BIOSTRATIGRAPHY OF THE *ALBERTELLA* AND *GLOSSOPLEURA* ZONES (LOWER MIDDLE CAMBRIAN) OF NORTHERN UTAH AND SOUTHERN IDAHO

by

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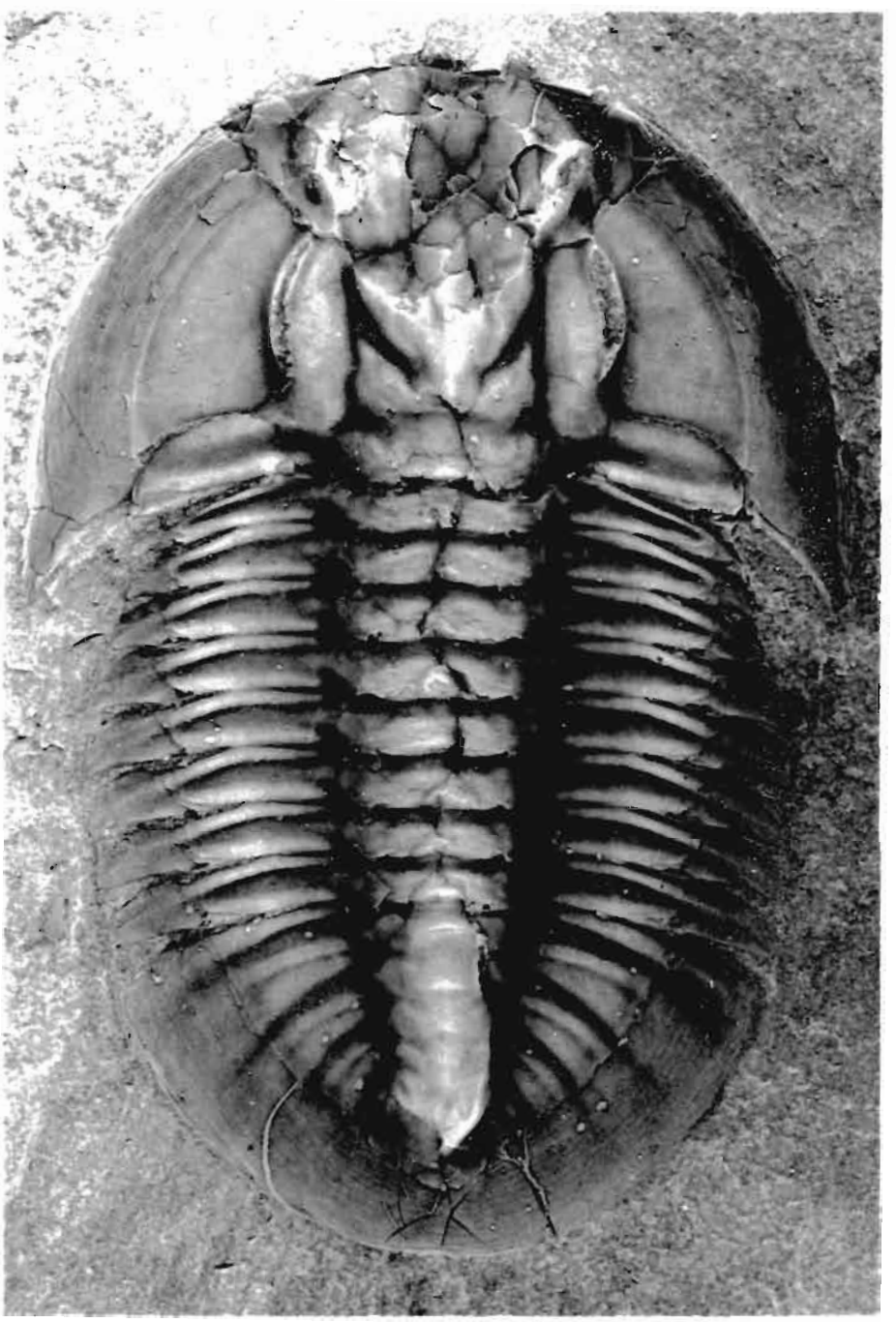

Athabaskia wasatchensis

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ABSTRACT

Lower Middle Cambrian rocks in northern Utah and southeastern Idaho are diverse in composition and sequence. Contrasts in the rock sequence have required new nomenclature and modified usuages of the names Brigham, Langston, and Ute. Strata formerly assigned to the Langston Formation have been divided into the Naomi Peak Tongue of the Twin Knobs Formation, the Spence Tongue of the Lead Bell Shale, the High Creek Limestone, and the Langston Dolomite.

During the Middle Cambrian, lithofacies of the inner detrital, middle carbonate, and outer detrital belts developed roughly parallel to the ancient Cambrian coastline. Detrital sediments of the Brigham Quartzite and the Ute Formation were deposited in the inner detrital belt. The outer detrital belt is represented by the Spence Tongue of the Lead Bell Shale. The Naomi Peak Tongue of the Twin Knobs Formation, the High Creek Limestone, the Langston Dolomite, and the carbonate units of the Ute Formation represent the middle carbonate belt.

The biostratigraphic framework for the part of the Cambrian represented by the Twin Knobs Formation, Spence Tongue, Langston Dolomite, High Creek Limestone, and Ute Formation consists of the Albertella, Glossopleura, and possibly the lower part of the Bathyuriscus-Elrathina Zone.

In this paper, the trilobite faunas of each zone are subdivided into informal units designated as faunules. The Albertella Zone fauna is divided into four distinct faunules and the Glossopleura Zone fauna consists

of two less distinct faunules. The distribution and succession of faunules appears to be environmentally controlled.

The boundary between the Albertella and Glossopleura Zones is placed at the first occurrence of Glossopleura in the lower Spence Shale Tongue although no significant faunal change appears at this point. The lower boundary of the Bathyuriscus-Elrathina Zone is tentatively placed at the first occurrence of typical Ehmaniella in the basal shales of the Ute Formation.

Forty-seven genera and 99 species of trilobites, seven unassigned trilobites, and two genera and four species of echinoderms were collected, described, and illustrated. In addition, several of Resser's type specimens were reillustrated for comparison.

One new Eodiscoid species of Agnostida, Pagetia lira, is described. One new genus, Zeugospina, and 16 new species of Corynexochids are described which include Albertella gynthos, Albertelloides fritzi, Dorypyge wellsvillensis, Glossopleura granosa, G. punctatum, Kootenia arcuata, K. melindensis, K. wellsvillensis, Olenoides spencei, Poliella milleri, Ptarmiganoides stokesi, Zacanthoides avernus, Z. fedori, Z. latus, Z. prolixus, and Zeugospina guntheri.

Six new genera, Maladella, Naomiaspis, Nyellina, Oraspis, Palmerella, and Pseudomexicella, and 21 new species of Ptychoparioids are described, which include Alokistocare mccollumi, A. nannos, A. mutablis, A. melindensis, Achlysopsis punctatum, Caborcella cracens, Ehmaniella petalora, E. stibinus, Maladella oculatus, Mexicella granosa, Naomiaspis typicalis, Nyella periosus, N. limbus, Nyellina maladensis, Onchocephalus? stibinus, Oraspis limbus, Pachyaspis eurylimbus, Palmerella exiguus, Prohedinia? spencei, Pseudomexicella granulosa, and Volocephalina stokesi.

INTRODUCTION

For many years, the Langston Formation in northern Utah and southeastern Idaho, has been known to contain one of the most fossiliferous successions of lower Middle Cambrian rocks in western North America.

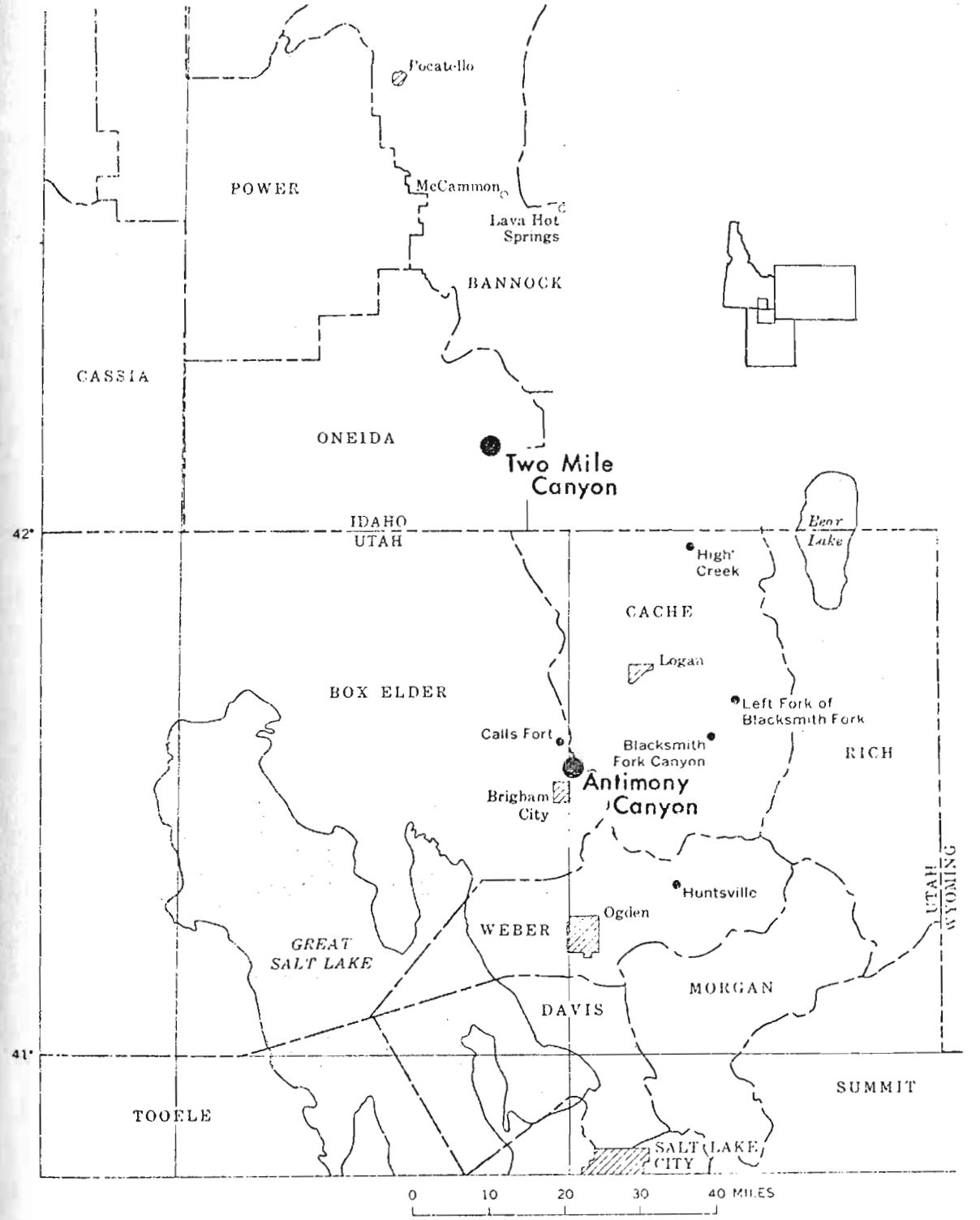
Cambrian stratigraphy of the region was first described by Walcott (1908b), who named the Brigham, Langston, Ute, Blacksmith, Bloomington, Nounan, and St. Charles Formations. Subsequent stratigraphic contributions were made by Richardson (1913), Mansfield (1927), Anderson (1928), Deiss (1938), Resser, (1939a, 1939b), Williams and Maxey (1941), Williams (1948), Coulter (1956), Maxey (1958), Bright (1960), Carr and Trimble (1962), Oriel (1965, 1968), and Oriel and Armstrong (1971). Stratigraphic nomenclature proposed by Oriel and Armstrong (1971) for the Langston and related units is used here.

Geologic mapping of the northern Malad Range, Idaho, was done by Axtell (1967). Geologic mapping of the southern Wellsville Mountains, Utah, was done by Gelnett (1958).

Paleontologic investigations dealing with the faunas of the Langston Formation have been published by Walcott (1916a, 1916b), Resser (1939a, 1939b), Rasetti (1966), Robison (1965, 1969a, 1969b, 1969c), and Fritz (1971). The rich faunas of trilobites and other fossils were described principally by Walcott (1916) and Resser (1939), but little biostratigraphic information was included.

The purpose of this study is to document the biostratigraphy of trilobite and echinoderm faunas in the Langston and related units.

Field and laboratory research was conducted during various intervals from 1972 to 1974. Two stratigraphic sections were measured using a five-foot Jacob's staff and a Brunton compass. One section is located two miles southeast of Malad City, Idaho, and the other is located about 2.5 miles north of Brigham City, Utah (Text-fig. 1). Fossils were collected from each fossiliferous bed encountered, and were prepared, identified, and described at the University of Utah.



Text-fig. 1--Index map of southeastern Idaho and northern Utah showing the locations of the measured sections.

LITHOSTRATIGRAPHY

The Cambrian Period was a tranquil time in western North America. No major tectonic event is indicated by the Cambrian sedimentary rocks. The marine succession commences with a basal quartzite and indicates a gradual subsidence and inundation of the region from the southwest.

Oriel and Armstrong (1971) have proposed modification of the basic stratigraphic nomenclature used by Walcott (1908b). The modifications appear to be valid in southeastern Idaho, where Oriel and Armstrong did their field work, but problems are encountered when the new terminology is applied to sections in northern Utah. Therefore, I will discuss the previously used stratigraphic nomenclature, and then discuss the modifications proposed and the problems that arise when the new and modified stratigraphic terminology is applied in northern Utah.

Previously Used Nomenclature

Brigham Quartzite

The Brigham Quartzite was named by C. D. Walcott (1908a). In northern Utah and southeastern Idaho it consists of a thick sequence of detrital rocks, mainly quartzite, directly beneath fossiliferous limestones and mudstones of Middle Cambrian age. Minor argillite and phyllite units in the Brigham Quartzite differ from claystones in overlying units in being less well-sorted, and more highly metamorphosed.

Langston Formation

The Langston Formation conformably overlies the Brigham Quartzite. Walcott (1908a) proposed the name Langston Formation for a unit of massive-bedded dolomite and limestone in Blacksmith Fork Canyon, Utah. The formation was named after Langston Creek into which the beds strike. Despite heterogeneous composition, rocks immediately above the Brigham Quartzite in northern Utah and southeastern Idaho have commonly been assigned to the Langston Formation.

Maxey (1958, p. 669) recognized the Langston Formation in sections he measured and described, and suggested that "the north side of the High Creek Canyon is the best and most typical exposure of the Langston Formation". Maxey further regarded the type Blacksmith Fork section as "an abnormal development of the dolomite members" at the expense of the "typical" shale and limestone members. He further divided the "typical" Langston Formation into the Naomi Peak Limestone, Spence Shale, and an upper carbonate member.

The name, Naomi Peak Limestone Member, was proposed by Maxey (1958, p. 671) for the lowest unit of the Langston Formation. It consists of 25 to 40 feet of fossiliferous gray limestone that directly overlies the Brigham Quartzite and underlies the Spence Shale Member of the Langston Formation. The Naomi Peak strata had previously been informally designated as the "Ptarmigania Strata" by Resser (1939b).

The Langston Formation was originally described as being directly overlain by the Spence Shale Member of the Ute Formation (Walcott, 1908a). The Spence Shale consists of 100 to 200 feet of abundantly fossiliferous shales and thin-bedded limestone and was named after Spence Gulch, 40 miles northwest of Blacksmith Fork Canyon, Utah, and

five miles southeast of Liberty, Idaho. Williams and Maxey (1941) and Maxey (1958) recognized that the Spence Shale was actually a member of the Langston Formation "separated in normal sequence from the Brigham Quartzite by only a few feet of crystalline limestone" (Williams and Maxey, 1941, p. 281). This thin limestone unit is Maxey's (1958) Naomi Peak Limestone Member.

The remainder of the Langston above the Spence Shale Member consists of a thick-bedded limestone, dolomite, or limestone and dolomite. These carbonates usually range from 100 to 300 feet in thickness. The Ute Formation conformably overlies the Langston Formation, its base being defined as the first shale unit above the Spence Shale Member of the Langston Formation.

Ute Formation

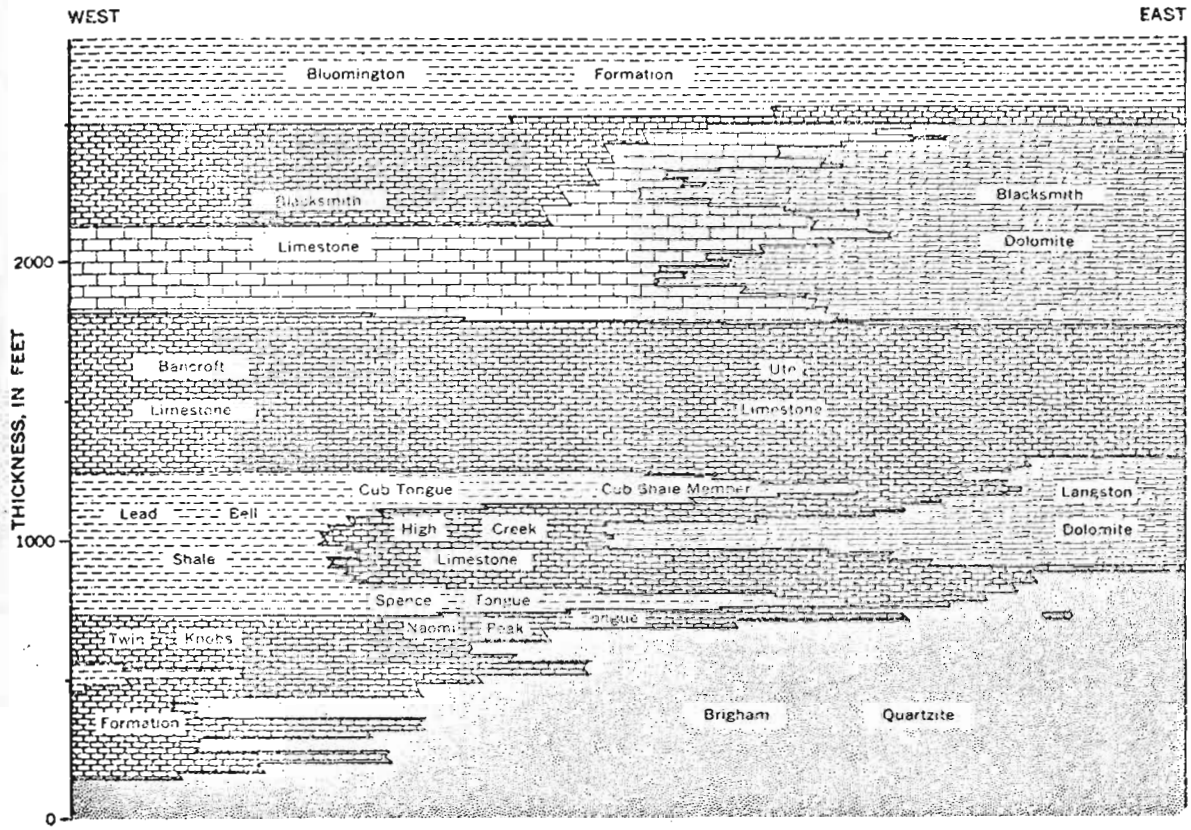
King (1876) used the name, Ute Limestone, to describe 2,000 feet of limestone that overlies the basal Cambrian quartzite. The formation was not defined in its modern sense until Walcott (1908a) restricted the term, Ute, to the lower 759 feet of limestone in Blacksmith Fork Canyon, Utah. Williams and Maxey (1941, p. 281) further restricted the Ute and defined the formation as "thin-bedded silty limestone and green shales", which is "a natural unit bounded above and below by dolomites" of the Blacksmith Dolomite and Langston Formation, respectively.

The Ute Formation consists of alternating units of shale and thin-bedded limestone. It is gradational upward into massive cliff-forming limestone and dolomite referred to the Blacksmith Formation or Blacksmith Dolomite.

Redefinition of the Brigham, Langston, and Ute Formations

Because of heterogeneities in the composition and sequence of lower Middle Cambrian rocks in northern Utah and southeastern Idaho, Oriel and Armstrong (1971) have proposed changes in the stratigraphic nomenclature of the region. They retained the term Brigham but proposed that it be raised to group status in areas where it can be divided, and that the age of the Brigham be designated as Cambrian and Precambrian. The uppermost beds of the Brigham Quartzite in several areas consist of interbedded limestone, sandstone, and claystone, which led Oriel and Armstrong (1971) to propose the name Twin Knobs Formation for this sequence of strata. The Naomi Peak Limestone Member of the Langston Formation as used by Maxey (1958) is regarded as an eastern tongue of the Twin Knobs Formation by Oriel and Armstrong (1971, p. 37) who reassigned it to the Twin Knobs Formation. They also proposed the name Lead Bell Shale for the shale beds overlying the Twin Knobs Formation in the Portneuf Range, Idaho. The Spence Shale and the lowest unit of the Ute Formation are regarded as tongues of the Lead Bell Shale (Text-fig. 2). Maxey's (1958) Spence Shale Member of the Langston Formation is referred to as the Spence Tongue of the Lead Bell Shale, whereas the upper tongue is termed the Cub Tongue of the Lead Bell Shale.

