An Unusual Lower Cambrian Trilobite Fauna from Nevada

GEOLOGICAL SURVEY PROFESSIONAL PAPER 483-F

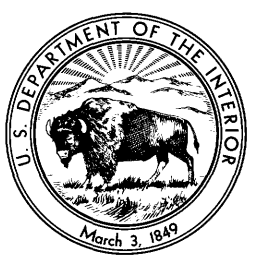
An Unusual Lower Cambrian Trilobite Fauna from Nevada

By ALLISON R. PALMER

CONTRIBUTIONS TO PALEONTOLOGY

GEOLOGICAL SURVEY PROFESSIONAL PAPER 483–F

Twelve species representing the Olenellidae, Oryctocephalidae, Ogygopsidae, Dorypygidae, Zacanthoididae, and Ptychopariidae are described and figured



UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON : 1964

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–

An unusual Lower Cambrian trilobite fauna from Nevada. Washington, U.S. Govt. Print. Off., 1964.

iii, 14 p. 3 plates, map, diagr. 30 cm. (U.S. Geological Survey. Professional Paper 483–F)

Contributions to paleontology. Bibliography: p. 12.

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

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

CONTENTS

ILLUSTRATIONS

[Plates follow index]

CONTRIBUTIONS TO PALEONTOLOGY

AN UNUSUAL LOWER CAMBRIAN TRILOBITE FAUNA FROM NEVADA

By ALLISON R. PALMER

ABSTRACT

A fauna of at least 12 species of trilobites, from lower Cambrian rocks in Esmeralda County, Nev., constitutes the largest single assemblage of trilobites yet described from Lower Cambrian beds in North America. Well-preserved specimens of the Olenellidae, Oryctocephalidae, Ogygopsidae, Dorypygidae, Zacanthoididae, and Ptychopariidae are present. New taxa include *Paedeumias granulatus* n. sp.; *Goldfieldia pacifica* n. gen., n. sp.; *Bonnia caperata* n. sp.; *Zacanthopsis contractus* n. sp.; *Zacanthopsina eperephes* n. gen., n. sp.; and *Stephenaspis? avitus* n. sp.

INTRODUCTION

During reconnaissance geologic mapping of Esmeralda County, Nev., J. P. Albers and J. H. Stewart, of the U.S. Geological Survey discovered many localities of fossiliferous Lower Cambrian rocks. Collections from most of these localities were submitted to me for examination. In 1960 a collection from one of these localities (fig. 1) was found to contain an association of nonolenellid trilobites of Middle Cambrian aspect together with undoubted olenellids. In 1961 I was guided to this locality by J. H. Stewart and obtained a large supplemental collection. That collection is the principal source of the specimens described here.

Lower Cambrian trilobite collections from the Western States rarely contain assemblages of more than half a dozen species. Most of the trilobites in any one collection are olenellids, although occasionally a simple ptychoparioid or a species of *Bonnia* or of *Zacanthopsis* may be present. Rarely are the specimens well preserved. Thus, the discovery of an excellently preserved Lower Cambrian trilobite assemblage that contains at least 10 genera representing at least 6 families can be properly termed unusual.

The fossil-bearing beds (USGS Colln. 3748–CO) crop out in a series of low north-facing hills about 3 miles southeast of the junction of Nevada Highways 3 and 71 south of Goldfield, Nev., and about 5 miles northeast of Gold Point in the SW¼ sec. 28, T. 6 S., R. 42 E., Goldfield (1:250,000) quadrangle, Nevada. The trilobites are preserved in dark-gray limestone beds less than 6 inches thick that are characterized by well-rounded grains of quartz sand "floating" in the limestone matrix or concentrated in the lower part of the beds. These

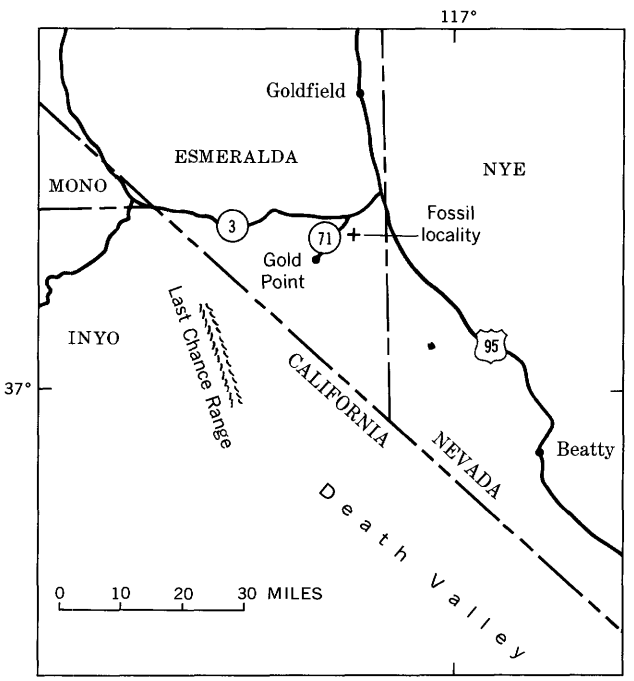


FIGURE 1.—Map showing the locality of the fossil collection described in this report.

beds are about 40 feet above a 45-foot-thick brown sandstone unit (Stewart, written communication, June 1963). The sandy limestones have the characteristics of a rock type that is found in the lower part of the Saline Valley Formation (Nelson, 1962) just above a basal sandy or quartzite unit. Nelson subsequently visited this locality and confirmed the identification of the fossiliferous beds as the lower part of the Saline Valley Formation. Nelson also examined stratigraphically important sections in the Last Chance Range, Calif. (fig. 1), in company with J. H. Stewart and me in April 1963. It was determined that the basal quartzites of the Saline Valley Formation in the northern part of the range correlate with the Zabriskie Quartzite exposed in the southern part of the range. Collections from the upper part of the Saline Valley Formation have yielded species of the olenellid genus *Bristolia*. This is a characteristic and locally abundant genus in the Lower Cambrian part of the Carrara Formation, which is above the Zabriskie Quartzite, in the Death Valley

region. Thus, the fauna described here from the lower part of the Saline Valley Formation seems firmly established in the upper part of the Lower Cambrian in a position slightly older than that yielding the *Bristolia* fauna (fig. 2).

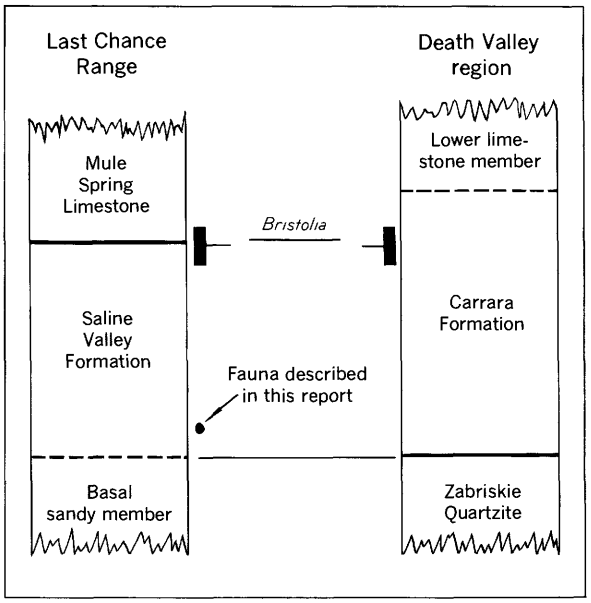


FIGURE 2.—Correlation of parts of the Lower Cambrian formational sequences between the Last Chance Range and the Death Valley region, California, showing the approximate stratigraphic position of the fauna described in this report.

This trilobite assemblage cannot be compared at present with any other known assemblage in the Cordilleran region of North America. Lower Cambrian assemblages, which include various nonolenellids but fewer total species, have been described by Rasetti (1948) from boulders in the Levis conglomerates of Quebec and by Resser (1938) from limestones of the Austinville district, Virginia; but the fauna described here is by far the largest and most varied assemblage of Lower Cambrian trilobites yet described from North America. Entirely new forms are *Zacanthopsina eperephes* n. gen., n. sp., and *Stephenaspis? avitus* n. sp. Typical Lower Cambrian species include *Paedeumias granulatus* n. sp., *Wanneria* cf. *W. walcottana* (Wanner), *Zacanthopsis contractus* n. sp., *Bonnia caperata* n. sp., and *Syspacephalus* sp. In addition, the fauna includes *Ogygopsis batis* (Walcott), which represents a long-ranging genus that until recently (Nelson, 1963) was not definitely known to occur in Lower Cambrian beds; the fauna also includes the first Cordilleran record of Lower Cambrian representatives of *Olenoides* (at least two unnamed species) and of the family Oryctocephalidae (*Goldfieldia pacifica* n. gen., n. sp.). It is rather surprising that eodiscids, described by Rasetti (1948) from the Lower Cambrian of Quebec and reported by him (Rasetti, 1951) from the Lower Cambrian of British Columbia, are absent from this assemblage. Sampling of the Lower Cambrian faunas of the Western States has just begun, however, and an increase in our knowledge of these older trilobite faunas can be anticipated.

