
12



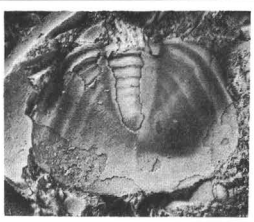
15



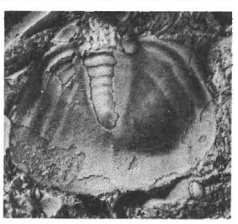
16



17



18



PTEROCEPHALIINAE

PLATE 16

FIGURES 1–3. *Strigambitus bilobus* n. gen., n. sp. (p. 76).
1. Free cheek, × 4, USNM 141725.
2. Stereogram of cranidium, × 5, USNM 141726.
3. Stereogram of holotype pygidium, × 5, USNM 141727.
All from USGS colln. 2608–CO, *Dunderbergia* zone, Ruby Range, Nev.

4, 5. *Strigambitus utahensis* (Resser) (p. 77).
4. Stereogram of latex cast of paratype cranidium, × 2, USNM 108785c.
5. Stereogram of latex cast of paratype pygidium, × 1.5, USNM 108785b.
Both from USNM loc. 33d, *Dunderbergia* zone, Fish Springs Range, Utah.

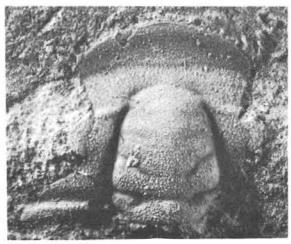
6–10. *Strigambitus transversus* n. gen., n. sp. (p. 77).
6. Free cheek, × 4, USNM 141728.
7. Stereogram of cranidium, × 3, USNM 141729.
8. Pygidium, × 4, showing an extreme variation of shape, USNM 141730.
9. Stereogram of holotype pygidium, × 2, USNM 141731.
10. Free cheek, × 3, showing long genal spine, USNM 141732.
All from USGS colln. 2612–CO, *Dunderbergia* zone, Deep Creek Range, Utah.

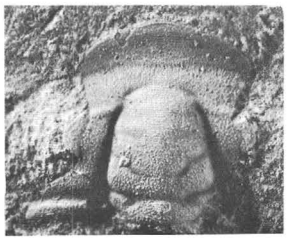
11–13. Genus and species undetermined 4 (p. 92).
11, 12. Cranidia, × 5, USNM 141733, 141734.
13. Pygidium, × 3, USNM 141735.
Both from USGS colln. 2598–CO, *Prehousia* zone, Ruby Range, Nev.

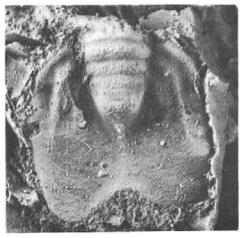
14–18. *Strigambitus? blepharina* n. gen., n. sp. (p. 76).
14. Stereogram of holotype cranidium, × 3, USNM 141736.
15. Free cheek, × 2, USNM 141737.
16. Stereogram of pygidium, × 3, USNM 141738.
17. Small cranidium, × 4, USNM 141739.
All from USGS colln. 756–CO, *Dunderbergia* zone, Quartz Spring area, California.
18. Free cheek, × 3, showing a variation in form, USNM 141740. USGS colln. 1268–CO, *Dunderbergia* zone, Quartz Spring area, California.

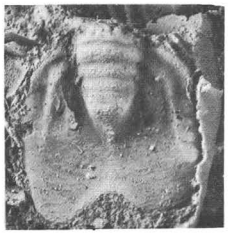
19. Genus and species undetermined 5 (p. 92), × 3.
Cranidium, USNM 141741, USGS Colln. 2607–CO, *Dunderbergia* zone, Ruby Range Nev.