The limestone and dolomite sequences of the Langston Formation have been divided by Oriel and Armstrong (1971, p. 36) into the High Creek Limestone and the Langston Dolomite, respectively. The Lead Bell Shale intertongues with and grades into the High Creek Limestone.



Text-fig. 2--Diagrammatic west-to-east section of the rocks between the Bloomington Formation and the Brigham Quartzite, showing the distribution of facies and the stratigraphic relations of rock names proposed by Oriel and Armstrong (from Oriel and Armstrong, 1971).

Typically, the High Creek Limestone is bracketed by the Spence and Cub Tongues of the Lead Bell Shale.

Toward the east, the section above the Brigham Quartzite becomes dominantly dolomite, and is referred to as the Langston Dolomite (Oriel and Armstrong, 1971, p. 37). The Langston Dolomite intertongues with the High Creek Limestone toward the west (Text-fig. 2).

The laterally interfingering sequence of rocks assigned to the Lead Bell Shale, High Creek Limestone, and Langston Dolomite is overlain by a thin-bedded limestone that Oriel and Armstrong (1971) have assigned to the Ute Limestone in some places and to the Bancroft Limestone in others (Text-fig. 2).

Redesignation of Middle Cambrian rock-stratigraphic units in northern Utah and southeastern Idaho has made them more meaningful in terms of origin. It also has served to link observations in the region to genetic concepts evolving throughout the western United States. However, as mentioned previously, problems are encountered in applying the new terminology to sections in northern Utah.

The Cub Tongue of the Lead Bell Shale, in particular, needs further study and classification. The Cub Tongue cannot be traced physically away from the type area, and shale units in Utah that have been assigned by Oriel and Armstrong (1971, p. 36) to the Cub Tongue do not resemble the type Cub Tongue lithologically.

Problems are also encountered in distinguishing the High Creek Limestone and the Langston Dolomite from one another. Complex secondary dolomitization above the Spence Tongue of the Lead Bell Shale makes differentiation of these units difficult.

With the exception of these problems, the new units and modified

usuages of the names Brigham, Langston, and Ute, as proposed by Oriel and Armstrong, seem to be generally applicable and are therefore adopted in this thesis.

Depositional History

Lower and Middle Cambrian rocks crop out in numerous areas of northern Utah and southeastern Idaho. These rocks represent sediment deposited in a sea that generally transgressed toward the east. During the Middle Cambrian, several lithofacies developed. These lithofacies consisted of an inner detrital belt, a middle carbonate belt, and an outer detrital belt, all three of which roughly paralleled the ancient Cambrian coastline (Robison, 1960, and Palmer, 1960, 1971). Kepper (1972, p. 503, 504) has described the same lithofacies in terms of relative water depth and environment of deposition. Listed from shore seaward, his designations are shallow shelf-lagoon, near-sea-level shoal, and deeper water open shelf.

The Middle Cambrian sea made a series of advances eastward, which were followed by stable periods or periods of regression (Robison, 1960). These oscillations in sea level produced interfingering of the sediments deposited in each of the three belts. The middle carbonate belt is thought to represent a complex of carbonate shoals generally flanked on both east and west by areas of predominantly detrital sediment.

The inner detrital belt generally consists of a near-shore quartzite facies and an outer facies composed of brown, green, and red shales (Robison, 1960, p. 44). The middle carbonate belt consists of several kinds of limestone and dolomite. The outer detrital belt

generally consists of dark argillaceous micritic limestones, dark shales, and brown or gray mudstones (Robison, 1960, p. 44-47).

The boundary between the carbonate and outer detrital belts appears to have been a zone of marked change between physical environments. Algal stromatolites, oolites, and dissarticulated and broken fossils, which commonly occur at the outer edge of the carbonate belt, suggest a high-energy environment. In comparison, claystone, calcareous shale, and laminated argillaceous limestones with delicate articulated fossils, typical of the outer detrital belt, indicates a deeper low-energy environment. Agnostid trilobites are commonly restricted to the outer detrital belt and the outer margin of the carbonate belt (Robison, 1972). Agnostids seem to have been adapted for a pelagic mode of life in the ocean province. Thus in the Middle Cambrian, the oceanic-neritic boundary appears to have coincided with the boundary between the carbonate belt and the outer detrital belt (Robison, 1972).

The Brigham Quartzite represents the near-shore inner detrital belt facies. The quartzite is generally characterized by poor sorting. Grain sizes range from fine to very coarse, and granule conglomerates are common at some horizons. The rocks are generally chemically mature, and medium to large-scale cross-bedding is common. Argillites in the Brigham are poorly sorted and show the effects of metamorphism to a greater degree than overlying sediments. Argillaceous laminae consist of quartz, sericite, muscovite, and some chlorite (Oriel and Armstrong, 1971, p. 5).

As the Middle Cambrian sea transgressed, the lithofacies belts migrated toward the east. The Twin Knobs Formation appears to

represent an interfingering of inner detrital and middle carbonate sediments and probably reflect the oscillatory border between a shallow-shelf lagoon and the inner edge of the carbonate shoals. The Naomi Peak Tongue of the Twin Knobs Formation is a relatively pure carbonate unit with minor sandstone beds and lenses, which appears to represent a narrow carbonate shoal between the inner and outer detrital belts. The Naomi Peak Tongue is overlain by the Spence Tongue of the Lead Bell Shale. The lower part of the Spence consists of dark, silty, micrite and gray to gray-black laminated shales, both of which contain agnostid trilobites, and is considered to represent outer detrital belt environments. Sediments deposited during a regression of the Middle Cambrian sea follow, and the upper part of the Spence Tongue lacks agnostids, and at least in the Wellsville Mountains, has thin-bedded sparry limestone with minor amounts of oolites and oncolites.

The High Creek Limestone and the Langston Dolomite represent sediments deposited in the middle carbonate belt. The High Creek Limestone is composed dominantly of sparry limestone with common oolites and Girvanella.

According to Newell and others (1960, p. 493) the formation of oolites is basically an intertidal zone process, but may take place down to six feet below low tide. Bathurst (1967, p. 452) states that they may form in depths down to about 33 feet (10 meters). These depths fall within tidal and subtidal environments and both are listed as part of the shoal facies by Kepper (1972, p. 504).

The Ute Formation consists of interbedded thin limestone with silty partings and inner detrital belt shales. The Ute seems to represent very shallow conditions. Oolite beds, stromatolites and

mud cracks are common, indicating very shallow water conditions. The overlying Blacksmith Dolomite is a product of the middle carbonate belt.

BIOSTRATIGRAPHY

Trilobite Zonation

Previous Work

C. D. Walcott (1908b, p. 191-200) published the first faunal lists for what is now designated the Langston Dolomite and Ute Formation at Blacksmith Fork, Utah (Text-fig. 1). Walcott collected extensively at several localities during 1906, and shortly thereafter illustrations of the more conspicuous elements of the fauna were prepared. Walcott's 1912 monograph includes the brachiopods from the Spence Shale, and from time to time trilobite species were described incidentally in other papers (Walcott, 1916a, 1916b).

C. E. Resser, Walcott's assistant, continued work on the Spence Shale and the "Ptarmigania Strata" after Walcott's death. In 1939, Resser published "The Spence Shale and its Fauna" and later that same year, "The Ptarmigania Strata of the Northern Wasatch Mountains". Although both works represented a great advance over previous knowledge of the faunas, little biostratigraphic data was included.

Much of the material that Resser studied had been collected by Walcott and others, and even though Resser had visited most of the localities, stratigraphic occurrence of individual taxa was not noted. In fact, some of Resser's material appears to have been mixed from several stratigraphic intervals. Resser assigned most, if not all, specimens in limestone matrix to the "Ptarmigania Strata" and all

specimens occurring in shale matrix to the Spence Shale fauna.

This practice has led to some confusion because limestone beds occur within the Spence Shale and comprise the overlying High Creek Limestone. It is doubtful that Glossopleura prona, G. arrecta, Athabaskia wasatchensis, A. bithus, and Kootenia mendosa belong to the "Ptarmigania Strata". Rathyuriscus wasatchensis (Resser) and Alokistocarella brighamensis Resser have been found in the Naomi Peak Tongue, although the specimens illustrated by Resser in "The Ptarmigania Strata of the Northern Wasatch Mountains" come from the basal shales of the Spence.

W. H. Fritz, of the Geological Survey of Canada, has recently completed a preliminary survey of the Twin Knobs Formation at Two Mile Canyon, Idaho, and the Spence Tongue of the Lead Bell Shale at Copenhagen Canyon, Idaho (in Oriel and Armstrong, 1971, p. 39-47). This is the first information available on the biostratigraphy of these strata. Faunal lists from his upper collections (83454, 83455, and 83456) agree well with my data. However, faunas from collections which he made lower in the section (83457 and 83452) do not resemble faunas from my collections in this stratigraphic interval. I have studied the section in detail and can only conclude that Fritz's collections (83457 and 83452) came from float or a downfaulted block of Naomi Peak Limestone. Fritz (1974, personal communication) was unable to relocate his collection sites in the field during August, 1974, and indicated that this was a possibility.

Middle Cambrian Zones

The biostratigraphic framework for the part of the Cambrian

represented by the Twin Knobs Formation, Spence Tongue of the Lead Bell Shale, Langston Dolomite, High Creek Limestone and the Ute Formation consists of the Albertella, Glossopleura, and possibly the lower part of the Bathyuriscus-Elrathina Zone (Lochman and Wilson, 1958). These zones, used in the sense of assemblage zones, are generally useful biostratigraphic units of regional applicability.

The present Cambrian zonation is the result of many years of development. However, a considerable amount of work is still needed in the Cordilleran region of the United States and Canada before a refined zonation of the Cambrian System of North America can be established. Palmer (1971, p. 55-59) has adequately discussed the present status of biostratigraphic zonation of Cambrian deposits of the Great Basin Region.

In keeping with some present trends in defining zones (Grant, 1962), the base of a zone is placed at the lowest appearance of the index genus or genera. Upper boundaries are best defined by the lower boundaries of the next higher units (Grant, 1962).

Faunules

General Statement

In this paper, the trilobite faunas of each zone are divided into informal units designated as faunules. Faunules are biologic units which represent smaller, distinct assemblages of fossils within each zone. Informal faunules, rather than zonules, are used for two reasons. First, the geographic area covered by this study is small and regional relationships between the faunules are at present poorly understood. Secondly, the succession of faunules appears to be environmentally controlled and if the sequence of lithofacies differs among areas, it

may be possible to find the same faunules in reverse stratigraphic sequence. Under certain conditions, it also may be possible to find two or more faunules occurring together. In the following sections the zones of each section are discussed in order from youngest to oldest. Faunules are discussed under their respective zones. Text-figs. 3 and 4 show the observed stratigraphic ranges for the taxa in each section.

Two Mile Canyon

Olenellus Zone

Although detailed collecting was confined to strata above the Brigham Quartzite, it should be noted that Olenellus occurs approximately 210 feet above the base of the measured section. The section at Two Mile Canyon begins at the lowest exposure of Brigham Quartzite. This places strata below this point in the upper part of the youngest Early Cambrian Bonnia-Olenellus Zone (as defined by Fritz, 1972).

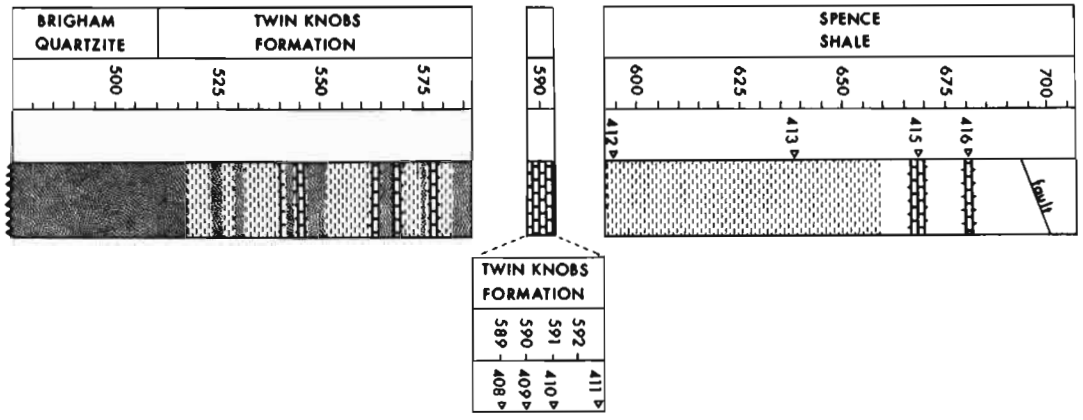
Plagiura-Kochaspis Zone

An undescribed fauna that appears to represent the Plagiura-Kochaspis Zone was discovered in the Brigham Quartzite approximately 430 feet above the base of the measured sections. Thus the Lower Cambrian-Middle Cambrian boundary is between 210 and 430 feet above the base of the measured section at Two Mile Canyon, Idaho.

Albertella Zone

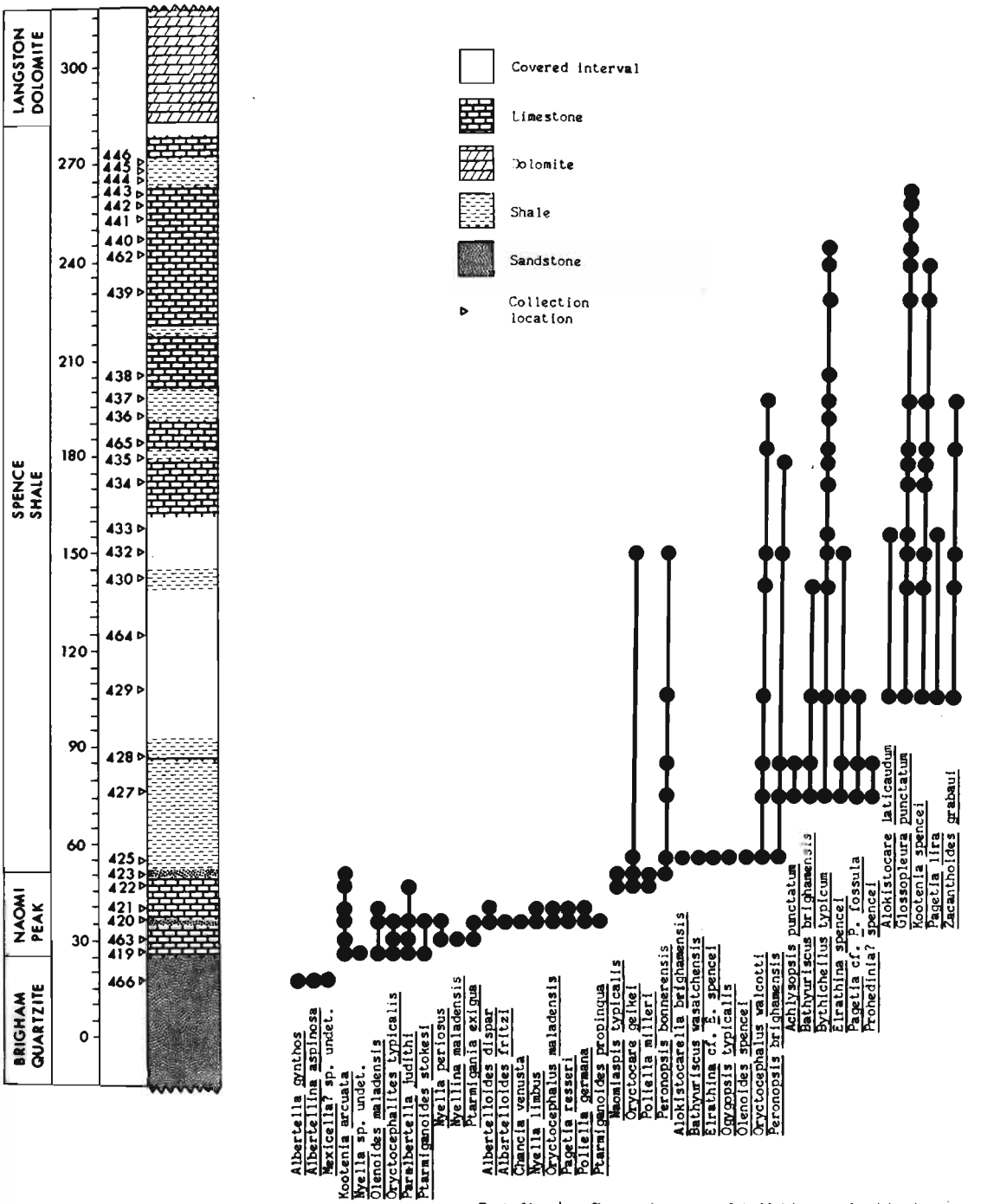
This zone contains a rich assemblage of trilobites. In accordance with recent practice (Grant, 1962), the base of the zone is defined as the lowest appearance of Albertella.

Text-fig. 3.-- Observed ranges of trilobites from the section at Two Mile Canyon, Malad Range, Idaho.

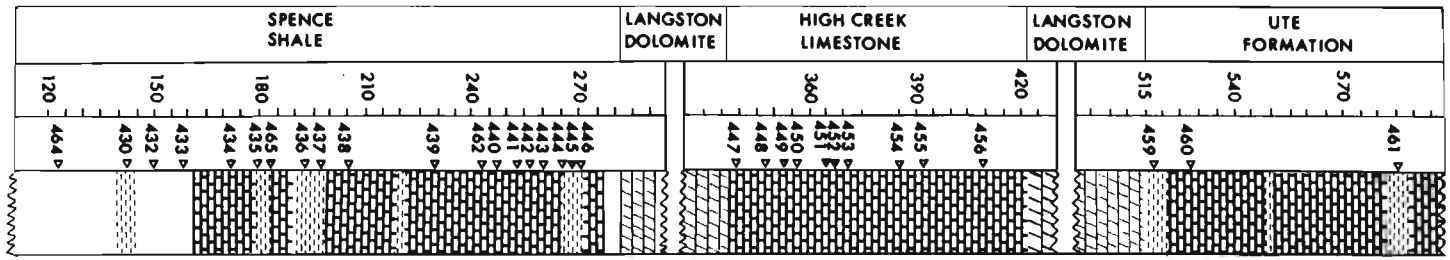


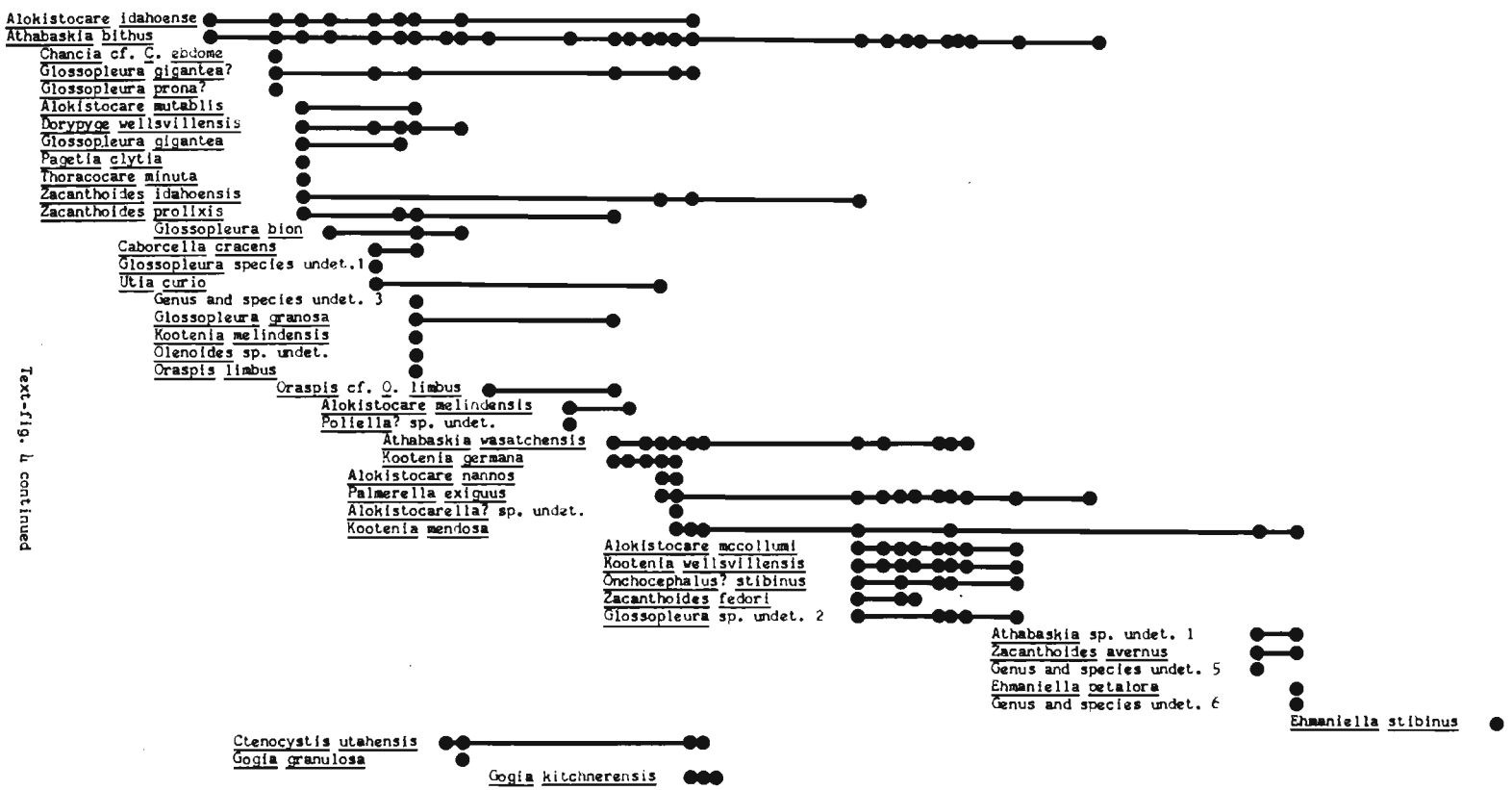
Alokistocare laticaudum
Kootenia sp. undet.
Oryctocare geikei
Pachyaspis eurylimbus
Zacanthoides latus
Alokistocarella brighamensis
Alokistocarella occidens
Bathyuriscus wasatchensis
Kochina vestita
Ogygopsis typicalis
Pagetia maladensis
Pagetia rugosa
Peronopsis bonnerensis
Peronopsis brighamensis
Prohedinia maladensis
Thoracocare idahoensis
Elrathina cf. E. spencei
Oryctocephalus walcotti
Thoracocare minuta
Pagetia clytia

Text-fig. 3 continued



Text-fig. 4-- Observed ranges of trilobites and echinoderms at Antimony Canyon, Wellsville Mountains, Utah.