SYSTEMATIC PALEONTOLOGY

The descriptive terminology used for the olenellids is the same as that used earlier by me. (See Palmer, 1957.) Descriptive terminology for the other trilobites is that found in the illustrations or glossary of the Treatise on Invertebrate Paleontology, Part O, Arthropoda 1 (Harrington and others, 1959). Familial or generic assignments that have no comment indicate acceptance of the classification in the treatise. Locality data and identifying locality numbers for figured specimens are recorded in the Cambrian-Ordovician locality catalog of the U.S. Geological Survey. All figured specimens, unless otherwise indicated, are from U.S. Geological Survey collection 3748–CO.

Order REDLICHIIDA Richter

Family OLENELLIDAE Vogdes

Genus PAEDEUMIAS Walcott

Paedeumias Walcott, 1910, p. 304; Resser, 1928, p. 4; Poulsen, 1932, p. 26; Resser and Howell, 1938, p. 225; Poulsen, 1959, p. 192.

Type species.—*Paedeumias transitans* Walcott, 1910, p. 305, pl. 34, fig. 1.

Diagnosis.—Olenellidae having glabella distinctly separated from cephalic border by preglabellar field but generally connected to border by narrow median ridge. Cephalic border wirelike. Palpebral lobes long; line connecting posterior tips crosses glabella posterior to midlength of preoccipital segment. Intergenal spines short and directed nearly straight posteriorly in mature holaspids; near genal spines.

Discussion.—Walcott originally diagnosed *Paedeumias* as a genus differing from *Olenellus* by having thoracic segments posterior to the spine-bearing 15th segment. Resser (1928) correctly referred one of Walcott's best paratypes (Walcott, 1910, pl. 33, fig. 1) to *Olenellus*, thus negating the generic differentiation proposed by Walcott. However, Resser then presented a new diagnosis based on cephalic features. With some modifications and additions, this is the concept of *Paedeumias* presently in use. Resser and Howell (1938) noted the distinctive narrowness of the cephalic border as a generic feature. The usefulness of this characteristic was demonstrated statistically by Palmer (1957) on a silicified sample of associated species of *Olenellus* and *Paedeumias*.

Several olenellid species share the characteristics of long palpebral lobes, narrow cephalic border, and distinct preglabellar field but differ in sagittal length of the preglabellar field, length of the palpebral lobe, ornamentation, and other features. They constitute a supraspecific taxon (*Paedeumias*) that differs from another taxon of comparable rank (*Olenellus*) in which the species have a characteristically broader border. The arguments of Bell (1931) and Shaw (1955) for suppression of *Paedeumias* as a synonym of *Olenellus* are no longer valid. Discussion of subgeneric versus generic status for *Paedeumias* is moot, at least until an acceptable classification is presented for the Olenellidae. Therefore, *Paedeumias* is considered here as a distinctive genus of the Olenellidae.

Paedeumias granulatus n. sp.

Plate 1, figures 1–10

Description.—Cephalon subsemicircular in outline, gently to moderately convex transversely and longitudinally. Anterior and lateral margins evenly curved. Posterior margin straight and perpendicular to axial line between intergenal spines; directed slightly anterolaterally between intergenal and genal spines. Genal spine slender, directed straight posteriorly; length slightly more than one-half distance from genal angle to base of occipital segment. Intergenal spine present only as node on posterior margin; separated from genal spine by distance slightly less than three times basal width of genal spine.

Glabella prominent and has well-defined glabellar furrows; separated from border by sagittal distance equal to slightly less than twice sagittal length of border and connected to border by low, poorly defined median ridge. Glabellar segments generally defined only at distal ends. Occipital and preoccipital furrows deep, narrow at sides of glabella, hardly apparent across top. The two remaining furrows represented by deep narrow slots isolated from sides of glabella by ocular lobe or by posterolaterally directed distal ends of first leg segment. Posterior pair of slots generally shorter transversely than anterior pair. A moderately well-defined furrow may connect anterior pair of slots and outline posterior margin of frontal lobe of glabella. Larger cephala (pl. 1, fig. 10) consistently bear small dimple on axial line just anterior to this furrow on posterior part of frontal lobe. Occipital ring has distinct node on axial line at posterior margin.

Ocular lobes long, slender, gently curved; posterior tips opposite midlength of occipital segment and barely separated from it by narrow posterior extension of infraocular cheek. Each ocular lobe has distinct furrow delineating a narrow lateral rim along entire length of lobe; transverse width of this rim about one-fourth width of ocular lobe.

Interocular area narrow and depressed below glabella and ocular lobe; has moderately to poorly defined hump in posterior part and, on largest specimens, distinct veination. Greatest width about equal to width of ocular lobe.

Extraocular cheek broad and nearly flat and has moderately well-defined radial veination; greatest width about one-fourth or slightly less than one-fourth greatest width of cephalon. Cephalic border narrow; width one-fifth or less than one-fifth width of extraocular cheek.

External ornamentation of most specimens consists of closely spaced fine granules, often apparent only after whitening, on all parts except furrows and cheek area in front of glabella. Some large specimens have external surface nearly smooth or have irregular short terrace lines on all observed parts.

Hypostome has anterior lobe of middle body inflated. Anterior margin slightly acuminate on axial line, rim narrow, upturned. Middle furrows deep. Posterior lobe of middle body reduced; six pairs of marginal spines on specimen 6 mm in length.

Discussion.—This distinctive species of *Paedeumias* differs from all others so far described by the granular ornamentation of many specimens and by the well-defined furrow on the lateral parts of the ocular lobes. The intergenal spines are farther from the genal spines, the ocular lobes are longer, and the interocular areas are narrower than in many other species of the genus.

All known specimens of this species are broken, but parts of at least 50 cephala are in the collection. These cephala range from 2 mm to about 20 mm in sagittal length. The small meraspid specimens do not have a well-defined furrow on the ocular lobe, but the granular ornamentation can be seen on the extraocular cheeks. The principal variable features of the holaspid specimens are the ornamentation and the definition of the furrow outlining the posterior part of the frontal lobe of the glabella.

Genus WANNERIA Walcott

Wanneria Walcott, 1910, p. 296; Poulsen, 1932, p. 35; Lake, 1937, p. 245; Resser and Howell, 1938, p. 227; Poulsen, 1958, p. 16; Poulsen, 1959, p. 197.

Type species.—*Olenellus* (*Holmia*) *walcottanus* Wanner, 1901, p. 267, pl. 31, figs. 1, 2; pl. 32, figs. 1–4.

Diagnosis.—Olenellidae in which cephalon has genal spines at posterolateral corners; intergenal spines not apparent. Glabella has expanded frontal lobe reaching to or nearly to inner edge of border. Ocular lobe arcuate and has well-defined longitudinal furrow. Ex-

ternal surfaces of all parts generally have characteristic strong reticulate meshwork of raised ridges.

Anterior width of thorax nearly as great as width of cephalon; third segment not macropleural.

Wanneria cf. W. walcottana (Wanner)

Plate 1, figures 11–13, 15

Wanneria walcottana Wanner. Walcott, 1910, p. 302, pl. 30, figs. 1–12.

Description.—Cephalon subsemicircular in outline, gently to moderately convex transversely and longitudinally. Anterior and lateral margins evenly curved. Posterior margin nearly straight; curved gently backward distally to base of genal spine. Genal spine moderately short, not divergent from lateral margin of cephalon; length on small holaspid (sagittal length of cephalon 12 mm) slightly less than distance from inner edge of spine to base of occipital segment. Separate intergenal spine not apparent.

Glabella prominent, reaching to or nearly to inner edge of border. Glabellar furrows well defined, deepest distally, shallow across axial line. Distal ends of first leg segment directed for short distance posterolaterally outside of anterolateral ends of second leg segment.

Ocular lobes strongly curved, moderately close to glabella; line connecting posterior tips passes about over occipital furrow. Distinct longitudinal furrow on ocular lobe, delineating narrow lateral rim.

Interocular area depressed; greatest width opposite preoccipital furrow and about equal to transverse width of ocular lobe on same line.

Extraocular cheek gently to moderately convex; has moderately wide well-defined lateral and posterior borders. Border furrows joined at moderately acute genal angle. Width of lateral border about one-third greatest distance from lateral margin of eye to border furrow.