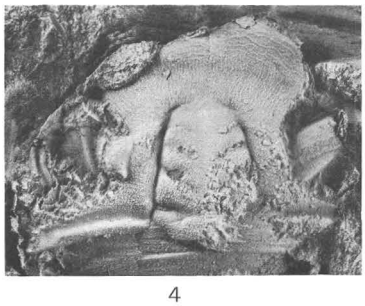

1

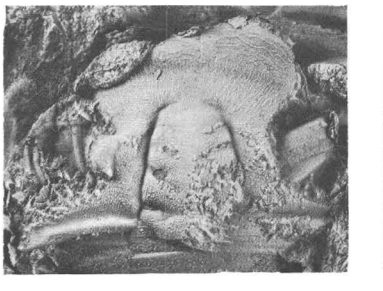

2


3

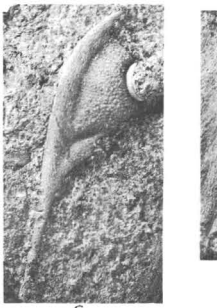

4

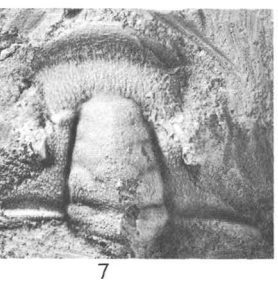

5


6


7

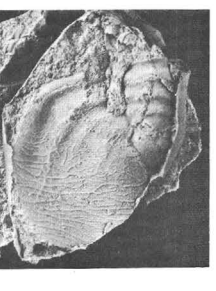
8

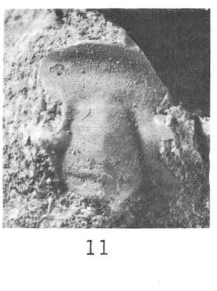

9

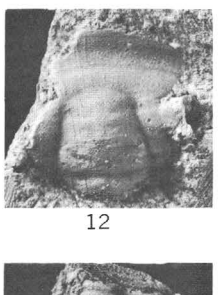

10

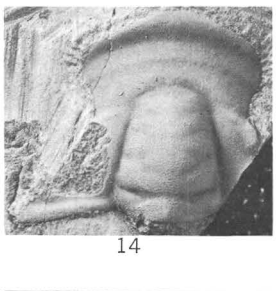

11

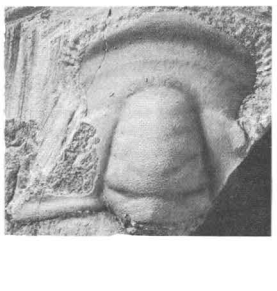

12

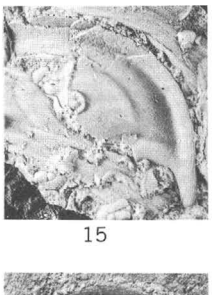

13


14


15


16


17


18


19

PTEROCEPHALIINAE

PLATE 17

FIGURES 1–3. *Pterocephalia sanctisabae* Roemer (p. 72).

1. Free cheek, × 2, USNM 136889b.
2. Stereogram of cranidium, × 3, USNM 136889a.

Both from USGS colln. 2302–CO, *Elvinia* zone, Eureka, Nev.

3. Stereogram of pygidium, × 3, USNM 136890, USGS colln. 2300–CO, *Elvinia* zone, Eureka, Nev.

4–7. *Pterocephalia concava* Palmer (p. 72).

4. Small pygidium, × 2, USNM 136888h.
5. Latex cast of large pygidium, × 1, USNM 136888f.
6. Stereogram of holotype cranidium, × 2, USNM 136887.
7. Free cheek, × 1, USNM 136888e.

All from USGS colln. 2297–CO, *Dunderbergia* zone, Eureka, Nev.

8, 12, 13. *Pterocephalia? punctata* n. sp. (p. 71).

8. Stereogram of holotype cranidium, × 5, USNM 141742.
12. Stereogram of latex cast of pygidium, × 3, USNM 141743.
13. Latex cast of free cheek, × 8, USNM 141744.

All from USGS colln. 2603–CO, *Dunderbergia* zone, Ruby Range, Nev.

9–11. *Pterocephalia elongata* Palmer (p. 72).

9. Stereogram of holotype cranidium, × 2, USNM 136891, USGS colln. 873–CO, *Dunderbergia* zone, Eureka, Nev.
10. Free cheek, × 3, USNM 136893a.
11. Stereogram of pygidium, × 3, USNM 136893c.