Text-fig. 4 continued

The Twin Knobs Formation was collected in detail and the lowest collection (UU-400) yielded Albertella at 512 feet above the base of the section. Thus the boundary between the Plagiura-Kochaspis Zone and the Albertella Zone occurs between 430 and 512 feet above the base of the measured section. The Twin Knobs Formation begins at 510 feet above the base of the measured section so it is probable that the lower Albertella Zone boundary occurs in the upper part of the Brigham Quartzite. The Albertella Zone at Two Mile Canyon incorporates three or four different faunules (depending upon where the upper boundary of the zone is placed) whose constituents seem to reflect important differences in ecological paleogeography.

Albertella-Mexicella Faunule. The lowest faunule within the Albertella Zone is characterized by species of Albertella and Mexicella. In addition to these genera, Pseudomexicella, Volocephalina, Albertellina, and Nyella are common elements of this faunule. Regional evidence suggests that the Albertella-Mexicella faunas are representative of the inner detrital belt (restricted shelf environment) as reported by Palmer (Palmer, 1972, 1973).

Paralbertella-Albertelloides-

Zacanthoides Faunule. The second faunule is characterized by species of Paralbertella, Albertelloides, and Zacanthoides. This faunule is abundant and diverse, consisting of over 20 species of trilobites. In addition to Paralbertella, Albertelloides and Zacanthoides, this faunule contains Poliella, Ptarmigania, Ptarmiganoides, Nyella, Olenoides, Kootenia, and Pagetia among others. Rasetti (1951, p. 94; 1966, p. 510) has pointed out that there are two distinct assemblages in the "Ptarmigania Strata" at Two Mile Canyon. The Paralbertella-

Albertelloides Faunule is the same as his lower assemblage. This faunule seems to represent the middle carbonate shoal environment.

Ogygopsis-Peronopsis Faunule. The third faunule within the Albertella Zone is characterized by species of Ogygopsis, Pachyaspis, Pagetia, and Peronopsis and corresponds to Rasetti's upper assemblage of the "Ptarmigania Strata". This faunule brackets the boundary between the outer part of the middle carbonate belt and the outer detrital belt.

Boundary Between The Glossopleura And Albertella Zones

Fritz (1971, p. 41) favors placing the Albertella Zone-Glossopleura Zone boundary between the second and third faunules. However, I regard the boundary between the second and third faunules as merely a facies boundary with little time significance. The most diagnostic genus of the Glossopleura Zone is Glossopleura itself, and I favor placing the lower boundary of the Glossopleura Zone at the lowest occurrence of Glossopleura.

Peronopsis-Oryctocephalus-Elrathina Faunule. If the first occurrence of Glossopleura is used to define the lower boundary of the zone, then a fourth faunule is included in the Albertella Zone at Two Mile Canyon, Idaho. This faunule is characterized by species of Peronopsis, Pagetia, Oryctocephalus, Oryctocare and less commonly Elrathina. These genera range throughout the lower 100 feet of the Spence Shale (the top of the Spence Shale has been removed by faulting and only the lower 100 feet remain). Therefore, the lower boundary of the Glossopleura Zone cannot be determined

at Two Mile Canyon. This agnostid, oryctocephaloid fauna is representative of the outer detrital belt, or deeper-water open-shelf environment.

Antimony Canyon

Albertella Zone

Only the upper part of the Albertella Zone is represented by fossiliferous strata at Antimony Canyon. The lowest collection (UU-466) contains the Albertella-Mexicella faunule. The lower part of the Naomi Peak Tongue contains the Paralbertella-Albertelloides faunule although some species and genera differ between Antimony Canyon and Two Mile Canyon. The upper part of the Naomi Peak Tongue and the lower few feet of the Spence Shale contain a third faunule characterized by Ogygopsis, Bathyuriscus, and Poliella. The boundary between the Naomi Peak and Spence is characterized by similar faunas at both Antimony and Two Mile Canyons, but abundance of individual species of the faunas varies considerably between the two areas.

The fourth faunule of the Albertella Zone at Antimony Canyon is characterized by abundant Peronopsis, Elrathina, Bathyuriscus, and Pagetia. Oryctocephalus and Oryctocare also occur in this faunule and although the diversity is greater at Antimony, the faunules correlate well between Two Mile and Antimony Canyons. The lowest observed occurrence of Glossopleura at Antimony Canyon is in collection UU-429 at 56 feet aobve the base of Spence Shale, and this is where I favor placing the boundary between the Glossopleura and Albertella Zones. However, it should be noted that there is no significant break in the faunas at this boundary and several genera cross the boundary.

Glossopleura Zone

Lower Faunule. It is more difficult to discern distinct faunules in the Glossopleura Zone at Antimony Canyon, but two faunules are evident. The lower faunule is characterized by Glossopleura, Zacanthoides, Alokistocare, Athabaskia, Koctenia, Bythicheilus, Caborcella, Utia, Dorypyge and several other genera. This fauna is characteristic of the Spence Shale. Elements appear and disappear randomly rather than in distinct groups as in the Albertella Zone. Significant overlap exists between this faunule and the underlying and overlying faunules.

Upper Faunule. The second faunule is less diverse and is characterized by Palmerella and several other genera that are also common in the underlying faunule. This faunule occurs in the High Creek Limestone and is thought to represent the inner part of the middle carbonate belt.

The Glossopleura Zone in northern Utah is characterized by an extremely diverse fauna in contrast to other areas (Rasetti, 1951; Palmer, in press; Lochman, 1952; and Oldroyd, 1973) in which Glossopleura assemblages lack such diversity. Glossopleura faunas are most diverse in the lower parts of the zone and become less so towards the top. Diversity gradients seem to correlate well with depth indicators such as oolites and oncholites, which indicate a general decrease in depth towards the top of the zone.

The Glossopleura Zone includes most of the Spence Shale, the lower tongue of the Langston Dolomite, and the High Creek Limestone. It is difficult to establish an upper boundary for the Glossopleura Zone because a lower boundary has never been defined for the overlying Bathyuriscus-Elrathina Zone. Palmer (1971, p. 57) summarized the

situation as follows: "The interval between the Glossopleura Zone and the Bolaspidella Zone includes a variety of faunas that are presently included arbitrarily in the Bathyuriscus-Elrathina Zone. None of these faunas has been described in detail, and neither Bathyuriscus nor Elrathina seems to be a characteristic element."

Bathyuriscus-Elrathina Zone

Usually the lowest beds of the Bathyuriscus-Elrathina Zone contain several small ptychoparioid trilobites, including species of Ehmaniella. Schwimmer (1973) proposed subdivision of the Bathyuriscus-Elrathina Zone into four zones. These, from oldest to youngest are: the Ehmaniella, Bolaspis-Glyplaspis, Ehmania, and Parehmania Zones. Three of these (Bolaspis-Glyplaspis, Ehmania, and Parehmania) may be restricted to Montana and Wyoming, while the fourth (Ehmaniella) zone has a known distribution in other areas. Typical Ehmaniella first appear in the basal shales of the Ute Formation at Antimony Canyon and I favor placing the lower boundary of the Bathyuriscus-Elrathina (or Ehmaniella) Zone at the base of the Ute Formation based on the first occurrence of Ehmaniella.

Facies

Analysis of the biostratigraphy of the Twin Knobs Formation, Spence Tongue of the Lead Bell Shale, Langston Dolomite, High Creek Limestone, and lower Ute Formation provide a good example of the limitations that the spacial distribution of fossil remains imposes on our generalized biostratigraphic scheme. As Palmer (in press) has pointed out, "... we often obscure discrete contemporary biofacies..." in an attempt to produce a composite biostratigraphic framework.

Data from this study and Palmer's study of the Cararra Formation (in press) show the usual method of placing zones in stratigraphic apposition may be misleading. In fact, the Albertella-Mexicella and the Paralbertella-Albertelloides-Zacanthoides faunules of the Twin Knobs Formation are stratigraphically reversed in the Cararra Formation of Nevada (Palmer, in press). However, the Albertella-Mexicella faunule occurs in a dirty sandstone in both areas and the Paralbertella-Albertelloides-Zacanthoides faunule occurs in a relatively clean limestone in both areas, suggesting rather strong facies control of these faunules.

As Palmer (in press) noted, "Not only are contacts lacking between the zones, but distinct faunules showing few or no common forms may be incorporated within one generalized zone thus obscuring differences of possible biologic or paleocologic significance."

The four faunules within the Albertella Zone at Two Mile Canyon and Antimony Canyon seem to be dominantly facies controlled. Each of the faunules is distinct and there is little overlap between adjacent faunules. The boundaries between the faunules are marked by quite abrupt changes in lithology, which seem to indicate changes in environment. Also, faunas within the Glossopleura Zone undergo a gradual change in composition that apparently coincides with a gradual decrease in water depth.

It is also apparent from the range charts (in back pocket) that diversity varies considerably between collections. In general, collections from the inner detrital belt (restricted-shelf environment) and the outer detrital belt (deeper-water open-shelf environment) show low diversity. Collections from the Naomi Peak Tongue at both

localities and the Spence Shale Tongue at Antimony Canyon show a high diversity. The Naomi Peak Tongue and the Spence Shale at Antimony Canyon represent a transtional environment near the boundary between the middle carbonate belt (near sea-level shoals) and the outer detrital belt (deeper-water open shelf).

Thus, it seems that the transition (or ecotone) between the sea-level shoals and the deeper-water open shelf was characterized by high diversity. High diversity (or the edge effect) is commonly encountered in ecotones today.

Correlation

Biostratigraphy and lithostratigraphy of the Middle Cambrian in the Great Basin has been summarized by Palmer (1971). The Paralbertella-Albertelloides, and Ogygopsis-Pachyaspis faunules of the Twin Knobs Formation are most closely related to those of the lower part of the upper member of the Pioche Shale from east-central Nevada (Fritz, 1968). Fifteen genera and 14 species are common to the Pioche Shale and the Twin Knobs Formation. These faunules also contain a large number of species and genera in common with Albertella Zone faunas described from the southern Canadian Rockies (Rasetti, 1951) and from the Cararra Formation (Palmer, in press).

The Albertella-Mexicella faunule correlates well with the upper part of the Pahrump Hills Shale member and the lower part of the Jangle Limestone member of the Cararra Formation (Palmer, in press) and is closely related to Albertella Zone faunas of the Grand Canyon region (McKee and Resser, 1945) and the Caborca area of Mexico (Lochman, 1952).

The Spence Shale, High Creek Limestone and Langston Dolomite

include the Glossopleura Zone. Any attempts to correlate these formations depend mainly on the presence of Glossopleura. Therefore, the Spence Shale, High Creek Limestone, and Langston Dolomite are correlative with at least part of the upper Arrojos Formation in northwest Sonora, Mexico (Lochman, 1952); with the lower part of the Stephen Formation, southern Canadian Rocky Mountains (Rasetti, 1951); with the upper Bright Angel Shale, Grand Canyon, Arizona (McKee and Resser, 1945); the upper part of the upper member of the Pioche Shale, east-central Nevada (Fritz, 1968); the Chisholm Shale and lower Dome Formation of west-central Utah and east-central Nevada (Palmer, 1964a, Oldroyd, 1973); and the upper Gordon Shale and Damnation Limestone, north-western Montana (Schwimmer, 1973).

PALEONTOLOGY

General Information

Disposition and numbering of specimens

All specimens are in collections of the University of Utah unless indicated otherwise. Each collection is assigned a number prefixed "UU" to designate a University of Utah collection. The collection numbers are not necessarily in stratigraphic sequence because different beds were collected at different times. The following lists show collection numbers and the footage of each collection above the base of each section.

Antimony Canyon

UU-461 = 592'
UU-460 = 534'
UU-459 = 526'
UU-456 = 421'
UU-454 = 394'
UU-453 = 378'
UU-452 = 375'
UU-451 = 374'
UU-450 = 363'
UU-449 = 362'
UU-448 = 357'
UU-447 = 350'
UU-446 = 270'
UU-445 = 269'
UU-444 = 267'
UU-443 = 258'
UU-442 = 256'
UU-441 = 254'
UU-440 = 249'
UU-462 = 245'
UU-439 = 230'
UU-438 = 206'
UU-437 = 198'
UU-436 = 194'
UU-465 = 182'
UU-435 = 179'
UU-434 = 174'
UU-433 = 159'
UU-432 = 149'
UU-430 = 142'
UU-464 = 124'
UU-429 = 106'
UU-428 = 87'
UU-427 = 77'
UU-425 = 54'
UU-423 = 50'
UU-422 = 49'
UU-421 = 41'
UU-420 = 37'
UU-463 = 30'
UU-419 = 27'
UU-466 = 17'

Two Mile Canyon

UU-416 = 680'
UU-415 = 669'
UU-413 = 634'
UU-412 = 594'
UU-411 = 593'
UU-410 = 592'
UU-409 = 591'
UU-408 = 589'
UU-407 = 588'
UU-405 = 567'
UU-404 = 566'
UU-403 = 565'
UU-417 = 546'
UU-402 = 543'
UU-401 = 541'
UU-400 = 512'

An indication of the abundance and occurrence of each species is listed after the taxonomic discussion. The terms "rare (one to four specimens), "common" (five to nine specimens), and "abundant" (10 or more specimens) indicate the number of specimens in my collections that are assignable to a particular species.

Preservation

Nearly all specimens collected from the Twin Knobs Formation, the Naomi Peak Tongue of the Twin Knobs Formation, the High Creek Limestone, and the Ute Formation are disarticulated. Although most of the specimens from the Spence Shale are disarticulated, a significant number are articulated. Specimens preserved in limestone show little evidence of diagenetic flattening. Silicification of the exoskeleton is found in specimens from some collections, although the quality of surface detail has been lost on some specimens. All descriptions refer to features of the external surface of the exoskeleton unless specifically stated otherwise.

Terminology

Most morphological terms used in the descriptions are those defined in Part O of the Treatise on Invertebrate Paleontology (Harrington and others, 1959, p. 117-126). However, some modifications are made. Cranidial width was measured across the widest points of the palpebral lobes, which corresponds with Henningsoen's (1957, fig. 1) "eye line". Glabellar length, unless otherwise specified, was measured without the occipital ring. Fixigenal width includes the palpebral lobes only where specified. Henningsmoen's (1957, p. 2) terminology for facial sutures is followed in this thesis. Pygidial length, unless otherwise

stated, is exclusive of the articulating half-ring and spines. Generally, an average is given for a specific measurement.

Synonomies are shortened wherever possible by referring to a readily available published article with a more complete listing of all citations for the taxon in question.

Classification

The classification of the Treatise on Invertebrate Paleontology (Harrington and others, 1959, p. 217-231) is followed for the corynexochid genera. The ptychoparioid genera, however, are arranged alphabetically, because of the lack of an acceptable classification for those trilobites.

SYSTEMATIC DESCRIPTIONS

Phylum ECHINODERMATA Klein, 1734

Class CTENOCYSTOIDEA Robison and Sprinkle, 1969

Genus CTENOCYSTIS Robison and Sprinkle, 1969

Ctenocystis ROBISON and SPRINKLE, 1969, p. 1513-1514; ROBISON, 1969b, p. 1-2.

Type species.--Ctenocystis utahensis ROBISON and SPRINKLE (1969, p. 1514), figs. 1-2.

The generic concept by Robison and Sprinkle (1969, p. 1513-1514) is followed here.

CTENOCYSTIS UTAHENSIS Robison and Sprinkle

Pl. 2, figs. 5, 6, 9

Ctenocystis utahensis ROBISON and SPRINKLE, 1969, p. 1514, figs. 1-2; ROBISON, 1969, p. 1-2.

Discussion.--The species concept of Robison and Sprinkle is followed here.

Several dozen individuals of this unusual, free-living echinoderm have been collected. Ctenocystoids and an associated undescribed stylophoran are the oldest known "carpoids" of the echinoderm subphylum Homalozoa, and ctenocystoids are known only from the Spence Shale of northern Utah and southeastern Idaho. They were free-living benthonic animals characterized by a unique ctenoid feeding apparatus and a flattened flexible theca with near bilateral symmetry.

The ctenocystoids were prepared for study by dissolving the calcareous skeletal plates from a hard noncalcareous matrix with hydrochloric acid. The resulting artificial molds were then cast with latex rubber to obtain detailed replicas of the original exterior morphology.

Occurrence.--Common in collections UU-436, UU-437, UU-444, and UU-445.

Class EOCRINOIDEA Jaekel, 1918

Genus GOGIA Walcott, 1917

Gogia WALCOTT, 1917b, p. 68; HARKER and HUTCHINSON, 1953, p. 286; ROBISON, 1965b, p. 358-360; SPRINKLE, 1973, p. 76.

Type species.--Gogia prolifica WALCOTT, 1917b, p. 68-69, Pl. 8, figs. 1, 1a-b.

The generic concept by Sprinkle (1973, p. 76) is followed here.

GOGIA GRANULOSA Robison

Pl. 2, figs. 1-3

Eocrinus longidactylus (Walcott) RESSER, 1939b, p. 3-4, figs. 41, 42.

Gogia granulosa ROBISON, 1965b, p. 363-364, Pl. 51, fig. 3; SPRINKLE, 1973, p. 88-89, Pls. 14-15.

The description by Sprinkle (1973, p. 88-89) is adequate for this species.

Discussion.--Gogia granulosa is the most common species of Gogia in the Spence Shale. It differs from other species of Gogia by having multi-spiralled brachioles, a globular calyx with granular ornamentation over the entire surface, and a medium to long cylindrical holdfast.

Occurrence.--Rare at Antimony Canyon (one individual in collection

UU-437), but common two miles to the north in Cataract Canyon.

GOGIA GUNTHERI Sprinkle

Pl. 2, fig. 7

Gogia guntheri SPRINKLE, 1973, p. 93-96, Pl. 18, text-fig. 26.

Sprinkle's diagnosis of Gogia guntheri is followed here.

Discussion.--Gogia guntheri is distinguished from other species of Gogia by its strongly inflated holdfast. Although other species of Gogia have spiralled brachioles, guntheri is the only form with a relatively long, straight proximal part and a spiralled distal part on each brachiole.

Occurrence.--Two complete specimens and one disarticulated plate, which is tentatively assigned to the unusual species of Gogia, were found (UU-425). One complete specimen was collected in Cataract Canyon and the other in Antimony Canyon. Both were in talus. The disarticulated plate was found in place at Antimony Canyon. Cataract Canyon and Antimony Canyon have also yielded G. kitchnerensis and G. granulosa, but specimens of the three species have not been found together in place or on the same slab in float. Therefore, these species probably occur in different stratigraphic intervals of the Spence Shale.