External surfaces of smaller specimens covered with coarse ornamentation of poorly formed reticulations mixed with irregularly raised terrace lines, so that whitened specimens appear in part to be granular. Large specimens have coarse raised reticulate network on all parts.

Discussion.—This species, which is less common than *Paedeumias granulatus*, is represented by only two incomplete small cephala, a large hypostome, and many fragments of large specimens that display well-defined reticulate ornamentation. The species is not well enough represented to be separately named. However, it differs from the Mexican species, *Wanneria buelnaensis* Lochman (in Cooper and others, 1952), by having the genal spines at the posterolateral cephalic corners. *W. buelnaensis* is here considered a distinct species rather than a variety of *W. walcottana* (Wanner) because of the consistently advanced position of its genal spines. The general shape of the cephalon of the species described here is most like that of *W. nathorsti* Poulsen from Greenland. However, it differs from *W. nathorsti* by having deeper anterior glabellar furrows and by having the reticulate ornamentation less well defined at comparable stages of growth.

Small specimens that have relatively longer palpebral lobes than have associated large specimens of *Wanneria walcottana* in Pennsylvania were considered by Walcott to show that the size of the palpebral lobe relative to cephalic size decreased as individuals became larger (Walcott, 1910, p. 296, pl. 30, figs. 3, 4). Resser and Howell (1938, p. 229, pl. 8, fig. 10) assigned Walcott's small illustrated specimens to *Esmeraldina macer* (Walcott) without comment. The holotype of *E. macer*, which is from a different locality, is a small, nearly complete specimen having a narrow thorax. The posterior cephalic margin of this specimen is not well preserved, and it is not possible to determine whether morphologic features that usually indicate a narrow thorax are present. Walcott's small specimens are associated with large specimens of *W. walcottana* which has a broad thorax. These small specimens have posterior cephalic outlines essentially like those of the large specimens and there is no compelling reason for removing them from the species sample solely because of small size. The small cephala from Nevada also have long palpebral lobes and do not differ in any other observable feature from *W. walcottana*. Therefore, they may be conspecific with the specimens from Pennsylvania.

The ornamentation on large specimens in the Nevada collection is unusual. Fragments of the exoskeleton, when viewed from below, show a striking series of perforations arranged in a reticulate pattern exactly paralleling the pattern of reticulate ridges on the external surface (pl. 1, fig. 11). The exoskeleton breaks along the margins of the reticulations, showing that the perforations continue upward into the exoskeleton as tubes that do not reach the dorsal surface. These tubes outline polygonal plates, which make up the entire exoskeleton. This exoskeletal structure may well be a characteristic feature of the genus *Wanneria*. Similar perforations from the ventral surface outline polygonal plates on scraps associated with one of the paratypes of *W. buelnaensis* Lochman, and specimens of *W. walcottana* that are slightly crushed show breakage along lines of weakness around the margins of polygons.

Order CORYNEXOCHIDA Kobayashi

Family DORYPYGIDAE Kobayashi

Genus BONNIA Walcott

Corynexochus (Bonnia) Walcott, 1916, p. 325.

Bonnia Walcott. Raymond, 1928, p. 309; Resser, 1936, p. 6; Resser, 1937, p. 44; Lermontova, 1940, p. 142; Lochman, 1947, p. 68; Rasetti, 1948, p. 14; Lermontova, 1951, p. 118; Pokrovskaya, 1959, p. 135; Poulsen, 1959, p. 217.

Type species.—*Bathyurus parvulus* Billings, 1861, p. 953, fig. 361.

Discussion.—Because this genus has been defined many times, there is now little controversy about its included species. Rasetti (1948) has pointed out, however, that species cannot be accurately defined without knowledge of well-preserved associated parts because the primary distingushing characteristics of external ornamentation are often different on the cranidium and on the pygidium of the same species. Secondary characteristics of taxonomic value are shape of glabella, particularly at its anterior end; depth of occipital furrow; size and shape of occipital ring; depth of glabellar furrows; depth of pleural and ring furrows on pygidium; number and length of pygidial border spines.

Bonnia caperata n. sp.

Plate 2, figures 11–16

Description.—Glabella well defined, moderately arched transversely and longitudinally, expanded slightly and evenly forward nearly to border; anterolateral corners strongly rounded; anterior end blunt. Glabellar furrows apparent only as shallow indentations adjacent to axial furrows. Occipital furrow deep at sides, shallow across axis. Occipital ring of nearly constant width and nearly flat; distinct axial node or spine absent. Frontal area consists only of narrow gently convex border. Fixed cheek gently convex, slightly downsloping; width, exclusive of palpebral lobe, slightly less than one-half basal glabellar width. Palpebral lobes well defined by change in slope of cheek surface, somewhat sunken, gently curved; length slightly more than one-third length of glabella exclusive of occipital ring. Line connecting midlengths of palpebral lobes crosses glabella slightly posterior to glabellar midlength. Ocular ridge low, poorly defined, parallel with and close to border; contact with glabella marked by shallow fossula in axial furrow. Posterior limb broad; tip bluntly rounded; transverse length slightly more than basal glabellar width. Posterior border furrow deep near glabella, shallow laterally. Posterior border has no noticeable geniculation.

Course of anterior section of facial suture short, slightly convergent anteriorly in gentle curve from palpebral lobe to anterior margin. Course of posterior section strongly divergent behind palpebral lobes, then curved strongly backward to posterior margin.

Free cheek narrow and has gently curved lateral margin and short blunt genal spine; width at eye about one-eighth length of cheek including genal spine. Border poorly defined, convex, wider than ocular platform. Posterior sutural margin intersects shallow lateral border furrow.

Pygidium subsemicircular in outline, slightly flared at anterolateral corners. Axis well defined, slightly tapered backward, strongly rounded at end; reaches to inner edge of border. Four ring furrows indicated posterior to articulating furrow; only first and, in some specimens second furrows continuous across axis. Pleural fields crossed by three or four shallow pleural furrows that do not cross border. Border narrow, convex, and of nearly constant width. One pair of short anterolateral border spines present.

External ornamentation variable. Glabella covered with concentrically arranged irregular terrace lines except over areas of muscle scars. Fixed cheeks may have irregular ornamentation of terrace lines in all places less well defined than on glabella; or, if terrace lines are subdued, the cheeks have scattered fine pits. Top of occiptal ring has moderately prominent irregular terrace lines. Palpebral lobes, tips of posterior limbs, and ocular platform of free cheek smooth or covered with scattered fine pits. Border of cranidium and free cheek has subparallel terrace lines. Pygidium either nearly smooth or has scattered fine pits on pleural fields and irregular coarse ridges on top of axis or irregular anastomosing ridges on all parts.

Discussion.—Although many species of *Bonnia* have been named, most are represented by material inadequate for meaningful comparison. The adequately represented Cordilleran species are *B. columbensis* Resser and *B. fieldensis* (Walcott). Both lack significant external ornamentation, although specimens of *B. fieldensis* have scattered fine pits. In addition, the first pleural furrows on the pygidia of both species continue across the border to the pygidial margin instead of stopping at the border furrow as in *B. caperata*. Species of *Bonnia* from other regions that are ornamented with terrace lines differ from *B. caperata* by having associated granular ornamentation and, generally, a differently shaped glabella and occipital ring. *Bonnia brennus* (Walcott) (Rasetti, 1948, pl. 3, figs. 16–25) is perhaps most typical of these forms.

Genus OLENOIDES Meek

Olenoides spp.

Plate 2, figures 7–10

Discussion.—At least two species have pygidia possessing the characteristic border spines and well-defined

pleural and interpleural furrows of *Olenoides*. One has four pairs of long slender border spines (pl. 2, figs. 9, 10), and the other has four pairs of short slender border spines (pl. 2, fig. 8). Both species have granular external surfaces.

All five fragmentary specimens of the short-spined species are from a small collection, USGS collection 3655–CO. This was the orignal collection submitted by Stewart. A later collection (3748–CO) from the locality yielded a large fauna, including six specimens of the long-spined species. Other species in collection 3655–CO are the same as those in the later collection. At the two times of collection, apparently slightly different beds were collected from, as is reflected by the different *Olenoides* species. This was confirmed by Stewart (written communication, June 1963), who re-evaluated his field notes after our collecting trip.

Four-spined species of *Olenoides* having a granular surface have been described from beds of Early and Middle Cambrian age. However, all such species are represented by so few individuals that variability cannot be determined, and minor differences between the known small samples cannot be evaluated. Cranidia that have a granular surface are associated with the long-spined specimens discussed here and may belong to the same species. However, until infraspecific variability of the pygidia, which have the principal characteristics of specific value, can be determined, specific identification of the specimens illustrated here will be meaningless.