Both from USGS colln. 2300–CO, *Dunderbergia* zone, Eureka, Nev.

14–16. *Erixanium? brachyaxis* n. sp. (p. 50), × 5.

14. Cranidium, USNM 141745.
15. Pygidium, USNM 141746.

Both from USGS colln. 3023–CO, *Dunderbergia* zone, McGill, Nev.

16. Stereogram of holotype pygidium, USNM 141747, USGS colln. 2608–CO, *Dunderbergia* zone, Ruby Range, Nev.

17, 18. *Erixanium multisegmentus* n. sp. (p. 49), × 5.

17. Cranidium, USNM 136915a.
18. Holotype pygidium, USNM 136916.

Both from USGS colln. 2297–CO, *Dunderbergia* zone, Eureka, Nev.

19–21. *Erixanium carinatum* n. sp. (p. 49).

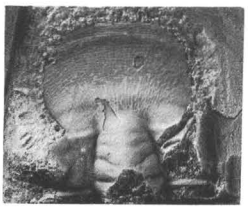
19. Cranidium, × 4, USNM 141748.
20. Holotype pygidium, × 6, USNM 141749.
21. Free cheek, × 5, USNM 141750.

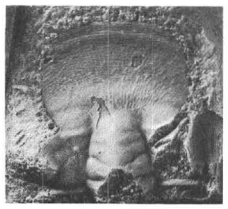
All from USGS colln. 3535–CO, *Dunderbergia* zone, Yucca Flat, Nev.

22. *Erixanium* sp. (p. 50), × 5.

Pygidium, USNM 141751, USGS colln. 2547–CO, *Dunderbergia* zone, Cherry Creek, Nev.

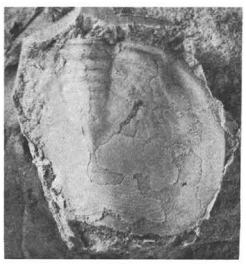

1

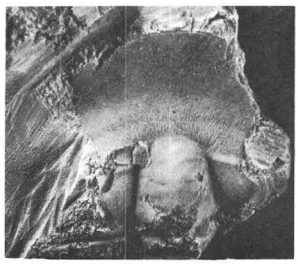

2

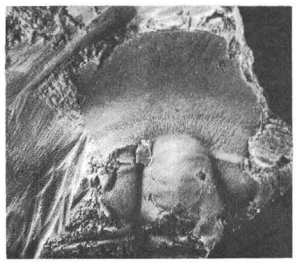


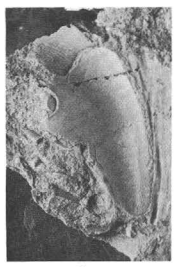

3


4

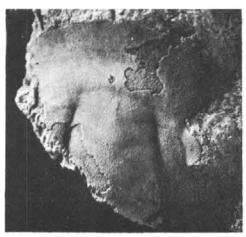

5


6

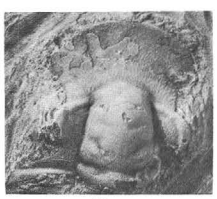



7


8




10


9


12

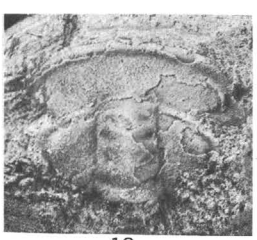

11


13

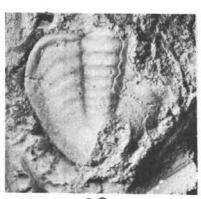

14


15


17

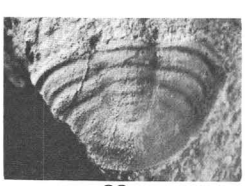

19

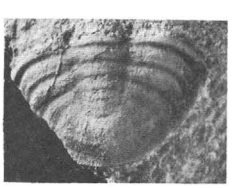

16


18


20


21




22

PTERICEPHALIINAE POSITION UNCERTAIN

PLATE 18

FIGURES 1–9. *Bromella veritas* n. gen., n. sp. (p. 81).

1. Free cheek, × 6, USNM 141752.
2. Stereogram of holotype cranidium, × 6, USNM 141753.
5. Pygidium, × 6, USNM 141754.
6. Cranidium, × 6, USNM 141755.