GOGIA KITCHNERENSIS Sprinkle

Pl. 1

Gogia prolifica HARKER and HUTCHINSON (not Walcott), 1953, p. 285-287, Pl. 40.

(?) Eocrinus n. sp. CASTER and POPE, 1960, p. 1840-1841.

Gogia kitchnerensis SPRINKLE, 1973, p. 96-100, Pls. 20-21, text-figs. 15 and 17.

The diagnosis by Sprinkle (1973, p. 96-100) is followed here.

Discussion.--G. kitchnerensis is most closely related to G. longidactylus from Nevada, but differs from that species by having somewhat less restricted epispires, fewer brachioles, fewer and larger calyx plates and a somewhat shorter holdfast with considerably fewer and larger plates around the circumference. G. kitchnerensis differs from other species of Gogia by having the epispires restricted to the upper part of the calyx and by having a long cylindrical holdfast strongly differentiated from the calyx. This is the first reported occurrence of the species in the Spence Shale.

Occurrence.--Abundant in collections UU-444 and UU-445.

Class STYLOPHORA Gill and Caster, 1960

Genus and species undetermined 1

Pl. 2, fig. 8

Discussion.--An undescribed stylophoran from the Spence Shale is figured in order to document the diversity of the echinoderm fauna. Three specimens have been collected by James Sprinkle, and they are believed to be the oldest known stylophorans. The specimens are currently under study by Sprinkle.

Phylum ARTHROPODA Siebold and Stennius, 1845

Class TRILOBITA Walch, 1771

Order AGNOSTIDA (nomen translatum Kobayashi, 1935) Salter, 1864

Family AGNOSTIDAE M'Coy, 1849

Genus PERONOPSIS Corda, 1847

Peronopsis CORDA in HAWLE and CORDA, 1847, p. 115; ROBISON, 1964a, p. 529 (synonomy to date).

Type species.--Battus integer BEYRICH, 1845, p. 44, Pl. 1, fig. 19.

Discussion.--Species of this genus are common in Middle Cambrian rocks in many parts of the world. They are characterized by a well-defined axial furrow, bilobed glabella, lack of a preglabellar median furrow, and usually poorly defined segmentation of the pygidial axis. R. A. Robison is at present studying Middle Cambrian agnostids (including the genus Peronopsis) and should add much to our present knowledge of these forms. R. A. Robison was kind enough to make his manuscript available to me.

PERONOPSIS BONNERENSIS (Resser)

Pl. 3, figs. 1-5

Agnostus bonnerensis RESSER, 1938b, p. 6, Pl. 1, figs. 16, 17; 1939a, p. 8, Pl. 2, figs. 24-26.

Peronopsis bonnerensis (Resser) IVSHIN, 1953, p. 10.

Agnostus lautus RESSER, 1939b, p. 25, Pl. 2, figs. 16-18.

Peronopsis lautus (Resser) FRITZ in ORIEL and ARMSTRONG, 1971, p. 40.

The following diagnosis and discussion by R. A. Robison (manuscript copy) pertains to this species:

> Diagnosis.--Cephalon subcircular with anterior margin bluntly rounded; moderately convex; width slightly greater than length. Glabella nearly parallel-sided, but may taper slightly toward anterior on specimens flattened in shale; width about equal to that of genal fields on undistorted specimens. Posterior genal width (tr.) ranges from 1.4-2.0 times preglabellar width (sag.), depending to some extent on diagenetic compaction. Basal lobes equilaterally triangular. Border furrows narrow and shallow on cephalon and pygidium. Cephalic

border widest anteriorly and narrows evenly toward posterolateral corners.

Thorax of usual generic form.

Pygidium subcircular and more convex than cephalon. Axis distinctly elevated above pleural fields when not diagenetically flattened; slightly constricted at second segment; posterior lobe ogival in shape, has slight medial depression, and extends to, or almost to posterior border furrow. Anterior transaxial furrow usually well defined and bowed forward; posterior transaxial furrow faint or absent. Axial node moderately strong and situated near posterior margin of second segment. Border has pair of tiny posterolateral spines situated on line anterior from posterior tip of axis; is widest at base of spines, and narrows toward anterolateral corners.

Discussion.--Most of the distinctive characters of P. bonnerensis are found on the pygidium, which has an axis that extends to, or almost to the posterior border furrow and the border has a pair of tiny posterolateral spines. The anterior transaxial furrow of the pygidium usually is faint or absent, and the posterior lobe of the axis usually has a medial depression, particularly on older holaspides. Border furrows of the cephalon and pygidium are narrow.

Agnostus lautus of Resser (1939b) has essentially the same features as P. bonnerensis, and it is surprising that Resser did not compare the two species. Furthermore, he did not mention any characters that are different on the two species, and the only difference apparent from his illustrations is in the extent of the pygidial axis. Of the specimens illustrated, those Resser assigned to A. bonnerensis (1938a, Pl. 1, fig. 17; 1939a, Pl. 2, figs. 24, 26) have a pygidial axis that reaches the posterior border furrow. In collections used in this study, which includes topotype specimens of both of Resser's species, the length of the pygidial axis is variable in early and late ontogenetic stages, and in some collections appears to have been influenced by differential diagenetic compaction. In limestone, specimens tend to be flattened and that accentuates the width of furrows and may cause the tip of the axis to touch the border furrow. In the absence of consistent differences, I therefore propose that A. lautus be suppressed as a subjective junior synonym of P. bonnerensis.

Occurrence.--Abundant in collections UU-411, UU-427, and UU-428. Common in collections UU-425 and UU-432. Rare in collections UU-412, UU-415, UU-423, and UU-429.

PERONOPSIS BRIGHAMENSIS (Resser)

Pl. 3, figs. 6, 7, 13, 14

Agnostus brighamensis RESSER, 1939a, p. 8, Pl. 2, figs. 27-29.

Peronopsis brighamensis (Resser) IVSHIN, 1953, p. 10.

The following diagnosis and discussion by R. A. Robison (manuscript copy) pertains to this species:

> Diagnosis.--Cephalon subcircular with anterior margin evenly rounded; moderately convex; width slightly greater than length. Glabella nearly parallel-sided; anterior lobe about equal in length and width, and strongly rounded anteriorly; width slightly less than genal fields. Basal lobes equilaterally triangular. Border furrows narrow and shallow on cephalon and pygidium. Border narrower on cephalon than pygidium.
>
> Thorax of usual generic form.
>
> Pygidium subrectangular to suboval and moderate to strongly convex. Axis slightly constricted at second segment; anterior segment usually about twice maximum width (trans.) of pleural fields; posterior lobe separated from border furrow by distance about equal to width (sag.) of posterior border. Anterior transaxial furrow well-defined and bowed forward; posterior furrow usually moderately well-defined and bowed backward. Axial node strong and situated near posterior margin of second segment. Postaxial furrow well-defined on meraspids and young holaspids, but tends to disappear on older holaspids. Border lacks spines, but has faint swellings at points opposite posterior tip of axis.
>
> Discussion.--This species is characterized by narrow border furrows, faint swellings on the posterolateral pygidial border, and a pygidial axis that is constricted at the second segment. Also, the axis is well separated from the posterior border furrow and has moderately to well-defined transaxial furrows.
>
> P. brighamensis commonly is associated with P. bonnerensis, but can be distinguished from that species by having the pygidial axis well separated from the posterior border furrows, and the posterior lobe of the axis is convex rather than with a slight medial depression as in P. bonnerensis.
>
> P. brighamensis and P. interstricta are the only species of Peronopsis that have faint swellings in place of posterolateral pygidial border spines. Pygidia of those two species can be easily distinguished, however, because P. interstricta has a more conical axis, and it lacks transaxial furrows.

Occurrence.--Abundant in collections UU-412, UU-415, UU-427, and UU-428. Common in collections UU-411, UU-425, and UU-432. Rare in collection UU-435.

Family EODISCIDAE Raymond, 1913

Genus PAGETIA Walcott, 1916

Pagetia WALCOTT, 1916b, p. 407; PALMER, 1968, p. 35 (synonomy to date).

Type species.--Pagetia bootes WALCOTT, 1916b, p. 48, Pl. 67, figs. 1-14.

Discussion.--Pagetia Walcott has been described and discussed many times, and its characteristics are well summarized by Rasetti (1966, p. 503).

PAGETIA CLYTIA Walcott

Pl. 3, figs. 8, 9

Pagetia clytia WALCOTT, 1916b, p. 408, Pl. 67, figs. 2, 2a-e; RASETTI, 1966, p. 507, Pl. 59, figs. 29-34 (synonomy to date).

The diagnosis by Rasetti (1966, p. 507) is followed here.

Discussion.--This form is quite close to P. fossula, but differs in the cranidium by having a somewhat shorter preglabellar field. The pygidium has a proportionately narrower axis, weaker axial nodes and pleural furrows, and a smooth rather than granular surface.

Occurrence.--One cranidium and three pygidia in collections UU-432 and UU-415.

PAGETIA cf. P. FOSSULA Resser

Pl. 3, figs. 25-29

Pagetia fossula RESSER, 1939a, p. 6, Pl. 1, figs. 8-11; RASETTI,

1966, p. 507-508, Pl. 59, figs. 22-28 (synonomy to date).

Discussion.--These specimens are similar to P. fossula and possibly conspecific with it. They differ in lacking granules on the ribs between the pleural furrows of the pygidium. Strength of the axial nodes varies considerably between individuals, but on the average is nearly as strong as P. fossula.

Occurrence.--Abundant in collections UU-427 and UU-428. Rare in collection UU-429.

PAGETIA LIRA n. sp.

Pl. 3, figs. 16, 19, 20

Diagnosis.--Cranidium slightly wider than long, moderately convex. Glabella slightly tapered, slightly pointed in front, has traces of lateral glabellar furrows. Axial furrow deep, nearly uniform in width and depth. Occipital ring bears broad-based, evenly tapered, spine. Border narrower than preglabellar area, average in width, with distinct radial markings. Fixigenae strongly elevated in posterolateral areas, slope down anteriorly, and are separated by relatively narrow preglabellar depression. Palpebral lobes narrow, faint. Eye ridges visible, poorly defined.

Pygidium strongly convex. Axis moderately broad, highly convex, and consists of four rings with prominent nodes, and terminal piece with long spine. Pleural regions crossed by five pairs of strong pleural furrows and four pairs of faint interpleural furrows. Border furrow well impressed, setting off narrow border.

Surface of cranidium and pygidium appears to be smooth.

Discussion.--This species is close to P. fossula and P. cf. P.

fossula, but there appears to be enough difference to warrant specific recognition. The most distinctive feature of this species is the prominent, well-developed pleural furrows on the pygidium. P. fossula has shallow pleural furrows, whereas those of P. lira are much more prominent, being comparable to the pleural furrows of P. resseri in strength.

Occurrence.--Abundant in collection UU-429. Rare in collection UU-433.

Holotype.--Nearly complete individual (1337), illustrated on plate 3, figures 16 and 19.

PAGETIA MALADENSIS Resser

Pl. 3, figs. 10-12, 15

Pagetia maladensis RESSER (part) 1939b, p. 25, Pl. 2, figs. 4 (part, only impression of cranidium in lower center), 5 (part, only cranidium in upper right corner); FRITZ, 1968, p. 190, Pl. 43, figs. 14-16 (synonomy to date).

The diagnosis by Rasetti (1966, p. 508) is adequate and is followed here.

Discussion.--This species differs distinctly from other species of the genus Pagetia in the greater elevation of the pygidial axis. P. maladensis is also characterized by a narrow truncate glabella, a narrow preglabellar depression, curved ocular ridges, and wide fixigenae. As Rasetti (1951, p. 94; 1966, p. 510) pointed out, there are two distinct faunal assemblages in Resser's "Ptarmigania fauna" at Two Mile Canyon, Idaho (USNM locality 54B). Pagetia maladensis and Pagetia rugosa are found exclusively in the upper assemblage.

Occurrence.--Common in collection UU-411.

PAGETIA RESSERI Kobayashi

Pl. 3, figs. 17, 18, 21, 22

Pagetia clytia RESSER (not Walcott), 1939b, p. 25, Pl. 2, figs. 6-8.

Pagetia resseri KOBAYASHI, 1943, p. 40; KOBAYASHI, 1944, p. 64; RASETTI, 1966, p. 509, Pl. 60, figs. 19-25; FRITZ, 1968, p. 192, Pl. 38, figs. 8-9.

Pagetia (Eopagetia) resseri KOBAYASHI, 1944, p. 37.

The species description by Rasetti (1966, p. 509) is adequate and is followed here.

Discussion.--The cranidium of this species is characterized by a long glabella, a narrow palpebral area, distinct palpebral furrows, and pit-like border markings. The pygidium is characterized by strong pleural furrows. P. lira, n. sp., also has strong pleural furrows but has a narrower axis, consisting of four rather than five axial rings and lacks granules on the distal portions of the ribs. As Rasetti pointed out (1951, p. 94; 1966, p. 510), there are two distinct assemblages within Resser's "Ptarmigania fauna" at Two Mile Canyon, Idaho, and P. resseri is common in the lower assemblage (UU-408, UU-409), but is rare in the upper assemblage (UU-410, UU-411). P. rugosa and Pagetia maladensis seem to be confined to the upper assemblage (UU-411). Pagetia resseri is found at approximately the same horizon at Antimony Canyon but P. rugosa and P. maladensis are absent.

Occurrence.--Abundant in collection UU-408, common in collections UU-420 and UU-421, and rare in collections UU-409, UU-410, and UU-411.

PAGETIA RUGOSA Rasetti

Pl. 3, figs. 23, 24, 30, 31

Pagetia maladensis RESSER (part), 1939b, p. 25, Pl. 2, figs. 4 (part, pygidium in upper right corner), 5 (part, cranidia at upper left and upper center, pygidium at lower right).

Pagetia rugosa RASETTI, 1966, p. 509, Pl. 60, figs. 1-7.

Pagetia arenosa FRITZ, 1968, p. 189, Pl. 43, figs. 10, 11.

The diagnosis by Rasetti (1966, p. 509) is adequate and is followed here.

Discussion.--This species is easily distinguished by its characteristic ornamentation. Dense, shallow punctae, not well separated, produce the effect of a slightly rough surface. The cranidium is distinctive in the presence of well-developed ocular ridges and faint palpebral furrows.

Occurrence.--Abundant in collection UU-411.

Order CORYNEXOCHIDA Kobayashi, 1935

Family DOLICHOMETOPIDAE Walcott, 1916

Genus ATHABASKIA Raymond, 1928

Athabaskia RAYMOND, 1928, p. 311; PALMER, 1954, p. 66 (synonomy to date).

Discussion.--The diagnosis by Palmer (1954, p. 66) is followed here. I agree with Rasetti (1951, p. 156), Lochman (1952, p. 128), and Palmer (1954, p. 66) who have considered Athabaskia to be distinct from both Bathyuriscus and Clavaspidella. The relationship of the genus to Clavaspidella is discussed and analyzed by Lochman (1952, p. 128).

ATHABASKIA BITHUS (Walcott)

Pl. 4, figs. 1-4, 6-8

Bathyuriscus? bithus WALCOTT, 1916b, p. 340, Pl. 47, fig. 4 only.

Clavaspidella bithus (Walcott) RESSER, 1935, p. 20; 1939, p. 13, Pl. 15, fig. 12.

Athabaskia bithus (Walcott) LOCHMAN, 1952, p. 128; FRITZ, 1971, p. 46.

Clavaspidella excavata RESSER, 1939, p. 43-44, Pl. 9, figs. 1-6.

Bathyuriscus (Athabaskia) excavata KOBAYASHI, 1942, p. 157-158.

Diagnosis.--Cephalon semicircular in outline; cranidium longer than wide. Glabella almost reaches anterior margin, straight-sided behind S2, expands in front of S2. Four pairs of glabellar furrows visible: S1 oblique backwards; S2 transverse; S3 and S4 oblique forwards. Occipital furrow distinct, deepest at sides, occipital ring rounded, unspined. Width of fixigenae ranges from 0.35 to 0.50 width of glabella. Palpebral lobes long, distinct; anterior ends almost touch dorsal furrow. Posterior limbs long, strap-like. Preocular facial sutures strongly divergent, straight. Postocular facial sutures divergent, convex.

Thorax has eight segments. Axis distinctly narrower than pleural fields. Pleural limbs of each segment subequally divided by broad pleural furrows and extend distally into short falcate spine.

Pygidium subelliptical. Axis convex, slightly tapered, and has rings and long terminal piece that extends into well-developed post-axial ridge. Pleural platforms small, crossed by five pairs of equally spaced pleural and interpleural furrows; fifth pair usually indistinct. Both pleural and interpleural furrows well developed, extend onto border where they become deeper; anterior pairs extend nearly to margin, posterior pairs end abruptly some distance from margin. Border furrow obsolete; border wide, concave, giving pygidium a concave appearance. Border smooth and anterolateral corners often form gentle bulge.

Posterior border straight or with slight indentation.

Surface smooth except border of pygidium which is covered with fine terrace lines.

Discussion.--Walcott (1916b, p. 340) based this species on two distorted pygidia that in my opinion represent two distinct species. Resser (1939a, p. 13) refigured one of Walcott's specimens, but assigned it to Clavaspidella. Because Walcott did not designate a holotype, I here designate the pygidium (USNM 62635) that Walcott figured (Pl. 47, fig. 4, not 4a) as the lectotype for the species. This pygidium was also illustrated by Resser, 1939a, Pl. 5, fig. 12. Resser then discussed pygidia belonging to A. bithus preserved in limestone and proposed a new name, C. excavata to include these specimens.

Occurrence.--This is one of the most common species in the Spence Shale. Abundant in collections UU-432, UU-433, UU-434, UU-437, UU-440, UU-442, UU-447, UU-449, UU-451, UU-452, UU-453, UU-454, UU-462, and UU-465. Common in collections UU-435, UU-439, UU-441, UU-448, and UU-464. Rare in collections UU-430, UU-436, UU-443, UU-444, and UU-456.

ATHABASKIA WASATCHENSIS (Resser)

Pl. 4, figs. 16, 17

Clavaspidella wasatchensis RESSER, 1939b, p. 43, Pl. 8, figs. 15-20.

Bathyuriscus (Athabaskia) wasatchensis KOBAYASHI, 1942, p. 157-158.

The species concept given by Resser (1939b, p. 43) is generally adequate. It need be modified only slightly to include specimens that lack fine granules.

Discussion.--This species differs from A. bithus in having much weaker pleural and interpleural furrows, and in having a flat rather

than concave border.

Occurrence.--This species is abundant in collections UU-443 and UU-444. It is rare in collections UU-441, UU-442, UU-445, UU-447, UU-449, UU-451, UU-453, and UU-462.

ATHABASKIA sp. undet. 1

Pl. 4, fig. 5

Diagnosis.--Cephalon semicircular. Glabella extends nearly to anterior margin; parallel-sided posterior to S2, expands anterior to S2. Three pairs of glabellar furrows visible: S1 oblique backwards; S2 transverse; S3 oblique forwards. Axial furrow distinct; has shallow fossulae opposite S3. Occipital furrow distinct, deepens laterally. Occipital ring flat, about 0.15 length of glabella. Border narrow, slightly upturned. Fixigenae about 0.50 width of glabella at eye line. Palpebral lobes long, distinct; anterior ends nearly touching axial furrow. Posterior limb narrow (tr.) wider than glabella at occipital ring. Preocular facial suture divergent, straight. Postocular facial suture divergent, sinuous.

Thorax has eight segments. Axial lobe slightly narrower than pleural lobes. Pleurae divided subequally by broad pleural furrows and are falcate.

Pygidium incomplete. Axis slightly narrower than pleural regions. Axis prominent, elevated, number of rings unknown, but probably four or five. First axial ring bears distinct node; second ring does not. Pleural fields downsloping, border slightly concave. Number of pleural and interpleural furrows unknown. Pleural furrows wider than interpleural furrows, extends onto border; both about equally impressed. Border

quite narrow.

Surface smooth.

Discussion.--This species is represented by one nearly complete individual which lacks most of its pygidium. The cranidia of Bathyuriscus and Athabaskia are quite similar, the pygidium being the most distinctive distinguishing feature. The specimen at hand is crushed in shale and retains only a small part of the pygidium, but is referred to Athabaskia rather than Bathyuriscus because it has eight instead of nine thoracic segments. This species clearly differs from A. bithus in having much weaker pleural and interpleural furrows. It differs from A. wasatchensis in having a much wider lateral border on the librigenae, a wider (exsag.) posterior area of the fixigenae, and a much narrower pygidial border.