Family OGYGOPSIDAE Rasetti

Genus OGYGOPSIS Walcott

Ogygopsis Walcott, 1889, p. 466; Walcott, 1916, p. 375; Raymond, 1912, p. 116; Shimer and Shrock, 1944, p. 613; Rasetti, 1951, p. 190; Rasetti, 1959, p. 219.

Taxioura Resser, 1939, p. 62; Shimer and Shrock, 1944, p. 617.

Type species.—*Ogygia klotzi* Rominger, 1887, p. 12, pl. 1, fig. 1.

Description.—Isopygous opisthoparian trilobites; cephalon subsemicircular in outline, gently to moderately convex transversely and longitudinally. Glabella long, large, reaching to or nearly to border, strongly rounded at front, moderately convex transversely and longitudinally; sides subparallel or bowed slightly outward. Glabellar furrows generally not apparent on uncrushed material. Occipital furrow moderately well defined, nearly straight. Occipital ring does not have obvious nodes or spines. Frontal area short; sagittal length less than one-eighth that of glabella. Border narrow, poorly defined by change in slope. Fixed cheeks gently convex, slightly downsloping; transverse width, exclusive of palpebral lobes, slightly less than one-half basal glabellar width. Palpebral lobes gently arcuate, well defined by shallow palpebral furrows, generally connected to glabella by low ocular ridge; length about one-third length of glabella exclusive of occipital ring. Line connecting midlengths of palpebral lobes passes over glabella posterior to glabellar midlength. Posterior limbs tapered laterally to blunt point; transverse length slightly greater than basal glabellar width.

Course of anterior section of facial suture nearly straight forward from palpebral furrow to border, then curved gently inward to cut anterior margin near anterolateral cranidial corners. Posterior section straight or slightly convex from palpebral lobes to posterior margin.

Lateral border of free cheek moderately defined by shallow border furrow that almost disappears near base of genal spine. Border distinctly narrower than ocular platform. Contact between ocular platform and eye surface marked by low collar that is separated from ocular platform only by sharp change in slope. Genal spine moderately short; length about equal to length of posterior section of facial suture.

Thorax consists of eight segments; tips of each segment have single short laterally directed slender spines. Axial rings do not have well-defined nodes or spines. Width of pleural regions distinctly greater than width of axis.

Pygidium subsemicircular in outline; length slightly more than one-half greatest width. Axis well defined, slender, reaching nearly to posterior margin; has seven or more complete ring furrows posterior to articulating furrow; width slightly less than one-fourth greatest width of pygidium. Pleural regions broad, gently convex, crossed by five or more moderately deep pleural furrows that reach to inner edge of narrow, convex border of nearly constant width. Interpleural furrows also present on some specimens. Margin of pygidium smooth or has one or more pairs of short, sharp spines.

Discussion.—This genus is easily recognizable by the combination of a cranidium having a prominent subparallel-sided glabella reaching almost the entire cranidial length and a large pygidium having a narrow axis and border and well defined ring and pleural furrows. Rasetti (1951, p. 191) concluded that *Taxioura* (Resser, 1939) was a subjective synonym of *Ogygopsis* after comparing the type species, *T. typicalis* Resser, with *O. klotzi*. Resser's second species of *Taxioura*, *T. magna*, was founded on an incorrect association of parts and is here removed from *Ogygopsis*. The pygidium of this species (Resser, 1939, pl. 14, figs. 1, 2) agrees in all morphological details with *T. typicalis*. The holotype and paratype cranidia of *T. magna* all have coarse granular external ornamentation and a short occipital spine. These cranidia probably belong to *Olenoides maladensis*

Resser, a species—from the same fauna—whose pygidia have a coarse granular surface.

Nelson noted (1963, p. 246) that *Bathyuriscus batis* Walcott, from Lower Cambrian beds in western Nevada, is actually a species of *Ogygopsis*. Other species presently assigned to *Ogygopsis* are *O. spinulosa* Rasetti and *Taxioura elongata* McLaughlin and Enbysk.

Specimens of all species of *Ogygopsis* except *O. elongata* (McLaughlin and Enbysk, 1950) were examined for this study. Two features of the pygidium were found to be valid for species discrimination. All species except *O. klotzi* have at least one pair of marginal pygidial spines, and the number of pairs of spines is constant for each species. Also, the number of well-defined pleural furrows is constant for each large collection studied. If these characters are used in combination, at least five species of *Ogygopsis* can be recognized. Pygidia of *O. klotzi* (Rominger) lack marginal spines and have seven well-defined pleural furrows. Pygidia of *O. typicalis* (Resser) have one pair of anterolateral spines and seven well-defined pleural furrows. Pygidia of *O. spinulosa* Rasetti have at least seven pairs of marginal spines, indications of two additional pairs of marginal spines and seven well-defined pleural furrows. These three species are of Middle Cambrian age. Pygidia of *O. batis* (Walcott) from Lower Cambrian beds have one pair of anterolateral marginal spines and five or six well-defined pleural furrows. Pygidia of a second, undescribed Lower Cambrian species from Esmeralda County, Nev., have six or seven pairs of marginal spines and five or six well-defined pleural furrows. Thus, the principal character of stratigraphic value seems to be the number of pleural furrows. No Lower Cambrian specimens have more than six pleural furrows, whereas all Middle Cambrian specimens have seven pleural furrows.

Ogygopsis elongata (McLaughlin and Enbysk) may be a synonym of *O. typicalis* (Resser). Well-preserved specimens from the Metaline Limestone in the type region for *O. elongata* have all the characteristics of *O. typicalis*, and the differences in proportion used for discrimination of the distorted specimens of *O. elongata* may not be valid.

In addition to the easily recognizable pygidial differences, each species may have characteristic external ornamentation. Only *Ogygopsis klotzi*, *O. typicalis*, and *O. batis* are represented by specimens well enough preserved to check this character. The external surfaces of all well-preserved specimens of *O. klotzi* are smooth except for low terrace lines on the margins of the cranidium, free cheek and pygidium. *O typicalis* has a finely formed "fingerprint" pattern of terrace lines on the glabella and an irregular close-spaced pattern of terrace lines on other parts of the cranidium and free cheeks. The terrace lines on the pygidium form a fine meshwork of irregular polygons. On *O. batis* the terrace lines on the cheek regions of the cephalon, as well as those on the pygidium form an irregular meshwork of tiny polygons; in addition, the surfaces of all parts are covered with numerous fine pits. This ornamentation is apparent only after whitening of well-preserved specimens.

Ogygopsis batis (Walcott)

Plate 2, figures 1–6

Bathyuriscus batis Walcott, 1916, p. 337, pl. 48, figs. 4, 4a.

Diagnosis.—Species of *Ogygopsis* in which cranidium has moderately well-defined anterior border separated from glabella by narrow brim; course of border furrow an even curve, uninterrupted and undeflected by front of glabella. Pygidium has one pair of short, sharp, anterolateral border spines and no more than six well-defined pleural furrows. Interpleural furrows shallow or absent. External surfaces of pleural regions of cephalon, thorax, and pygidium, and tops of axial rings and occipital ring have fine polygonal network of terrace lines. Surface of glabella has fine "finger print" ornamentation of terrace lines. All parts finely pitted.

Discussion.—The type of *Ogygopsis batis* is a poorly preserved specimen from slightly metamorphosed Lower Cambrian rocks at Miller Mountain, Nev. Unfigured paratype and topotype specimens show a single pair of anterolateral pygidial spines and fewer than seven pleural furrows. Because these characteristics seem to be of specific value for the well-preserved specimens described here, these specimens are considered conspecific with the specimens from Miller Mountain.

Family ORYCTOCEPHALIDAE Beecher

Genus GOLDFIELDIA n. gen.

Type species.—*Goldfieldia pacifica* n. sp.

Diagnosis.—Oryctocephalidae which have glabella poorly defined at front, narrowest at occipital ring; frontal lobe has median depression in anterior part. Posterior pair of glabellar furrows connected laterally to axial furrows. Cranidial border wirelike.

Discussion.—This is a monotypic genus. Its relations to other trilobites are discussed after the description of the type species.

Goldfieldia pacifica n. sp.

Plate 1, figures 14, 16–18

Description.—Oryctocephalidae which have cranidium subtrapezoidal in outline, gently convex transversely and longitudinally; width between anterior sec-

tions of facial sutures about two-thirds width between tips of posterior limbs. Anterior margin gently curved.