All from USGS colln. 2560–CO, *Prehousia* zone, Shingle Pass, Nev.

3. Cranidium, × 5, USNM 141756, USGS colln. 1439–CO, *Prehousia* zone, Snake Range, Nev.
4. Free cheek, × 5, USNM 141757.
8. Cranidium, × 6, USNM 141758.
9. Pygidium, × 6, USNM 141759.

All from USGS colln. 2997–CO, *Prehousia* zone, House Range, Utah.

7. Cranidium, × 10, showing short occipital spine, USNM 141760, USGS colln. 1440–CO, *Prehousia* zone, Snake Range, Nev.

10–13. *Dytremacephalus asperaxis* n. sp. (p. 85), × 10.

10. Sterogram of silicified holotype cranidium, USNM 141761.
11. Silicified free cheek, USNM 141762.
12. Silicified pygidium, USNM 141763.

All from USGS colln. 3026–CO, *Dunderbergia* zone, McGill, Nev.

13. Cranidium, USNM 141764, USGS colln. 3012–CO, *Dunderbergia* zone, Bastian Peak, Nev.

14, 16–19, 21. *Dytremacephalus granulosus* Palmer (p. 85).

14. Stereogram of cranidium, × 8, USNM 141765.
16. Free cheek, × 10, USNM 141766.
21. Pygidium, × 10, USNM 141767.

All from USGS colln. 3473–CO, *Dunderbergia* zone, House Range, Utah.

17. Silicified free cheek, × 10, USNM 141768.
18. Silicified cranidium, × 10, USNM 141769.
19. Silicified pygidium, × 10, USNM 141770.

All from USGS colln. 3003–CO, *Dunderbergia* zone, Bastian Peak, Nev.

15. *Minupeltis conservator* Palmer (p. 86), × 8.
Stereogram of holotype cranidium, USNM 136905, USGS colln. 2294–CO, *Dunderbergia* zone, Eureka, Nev.

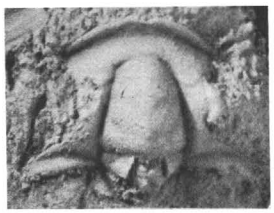
20. *Minupeltis definita* n. sp. (p. 86), × 8.
Stereogram of holotype cranidium, USNM 141771, USGS colln. 2541–CO, *Dunderbergia* zone, Cherry Creek, Nev.

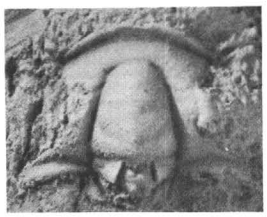
22, 23. *Bynumina globosa* (Walcott) (p. 82), × 10.

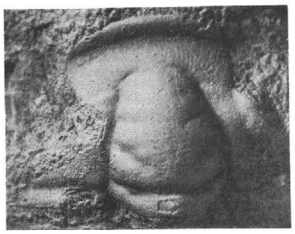
22. Cranidium, USNM 141772, USGS colln. 3109–CO, *Elvinia* zone, Snake Range, Nev.
23. Cranidium, questionably assigned, USNM 141773, USGS colln. 2563–CO *Dunderbergia* zone, Shingle Pass, Nev.

24. Genus and species undetermined 6 (p. 93), × 8.
Cranidium, USNM 141774, USGS colln. 2581–CO, *Elvinia* zone, Eureka, Nev.