Occurrence.--Rare in collection UU-459.

ATHABASKIA sp. undet. 2

Pl. 4, figs. 9, 10

Diagnosis.--Pygidium semielliptical, nearly twice as wide as long. Axis relatively short, prominent, convex; has three rings, terminal piece and a short postaxial ridge that reaches inner edge of border. Pleural regions crossed by four pleural and four interpleural furrows of about equal strength. Inner pleural area convex, outer pleural area and border concave. Pleural and interpleural furrows extend onto border.

Surface of pygidium is smooth.

Discussion.--This species of Athabaskia is represented by one small pygidium. It most closely resembles A. bithus but specimens of A. bithus, which are similar in size, differ in having five rather than

four pairs of pleural and interpleural furrows. A. bithus also has distinctly stronger pleural and interpleural furrows, a much more convex pleural field, a better defined and more concave border and a more circular outline.

Occurrence.--One pygidium in collection UU-408.

Genus BATHYURISCUS Meek, 1873

Bathyuriscus MEEK, 1873, p. 484; PALMER, 1968, p. 44 (synonomy to date).

Discussion.--The diagnosis of Bathyuriscus by Robison (1964a, p. 534) is generally adequate and need be modified only slightly to read, "one pair of fossulae present in axial furrow", rather than "two pairs of fossulae present in axial furrow". Robison also has reviewed the content and concept of the genus.

BATHYURISCUS BRIGHAMENSIS Resser

Pl. 4, figs. 11-15

Bathyuriscus brighamensis RESSER, 1939a, p. 11, Pl. 5, figs. 3, 4.

Diagnosis.--Cranidium moderately convex, subquadrate. Glabella prominent, elongate, expands anteriorly. Four pairs of glabellar furrows evident: S1 well developed, oblique backward; S2 oblique backwards; S3 transverse; S4 oblique forwards. Occipital furrow relatively wide, shallow. Occipital ring bears small median node. Anterior border poorly defined. Anterior areas of fixigenae greater than 0.50 width of palpebral area. Fossulae present at intersection of eye ridge and axial furrow. Fixigenae narrow, slightly convex and nearly flat. Palpebral lobes prominent, slightly more than 0.30 glabellar length; anterior ends almost touch glabella. Eye ridges short, faint. Preocular facial suture divergent, straight. Posterior limbs moderately

long (tr.). Postocular facial suture rapidly divergent, sinuous.

Thorax has nine segments. Pleural fields slightly wider than axis. Each pleura has shallow pleural furrow and is falcate.

Pygidium semielliptical. Axis has four to five rings, a terminal piece, and a postaxial ridge that reaches inner edge of border. Pleural field slightly convex, crossed by four or five pairs of pleural and three or four pairs of interpleural furrows that extend onto border; last pair of furrows faint. Border narrow; first segment of the pygidium may have small spine or border swelling, or spines may be absent. Posterior border has weak median notch.

Discussion.--The holotype of this species (Pl. 4, fig. 15) is an unusually large individual and possesses a pair of small anterolateral spines. Based on many individuals in my collections, the presence of anterolateral spines appears to be a variable character. Some pygidia lack spines, some possess small swellings or incipient spines and some possess distinct, but small spines. All individuals agree well in other characters with the holotype and are here considered conspecific.

The holotype is a pathological specimen. The anterior two pleural segments on the right side are coalesced and have a single extraordinarily long spine on the anterior most thoracic segment. The posterior part of the border on the left side of the pygidium is deformed and has a small notch and spine.

Occurrence.--Abundant in collections UU-427 and UU-426; rare in collections UU-429 and UU-430.

BATHYURISCUS WASATCHENSIS (Resser)

Pl. 5, figs. 1, 2, 5, 6, 9

Poliella wasatchensis RESSER, 1939b, p. 30, Pl. 13, fig. 26.

Bathyuriscus (Athabaskia) wasatchensis (Resser) KOBAYASHI, 1942, p. 157-158.

Athabaskia wasatchensis ROBISON, 1964, p. 535.

Diagnosis.--Cephalon semicircular. Glabella elongate, extends to anterior border and expands slightly anteriorly. Axial furrow moderately deep. Four pairs of lateral glabellar furrows are present: S1 fairly strong, oblique backwards; S2 oblique backwards; S3 transverse; S4 oblique forwards. Occipital furrow broad, shallow. Occipital ring apparently bears small medial node. Anterior border narrow, slightly upturned. Fixigenae relatively narrow. Palpebral lobes prominent, approximately 0.35 glabellar length. Eye ridges faint. Width of anterior areas of fixigenae slightly less than 0.50 that of palpebral areas. Posterior limbs strap-like. Preocular facial sutures divergent, straight. Postocular sutures divergent, sinuous. Librigenae are attached on several individuals; are of moderate width with nearly flat genal fields; border narrow. Genal spine extends posteriorly to fourth or fifth thoracic segment.

Thorax has nine segments. Axis convex; elevated above, and slightly narrower than pleural fields. Each pleura has wide furrow and is falcate.

Pygidium semielliptical, slightly convex. Axis moderately convex, tapers posteriorly, has three to four rings, terminal piece, and post-axial ridge that extends to inner edge of border. Last axial ring furrow faint. Pleural fields slightly convex, crossed by five pleural furrows and four less distinct interpleural furrows. Pleural furrows end in slight depressions on border. Border narrow, slightly upturned.

Anterior segment of pygidium extends into well-developed, recurved spine. Posterior border has weak median notch.

Discussion.--I agree with Kobayashi (1942, p. 157-158) in his assignment of this species to Bathyuriscus. Robison (1964, p. 535), in his discussion of the genus Bathyuriscus, considered Bathyuriscus wasatchensis to have features more typical of Athabaskia than Bathyuriscus because he interpreted the holotype to have only eight thoracic segments and a slightly concave border. The holotype of Bathyuriscus wasatchensis (Resser) does appear to have eight thoracic segments, but all other complete individuals from the type locality possess nine thoracic segments. Several individuals would have appeared to have eight thoracic segments if the cranidium had not weathered away revealing that the anterior thoracic segment had been covered by the cranidium during preservation. I believe this is what happened to the holotype, and Resser was correct in indicating that it had nine thoracic segments.

This species most closely resembles B. brighamensis but differs from that species in having a pair of well-developed anterolateral spines on the pygidium. In B. brighamensis the spines are small or absent.

Occurrence.--Rare in UU-411 and common in UU-425.

Genus GLOSSOPLEURA Poulsen, 1927

Glossopleura C. POULSEN, 1927, p. 268; KOBAYASHI, 1935, p. 132; 1942, p. 159; SHIMER and SHROCK, 1944, p. 611; PALMER, 1954, p. 67; V. POULSEN, 1959, p. 224.

Sonoraspis STOYANOW, 1952, p. 50.

Type species.--Dolichometopus boccar WALCOTT, 1916, p. 363, Pl. 52,

figs. 1, 1a-f.

Discussion.--Palmer (1954, p. 67) has given a thorough generic diagnosis that is generally adequate and need be modified only slightly to include species with: (1) a short anterior border in front of the glabella; (2) occipital nodes; and (3) spines on the axial rings of the thoracic segments.

The taxonomy of Glossopleura is currently in need of revision. Over 50 species are assigned to the genus, and many have been based on a single pygidium or on a single cranidium and pygidium. In addition, the discrimination of species is difficult because the exoskeleton shows relatively few features because of its weak furrows. A reevaluation of the genus is beyond the scope of this thesis, and I restrict my discussions to individuals from northern Utah and southeastern Idaho.

GLOSSOPLEURA ARRECTA (Resser)

Pl. 5, figs. 12, 13

Glossopleura arrecta RESSER, 1939b, p. 42, Pl. 8, figs. 8-10.

Bathyuriscus (Glossopleura) arrecta (Resser) KOBAYASHI, 1942, p. 159.

Discussion.--The diagnosis of Resser (1939b, p. 42) is adequate. Resser separated G. prona and G. arrecta on the degree of convexity of the pygidium, which may have been a variable character, or could have been influenced by distortion caused by compaction. He also assigned all the cranidia in his collections to G. prona although both forms are from the same locality and horizon. Additional material would be necessary to determine if both species are valid. Although this species was not found at Antimony or Two Mile Canyons, Resser's material has been reillustrated for comparison with G. prona.

Occurrence.--Resser's type material come from localities 55p and 55q.

GLOSSOPLEURA BION (Walcott)

Pl. 5, figs. 3, 4

Glossopleura bion (Walcott) RESSER, 1939a, p. 12, figs. 1, 2 (synonomy to date).

Discussion.--Only one small cranidium and one pygidium of this species have been found during my collecting. They agree well with the illustrations of Walcott (1916b) and Resser (1939a) and are considered conspecific. The cranidium differs from all other species of Glossopleura in the Spence Shale by having a frontal area. The pygidium is characterized by a short axis and a broad border.

Occurrence.--Rare in collections UU-433 and UU-465.

GLOSSOPLEURA GIGANTEA Resser

Pl. 6, figs. 10-12

Glossopleura gigantea RESSER, 1939a, p. 13, Pl. 5, fig. 19

Diagnosis.--Cranidium slightly convex, slightly longer than wide. Glabella prominent, elongate, expands slightly toward anterior, reaches anterior margin of cranidium, bluntly rounded anteriorly. Four pairs of faint glabellar furrows visible: S1 oblique backwards; S2 oblique backwards; S3 and S4 oblique forwards. Axial furrow fairly well defined, faint fossulae present. Occipital furrow composite, shallow, deepens slightly laterally. Occipital ring about 0.15 glabellar length, appears to lack node or spine. Frontal area absent. Fixigenae about 0.45 glabellar width at eye line, slightly convex, probably near horizontal. Palpebral lobes long, prominent, fairly well defined by palpebral

furrow; anterior end opposite S3, posterior end opposite L1. Eye ridges indistinct. Posterior area of fixigenae about same width as glabella at occipital furrow. Preocular facial suture nearly parallel or slightly divergent, convex. Postocular facial suture divergent, sinuous.

Thorax has eight segments. Axis about same width as pleural regions. Segments terminate distally in moderately short recurved spines.

Pygidium semielliptical, anterolateral margin broadly rounded, length about 0.70 width. Axis prominent, tapered, apparently consists of seven to eight faint segments, and a terminal piece that extends onto border but does not reach posterior margin. Pleural regions slightly convex, downsloping, nearly smooth. Border moderately wide, nearly horizontal, flat or slightly concave.

Surface of exoskeleton smooth except for faint terrace lines on glabella and border of pygidium.

Discussion.--This species is distinguished by its large size, large expanded glabella and eight thoracic segments. Its pygidium is characterized by an axis that does not reach the posterior margin, a relatively wide border, and rounded anterolateral margins. The holotype is over five inches long and some fragments show that some individuals were even larger. One pygidium in my collections is over three inches wide and about two inches long.

Occurrence.--Rare in collections UU-432, UU-435, and UU-437.

GLOSSOPLEURA GIGANTEA? Resser

Pl. 5, figs. 16-18

Diagnosis.--Cephalon semicircular, posterior margin straight, distinct genal spines extend backward from posterolateral corners. Glabella poorly defined, extends to anterior margin, slightly expanded forward, bluntly rounded anteriorly. Glabellar furrows indistinct on most specimens, one well preserved cranidium has four very faint furrows: S1 oblique backwards; S2 transverse; S3 and S4 oblique forwards. Occipital furrow moderately deep, deepens slightly laterally. Occipital ring about 0.15 glabellar length, bears faint median node. Frontal area and border absent. Fixigenae about 0.40 glabellar width at eye line, slightly convex, downsloping. Palpebral lobe long and fairly well defined by palpebral furrow; anterior end nearly touches axial furrow, posterior end opposite L1. Posterior area of fixigenae narrower than glabella at occipital furrow. Preocular facial suture nearly parallel, straight. Postocular facial suture divergent, sinuous. Librigenae with evenly rounded margin and prominent, stout, relatively short, genal spine. Border about 0.35 width (tr.) of genal field.

Thorax has seven segments. Axis about same width as pleural lobes. Each axial ring bears prominent spine. Pleurae falcate and subequally divided by pleural furrows.

Pygidial length about 0.60 width. Axis prominent, convex, well defined by dorsal furrow, consists of seven to eight faint rings, a terminal piece, and a short postaxial ridge that does not reach posterior margin. Pleural regions moderately convex, downsloping; pleural furrows indistinct. Border moderately wide, downsloping, slightly concave.

Border areas and higher parts of surface covered with faint terrace lines, remainder of surface smooth.

Discussion.--These specimens closely resemble the much larger ones of G. gigantea. They differ in having seven rather than eight thoracic segments and the pygidium lacks the rounded anterolateral margin characteristic of the larger G. gigantea. They are quite similar in their features however, and ontogenetic changes could account for the differences noted. Based on such a small sample (only two complete G. gigantea and three complete smaller individuals are known) it is impossible to assign the smaller specimens with certainty.

Occurrence.--Rare in collections UU-430, UU-434, UU-443, UU-444, UU-462, and UU-465.

GLOSSOPLEURA GRANOSA n. sp.

Pl. 6, figs. 1-6

Diagnosis.--Cranidium subquadrate, slightly wider than long, moderately convex. Glabella prominent, moderately well defined, expands slightly, reaches anterior margin of cranidium, broadly rounded anteriorly. Four pairs of glabellar furrows visible: S1 strong, straight, oblique backwards; S2 weak, transverse; S3 faint, transverse; S4 indistinct, oblique forwards. Axial furrow moderately well defined, fossulae present. Occipital furrow relatively deep, deepens slightly laterally. Occipital ring about 0.20 glabellar length, slightly upsloping, bears a faint median node surrounded by five distinct punctae. Frontal area absent. Fixigenae about 0.35 glabellar width at eye line, slightly convex, nearly horizontal. Palpebral lobes long, well defined by palpebral furrow, situated slightly below level of palpebral area of fixigenae, anterior ends nearly touch axial furrow. Posterior area of fixigenae about 0.70 glabellar width at occipital furrow. Preocular facial suture slightly divergent, straight. Postocular facial suture diver-

gent, sinuous.

Pygidium semielliptical, moderately convex, length about 0.60 width. Axis prominent, very slightly tapered, consists of five rings with distinct nodes, a terminal piece, and a postaxial ridge that reaches posterior margin of pygidium. Pleural regions downsloping, flat or slightly concave, relatively narrow.

Surface of glabella and palpebral lobes covered with an unusual pattern of elongate granules. Fixigenae covered with fine granules and punctae. Pygidium covered with fines granules, and pleural regions also have distinctive pattern of caecal lines.

Discussion.--A single cranidium is tentatively assigned to this species based on association and surface ornamentation. That cranidium is characterized by a glabella with moderately well defined furrows, a slightly upsloping occipital ring, an occipital node surrounded by five prominent punctae and the distinctive ornamentation. The pygidium is characterized by a prominent axis that extends to the posterior border, nodes on the axial rings, and the ornamentation.

Occurrence.--Common in collection UU-465 and rare in collections UU-432 and UU-462.

Holotype.--Pygidium (1365) illustrated on plate 6, figures 4 and 5.

GLOSSOPLEURA PRONA Resser

Pl. 5, figs. 7, 8, 10, 11

Glossopleura prona RESSER, 1939b, p. 42, Pl. 8, figs. 11-14.

Bathyuriscus (Glossopleura) prona (Resser) KOBAYASHI, 1942, p. 159.

Discussion.--Resser's diagnosis of Glossopleura prona is adequate. Pygidia of G. prona most closely resemble those of G. bion but cranidia

of the two species are distinctly different. The glabella of G. prona expands less rapidly anteriorly and lacks the distinctive frontal area of G. bion. G. prona and G. arrecta are compared under that species. Resser's material has been reillustrated for comparison with G. prona? from Antimony Canyon.

Occurrence.--Resser's type material from localities 55p and 55q. (Seven miles above mouth of Blacksmith Fork, Bear River Range, Utah).

GLOSSOPLEURA PRONA? Resser

Pl. 5, figs. 14, 15

Diagnosis.--Glabella elongate, nearly parallel-sided, reaching to anterior margin, rounded anteriorly, bears faint median longitudinal keel. Glabellar furrows shallow. Axial furrow of moderate depth. Occipital furrow well defined, moderately deep. Occipital ring about 0.15 glabellar length, flat. Border and frontal area absent. Fixigenae about 0.50 glabellar width at eye line. Palpebral lobe long, moderately well defined by palpebral furrow, anterior ends nearly touching axial furrow, posterior ends opposite L1. Posterior area of fixigenae appear to be narrower than glabella at occipital furrow. Preocular facial suture parallel, straight. Postocular facial suture divergent, sinuous.

Pygidium nearly twice as wide as long, slightly convex. Axis about 0.65 pygidial length, slightly tapered, axial rings indistinct. Pleural regions slightly downsloping, unfurrowed. Border wide, prominent, slightly downsloping, nearly flat. Surface smooth except for faint terrace lines on front of glabella and outer margins of pygidium.

Discussion.--Only one crushed cranidium and one small distorted

pygidium of this taxon have been found. Both occur in collection UU-430 and are tentatively assigned to the same species. Both the cranidium and pygidium are similar to specimens assigned to G. prona by Resser (1939b) and are questionably assigned to this species. The cranidium has a distinctively rounded anterior margin, a nearly smooth surface, and parallel preocular facial sutures. The anterior margin of the cranidium of G. prona is broken so comparison is difficult but other features seem to agree well. The pygidia are both unfurrowed, have a wide border, and a short axis.

Occurrence.--Rare in collection UU-430.

GLOSSOPLEURA PUNCTATUM n. sp.

Pl. 7, figs. 1-6

Diagnosis.--Cranidium slightly to moderately convex, length nearly equal to width. Glabella low, fairly well defined, slightly expanded and bluntly rounded anteriorly. Glabellar furrows indistinct or faint: S1 oblique backwards; S2 convex, oblique backwards; S3 transverse; S4 oblique forwards. Axial furrow faint. Occipital furrow moderately deep, simple. Occipital ring about 0.20 glabellar length, slightly upsloping, has faint median elevation. Frontal area absent. Fixigenae 0.35 to 0.45 glabellar width at eye line, slightly convex, faintly downsloping. Palpebral lobes long, horizontal, slightly below level of palpebral area of fixigenae, poorly defined by palpebral furrow. Preocular facial suture nearly parallel, straight.

Pygidium slightly convex, semielliptical, length about 0.60 width. Axis prominent, slightly tapered, consists of five or six faint rings, a short terminal piece and a postaxial ridge that reaches posterior border. Axial rings have faint elongate (tr.) nodes. Pleural regions

slightly convex, downsloping, crossed by four or five faint pleural furrows. Border narrow, slightly downsloping, nearly flat.

Surface of cranidium faintly to moderately punctae and border shows faint terrace lines, but small individuals and exfoliated specimens are nearly smooth.

Discussion.--The pygidium of this species is quite similar to the pygidium of G. similaris Resser, the only significant difference being the surface ornamentation. Resser (1939a, p. 12) states that the surface of G. similaris is covered with fine irregular lines. The surface of G. punctatum is punctae and only the outer border has faint terrace lines. Also, the cranidia of the two species seem to differ significantly. For some reason (possibly collecting bias) cranidia of all species of Glossopleura are much less common than pygidia. G. punctatum is the most common species of Glossopleura at Antimony Canyon but only two cranidia of this species have been located. Assignment of the cranidia, based on ornamentation, is fairly certain however. The anterior area of the fixigenae is very narrow in G. punctatum and the preocular facial suture is nearly parallel and straight. The anterior area of the cranidium assigned to G. similaris is well developed and the preocular facial suture is distinctly divergent. No cranidia resembling those of G. similaris are in my collections.

Occurrence.--Abundant in collection UU-462; common in collections UU-443 and UU-465, and rare in collections UU-429, UU-430, UU-432, UU-433, UU-434, UU-435, UU-437, UU-439, UU-440, UU-441, and UU-444.

Holotype.--Pygidium (1373) illustrated on plate 7, figure 5.

GLOSSOPLEURA SIMILARIS Resser

Pl. 6, fig. 9

Glossopleura similaris RESSER, 1939a, p. 12, Pl. 5, figs. 9-11.

Discussion.--The diagnosis of Resser (1939a, p. 12) is adequate. No individuals of this species have been found by me, but the holotype pygidium is reillustrated for comparison with a new, similar species in my collections. G. similaris most closely resembles G. punctatum, the differences being discussed under that species.

Locality.--Type material from localities 55c and 54L.

GLOSSOPLEURA sp. undet. 1

Pl. 6, figs. 7, 8

Diagnosis.--Pygidium slightly wider than long, moderately convex; anterior and posterior margins broadly rounded. Axis prominent, convex, slightly tapered, occupies about 0.70 pygidial length. Axis consists of five faint rings, a terminal piece, and a short postaxial ridge that does not reach posterior margin. Pleural regions downsloping, crossed by five pairs of faint pleural furrows that extend onto border. Border wide, concave. Dorsal expression of inner margin of doublure distinct. Posterior margin of pygidium has distinct median notch.