Glabella well defined at sides; axial furrows subparallel between occipital and preoccipital furrows, divergent slightly forward between preoccipital and second glabellar furrows, where divergence increases width of glabella by about one-fourth, then subparallel to junction with ocular ridge. Front of glabella anterior to ocular ridges not clearly defined. Four pairs of lateral glabellar furrows present but not connected across top of glabella; posterior and anterior pairs connected laterally to axial furrows; second pair from rear consists of isolated pits. Frontal glabellar lobe has shallow median depression on anterior part. Occipital furrow shallow; occipital ring has small median node.

Frontal area gently concave; border narrow, wirelike.

Fixed cheek broad, gently convex, horizontal; width, exclusive of palpebral lobe, about equal to basal glabellar width. Palpebral lobe well defined by sharp change in slope, slightly curved, at distinct angle to axial line; length about equal to basal glabellar width; line connecting posterior tips passes over preoccipital furrow. Ocular ridge poorly defined, reaching axial furrow about opposite anterior glabellar furrow.

Posterior limbs moderately long, tips rounded; transverse length nearly twice basal glabellar width. Posterior border furrow moderately deep distally, becoming shallower toward glabella and nearly disappearing just before reaching axial furrow.

Course of anterior section of facial suture straight forward from palpebral lobe. Course of posterior section of facial suture moderately to strongly convex; strongly divergent immediately behind palpebral lobe.

External surfaces of all parts of cranidium smooth.

Other parts not known.

Discussion.—The most distinctive features of this species are the poorly defined front of the glabella, the median depression in the anterior part of the frontal glabellar lobe, the wirelike cranidial border, the glabellar shape, and the posterior pair of glabellar furrows connected laterally with the axial furrows. No other oryctocephalid species described possesses this combination of characteristics. Forms such as *Lancastria roddyi* (Walcott) and *Tonkinella valida* Chernysheva have a wirelike border on the front of the cranidium in addition to a broader border that is in contact with the glabella. Nothing on the cranidia of *Goldfieldia pacifica* indicates the presence of any border other than the wirelike one. *L. roddyi* is the only previously described Lower Cambrian oryctocephalid, and the known specimens are rare and are deformed. The holotype of *L. roddyi* shows the apparent connection of the posterior glabellar furrows across the top of the glabella but no clear indication of their connection to the axial furrow. This character, plus the apparent presence of a broad cranidial border is sufficiently different from *G. pacifica* n. sp. to warrant placing the forms in different genera.

Family ZACANTHOIDIDAE Swinnerton

Genus STEPHENASPIS Rasetti

Stephenaspis Rasetti, 1951, p. 180; Rasetti, 1959, p. 229.

Type species.—*Stephenaspis bispinosa* Rasetti, 1951, p. 181, pl. 10, figs. 1–6.

Diagnosis.—Cephalon has slender anteriorly expanded glabella that reaches to narrow anterior border. Fixed cheeks narrow; width exclusive of palpebral lobes one-half or less than one-half basal glabellar width. Palpebral lobe long, slender, curved; anterior end separated from axial furrow by moderately narrow part of fixed cheek. Posterior limb slender; posterior fixigenal spine absent.

Pygidium subquadrate in outline; has prominent axis and gently convex pleural region lacking well-defined border. Posterolateral margin has pair of slender posteriorly directed spines.

Stephenaspis? avitus n. sp.

Plate 3, figures 10–14

Description.—Cranidium, exclusive of posterior limbs, subquadrate in outline and moderately convex transversely and longitudinally; width between palpebral lobes about equal to sagittal length. Anterior margin moderately curved. Frontal area constricted in front of glabella, divided laterally into brim and border by sharp change in slope. Glabella low, clearly defined, reaching onto border; gently and evenly expanded forward, anterolateral corners sharply rounded. Four pairs of lateral glabellar furrows present; posterior pair deepest, directed backward at acute angle to axial furrow; second pair nearly at right angles to axial furrow; anterior two pairs directed slightly anteriorly from axial furrow. Occipital furrow moderately deep at sides of glabella, shallower across axial line. Occipital ring nearly flat, moderately long sagittally; some specimens have low axial keel and all specimens have a short median spinule on posterior margin.

Fixed cheeks gently convex; width, exclusive of palpebral lobes, about one-half basal glabellar width. Palpebral lobes well defined by deep palpebral furrows, strongly curved, connected to axial furrows at junction with fourth pair of glabellar furrows by low ocular ridge that crosses moderately narrow part of fixed cheek; length of palpebral lobe slightly less than one-half sagittal length of glabella.

Posterior limb long and slightly backswept and has bluntly rounded tip; transverse length generally

slightly more than basal glabellar width. Posterior border furrow broad, deep.

Course of anterior section of facial suture slightly divergent forward from palpebral lobe to border, then sharply turned inward across border to merge imperceptibly with anterior margin. Course of posterior section of facial suture moderately convex from palpebral lobe to posterior margin.

Free cheek has moderately curved lateral margin continuing backward into short genal spine. Border narrow, well defined; width distinctly less than width of ocular platform. Lateral and posterior border furrows of even depth, joined in sharp curve at genal angle.

External surfaces of most parts covered with fine closely spaced granules generally apparent only after whitening.

Discussion.—The general cranidial characteristics of this species, including the long anteriorly expanded glabella, the long palpebral lobes that have the anterior ends moderately separated from the axial furrows, and the posterior limbs that have no posterior fixigenal spines, are those of *Stephenaspis*. On *S.? avitus* the facial sutures are less divergent forward and the cheek width between the anterior end of the palpebral lobe and the axial furrow is greater than on the genotype, *S. bispinosa* Rasetti. The genal spine on the free cheek is also somewhat shorter. However, without knowledge of the structure of the pygidium, which is of critical importance for generic identification in this group, the species described here cannot be definitely assigned to *Stephenaspis*. If the pygidia described on page F12 belong in *S.? avitus*, the trilobite resembles *Poliella denticulata* (Rasetti, 1951, pl. 12, figs. 6–9). However, *P. denticulata* has distinctly narrower fixed cheeks adjacent to the anterior ends of the palpebral lobes.

Ptarmigania and *Ptarmiganoides* are two somewhat similar genera in which cranidia have long palpebral lobes and have a moderate distance between the anterior end of the palpebral lobe and the axial furrow. In both these genera, however, the genal spines are advanced, and the posterior limbs of the cranidia bear prominent posterior fixigenal spines. These characteristics are so much like those of *Zacanthoides* that both *Ptarmigania* and *Ptarmiganoides* probably should be removed from the Dolichometopidae, in which they were placed by Rasetti (1951) and by Poulsen (1959), and placed in the Zacanthoididae.

Genus ZACANTHOPSIS Resser

Type species.—*Olenoides levis* Walcott, 1886, p. 187, pl. 25, figs. 3, 3a.

Description.—Small corynexochid trilobites; total length of largest known specimen estimated as 25 mm. Cranidium subquadrate in outline, gently to moderately convex transversely and longitudinally. Glabella long, slender, expanded slightly at anterior end, bluntly rounded in front. Glabellar furrows poorly defined. Occipital furrow deep, straight. Occipital ring has slender posteriorly directed axial spine extending from posterior margin. Frontal area moderately short; sagittal length between one-third and one-fourth of sagittal length of glabella exclusive of occipital ring. Border moderately to poorly defined; where apparent, separated from glabella by narrow concave brim. Fixed cheeks broad, horizontal or gently upsloping, flat or gently convex; width, exclusive of palpebral lobes, about three-fourths basal glabellar width. Palpebral lobes long, strongly bowed, transversely convex, well-defined by palpebral furrows, generally slightly elevated above surface of fixed cheek; lateral margins vertical; anterior ends distinctly separated from axial furrows by moderately narrow part of cheek that is crossed by distinct ocular ridges. Transverse line through midpoints of palpebral lobes passes over posterior half of glabella. Posterior limbs short and have rounded tips barely extending laterally beyond palpebral lobes.

Course of anterior section of facial suture divergent forward from palpebral lobe to border, then curved inward across border to merge imperceptibly with anterior margin. Posterior section of facial suture divergent almost straight laterally behind palpebral lobe, then curved strongly backward to posterior margin.

Free cheek known only for type species. Border broad, gently convex, extending laterally into broad-based genal spine that is distinctly anterior to genal angles of cephalon. Lateral border furrow shallow. Posterior border furrow narrow, moderately deep, connected to lateral furrow at base of genal spine. Eye surface joined to ocular platform without intervening infraocular ring. Ocular platform gently convex, about as wide as border. Anterior sutural margin about parallel to posterior border furrow.

Pygidium small, subovate in outline; known only for type species. Axis prominent, tapered backward, bluntly rounded at rear; width about equal to width of pleural region, length slightly less than that of pygidium. Two ring furrows present posterior to articulating furrow. Pleural fields crossed by one or two shallow pleural furrows. Border poorly defined and narrow and has three or four pairs of short marginal spines.