1

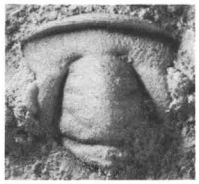

2

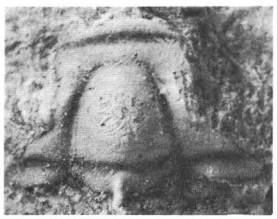


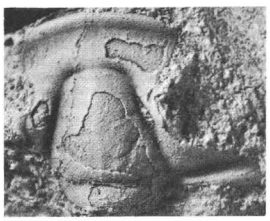

3


4

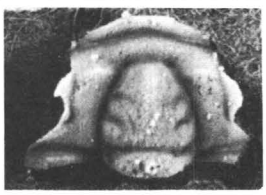

5

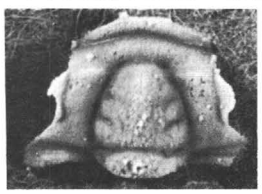

6

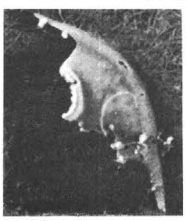

7


8

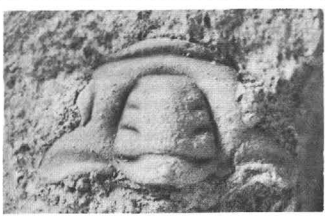

9

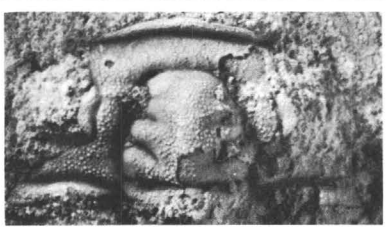

10

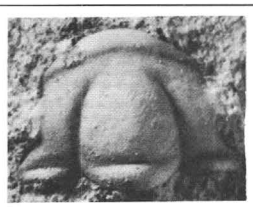


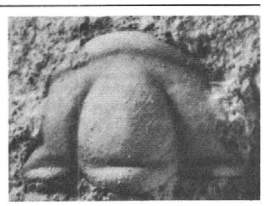

11


12


13

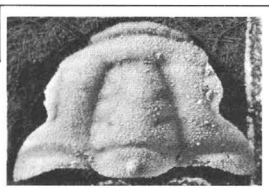

14



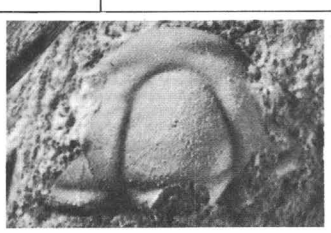

15

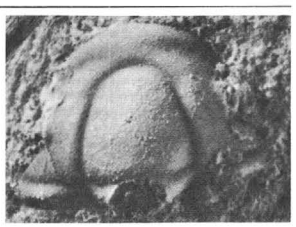

16


17

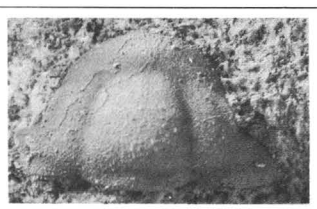

18

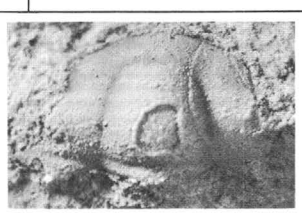

19

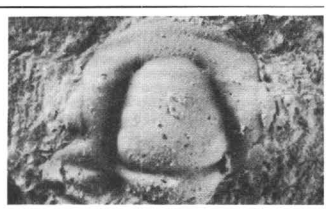



20


21


22


23


24

POSITION UNCERTAIN

PLATE 19

FIGURES 1, 3–6. *Aphelotoxon acuminata* (Palmer) (p. 79), × 10.

1. Stereogram of holotype cranidium, USNM 136903, USGS colln. 2296–CO, *Dunderbergia* zone, Eureka, Nev.
3. Cranidium, USNM 141775, USGS colln. 2605–CO, *Dunderbergia* zone, Ruby Range, Nev.
4. Silicified free cheek, USNM 141776.
5. Silicified cranidium, USNM 141777.
6. Silicified pygidium, USNM 141778.

All from USGS colln. 3003–CO, *Dunderbergia* zone, Bastian Peak, Nev.

2, 7. *Aphelotoxon punctata* n. sp. (p. 80), × 10.

2. Stereogram of holotype cranidium, USNM 141779, USGS colln. 2601–CO.
7. Cranidium, USNM 141780, USGS colln. 2603–CO. Both from *Dunderbergia* zone, Ruby Range, Nev.

8, 10, 11. *Aphelotoxon limbata* n. sp. (p. 80), × 10.