Pygidium covered with terrace lines that are most prominent on border.

Discussion.--This pygidium is quite distinctive. It differs from those of other species of Glossopleura by its broadly rounded anterolateral margin, wide border, and distinct median notch in the posterior margin. I know of no species of Glossopleura with this set of

characters, but the material available does not warrant the establishment of a new species.

Occurrence.--One pygidium in collection UU-434.

GLOSSOPLEURA sp. undet. 2

Pl. 7, figs. 7, 8, 12

Diagnosis.--Cranidium moderately convex, length nearly equal to width. Glabella low, defined by faint axial furrow, slightly expanded and bluntly rounded anteriorly. One faint glabellar furrow visible: S1 oblique backwards. Occipital ring flat, about 0.15 glabellar length. Frontal area absent. Fixigenae slightly less than 0.50 glabellar width at eye line, slightly convex downsloping. Palpebral lobes long, poorly defined, anterior ends nearly touch axial furrow, posterior ends opposite occipital ring. Preocular facial suture divergent, convex.

Pygidium moderately convex, nearly twice as wide as long. Axis prominent, convex, consists of four or five indistinct rings, a terminal piece, and a postaxial ridge that nearly reaches posterior margin. Pleural fields downsloping, slightly convex, crossed by two or three indistinct pleural furrows. Border fairly wide, slightly concave.

Surface of cranidium appears to be smooth. Surface of pygidium covered with faint wavy lines.

Discussion.--This taxon is represented by one small cranidium, one small pygidium and several larger, poorly preserved fragmentary pygidia. They are characterized by having a moderately narrow pygidial border and an axis which does not reach the posterior border of the pygidium. Better preserved material is necessary to identify

this species.

Occurrence.--Rare in collections UU-447, UU-451, UU-452, UU-453, and UU-454.

Genus POLIELLA Walcott, 1916

Bathyuriscus (Poliella) WALCOTT, 1916b, p. 349.

Poliella WALCOTT, 1916b, p. 349; RAYMOND, 1928, p. 310; RESSER, 1935, p. 43; KOBAYASHI, 1942, p. 153; POULSEN in HARRINGTON, 1959, p. 226; FRITZ, 1968, p. 206.

Type species.--Bathyuriscus (Poliella) anteros WALCOTT, 1916b, p. 349, Pl. 46, fig. 5.

Discussion.--The concept of Poliella as a long-eyed corynexochid characterized by a small, poorly segmented pygidium seems to have been consistently applied by all authors who have assigned species to the genus. However, as pointed out by Fritz (1968, p. 206), the genus includes at present species with and without axial spines on the occipital ring and thoracic segments.

POLIELLA GERMANA (Resser)

Pl. 7, figs. 9-11, 13-17

Poliella germana (Resser) FRITZ, p. 207, Pl. 37, figs. 1-9 (synonomy to date).

Discussion.--Fritz (1968, p. 207) has given an adequate description of this species and has clarified the asignments of many of the specimens described and excessively split by Resser (1939b). This species is distinguished by having a non-denticulate pygidial margin and having two or three shallow pleural furrows which continue onto the inner edge of the pygidial border.

Occurrence.--Abundant in collection UU-408, rare in collections UU-420 and UU-421.

POLIELLA MILLERI n. sp.

Pl. 7, figs. 18-21, 23-25

Diagnosis.--Cranidium subquadrate, quite convex, length equals width. Glabella prominent, expands slightly anteriorly, nearly reaches anterior margin of cranidium, broadly rounded anteriorly. Four pairs of faint glabellar furrows visible: S1 and S2 oblique backwards; S3 transverse; S4 oblique forwards. Axial furrow shallow, distinct fossulae present. Occipital furrow shallow, composite, deepens laterally. Occipital ring triangular, about 0.25 glabellar length; bears small median node. Frontal area indistinct. Border faint, narrow, more distinct laterally. Border furrow narrow, faint. Fixigenae about 0.50 glabellar width at eye line, moderately convex, downsloping. Palpebral lobes slightly downsloping, slightly less than 0.50 length of glabella, midpoint situated behind midpoint of glabella. Palpebral furrows shallow, distinct. Eye ridges short, faint, meet axial furrow opposite fossulae. Posterior area of fixigenae distinctly narrower than glabella at occipital furrow. Preocular facial suture divergent, straight. Postocular facial suture divergent, sinuous.

Pygidium moderately convex, twice as wide as long. Axis prominent, convex, tapered, consists of two rings, a terminal piece, and a short postaxial ridge that reaches posterior margin of pygidium. Anterior ring bears low, transverse ridge. Pleural field slightly convex, downsloping, crossed by three pleural and two less distinct interpleural furrows. Furrows extend across weak border furrow onto

border. Border relatively narrow, extended into two pairs of bulges or faint blunt spines opposite first two pleural furrows, which give the border a scalloped appearance. Posterior margin has slight median notch.

Surface of test smooth or faintly punctate. Faint venation may be present on pygidial border.

Discussion.--The cranidium of this species is characterized by a slightly expanded glabella with faint glabellar furrows and a broad, evenly rounded anterior margin. The pygidium has a prominent, tapered axis that reaches the posterior border. The pygidial border is extended into two pairs of swellings or faint spines. This species differs from P. germana in having less distinct glabellar furrows and a more broadly rounded anterior cranidial margin. The preocular facial sutures are less strongly divergent and the occipital ring slopes upward posteriorly rather than being flat. The pygidium of P. milleri has one less axial ring, one less pleural furrow, a denticulate margin, and the border is narrower and better defined than in P. germana.

Occurrence.--Abundant in collections UU-422 and UU-423.

Holotype.--Cranidium (1383) illustrated on plate 7, figures 20, 23, and 24.

POLIELLA? sp. undet.

Pl. 7, figs. 22, 26

Diagnosis.--Pygidium semielliptical, length 0.60 width, moderately convex. Axis prominent, highly convex, tapered, consists of four rings, a very short terminal piece, and a short postaxial ridge that reaches posterior margin of pygidium. Anterior three rings have elongate (tr.)

nodes that decrease in size posteriorly. Pleural field moderately convex, downsloping, crossed by four distinct pleural furrows and three less prominent interpleural furrows. Furrows extend onto border. Border fairly prominent, horizontal, extended into what appears to be four small nodes or indistinct spines that are less distinct posteriorly. Surface covered with fine granules.

Discussion.--This species is represented by one small distinctive pygidium that is questionably referred to Poliella. The axis is prominent, reaches the posterior border, and the axial rings have well-developed nodes. The pleural fields are crossed by distinct pleural and interpleural furrows and the border is extended into what appears to be indistinct nodes or spines.

Occurrence.--One pygidium in collection UU-439.

Genus POLYPLEURASPIS Poulsen, 1927

Polypleuraspis POULSEN, 1927, p. 270. RASETTI, 1951, p. 175-176, POULSEN, 1959, p. 226.

Type species.--Polypleuraspis solitana POULSEN, 1927, p. 272, Pl. 17, figs. 8-9.

Discussion.--Rasetti's (1951, p. 175) diagnosis of Polypleuraspis is followed here. As Rasetti noted, this genus is closely related to Glossopleura, but differs chiefly in the characters of the pygidium.

POLYPLEURASPIS sp. undet.

Pl. 8, fig. 1

Diagnosis.--Pygidium subtriangular. Original convexity modified by compaction in shale. Axis moderately tapered, probably extends onto posterior border. Fourteen axial rings and a terminal piece are

distinguishable; moderately wide, separated by narrow ridges. Border narrow and slightly concave; widens posteriorly; surface appears to be smooth. Pygidium 11.1 mm long and 12.0 mm wide.

Discussion.--Only one large pygidium of this genus has been found, and it is an impression flattened in shale. The specimen most closely resembles Polypleuraspis insignis Rasetti (1951, p. 176), but it is difficult to compare the flattened pygidium preserved in the Spence Shale with undeformed specimens preserved in limestone of the Stephen Formation in British Columbia. It differs from P. insignis by having more axial rings, which are more distinct, and narrower pleural furrows. The size of this pygidium is slightly smaller than the largest reported pygidium of P. insignis.

A single cranidium and a single juvenile pygidium of Polypleuraspis sp. have been reported from the Chisholm Formation of the Drum Mountains of west-central Utah (Oldroyd, 1973, p. 64). Because the pygidium is very small, it is not possible to compare the two adequately.

I know of no established species to which this pygidium can be assigned with confidence, and the pygidium is judged inadequate to be a holotype for a new species.

Occurrence.--One pygidium in collection UU-432.

Genus PTARMIGANIA Raymond, 1928

Ptarmigania RAYMOND, 1928, p. 310; KOBAYASHI, 1935, p. 130; RESSER, 1939b, p. 37; KOBAYASHI, 1942, p. 151-153; RASETTI, 1951, p. 177, 178; LOCHMAN, 1952, p. 131-133; RESSER, 1945, p. 195; HUPE, 1953, p. 107; IVSHIN, 1957, p. 31; POULSEN, 1959, p. 226.

Type species.--Bathyuriscus rossensis WALCOTT, 1917a, p. 46-49, Pl. 5, figs. 5, 5a-d.

Discussion.--The diagnosis by Raymond (1928, p. 310) is adequate and is followed here. Ptarmigania is characterized by a pygidium with one pair of anterolateral border spines and nubs of one or two additional spines. Cranidia are generally indistinguishable from those of Ptarmiganoides without associated pygidia. Ptarmigania and the closely related Ptarmiganoides are compared under the discussion of that genus.

PTARMIGANIA EXIGUA Resser

Pl. 8, figs. 2-9, 13

Ptarmigania exigua RESSER, 1939b, p. 38, Pl. 4, figs. 1-10.

Ptarmigania natalis RESSER, 1939b, p. 39, Pl. 4, figs. 13-18.

Ptarmigania ornata RESSER, 1939b, p. 39, Pl. 4, figs. 25-32.

Ptarmiganoides exigua (Resser) FRITZ, 1971, p. 39.

Diagnosis.--Cranidium convex, subquadrate. Glabella extends to anterior border, moderately convex, slightly expanded anteriorly, bluntly rounded at front. Axial furrow strong, fossulae well developed. Four pairs of distinct glabellar furrows visible: S1 straight, oblique backwards; S2 slightly convex, oblique backwards; S3 transverse, deepest medially; S4 oblique forwards. Occipital furrow well developed, composite, deepens laterally. Occipital ring triangular, about 0.20 length of glabella, extended into strong spine. Frontal area undivided, about 0.10 length of glabella, flat or slightly upturned medially, becomes distally upturned laterally. Anterior area of fixigenae about 0.25 maximum glabellar width, slope downward. Palpebral area of fixigenae slightly to moderately convex, nearly horizontal, about 0.60

width of glabella at eye line. Palpebral lobes well developed, about 0.50 glabellar length. Eye ridges short, strong, meet axial furrow opposite S4. Posterior area of fixigenae about same width as glabella at occipital furrow, distinct spine directed posterolaterally from tip. Preocular facial suture divergent, convex. Postocular facial suture divergent, sinuous.

Pygidium convex, semielliptical, much wider than long. Axis prominent, consists of two or three rings, a terminal piece, and a short postaxial ridge which extends onto border. Anterior ring bears strong spine, posterior ring is usually indistinct. Pleural regions downsloping, crossed by three pleural and two faint interpleural furrows that extend onto border. Border distinct. Anterolateral corner extended into a blunt posteriorly directed spine. Remainder of border extended into three or four short nubs.

Surface of test covered with well-developed granular ornamentation with exception of furrows. In addition, frontal area and palpebral lobes of cranidium, and pleural regions of pygidium are finely punctate. Anterior border striated.

Discussion.--Resser has caused a great deal of confusion by excessive splitting of this species. In the above synonomy are listed three of Resser's species that were based on slight variations in morphology, size, and ornamentation. P. exigua is characterized by a well-developed granular ornamentation and only one pair of short pygidial spines and several nubs of additional spines.

Occurrence.--Abundant in collections UU-408 and UU-420. Rare in collections UU-409 and UU-463.

Genus PTARMIGANOIDES Rasetti, 1951

Ptarmiganoides RASETTI, 1951, p. 178; POULSEN in Harrington and others, 1959, p. 226.

Type species.--Ptarmiganoides bowensis RASETTI, 1951, p. 179, Pl. 20, figs. 1-8.

Discussion.--The diagnosis by Rasetti (1951, p. 178) is adequate and is followed here. Rasetti (1951, p. 178) proposed the genus Ptarmiganoides for the species from the Naomi Peak Tongue of the Twin Knobs Formation that Resser (1939b) assigned to Dolichometopsis, and included a new species from the Cathedral Formation, at Bow Lake, in the Canadian Rocky Mountains. Ptarmiganoides differs from Ptarmigania primarily by having three or more pairs of well-developed pygidial border spines. Ptarmigania typically has one pair of anterolateral border spines and nubs of one or two additional spines. The cranidia of both genera, as Resser himself states are generally indistinguishable; nor can they be separated from cranidia of Paralbertella and certain other long-eyed corynexochids without knowledge of the associated pygidia.

Resser (1939b) has caused a great deal of confusion by excessive splitting of species and inadequate evaluation of their morphology. Palmer (in press) has re-evaluated Resser's species and states:

> Instead of twenty-one species assigned to two genera, there are now considered to be three species of three genera. The three species are: Poliella germana (Resser) already revised by Fritz (1968); Ptarmiganoides propinqua (Resser) chosen from eleven names because its "type" lot contains the most representative specimens for the species; and Ptarmigania exigua Resser. P. germana has smooth or pitted ornamentation, lacks fixigenal spines and has a pygidium that lacks border spines; P. propinqua has a weakly granular ornamentation and four pairs of

slender pygidial spines; and P. exigua has a well-developed granular ornamentation and only one pair of short pygidial spines and several nubs of additional spines.

Fritz (1968, p. 207) also notes that not all paratypes of Resser's "species" were conspecific with their holotypes.

PTARMIGANOIDES PROPINQUA (Resser)

Pl. 8, figs. 10-12, 14, 16, 17, 19, 20

Dolichometopsis propinqua RESSER, 1939b, p. 34, Pl. 5, figs. 11-13.

Dolichometopsis comis RESSER, 1939b, p. 33, Pl. 4, figs. 22-24.

Dolichometopsis communis RESSER, 1939b, p. 35, Pl. 6, figs. 5-8.

Dolichometopsis gregalis RESSER, 1939b, p. 34-35, Pl. 6, figs. 1-4.

Dolichometopsis lepida RESSER, 1939b, p. 31, Pl. 3, figs. 31-33.

Dolichometopsis mansfieldi RESSERM 1939b, p. 36, Pl. 6, figs. 11-16.

Dolichometopsis media RESSER, 1939b, p. 32, Pl. 4, figs. 11-12.

Dolichometopsis poulseni RESSER, 1939b, p. 33-34, Pl. 5, figs. 1-10.

Dolichometopsis stella RESSER, 1939b, p. 32, Pl. 3, fig. 37.

Ptarmiganoides sobrina RESSER, 1939b, p. 40, Pl. 17, figs. 12-15.

Ptarmiganoides aurita RESSER, 1939b, p. 37-38, Pl. 3, figs. 35-36.

Diagnosis.--Cranidium moderately convex, subquadrate, length nearly equal to width. Glabella prominent, elongate, slightly expanded, bluntly rounded anteriorly, nearly extends to anterior margin of cranidium. Four pairs of glabellar furrows faintly to moderately well defined: S1 convex, oblique backwards; S2 straight, oblique backwards; S3 transverse; S4 oblique forwards. Axial furrow narrow, relatively deep, shallow fossulae present. Occipital furrow wide (sag.) shallow, deepens slightly laterally. Occipital ring 0.20 to 0.25 glabellar length, triangular, extended into a strong posteriorly directed

occipital spine. Frontal area about 0.05 glabellar length medially. Border narrow medially, becomes wider laterally, slightly upturned. Border furrow shallow, becomes indistinct medially. Fixigenae 0.40 to 0.50 glabellar width at eye line, moderately convex, slightly upsloping to nearly horizontal. Palpebral lobes prominent, situated below level of palpebral area of fixigenae, 0.40 to 0.50 glabellar length. Eye ridges distinct, short, meet axial furrow just in front of S3. Posterior area of fixigenae slightly narrower (tr.) than glabella at occipital furrow, distal extremeties extended into long, thin, posteriorly directed spines. Preocular facial suture divergent, convex. Postocular facial suture divergent, sinuous.

Librigenae moderately convex, lateral margin broadly rounded. Genal field slightly convex, downsloping. Border wide, slightly downsloping. Border furrow shallow. Genal spine broad based, long, evenly tapered, directed posteriorly.

Pygidium large, highly convex, length about 0.65 width. Axis prominent, highly convex, slightly tapered, consists of three distinct rings, a faint fourth ring on larger specimens, a terminal piece, and a low postaxial ridge that reaches posterior margin. First axial ring bears a strong upright spine, second and third rings have low elongate (tr.) nodes. Pleural regions moderately convex, downsloping, crossed by three pleural furrows which end in deep pits on border. Interpleural furrows indistinct. Border prominent, horizontal margin extended into four pairs of strong, cyclindrical spines. Spines of about equal strength may become slightly stronger posteriorly.

Surface of cranidium, librigenae, and pygidia weakly granular. Granules are more prominent on higher parts of the exoskeleton.

Discussion.--In the above synonomy are included 11 of Resser's species that I believe have been based upon inadequate morphological evaluation, slight intraspecific variation, and artificial mixing of parts. P. propinqua is distinguished by its weakly granular ornamentation and four pairs of slender pygidial spines.

Occurrence.--Abundant in collection UU-408. Rare in collection UU-420.

PTARMIGANOIDES STOKESI n. sp.

Pl. 9, figs. 1-8

Diagnosis.--Cranidium subrectangular, moderately convex. Glabella prominent, expands moderately forward, extends to anterior margin of cranidium. Four pairs of glabellar furrows: S1 deeply impressed, straight, oblique backwards; S2 convex, oblique backwards; S3 transverse; S4 indistinct, oblique forwards. Axial furrow distinct, deepens to form prominent elongate fossulae. Occipital furrow shallow, composite, deepens laterally. Occipital ring about 0.20 glabellar length, bears faint elongate (sag.) node. Fixigenae less than 0.40 glabellar width at eye line, slightly convex, slightly downsloping. Palpebral lobes prominent, about 0.35 glabellar length, anterior ends opposite S3. Palpebral lobes situated well behind glabellar midpoint. Palpebral furrows distinct. Eye ridges strong, short, meet axial furrow slightly in front of S3. Posterior area of fixigenae about same width as glabella at occipital furrow, lacks spines. Preocular facial suture divergent, convex. Postocular facial suture divergent, slightly convex.

One incomplete specimen has six poorly preserved thoracic segments associated with a pygidium. Axial lobe of thorax distinctly narrower

than pleural lobes. Posterior part of each ring is broken off, and may have had a node or spine. Pleurae are not extended into spines.

Pygidium semielliptical, moderately convex. Axis consists of three rings and long terminal piece; reaches inner edge of border. Anterior ring bears distinct node. Pleural fields crossed by four pleural furrows and three less-distinct interpleural furrows; fourth pleural and third interpleural furrows faint. Border moderately well defined, has four pairs of relatively short, broad-based, flat spines; two anterior pairs of spines directed posterolaterally; third pair directed posteriorly; posterior pair widely spaced, directed posteriorly or slightly inward.

Surface of cranidium smooth, pygidium covered with fine anastomosing caecae that are most prominent on the posterior pleural fields.

Discussion.--P. stokesi is quite distinct from other species of Ptarmiganoides. The cranidium is characterized by well-developed S1 lateral glabellar furrows and a moderately expanded, large glabella. The pygidium has a node rather than a strong axial spine on the first axial ring, and the border spines are triangular and short rather than long and slender as in other species of Ptarmiganoides. This species is referred to Ptarmiganoides rather than Ptarmigania because pygidia typical of Ptarmigania have one pair of anterolateral border spines and only nubs of one or two additional pairs, whereas the pygidium in question has four pairs of equally developed, but short spines.

Occurrence.--Common in collection UU-420. Rare in collection UU-419.

Holotype.--Pygidium and associated thoracic segments (1408) illustrated on plate 9, fig. 12.

Family DORYPYGIDAE Kobayashi, 1935

Genus DORYPYGE Dames, 1883

Dorypyge DAMES, 1883, p. 23; MATTHEW, 1897, p. 186; GRONWALL, 1902, p. 126; WALCOTT, 1913, p. 107; KOBAYASHI, 1935, p. 145; LAKE, 1938, p. 250; LERMONTOVA, 1940, p. 141; RESSER, 1942, p. 15; WHITEHOUSE, 1945, p. 118; POULSEN, 1959, p. 217; PALMER, 1968, p. 47.