External surfaces of known species partly or wholly covered with fine closely spaced granules.

723 - 401 O - 64 - 2

Discussion.—The description is based on the study of all the specimens of *Zacanthopsis* in the collections at the U.S. National Museum or in the U.S. Geological Survey. The slender anteriorly expanded glabella and the wide fixed cheeks having long arcuate palpebral lobes whose anterior ends are distinctly separated from the axial furrows, combined with the presence of a moderately well-defined frontal area and short posterior limbs distinguish species of this genus from other corynexochid trilobites. All known specimens of *Zacanthopsis* are from Lower Cambrian rocks. Because the associated parts of *Z. levis* (Walcott), the type species, have never been adequately illustrated, they are presented here (pl. 3 figs. 1–3) for comparison with *Z. contractus* n. sp. and for future reference.

Zacanthopsis contractus n. sp.

Plate 3, figures 4–6

Diagnosis.—Species of *Zacanthopsis* in which the cranidium has anterior border convex, moderately well defined; width between anterior sections of facial sutures considerably less than width between lateral margins of palpebral lobes; occipital ring has short slender occipital spine. Axial part of glabella has fine closely spaced granules. Granules also apparent on fixed cheeks of some specimens; not observed on frontal area.

Discussion.—This species is distinguished from *Zacanthopsis levis* (Walcott) and from *Z. virginica* Resser by having a better defined anterior border and by being distinctly narrower between the anterior sections of the facial sutures than between the palpebral lobes. Although the species is known from only five cranidia, these characteristics seem constant. The small occipital spine, unfortunately, was broken from the holotype during preparation.

Genus ZACANTHOPSINA n. gen.

Type species.—*Zacanthopsina eperephes* n. sp.

Diagnosis.—Small Corynexochida that have prominent ocular ridges undifferentiated from arcuate palpebral lobes; ridges expanded slightly adjacent to glabella and merged with frontal glabellar lobe.

Discussion.—The genus most similar to *Zacanthopsina* is *Zacanthopsis*, which also has broad fixed cheeks, short posterior limbs, and a short frontal area that has a strongly concave brim and strongly convex, elevated border. In *Zacanthopsis*, however, the ocular ridge reaches the glabella at the posterior part of the frontal lobe and does not merge with the frontal lobe.

Zacanthopsina eperephes n. sp.

Plate 3, figures 7–9

Description.—Small corynexochid trilobites; total length of largest individual probably less than 2 cm. Cranidium subquadrate in outline; sagittal length about two-thirds greatest width. Glabella long, slender, and well defined in posterior part, expanded forward and poorly defined anteriorly, reaching nearly to border. Three pairs of shallow lateral glabellar furrows apparent. Occipital furrow deep, straight. Posterior margin of occipital ring produced posteriorly into short, slightly upsloping median spine. Frontal area short; sagittal length between one-third and one-fourth sagittal length of glabella; anterolateral corners depressed. Brim in front of glabella strongly concave, differentiated only by change in slope from strongly convex, elevated border. Fixed cheeks broad, flat, nearly horizontal; width, exclusive of palpebral lobes, slightly greater than basal glabellar width. Palpebral lobes prominent, long, strongly arcuate, continuous with prominent ocular ridge that extends to and merges with anterior part of frontal lobe of glabella; line connecting posterior tips of palpebral lobes crosses glabella just anterior to occipital furrow. Lateral parts of palpebral lobes strongly curved downward and inward, so that sutural margin is slightly underneath dorsal part of palpebral lobe. Posterior limbs short, blunt; transverse width of cranidium between tips of posterior limbs slightly less than cranidial width between lateral margins of palpebral lobes. Posterior border furrow deep, straight.

Course of anterior section of facial suture slightly convergent forward from palpebral lobe to inner edge of border, then more strongly curved across border to merge imperceptibly with anterior margin of cranidium. Course of posterior section strongly convex from palpebral lobe to posterior margin.

External surfaces of all parts of cranidium smooth.

Other parts of exoskeleton unknown.

Discussion.—The inner end of the ocular ridge of *Zacanthopsina eperephes* is slightly expanded at its contact with the glabella, somewhat like that shown by Hupé (1953, p. 264, fig. 63A) for *Kingaspis campbelli* (King). Also, each palpebral lobe has its lateral margin turned down and slightly inward, so that the sutural margin is actually beneath the dorsal surface of the palpebral lobe, similar to the structure of the palpebral lobe of *Periomella yorkensis* Resser (Rasetti, 1955, pl. 5, fig. 2). However, in *Z. eperephes*, the ocular ridge forms a continuous band, diverging only slightly posterolaterally from the anterior part of the frontal lobe of the glabella to the palpebral lobe. This structure is unique among members of the order Corynexochida.

This is a relatively rare species in the fauna and is represented by fewer than 10 specimens.

Order PTYCHOPARIIDA Swinnerton

Family PTYCHOPARIIDAE Matthew

Genus SYSPACEPHALUS Resser

Syspacephalus? sp.

Plate 3, figures 15, 20

Discussion.—Several fragmentary cranidia and a pygidium may represent a species of *Syspacephalus*. The cranidia are characterized by gently convex downsloping fixed cheeks, small palpebral lobes situated opposite the anterior half of the glabella, and facial sutures that converge slightly forward. These have been cited by Rasetti (1955) as distinctive characteristics of *Syspacephalus*. However, the species illustrated here has much longer distal parts of the posterior limbs than does the type species, *S. charops* (Walcott). In *S. charops* the transverse length of the distal part of the posterior limb is less than half the transverse length of the proximal part. On the specimen illustrated here the transverse length of the distal part of the posterior limb is nearly equal to that of the proximal part. The form of the posterior limb is generally not so variable in younger ptychoparioid genera; for this reason, the generic assignment of the illustrated specimen is questioned. An associated pygidium having fine granular ornamentation similar to that of the illustrated cranidium may belong to the species. It is characterized by being nearly twice as wide as it is long, by having a low axis that tapers backward and merges with the posterior part of the pygidium, and by having four or five ring furrows and two or three pleural furrows. No clearly defined border is present. Without a larger sample, these specimens cannot be adequately identified.

POSITION UNCERTAIN

Pygidia of at least four species of trilobites cannot be assigned with certainty to the cranidia described herein. Their description and possible affinities are discussed below.

Genus and species undetermined 1

Plate 3, figure 16

Description.—Pygidium subsemicircular in outline. Axis long; sides subparallel; posterior end strongly rounded, prominent, reaching to inner edge of border. Four or five complete ring furrows posterior to articulating furrow. Pleural fields crossed by five broad, deep pleural furrows and four narrower interpleural furrows that terminate at inner edge of border. Border narrow, of nearly constant width; has two pairs of short prominent anterolateral border spines. External surfaces of all parts covered with moderately coarse granules.

Discussion.—This species, known from 10 pygidia ranging in sagittal length from 2 mm to 9 mm, is characterized particularly by well defined pleural and interpleural furrows and by two pairs of anterolateral border spines.

The species is most like *Olenoides hybridus* Resser (1938, p. 91) from the Lower Cambrian of Virginia in possessing two pairs of short anterolateral spines. It differs from the eastern species by having the ridges adjacent to each interpleural furrow on the pleural field of the pygidium of nearly constant and equal width. In this respect, the pleural fields are more like those of *Bonniopsis virginica* Resser, which also has two border spines. In *B. virginica*, however, the border behind the spines is a flat flange. More must be learned about the other parts of the trilobite described here before it can be adequately understood and formally named.

Genus and species undetermined 2

Plate 3, figure 17

Description.—Small pygidia, subovate in outline; sagittal length about five-eights maximum width. Axis prominent, broad, strongly rounded at rear, nearly reaching to posterior margin; width slightly less than one-half maximum pygidial width. Two ring furrows posterior to articulating furrow; first furrow unusually deep, overshadowed by strongly convex ring of first segment. Pleural regions narrow, subtriangular; border not well defined. Two shallow pleural furrows, not reaching to margin. Margin has four pairs of short spines decreasing in size posteriorly. External surface covered with fine closely spaced granules.

Discussion.—This pygidium is most like the pygidium of *Zacanthopsis levis* (Walcott) and may be the pygidium of *Z. contractus* n. sp. However, the possibility that it may be the pygidium of either *Zacanthopsina eperephes* n. sp. or *Stephenaspis? avitus* n. sp. cannot be excluded, and therefore, the generic assignment is in doubt.

Genus and species undetermined 3

Plate 3, figure 18

Description.—Small pygidia, subsemicircular in outline, length slightly less than one-half maximum width. Axis prominent, tapered backward, strongly rounded at end; length from articulating furrow about eight-tenths length of pygidium; width slightly less than one-third maximum pygidial width. Two complete ring furrows posterior to articulating furrow. Pleural regions have poorly defined narrow border and three shallow furrows and two even shallower interpleural furrows, not crossing border. Pygidial margin does not have spines. External surface smooth or slightly roughened.