8. Stereogram of holotype cranidium, USNM 141781, USGS colln. 2999–CO, *Dunderbergia* zone, House Range, Utah.
10. Cranidium, USNM 141782.
11. Pygidium, USNM 141783.

Both from USGS colln. 3021–CO, *Dunderbergia* zone, McGill, Nev.

9, 12, 13. *Aphelotoxon spinosus* n. sp. (p. 80), × 10.

9. Stereogram of holotype cranidium, USNM 141784.
12. Free cheek, USNM 141785.
13. Small cranidium, USNM 141786.

All from USGS colln. 2998–CO, *Dunderbergia* zone, House Range, Utah.

14, 16. *Aphelotoxon marginata* n. sp. (p. 80), × 10.

14. Small pathologic cranidium; left side like that of *A. limbata*, USNM 141787.
16. Stereogram of holotype cranidium, USNM 141788.

Both from USGS colln. 3034–CO, *Dunderbergia* zone, McGill, Nev.

15, 17–20. *Comanchia minus* n. sp. (p. 83).

15. Stereogram of holotype cranidium, × 5, USNM 141789.
17. Stereogram of pygidium, × 5, USNM 141790.

Both from USGS colln. 2472–CO, *Elvinia* zone, McGill, Nev.

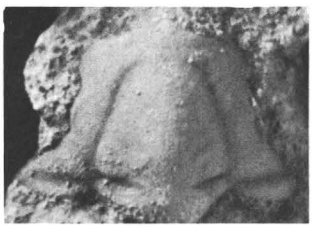
18. Free cheek, × 8, USNM 141791.
19. Cranidium, × 5, USNM 141792.
20. Pygidium, × 5, USNM 141793.

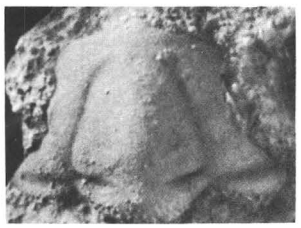
All from USGS colln. 1193–CO, *Elvinia* zone, Snake Range, Nev.

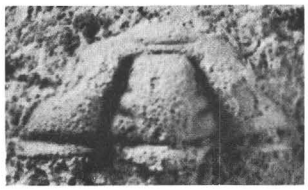
21, 22. *Aphelotoxon granulosus* n. sp. (p. 79), × 10.

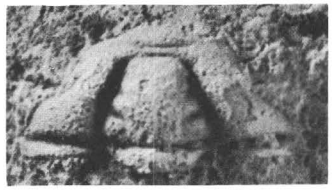
21. Free cheek, USNM 141794.
22. Holotype cranidium, USNM 141795.

Both from USGS colln. 2316–CO, *Dunderbergia* zone, Arizona Peak, Nev.