Type species.--Dorypyge richtofeni DAMES, 1883, p. 24, Pl. 1, figs. 1-6.

Discussion.--The concept of the widespread Middle Cambrian genus Dorypyge given by Poulsen (1959, p. 217) generally is adequate. It need be modified only slightly to include four-spined specimens discovered in Alaska and Siberia since 1959.

DORYPYGE WELLSVILLENSIS n. sp.

Pl. 9, figs. 9, 10, 12, 13

Diagnosis.--Cranidium subtrapezoidal, broadly rounded anteriorly, slightly wider than long. Glabella prominent, convex, very slightly expanded anteriorly, straight-sided, rounded anteriorly, nearly reaches anterior margin of cranidium. Four pairs of very faint glabellar furrows visible: S1 bifurcate, oblique backwards; S2 oblique backwards; S3 transverse; S4 oblique forwards. Axial furrow relatively wide, deep, faint fossulae present. Occipital furrow composite, deep. Occipital ring about 0.20 glabellar length, probably bears a median node or spine. Frontal area about 0.10 glabellar length. Border slightly thickened, upturned, narrow medially, widens laterally. Border furrow well developed laterally, narrows medially. Fixigenae about 0.40

glabellar width at eye line, moderately convex, slightly downsloping. Palpebral lobes about 0.25 glabellar length, nearly horizontal, situated behind midline of glabella. Eye ridges faint, meet axial furrow opposite fossulae. Posterior area of fixigenae relatively long (sag.) about same width as glabella at occipital ring. Preocular facial suture slightly divergent, straight. Postocular facial suture divergent, sinuous.

Thorax has seven segments. Axis wider than pleural regions. Each axial segment extended into prominent spine. Each pleural segment ends distally in a sharp recovered spine.

Pygidium semielliptical. Axis well defined, strongly convex, reaches to inner edge of border; has four rings and short terminal piece. Fourth ring poorly defined except on exfoliated specimens. Pleural field moderately convex and has four shallow pleural furrows. Anterior pleural furrow deepest, and three posterior furrows end in depressions on border. Three interpleural furrows weak and become less distinct toward posterior. Border narrows anteriorly, widens posteriorly, extended into five pairs of spines. Three anterior pairs of border spines short, sharply pointed, directed posteriorly, and increase slightly in size toward posterior. Fourth pair of spines stout, as long as pygidium, bent upward, bowed slightly inward. Posterior pair of spines vary from incipient nubs to small triangular spines.

Surface of exoskeleton faintly granulose. Anterior border of cranidium has fine terrace lines. Pygidial border spines are covered with elongate granules.

Discussion.--Pygidia of most species of Dorypyge have at least five pairs of border spines, and generally the fifth pair is consider-

ably enlarged. However, four species, (D. bispinosa Walcott, 1905; D. danica Gronwall, 1902; D. grandispinosa Resser and Endo, 1937; and D. olenekensis Lazarenko, 1960) have the fourth pair of spines enlarged. D. bispinosa and D. danica also have the fifth pair of spines enlarged, and D. olenekensis has only four pairs of spines. D. wellsvillensis, n. sp., and D. grandispinosa have a short fifth pair of spines. D. wellsvillensis differs from D. grandispinosa by having a more posteriorly situated and less divergent fourth pair of spines. It also differs by having less divergent and apparently smaller anterior pairs of spines.

Occurrence.--Rare in collections UU-432, UU-434, UU-435, and UU-465.

Holotype.--Pygidium (1407) illustrated on plate 9, figs. 10 and 13.

Genus KOOTENIA Walcott, 1918

Bathyuriscus (Kootenia) WALCOTT, 1889, p. 446.

Kootenia WALCOTT, 1918, p. 131, 132; PALMER, 1968, p. 47 (synonomy to date).

Type species.--Bathyuriscus (Kootenia) dawsoni WALCOTT, 1889, p. 446.

Discussion.--The concept of Kootenia given by Palmer (1968, p. 47) generally is adequate. It need be modified only slightly to include species that have up to seven pleural furrows and eight pairs of spines.

Kootenia is characterized by a pygidium that has a spinose margin and lacks well-defined interpleural furrows. The genus is widespread and has approximately 100 species, some of which may be synonyms. Development and number of pygidial spines is most often used as a

differentiating character between species of this genus, At many localities, two or more strikingly different species of Kootenia are associated, which led Palmer (1968, p. 48) to propose that pygidial spine development may be particularly susceptible to minor ecologic differences.

KOOTENIA ARCUATA n. sp.

Pl. 9, figs. 11, 14-19

Diagnosis.--Cranidium convex, nearly as long as wide. Glabella prominent, convex, subparallel to slightly convex along sides, narrows distinctly at fossulae, rounded anteriorly. One or two sets of faint glabellar furrows visible: S1 oblique backwards; S2 indistinct. Axial furrow deep, strong fossulae present. Occipital furrow strong, wide. Occipital ring triangular, upsloping, about 0.15 glabellar length, extended into a posteriorly directed spine. Border indistinct medially, prominent laterally. Border furrow nearly absent medially. Fixigenae about 0.35 glabellar width at eye line, convex, moderately to strongly downsloping. Palpebral lobes centered well posterior to glabellar midpoint, about 0.25 glabellar width, defined by a shallow palpebral furrow. Eye ridge faint, meets axial furrow at fossulae. Posterior area of fixigenae about 0.70 width of glabella at occipital furrow. Preocular facial suture convergent, convex. Postocular facial suture divergent, sinuous.

Pygidium moderately convex, length about 0.60 width. Axis prominent, consists of three distinct rings, a faint fourth ring, a terminal piece, and a short postaxial ridge that reaches posterior margin. Pleural field crossed by four pleural and three less distinct inter-

pleural furrows. Border moderately well defined, downsloping, bears five pairs of relatively short tapered spines that produce swelling on the border. Spines decrease in size posteriorly and slope downward.

Both cranidium and pygidium are granular and punctae although strength of ornamentation varies considerably between individuals. Anterior border of cranidium has terrace lines, and pygidial spines have scaly granulations.

Discussion.--This species most closely resembles K. crassinucha Fritz (1968, p. 198-199). K. arcuata differs from K. crassinucha in having a more convex cranidium both longitudinally and transversely, a more prominent construction of the glabella at the fossulae, and a narrower anterior border medially. The pygidia differ in having four rather than three axial rings, and in having pygidial spines that do not extend into thin points. K. arcuata has granules and punctae whereas K. crassinucha only has fine scattered punctae. K. convoluta Resser (1939b), the only other five-spined Kootenia in my collections, differs from K. arcuata by having a glabella that is more rectangular in outline and shorter, less rapidly tapering pygidial spines. The spines of K. convoluta do not produce a swelling on the border of the pygidium.

Occurrence.--Abundant in collections UU-408, UU-419, and UU-420. Common in collections UU-422, UU-423, and UU-463.

Holotype.--Pygidium (1411) illustrated on plate 9, figs. 15 and 18.

KOOTENIA BREVISPINA Resser

Pl. 8, figs. 15, 18, 21

Kootenia brevispina RESSER, 1939b, p. 50, Pl. 11, figs. 1-4; FRITZ, 1968, p. 196, Pl. 40, figs. 1-6.

Discussion.--Fritz (1968, p. 196) adequately described this species.

Kootenia brevispina most closely resembles K. pectinoides. Resser assigned K. pectinoides to the K. serrata group, which has six pairs of spines on the pygidium, but he then referred to it as having five pairs of marginal spines. Although only five pairs of spines are visible on the holotype (Resser, 1939a, Pl. 9, figs. 12, 13) it is evident from the illustration that the individual had six pairs of spines--the anterior pair not being visible. The only difference between the two species seems to be in the spines, which on K. pectinoides are closer together. If adequate material were available for comparison, it is probable that K. brevispina could be suppressed as a junior synonym of K. pectinoides.

Occurrence.--Rare; two pygidia from collection UU-408.

KOOTENIA CONVOLUTA Resser

Pl. 10, figs. 1-3, 5, 6, 9, 10

Kootenia convoluta RESSER, 1939b, p. 46, Pl. 10, figs. 1-11: FRITZ, 1968, p. 197, Pl. 41, figs. 17-24 (synonomy to date).

Discussion.--The diagnosis of Fritz (1968, p. 197) is adequate and is followed here. Fritz (1968, p. 197) placed Kootenia maladensis, Kootenia granulosa, and Kootenia nitida into synonomy with Kootenia convoluta. Resser based these species, from a single locality, upon slight variations between individuals which can be attributed to intraspecific variation and differences in preservation. I therefore agree with Fritz.

Occurrence.--Abundant in collection UU-408, and rare to common in collections UU-409 and UU-410.

KOOTENIA GERMANA Resser

Pl. 10, figs. 4, 7, 8, 11

Kootenia germana RESSER, 1939b, p. 49, Pl. 9, figs. 19-24.

Diagnosis.--Cranidium moderately convex, slightly wider than long. Glabella prominent, parallel-sided, front broadly rounded. Four pairs of indistinct glabellar furrows visible on well preserved individuals: S1 and S2 oblique backwards; S3 transverse; S4 oblique forwards. Axial furrow prominent, shallow fossulae present. Occipital furrow moderately deep, composite, deepens laterally. Occipital ring triangular, about 0.20 glabellar length, extended into a prominent spine. Frontal area indistinct. Border narrow medially, more pronounced laterally. Border furrow faint. Fixigenae about 0.50 glabellar width at eye line, moderately convex, downsloping. Palpebral lobes 0.35 glabellar length, horizontal, situated well behind midline of glabella. Palpebral furrows faint. Eye ridges visible, faint, meet axial furrow at fossulae. Posterior area of fixigenae narrower than glabella at occipital furrow. Preocular facial suture divergent, straight. Postocular facial suture divergent, convex.

Pygidium semielliptical, slightly convex. Axis prominent, relatively narrow, consists of three distinct rings, a faint fourth ring, a terminal piece, and a faint postaxial ridge that reaches posterior margin of pygidium. Pleural regions downsloping, crossed by four pleural and three less distinct interpleural furrows. Border extended into six pairs of relatively short, tapered spines. Spines are directed posterolaterally and slightly downward.

Surface of test covered with fine granules. Glabella has fine fingerprint pattern of lines. Surface of anterior border marked by

terrace lines. Border spines of pygidium covered with scaly granules.

Discussion.--The pygidia of this species in my collections are nearly identical to the holotype pygidium and are from approximately the same locality. The cranidia, however, differ significantly from the cranidia Resser assigned to K. germana. Pygidia and cranidia in my collections have a distinctive granular ornamentation and misassignment is unlikely. Cranidia which more closely resemble those Resser assigned to K. germana do occur with the K. germana pygidia, but these are smooth and have been assigned to K. spencei with certainty. Therefore I believe that the cranidia that Resser assigned to K. germana do not actually belong to that species. However, examination of the type material would be necessary to prove this interpretation.

Occurrence.--Abundant in collection UU-462. Common in collections UU-442 and UU-443. Rare in collections UU-440 and UU-441.

KOOTENIA MELINDENSIS n. sp.

Pl. 10, figs. 15, 16

Diagnosis.--Pygidium moderately convex, slightly wider than long. Axis well defined, reaches to inner edge of border, consists of six rings and a moderately long terminal piece. Anterior ring not completely ankylosed. Pleural field broadly convex, marked by seven pairs of pleural furrows and six pairs of interpleural furrows. Posterior pair of pleural furrows indistinct. Second through sixth pleural furrows end in depression on border. Border gives rise to eight pairs of round, slightly upturned spines. Anterior seven pairs of spines long, about equal in length. Eighth pair greatly reduced. Surface is smooth.

Discussion.--Only one pygidium of this species has been found. It is distinguishable from all other species of Kootenia by having

eight pairs of border spines.

Occurrence.--Rare in collection UU-465.

Holotype.--Pygidium (1422) illustrated on plate 10, figs. 15 and 16.

KOOTENIA MENDOSA Resser

Pl. 10, figs. 18-20, 22, 23

Kootenia mendosa RESSER, 1939b, p. 49.

Diagnosis.--Cranidium moderately convex transversely and longitudinally. Glabella long, well defined, moderately broad, unfurrowed, tapered anteriorly. Glabella extends onto border and nearly to cranidial margin. Fossulae produce distinct indentation on side of glabella. Occipital furrow moderately deep and broad, straight. Occipital ring has short medial spine. Fixigenae slightly convex, downsloping, width about 0.35 glabellar width at eye line. Palpebral lobe depressed below surface of fixigenae, length about 0.20 sagittal length of glabella, exclusive of occipital ring. Glabellar surface finely punctate, exfoliated specimens show fine granules, rest of cranidium smooth. Preocular margins convergent, straight. Postocular margins divergent, sinuous.

Thorax has seven segments that terminate in small, slender, posterolaterally directed spines. Node or small spine on each axial ring. Pleural regions about twice width of axis.

Pygidium semielliptical. Axis well defined, convex, reaches to inner edge of border, four rings and a terminal piece evident. Pleural fields crossed by four pleural furrows and two indistinct interpleural furrows. Border narrow, has six pairs of spines. Anterior two pairs of spines short, sharp, directed posteriorly, second pair smaller

than first. Remaining pairs greatly reduced, imparting a slight waviness to the border, becoming smooth in the rear.

Surface smooth.

Discussion.--The outstanding character of Kootenia mendosa is the reduction in size of the marginal spines, and it can be distinguished from all other species on this basis.

Occurrence.--Abundant in collection UU-459. Rare in collection UU-443, UU-444, and UU-445.

KOOTENIA SPENCEI Resser

Pl. 11, figs. 1-6

Kootenia spencei RESSER, 1939a, p. 15, Pl. 3, figs. 4, 5.

Kootenia mathewsi RESSER, 1939a, p. 16, Pl. 3, figs. 6, 7.

Diagnosis.--Cranidium convex, width about equal to length, broadly rounded anteriorly. Glabella prominent, sides slightly convex, tapered, rounded anteriorly. Four pairs of faint glabellar furrows visible on well preserved individuals: S1 oblique backwards; S2 transverse; S3 indistinct, pit-like; S4 oblique forwards. Axial furrow well developed, distinct fossulae present. Occipital furrow moderately deep, composite, deepens laterally. Occipital ring less than 0.20 glabellar length, triangular, bears a prominent spine. Frontal area short. Border distinct, slightly upturned. Border furrow well developed. Fixigenae about 0.40 glabellar width at eye line, slightly convex, slightly downsloping. Palpebral lobes fairly prominent, horizontal, about 0.25 glabellar length, situated well behind glabellar midpoint. Eye ridges visible, faint, meet axial furrow at fossulae. Posterior area of fixigenae about same width as glabella at occipital furrow. Preocular facial suture divergent, convex. Postocular facial

suture divergent, sinuous.

Thorax has seven segments. Axial lobe slightly narrower than pleural lobes. Distal extremeties of pleural segments extended into long, posterolaterally directed spines.

Pygidium semielliptical, distinctly wider than long. Axis prominent, rather narrow, consists of five distinct rings and a terminal piece that reaches posterior border. Pleural fields downsloping, crossed by five pairs of distinct pleural and four pairs of faint interpleural furrows. Border moderately well defined, pleural furrows end in pits on border. Border extended into seven pairs of long, cylindrical spines. Seventh pair of spines shorter and more slender than other pairs.

Surface smooth.

Discussion.--This species is characterized by having a prominent, convex-sided, broadly rounded glabella; a pygidium with seven long, slender pairs of border spines and a smooth surface.

Resser (1939a) differentiated K. spencei from K. mathewsi on slight variation in the spread and curvature of the border spines. The two pygidia that Resser assigned to K. spencei had medial furrows on the border spines caused by compaction, which Resser also regarded as a specific difference between the two species.

Occurrence.--Abundant in collections UU-432, UU-434, UU-439 and UU-465. Common in collections UU-435 and UU-437. Rare in collections UU-429, UU-430, and UU-462.

KOOTENIA WELLSVILLENSIS n. sp.

Pl. 10, figs. 12-14, 17, 21, 24

Diagnosis.--Cranidium moderately convex, slightly wider than long.

Glabella prominent, nearly extends to anterior margin of cranidium. Glabella parallel-sided, indented at fossulae, rounded anteriorly. Glabellar furrows indistinct, fossulae shallow, S1 visible, oblique backwards. Axial furrow distinct. Occipital furrow moderately deep, composite, deepens laterally. Occipital ring triangular, less than 0.20 glabellar length, bears a strong spine. Frontal area indistinct medially. Border faint medially, distinct laterally. Border furrow obsolete medially. Fixigenae 0.35 glabellar width, horizontal, situated behind midline of glabella. Eye ridges faint, intersect axial furrow at fossulae. Posterior limbs narrower than glabella at occipital ring. Preocular facial suture slightly divergent, straight. Postocular facial suture divergent, sinuous.

Pygidium semielliptical, moderately convex, distinctly wider than long. Axis prominent, relatively narrow, consists of three distinct rings, a variably developed fourth ring, a terminal piece, and a short postaxial ridge that nearly reaches posterior margin of pygidium. Pleural fields downsloping, crossed by four pleural and three faint interpleural furrows. Border distinct, horizontal, extended into six pairs of moderately short, relatively slender, tapered spines.

Surface of cranidium indistinctly punctate or smooth. Border has faint terrace lines. Pygidium smooth, border spines have faint scaly granulations.

Discussion.--K. wellsvillensis most closely resemble K. germana but averages larger in size and has a rounded rather than distinctly quadrate glabella. The pygidial border spines of K. germana are larger and stouter and the axis averages narrower. In addition, K. germana has well developed granular ornamentation on the cranidium and pygidium.

K. wellsvillensis differs from K. libertyensis in having shorter pygidial border spines and lacking irregular elongate granulations. It differs from K. brevispina in having slender rather than broad triangular border spines and has much shorter border spines than K. acicularis.

Occurrence.--Abundant in collections UU-447, UU-452, and UU-454. Common in collections UU-451 and UU-453. Rare in collections UU-448, UU-449, and UU-450.

Holotype.--Pygidium (1419) illustrated on plate 10, figures 12 and 21.

KOOTENIA sp. undet.

Pl. 11, figs. 7, 8

Diagnosis.--Pygidium semielliptical, distinctly wider than long, strongly convex. Axis prominent, convex, extends onto posterior border, consists of three rings, an indistinct fourth ring, and a terminal piece. Axial furrow distinct. Pleural regions strongly downsloping, crossed by four pleural and three indistinct interpleural furrows. Border extended into six pairs of moderately long spines. Spines decrease in length posteriorly.

Surface of axis and pleural regions covered with fine punctae. Border covered with fine granules. Spine covered with scaly granulations.

Discussion.--This species is represented by one fragmentary pygidium. It differs from all other species of Kootenia from the Naomi Peak Tongue of the Twin Knobs Formation, and the Spence Tongue of the Lead Bell Shale in having six moderately long marginal spines, a large prominent axis with four rings and a terminal piece and punctate ornamentation. Kootenia brevispina most closely resembles this species but

differs most notably in the length and taper of the border spines.

Occurrence.--One pygidium in collection UU-410.

Genus OGYGOPSIS Walcott, 1889

Ogygopsis WALCOTT, 1889, p. 466; 1916a, p. 375; RAYMOND, 1912, p. 116; SHIMER and SHROCK, 1944, p. 613; RASETTI, 1951, p. 190; 1959, p. 219; PALMER, 1964, p. 6.

Taxicura RESSER, 1939b, p. 62; SHIMER and SHROCK, 1944, p. 617.

Type species.--Ogygia klotzi ROMINGER, 1887, p. 12, Pl. 1, fig. 1.

Discussion.--The generic description given by Palmer (1964, p. 6) is adequate and is followed here. This genus is characterized by a large pygidium having a narrow axis and border, and well defined ring and pleural furrows. The cranidium is distinguishable by having a prominent subparallel-sided glabella that nearly reaches the anterior margin. I agree with Rasetti (1959, p. 219) who concluded that Taxioura (Resser, 1939b, p. 62) should be suppressed as a subjective synonym of Ogygopsis.

OGYGOPSIS TYPICALIS (Resser)

Pl. 11, figs. 9-14, 17, 18

Taxioura typicalis RESSER, 1939b, p. 62, Pl. 14, figs. 6-14.

Taxioura magna RESSER (part) 1939b, p. 63, Pl. 14, figs. 1-2 (not figs. 3-5).

Ogygopsis typicalis (Resser) RASETTI, 1951, p. 191; PALMER, 1964, p. 6-7.