Discussion.—This pygidium is most like the pygidium of *Wenchemnia* (Rasetti, 1951, pl. 11) in general morphology, but it has one less axial segment and one less pleural segment. Without good evidence for a correct association of a cranidium, a generic assignment is not possible.

Genus and species undetermined 4

Plate 3, figure 19

Description.—Small pygidia, subsemicircular in outline; sagittal length about one-half width. Axis prominent, broad, strongly rounded at end; length about three-fourths length of pygidium; width slightly more than one-third greatest pygidial width. Two ring furrows posterior to articulating furrow. Pleural regions do not have well defined border. Three pleural furrows, terminated laterally just before reaching pygidial margin. Three pairs of short, nubby marginal spines. External surface covered with fine closely spaced granules barely visible even after whitening.

Discussion.—This pygidium cannot be assigned with certainty to any of the described species in the fauna. If classified by relative abundance, size, and external ornamentation, it would seem to be the pygidium of *Stephenaspis? avitus* n. sp. Its structure, however, is completely unlike that of the type species of *Stephenaspis*. If the association is correct, *S.? avitus* may be more closely related to the early Middle Cambrian species, *Poliella denticulata*. (See p. F9).

REFERENCES

Bell, G. K., Jr., 1931, The disputed structures of the Mesonacidae and their significance: Am. Mus. Novitates, no. 475, 23 p.

Billings, Elkanah, 1861, On some new or little known species of Lower Silurian fossils from the Potsdam group (Primordial zone), *in* Hitchcock, Edward, and others, 1861, Report on the geology of Vermont, v. 2: Claremont, N.H., p. 942–960.

Cooper, G. A., and others, 1952, Cambrian stratigraphy and paleontology near Caborca, northwestern Sonora, Mexico: Smithsonian Misc. Colln., v. 119, no. 1, 184 p.

Harrington, H. J., and others, 1959, Arthropoda 1, *in* Treatise on invertebrate paleonthology, Part O: Lawrence, Kans., Geol. Soc. America and Univ. Kansas Press. 560 p.

Hupé, Pierre, 1953, Contribution à l'étude du Cambrian inférieur et du Précambrien III de L'anti Atlas Morocain: Serv. Géol. Moroc. Notes and Mém. 103, 402 p.

Lake, Philip, 1937, A Monograph of the British Cambrian trilobites, pt. X: Paleontographical Soc., v. 90, p. 225–248.

Lermontova, E. B., 1940, *in* Vologdin, A. G., Atlas of the leading forms of the fossil faunas of the U.S.S.R., v. 1, Cambrian: Moscow, VSEGEI, 193 p.

—— 1951, Nizhnekembriiskie trilobity i brakhiopody vostochnoy Sibiri: Moscow, VSEGEI, 218 p.

Lochman, Christina, 1947, Analysis and revision of eleven Lower Cambrian trilobite genera: Jour. Paleontology, v. 21, no. 1, p. 59–71.

McLaughlin, K. P., and Enbysk, B. B., 1950, Middle Cambrian trilobites from Pend Oreille County, Washington: Jour. Paleontology, v. 24, no. 4, p. 466–471.

Nelson, C. A., 1962, Lower Cambrian-Precambrian succession, White-Inyo Mountains, California: Geol. Soc. America Bull., v. 73, no. 1, p. 139–144.

—— 1963, Stratigraphic range of *Ogygopsis:* Jour Paleontology, v. 37, no. 1, p. 244–248.

Palmer, A. R., 1957, Ontogenetic development of two olenellid trilobites: Jour. Paleontology, v. 31, no. 1, p. 105–128.

Pokrovskaya, N. V., 1959, Trilobitovaya fauna i stratigrafiya kembriyskikh otlozheniy Tuvy: Akad. Nauk SSSR, Geol. Inst. Trudy, no. 27, 199 p.

Poulsen, Christian, 1932, Lower Cambrian faunas of east Greenland: Medd. om Grönland, v. 87, no. 6, 66 p.

——— 1958, Contribution to the paleontology of the Lower Cambrian Wulff River formation: Medd. om Grönland, v. 162, no. 2, 24 p.

——— 1959, *in* Harrington, H. J., and others, 1959.

Rasetti, Franco, 1948, Lower Cambrian trilobites from the conglomerates of Quebec (exclusive of the Ptychopariidea): Jour. Paleontology, v. 22, no. 1, p. 1–24.

——— 1951, Middle Cambrian stratigraphy and faunas of the Canadian Rocky Mountains: Smithsonian Misc. Colln., v. 116, no. 5, p. 1–277.

——— 1955, Lower Cambrian ptychopariid trilobites from the conglomerates of Quebec: Smithsonian Misc. Colln., v. 128, no. 7, p. 1–35.

——— 1959, *in* Harrington, H. J. and others, 1959.

Raymond, P. E., 1912, Notes on parallelism among the Asaphidae: Royal Soc. Canada Trans., 3d ser. v. 5, sec. 4, p. 111–120.

——— 1928, Two new Cambrian trilobites: Am. Jour. Sci., 5th ser., v. 15, p. 309–313.

Resser, C. E., 1928, Cambrian fossils from the Mohave Desert: Smithsonian Misc. Colln., v. 81, no. 2, 14 p.

——— 1936, Second contribution to nomenclature of Cambrian trilobites: Smithsonian Misc. Colln., v. 95, no. 4, 29 p.

——— 1937, Elkanah Billings' Lower Cambrian trilobites and associated species: Jour. Paleontology, v. 11, no. 1, p. 43–54.

——— 1938, Cambrian system (restricted) of the southern Appalachians: Geol. Soc. America Spec. Paper 15, 140 p.

——— 1939, The Ptarmigania strata of the northern Wasatch Mountains: Smithsonian Misc. Colln., v. 98, no. 24, 72 p.

Resser, C. E., and Howell, B. F., 1938, Lower Cambrian *Olenellus* zone of the Appalachians: Geol. Soc. America Bull., v. 49, no. 2, p. 195–248.

Rominger, C. L., 1887, Description of primordial fossils from Mt. Stephens, NW Territory of Canada: Acad. Nat. Sci. Philadelphia Proc. for 1887, p. 12–19.

Shaw, A. B., 1955, Paleontology of northwestern Vermont, pt. V, The Lower Cambrian fauna: Jour. Paleontology, v. 29, no. 5, p. 775–805.

Shimer, H. W., and Shrock, R. R., 1944, Index Fossils of North America: Massachusetts Institute of Technology, The Technology Press, 837 p.

Walcott, C. D., 1886, Second contribution to the studies on the Cambrian fauna of North America: U.S. Geological Survey Bull. 30, 368 p.

——— 1889, Description of new genera and species of fossils from the Middle Cambrian: U.S. Natl. Mus. Proc., v. 11, p. 441–446.

——— 1910, *Olenellus* and other genera of the Mesonacidae: Smithsonian Misc. Colln. v. 57, no. 6, p. 233–422.

——— 1916, Cambrian trilobites: Smithsonian Misc. Colln. v. 64, no. 5, p. 303–456.

Wanner, Atreus, 1901, A new species of *Olenellus* from the Lower Cambrian of York County, Pennsylvania: Washington Acad. Sci. Proc., v. 3, p. 267–272.

INDEX

[Italic page numbers indicate descriptions]

PLATES 1–3

Plate 1

FIGURES 1–10. *Paedeumias granulatus* n. sp. (p. F3).

1. Left side of cephalon, × 4, USNM 144250.
2. Latex cast of central part of cephalon, × 5, USNM 144251.
3. Holotype cephalon, × 3, USNM 144252.
4. Anterior part of cephalon showing granular ornamentation of frontal lobe, × 10, USNM 144253.
5, 7. Meraspid cephala, × 10, USNM 144254, 144255.
6. Central part of cephalon showing granular ornamentation, × 8, USNM 144256.
8, 10. Fragments of large cephala showing pit in posterior part of frontal lobe and variation in ornamentation, × 3, × 6, USNM 144257, 144258.
9. Hypostome, × 4, USNM 144259.

11–13, 15. *Wanneria* cf. *W. walcottana* (Wanner) (p. F4).

11. Detail of ventral surface of a thoracic segment showing perforations outlining margins of polygons, × 15, USNM 144260.
12. Small cephalon showing ornamentation, × 3, USNM 144261.
13. Small cephalon, × 2, USNM 144262.
15. Hypostome showing typical ornamentation of *Wanneria*, × 2, USNM 144263.