1

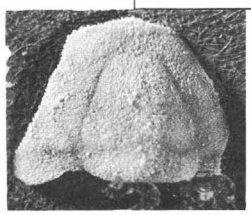


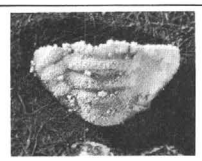

2



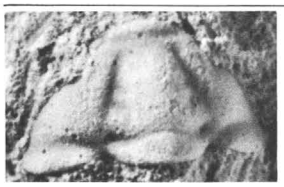

3

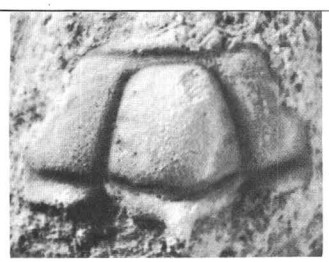

4

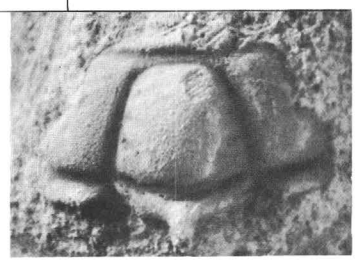

5


6


7


8


9

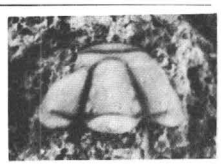


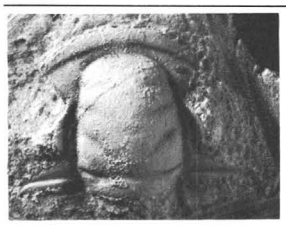

10

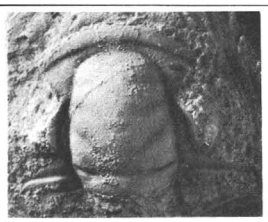

11

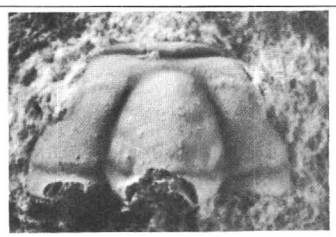

12

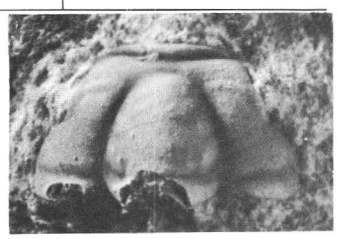

13


14


15




16



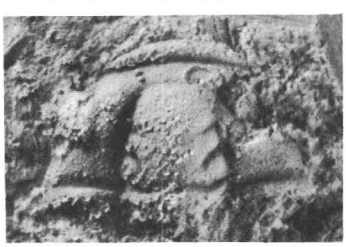

17


18


19


20


21


22

POSITION UNCERTAIN

PLATE 20

FIGURES 1–4, 6, 7, 11, 12. *Anechocephalus spinosus* n. sp. (p. 78).

1. Free cheek, × 5, USNM 141796.
2. Enlargement of ornamentation of holotype cranidium, × 10.
3. Stereogram of holotype crandium, × 5, USNM 141797.
4. Pygidium, × 5, USNM 141798.

All from USGS colln. 2579–CO, *Elvinia* zone, Eureka, Nev.

6. Cranidium, × 5, USNM 141799.
7. Pygidium, × 4, USNM 141800.

Both from USGS colln. 2581–CO, *Elvinia* zone, Eureka, Nev.

11. Cranidium, × 3, USNM 141801.
12. Pygidium, × 5, USNM 141802.

Both from USGS colln. 956–CO, *Elvinia* zone, Eureka, Nev.

5, 8–10, 13, 14. *Anechocephalus trigranulatus* Palmer (p. 78).

5. Cranidium, × 6, USNM 141803.
8. Enlargement of cranidium shown in fig. 5, × 10, showing ornamentation.
10. Cranidium, × 6, USNM 141804.
14. Pygidium, × 6, USNM 141805.

All from USGS colln. 2552–CO, *Elvinia* zone, Cherry Creek, Nev.

9. Cranidium, × 6, USNM 136886b.
13. Pygidium, × 5, USNM 136886a.

Both from USGS colln. 952–CO, *Dunderbergia* zone, Eureka, Nev.

15, 16, 20. *Morosa brevispina* n. sp. (p. 87), × 8.

15. Pygidium, USNM 141806.
16. Stereogram of holotype cranidium, USNM 141807.
20. Free cheek, USNM 141808.

All from USGS colln. 1268–CO, *Dunderbergia* zone, Quartz Spring area, Calif.

18–19. *Morosa longispina* Palmer (p. 87), × 6.

17. Pygidium, USNM 141809.
18. Stereogram of holotype cranidium, USNM 136909.
19. Latex cast of free cheek, USNM 141810.

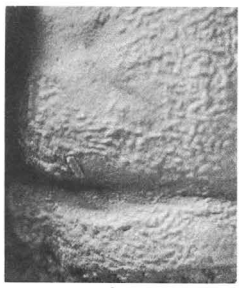
All from USGS colln. 2299–CO, *Dunderbergia* zone, Eureka, Nev.

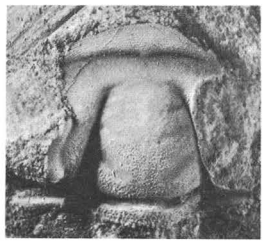
21–25. *Morosa extensa* n. sp. (p. 87).

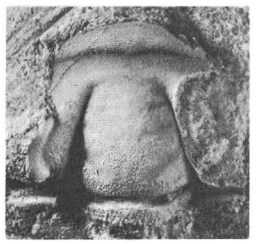
21. Free cheek, × 3, USNM 141811.
22. Stereogram of holotype cranidium, × 5, USNM 141812.
23. Stereogram of pygidium, × 3, USNM 141813,
24. Small cranidium, × 6, USNM 141814.
25. Small pygidium, × 6, USNM 141815.

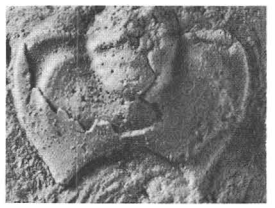
All from USGS colln. 2605–CO, *Dunderbergia* zone, Ruby Range, Nev.

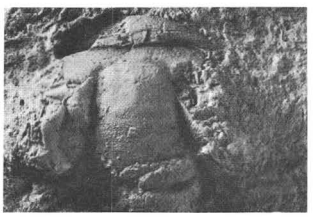

1

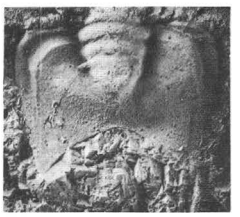

2

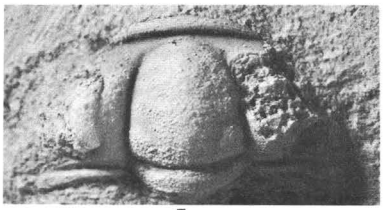

3

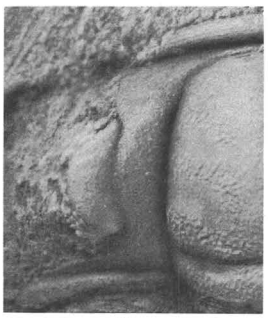



4


6


7

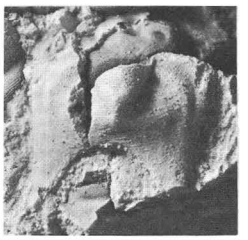

5

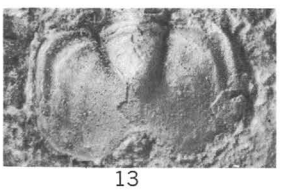

8


9


10

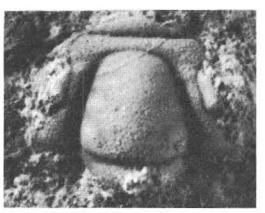

11

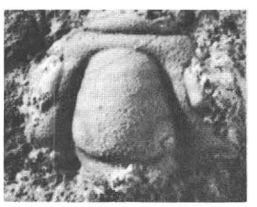

12


13

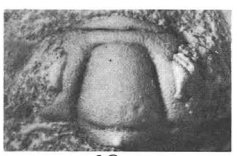

14

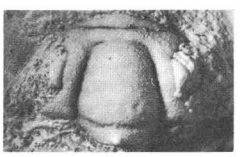

15

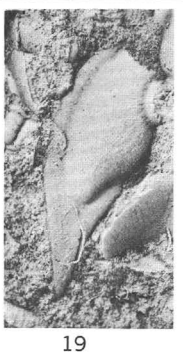

16

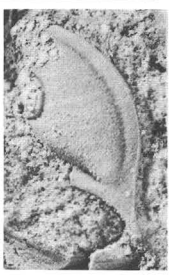



17

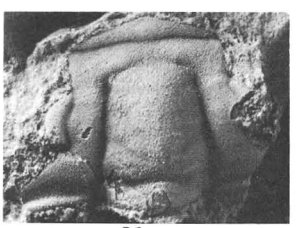

18

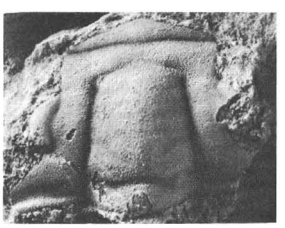


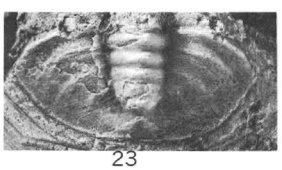

19


20


22


21




23


24


25

POSITION UNCERTAIN