14, 16–18. *Goldfieldia pacifica* n. gen., n. sp. (p. F7).

14. Stereogram of holotype cranidium, × 8, USNM 144264.
16. Cranidium, × 10, USNM 144265, USGS colln. 3659–CO.
17. Cranidium, × 8, USNM 144266.
18. Cranidium, × 10, USNM 144267.


1


2


3


4


5


8

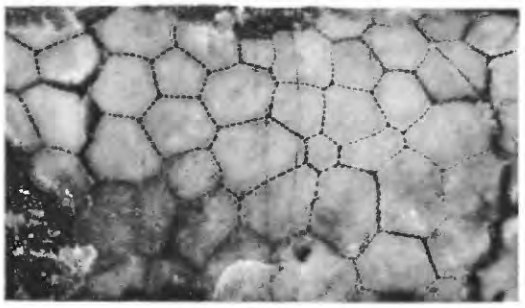

9

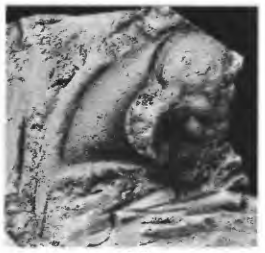

6

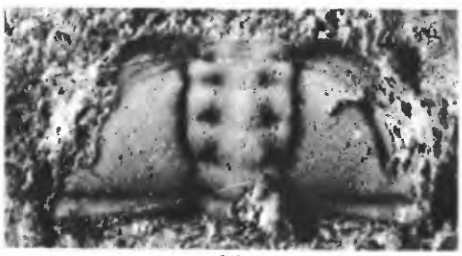

7

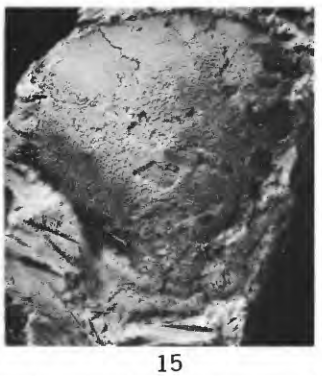

12


10


11


13


14


15


16


17


18

OLENELLIDAE, ORYCTOCEPHALIDAE

PLATE 2

FIGURES 1–6. *Ogygopsis batis* (Walcott) (p. F7).

1. Free cheek, × 3, USNM 144268.
2. Stereogram of typical cranidium, × 3, USNM 144269.
3. Pygidium, × 2, USNM 144270.
4, 5. Pygidia showing variation in ornamentation, and nature of anterolateral spine, × 5, USNM 144271, 144272.
6. Cranidium showing typical ornamentation, × 5, USNM 144273.

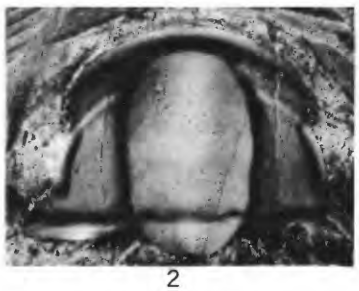
7–10. *Olenoides* spp. (p. F5).

7. Cranidium, × 4, USNM 144274.
8. Short-spined pygidium, × 3, USNM 144275, USGS colln. 3655–CO.
9, 10. Long-spined pygidia, × 4, and × 2 respectively, USNM 144276, 144277.

11–16. *Bonnia caperata* n. sp. (p. F5).

11. Stereogram of cranidium, × 3, USNM 144278.
12. Free cheek, × 3, USNM 144279.
13. Cranidium showing subdued ornamentation on fixed cheeks, × 3, USNM 144280.
14, 15. Pygidia showing variation in degree of development of ornamentation and of veins on pleural segments. × 3, USNM 144281, 144282.
16. Stereogram of holotype pygidium, × 3, USNM 144283.


1


2

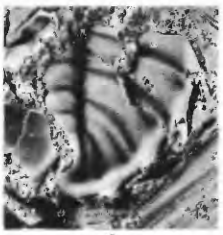

3


4


5


6

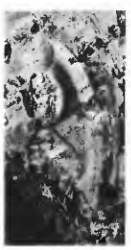

7


8


9


10


11


12


13


14


15


16

OGYGOPSIDAE, DORYPYGIDAE

PLATE 3

FIGURES 1–3. *Zacanthopsis levis* (Walcott) (p. F10).
1. Stereogram of cephalon, × 8, USNM 144284.
2. Free cheek, × 8, USNM 144285.
3. Pygidium, × 8, USNM 144286.
All from USGS colln. 1392–CO, Pioche, Nev.

4–6. *Zacanthopsis contractus* n. sp. (p. F10).
4. Stereogram of holotype cranidium, × 8, USNM 144287.
5, 6. Cranidia, × 5, USNM 144288, 144289.

7–9. *Zacanthopsina eperephes* n. gen., n. sp. (p. F10).
7. Stereogram of holotype cranidium, × 5, USNM 144290.
8. Holotype cranidium, right side view showing course of facial suture, × 5.
9. Latex cast of cranidium, × 5, USNM 144291.

10–14. *Stephanaspis? avitus* n. sp. (p. F8).
10. Stereogram of incomplete cephalon, × 5, USNM 144292.
11, 12. Cranidia, × 4, USNM 144293, 144294.
13. Free cheek, × 5, USNM 144295.
14. Stereogram of holotype cranidium, × 4, USNM 144296.

15, 20. *Syspacephalus?* sp. (p. F11).
15. Cranidium, × 10, USNM 144297.
20. Pygidium, × 10, USNM 144298.

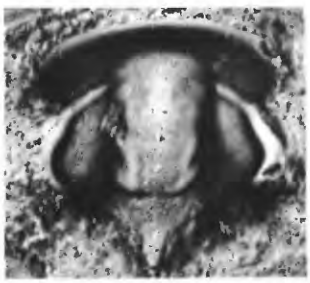
16. Genus and species undetermined 1 (p. F11).
Pygidium, × 3, USNM 144299.

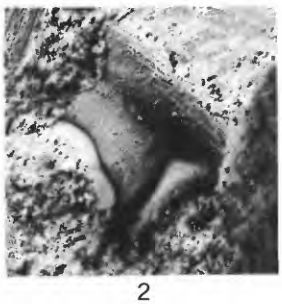
17. Genus and species undetermined 2 (p. F11).
Pygidium, × 10, USNM 144300.

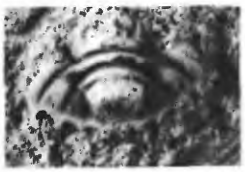
18. Genus and species undetermined 3 (p. F11).
Pygidium, × 6, USNM 144301.

19. Genus and species undetermined 4 (p. F12).
Pygidium, × 5, USNM 144302.

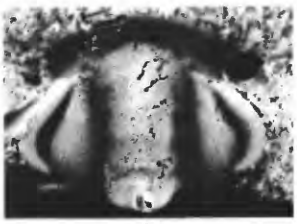
○

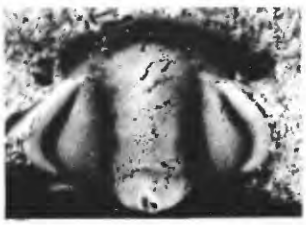

1


2


3


6


4



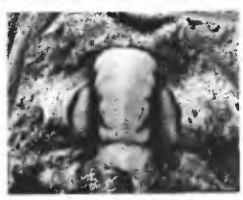

5


9

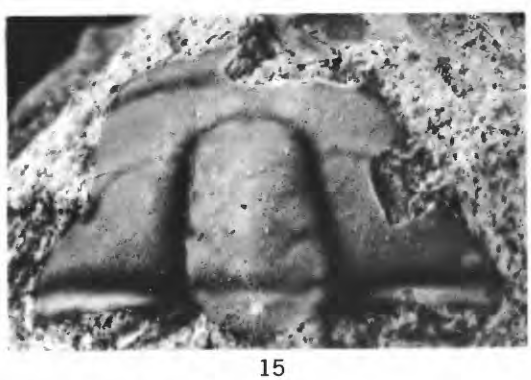

8


7

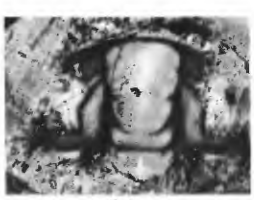

11

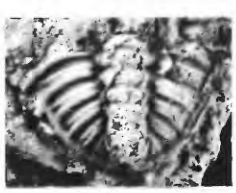

12


10


15


13

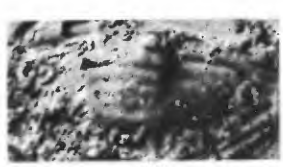

14


16


17


18


19


20

ZACANTHOIDIDAE, PTYCHOPARIIDAE, POSITION UNCERTAIN