Diagnosis.--Cephalon semicircular in outline, moderately convex. Glabella long, large, reaches to border, rounded in front. Sides subparallel, tapering slightly both anteriorly and posteriorly. Glabellar furrows not apparent. Occipital furrow well defined, occipital

ring lacks spine or node. Frontal area short; border narrow, poorly defined by a change in slope. Fixigenae average a little more than 0.33 width of the glabella. Eye ridges well defined, palpebral lobes gently arcuate, nearly 0.33 length of the glabella. Preocular facial sutures slightly divergent, straight. Postocular facial sutures divergent, sinuous. Lateral border of librigenae moderately defined by shallow border furrow, border narrower than ocular platform. Genal spines moderately short; length about equal to length of posterior section of facial suture. Surface ornamentation consists of fine "fingerprint" pattern of terrace lines on glabella, and anastomosing close-spaced terrace lines on other parts of the cranidium and fixigenae.

Thorax has eight segments; tips of each segment have short, slender, posterolaterally directed spines. Width of pleural regions about twice width of axis. Axial rings lack nodes or spines, but are covered with fine meshwork of irregular lines.

Pygidium semicircular. Axis well defined, narrow, and reaches to posterior margin. Axis has eight to ten rings and a terminal piece which extends into postaxial ridge. Pleural regions broad, gently convex, crossed by seven or eight pleural furrows, seven anterior furrows are moderately deep; eighth, when present, is poorly defined. Margin on well preserved individuals has three to four small spines opposite and slightly posterior to adjacent pleural furrows. First pair of spines is small and recurved; posterior pairs are greatly reduced and impart slight waviness to margin, which becomes smooth towards posterior. A well developed medial notch indents the posterior margin. Terrace lines form fine meshwork of irregular polygons.

Discussion.--Both Resser (1939b, p. 62) and Palmer (1964, p. 6-7)

state that O. typicalis has only one pair of anterolateral spines. However, upon close examination, up to three additional pairs of marginal irregularities or incipient spines are evident. O. typicalis can be distinguished from other species of Ogygopsis in that it only has one pair of well developed pygidial border spines, and has distinctive ornamentation.

An intriguing aspect of the stratigraphic distribution of Ogygopsis is its sporadic vertical occurrence (Nelson, 1963). The genus extends from the Lower Cambrian through half of the Middle Cambrian, but its vertical occurrence generally is sporadic. In the sections visited during this study, O. typicalis is usually very abundant and in certain areas the disarticulated shields often comprise most of the rock. However, the vertical occurrence is restricted to the top foot of the Naomi Peak Limestone and to the lower few feet of the Spence Shale. A possible explanation for the sporadic vertical occurrence of Ogygopsis is facies control. It often has been noted that the number of individuals, as well as number of species is high at interfaces between two types of habitats. In this case it seems that O. typicalis was restricted to, and thrived in a zone between carbonate shoals and an adjacent seaward basin.

Occurrence.--Common to abundant in collections UU-411, UU-412, and UU-425.

Genus OLENOIDES Meek, 1877

Olenoides MEEK, 1877, p. 25; ROBISON, 1964, p. 537 (synonomy to date).

Type species.--Paradoxides? maladensis MEEK, 1870, p. 62.

Discussion.--The diagnosis of Robison (1964, p. 537) is followed here. Walcott (1925, p. 92) and Palmer (1954, p. 62) have pointed out

that cranidia of Neolenus (Olenoides), Kootenia, Holtena, and Prypyge, in the absence of distinctive pygidia, could well be retained in one genus. The generic and specific characteristics are almost entirely in the pygidia and few cranidia show even specific characters.

OLENOIDES EVANSI Resser

Pl. 11, figs. 15, 16, 19

Olenoides evansi RESSER, 1939b, p. 15, Pl. 4, fig. 4; not fig. 3.

Diagnosis.--Cranidium subtrapezoidal, original convexity unknown because of compaction, glabella prominent, reaches anterior border, expands slightly anteriorly. Lateral glabellar furrows indistinct. Occipital furrow distinct and moderately wide; occipital ring bears small medial spine. Axial furrow well impressed, distinct fossulae present in axial furrows at junction with eye ridge. Anterior border narrow. Fixigenae about 0.30 width of glabella at eye line. Palpebral lobes small, about 0.20 length of glabella; situated opposite middle of glabella. Eye ridges distinct. Posterior limbs moderately long (tr.), wide (exsag.); posterior border furrow wide and shallow. Preocular facial sutures appear to be slightly divergent. Postocular facial suture, divergent, sinuous.

Librigenae, associated with holotype, have wide lateral border and long genal spine.

Number of thoracic segments unknown. Axis of thorax about same width as pleural regions. Axial rings bear small median spine or node, and pleurae are falcate.

Pygidium subelliptical, elongate. Axis slightly tapered, has five or six rings and terminal piece that reaches inner edge of border. Pleural field crossed by six or seven pleural, and five or six less

distinct interpleural furrows. Each pleural furrow ends in small depression on border. Border narrow and has eight pairs of nearly horizontal recurved spines. Anterior seven pairs of spines relatively long, evenly spaced, and directed posterolaterally; eighth pair smaller and directed posteriorly.

Discussion.--Resser (1939b, p. 15) incorrectly stated that Olenoides evansi had seven pairs of pygidial border spines. Careful examination of the paratype pygidia revealed an eighth pair of small spines, which because of poor preservation are easily overlooked. This species differs from all other species of Olenoides by having eight pairs of marginal spines.

Occurrence.--Spence Shale, USNM locality 55e, 4.5 miles north of Brigham City on west side of Wellsville Mountain, Utah.

OLENOIDES MALADENSIS Resser

Pl. 12, figs. 1-6, 8

Olenoides maladensis RESSER, 1939b, p. 46, Pl. 10, figs. 27, 28.

Taxioura magna (part) RESSER, 1939b, p. 63, Pl. 14, figs. 3-5 (not figs. 1, 2).

Diagnosis.--Cranidium large, moderately convex, subquadrate. Glabella prominent, nearly extends to anterior margin of cranidium, nearly parallel-sided except for construction at fossulae, broadly rounded anteriorly. Three pairs of glabellar furrows visible: S1 bifurcate, oblique backwards; S2 convex, oblique backwards; S3 transverse. Axial furrow narrow, distinct, fossulae present. Occipital furrow broad, composite; shallow medially; deepens laterally. Occipital ring about 0.15 glabellar length, extended into short, blunt, posteriorly directed spine. Frontal area short (sag.) medially,

consisting essentially of a narrow upturned border. Border becomes wider (exsag.) laterally. Border furrow distinct laterally. Fixigenae about 0.40 glabellar width at eye line, slightly concave, slightly downsloping. Palpebral lobes moderately prominent, slightly upturned, 0.20 to 0.25 glabellar length, situated behind midpoint of glabella. Eye ridges strong, nearly straight, make a relatively small angle with axial furrow. Posterior area of fixigenae long (exsag.) about same width (tr.) as glabella at occipital furrow, distal end extends into small posterolaterally directed spine. Preocular facial suture divergent, straight. Postocular facial suture divergent, sinuous.

Genal field of librigenae steeply sloping. Border prominent, slightly thickened, horizontal. Genal spine strong, length unknown.

Pygidium semicircular, slightly convex, nearly twice as wide as long. Axis stout, well defined, consists of four distinct rings, a faint fifth ring, and a short terminal piece. Each ring bears a small median node. Pleural field slightly convex, crossed by four strong pleural and three moderately strong interpleural furrows that extend onto border. Border distinct, horizontal. Border extended into four pairs of long, slightly tapered spines. Spines situated opposite distal ends of pleural furrows.

Surface of test covered with small and medium-sized granules.

Discussion.--Resser (1939b, p. 46) did not assign cranidia to this species but Palmer (1954, p. 6-7) has correctly suggested that a cranidia figured by Resser (1939b, p. 63, Pl. 14, fig. 3) as his holotype for Taxioura magna actually belongs to O. maladensis.

O. maladensis most closely resembles O. steptoenis Fritz (1968, p. 199-200). Fritz has adequately described the similarities and

differences between the two species.

Occurrence.--Common in collection UU-408. Rare in collections UU-419, UU-420, and UU-421.

OLENOIDES SPENCEI n. sp.

Pl. 12, figs. 9, 12

Diagnosis.--Pygidium semicircular, distinctively wider than long, original convexity unknown. Axis rather strongly tapered, shows four rings and a moderately long terminal piece that nearly reaches inner edge of border. Pleural fields crossed by four pleural and four less distinct interpleural furrows. Posteriorly, the furrows make progressively larger angles. Border narrow; five pairs of moderately long, slightly tapered marginal spines present. Posteriorly, spines make progressively smaller angles with the midline of the pygidium. Posterior pair of spines directed backward or backward and slightly towards the midline. All specimens are exfoliated, inner surface covered with medium-sized granules. Pygidia range from 19 to 23 mm in length and 31 to 38 mm in width.

Discussion.--This species most closely resembles Olenoides serratus (Rominger), which also has five marginal spines. Olenoides spencei differs from O. serratus by lacking well developed nodes on the axial rings, by having one less axial ring and a much longer terminal piece, and having a granular test.

Occurrence.--Three pygidia in collection UU-425.

Holotype.--Pygidium (1442) illustrated on plate 12, figure 12.

OLENOIDES sp.

Pl. 12, figs. 7, 10, 11

Diagnosis.--Pygidium semielliptical, distinctly wider than long. Axis moderately convex, slightly tapered, consists of five rings and terminal piece, which reaches inner edge of border. Ring furrows become progressively fainter posteriorly. Pleural fields crossed by five pleural and four interpleural furrows, pleural furrows end in slight depressions on border. Border narrow, extended into seven pairs of marginal spines. First six pairs of spines long, slightly tapered; posterior pair short and slender. Base of spines covered with faint scaly granulations, remainder of pygidium smooth.

Discussion.--This species is represented by a single small pygidium that cannot be assigned to any known species with certainty. Olenoides evansi Resser is the only previously reported species of Olenoides from the Spence Shale with seven pairs of spines, but examination of paratypes of Olenoides evansi shows that it actually has eight pairs of spines (see discussion of that species).

It is possible that this pygidium represents an immature Olenoides evansi but without additional material it is impossible to be certain.

Occurrence.--One pygidium in collection UU-465.

Family ORYCTOCEPHALIDAE Beecher, 1897

Genus ORYCTOCARA Walcott, 1908

Oryctocara WALCOTT, 1908d, p. 23; SHIMER and SHROCK, 1944, p. 613; LERMONTOVA, 1940, p. 137; RASETTI, 1959, p. 220; CHERNYSHEVA, 1952, p. 115; SUVOROVA and POKROVSKAIA, 1960, p. 82; CHERNYSHEVA, 1962, p. 34; SUVOROVA, 1964, p. 235.

Type species.--Oryctocara geikei WALCOTT, 1908d, p. 23, Pl. 1, figs. 9, 10.

The generic description of Walcott (1908d, p. 23) is generally adequate and need be modified only slightly to include specimens with 12 thoracic segments.

ORYCTOCARA GEIKEI Walcott

Pl. 12, figs. 18, 19

Oryctocara geikei WALCOTT, 1908d, p. 23; RESSER, 1939a, p. 14, RESSER, 1938 (part), fig. 21, SHIMER and SHROCK, 1944, p. 613, LERMONTOVA, 1940, p. 137.

Diagnosis.--The species description given by Walcott (1908d, p. 23) is generally adequate. It need be modified only to include specimens with 12 thoracic segments. In the population at hand the number of axial rings on the pygidium varies from five to six to seven? and a terminal piece.

Occurrence.--Abundant in collections UU-412, UU-415, and UU-416. Rare in collections UU-410, UU-422, UU-423, UU-425, and UU-432.

Genus ORYCTOCEPHALITES Resser, 1939

Oryctocephalites RESSER, 1939b, p. 44-45; SHIMER and SHROCK, 1944, p. 613; RASETTI, 1959, p. 220; SUVOROVA and POKROVSKAIA, 1960, p. 82; CHERNYSHEVA, 1962, p. 24; SHERGOLD, 1969, p. 28.

Type species.--Oryctocephalites typicalis RESSER, 1939b, p. 45, Pl. 3, figs. 1-6.

Discussion.--The diagnosis by Resser (1939b, p. 44-45) is adequate and is followed here. Oryctocephalites differs from Oryctocephalus in having an expanded glabella and a strongly curved anterior outline. The pygidium of Oryctocephalites has five axial segments rather than six as in Oryctocephalus.

ORYCTOCEPHALITES TYPICALIS Resser

Pl. 12, figs. 13, 15, 16, 20

Oryctocephalites typicalis RESSER, 1939a, p. 45, Pl. 3, figs. 1-6; FRITZ, 1968, p. 202-203, Pl. 41, figs. 9-11; SHERGOLD, 1969, p. 28, text-fig. 9.

Diagnosis.--The diagnosis by Resser (1939b, p. 44-45) is adequate and is followed here.

Discussion.--O. typicalis is characterized by a strongly convex cranidium and a swollen glabella. The palpebral areas are narrow and the cranidium has a strongly curved anterior outline. The pygidium has five axial segments and five pairs of border spines.

Occurrence.--Common in collections UU-411 and UU-463. Rare in collections UU-408, UU-419, and UU-420.

Genus ORYCTOCEPHALUS Walcott, 1886

Oryctocephalus WALCOTT, 1886, p. 210; PALMER, 1954, p. 68; RASETTI, 1959, p. 220; SHERGOLD, 1969, p. 15.

Type species.--Oryctocephalus primus WALCOTT, 1886.

Discussion.--The generic description by Palmer (1954, p. 68) is followed here. In this genus the cranidium is characterized by an elongate glabella with three pairs of pits representing the glabellar furrows. The pygidium, which has the principal diagnostic generic features, differs from the pygidia of most other genera of the family by having pleural furrows, interpleural grooves visible, and marginal spines. Oryctocephalus and Oryctocephalites are compared under the latter genus.

ORYCTOCEPAHLUS MALADENSIS Resser

Pl. 12, figs. 14, 17, 21

Oryctocephalus maladensis RESSER, 1939b, p. 45, Pl. 3, figs. 7-9; FRITZ, 1968, p. 202, Pl. 41, figs. 25-27; SHERGOLD, 1969, p. 18.

Discussion.--The diagnosis by Fritz (1968, p. 202) is adequate and is followed here.

O. maladensis resemble O. walcotti from the Spence Shale, the differences being discussed under the latter species. Cranidia of O. maladensis are abundant in collection UU-408 but no pygidia have been found. Shergold (1969, p. 18) in his discussion of the genus Oryctocephalus notes that O. maladensis is known solely from cephala and that its absolute classification must await the discovery of the thorax and pygidium. However, because the cephalic features are characteristic of Oryctocephalus, Shergold temporarily referred O. maladensis to Oryctocephalus.

Occurrence.--Abundant in collection UU-408; rare in collections UU-409, UU-420, and UU-421.

ORYCTOCEPHALUS WALCOTTI Resser

Pl. 13, figs. 1, 2, 4, 6

Oryctocephalus walcotti RESSER (part), 1938, p. 9, Pl. 1, fig. 23, (not fig. 22); RESSER, 1939a, Pl. 2, figs. 15-18.

Diagnosis.--Cranidium subquadrate, slightly convex, length about 0.70 width. Glabella prominent, expanded slightly anteriorly, truncated, extended onto border. Glabellar furrows marked by four pairs of pits, fourth pair is faint. S1 pits connected by a strong furrow across glabella, furrows indistinct between other pairs of pits. Occipital furrow distinct, with deep pits near dorsal furrow. Axial furrow narrow,

deep. Occipital ring flat, about 0.15 glabellar length, bears a faint or indistinct median node. Frontal area about 0.10 glabellar length medially, widens laterally. Border flat medially, slightly thickened laterally. Border furrow prominent laterally, faint medially. Fixigenae nearly as wide as glabella at eye line, slightly convex, nearly horizontal. Palpebral lobes situated below level of palpebral area of fixigenae, about 0.45 glabellar length, situated behind midpoint of glabella. Eye ridges prominent, meet axial furrow opposite S4. Posterior area of fixigenae slightly wider (tr.) than glabella at occipital furrow. Preocular facial suture slightly convergent, convex. Postocular facial suture divergent, sinuous.

Librigenae narrow, margin evenly rounded. Border furrow prominent, border wide. Genal spine well developed, long, evenly tapered posteriorly.

Thorax has seven segments, axial lobe prominent, slightly narrower than pleural region. Pleurae of each segment have deep diagonal pleural furrows; distal recurved spines moderately long.

Pygidium semicircular in outline, slightly convex. Axis relatively prominent, narrow, tapered, consists of five rings, a terminal piece and a low postaxial ridge that does not reach posterior margin. Pleural fields crossed by six distinct pleural furrows and five less distinct interpleural furrows. Border indistinct. Margin extended into six pairs of spines. Anterior three pairs slender, moderately long, recurved. Fourth pair long, prominent; remaining two pairs relatively short, slender.

Surface of exoskeleton smooth or faintly granular. Genal spines finely granular.

Discussion.--O. walcotti differs from O. maladensis in lacking prominent transverse furrows between the S2 and S3 glabellar pits, in having horizontal rather than distally upsloping fixigenae, in having a wider (sag.) anterior border and having a narrower (sag.) area between the eye ridges and the anterior border furrow. In addition, O. maladensis has a more prominent occipital node than O. walcotti.

Occurrence.--Abundant in collections UU-412, UU-415, and UU-416. Common in collection UU-428. Rare in collections UU-413, UU-425, UU-427, UU-429, UU-430, UU-432, UU-437, and UU-465.

Genus THORACOCARE Robison and Campbell, in press

Thoracocare ROBISON and CAMPBELL, in press.

Type species.--Vistoia? minuta RESSER, 1939a, p. 21, Pl. 2, fig. 2 (not. fig. 1).

Discussion.--Robison and Campbell (in press) have thoroughly diagnosed and evaluated this genus.

THORACOCARE IDAHOENSIS (Resser)

Pl. 13, figs. 3, 5, 8, 10

Tonkinella idahoensis RESSER, 1939b, p. 45.

Thoracocare idahoensis (Resser) ROBISON and CAMPBELL, in press.

Discussion.--This species is adequately described and discussed by Robison and Campbell (in press). T. idahoensis differs from T. minuta in having a less well defined glabella, a narrower pygidial axis, more commonly has anterolateral pygidial spines, and is smooth rather than faintly granular.

Occurrence.--Common in collection UU-411.

THORACOCARE MINUTA (Resser)

Pl. 13, figs. 7, 9, 11-13

Vistora? minuta RESSER, 1939a, p. 21.

Thoracocare minuta (Resser) ROBISON and CAMPBELL, in press.

Diagnosis.--The diagnosis and discussion by Robison and Campbell (in press) is adequate.

Occurrence.--Abundant in collections UU-415 and UU-416; rare in collections UU-412, UU-413, and UU-432.

Family ZACANTHOIDIDAE Swinnerton, 1915

Genus ALBERTELLA Walcott, 1908

Albertella WALCOTT, 1908, p. 18; RESSER, 1936, p. 1; RASETTI, 1951, p. 147; RASETTI in HARRINGTON, 1959, p. 227.

Type species.--Albertella helena WALCOTT, 1908, p. 19, Pl. 2, figs. 1-4.

Diagnosis.--The diagnosis and discussion of Palmer (in press) are repeated here:

> Small-to medium-sized corynexochid trilobites; sagittal length probably not exceeding 50 mm. Cranidium subtrapezoidal in outline, gently convex transversely and longitudinally; anterior margin gently rounded. Glabella elongate, reaches nearly to anterior margin, well defined, sides subparallel or slightly expanded anteriorly, straight or concave. Four pairs of shallow glabellar furrows may be present. Occipital furrow straight, generally shallow. Occipital ring simple, axial node may be present at posterior margin. Frontal area extremely narrow, undivided. Fixigenae gently convex, horizontal or slightly downsloping; width, including palpebral lobes generally small, well separated from glabella, situated opposite or slightly anterior to glabellar midlength. Occular ridge poorly developed. Posterior limbs broad, triangular. Posterior border furrow shallow, straight. Course of posterior section of facial suture gently convex.
>
> Hypostome and rostral plate fused; rostral area not clearly differentiated.

Librigenae narrow, with moderately to poorly defined gently convex border, and long, slender, cylindrical genal spine continuing curvature of cheek margin.

Thorax composed of seven segments. Third segment macropleural in all known species. Axis prominent, as wide or wider than pleurae.

Pygidium subquadrate, width usually greater than length. Axis prominent, reaches to or nearly to posterior margin, composed of four or five variably defined segments and terminal part. Pleural regions with pleural or interpleural furrows defining three or four segments variably defined. Margin bears pair of long, slender spines directed posterolaterally. Spines not clearly related to pleural segments. Posterior margin between spines curved posteriorly.

External surfaces of all parts smooth or covered with fine, closely spaced granules.

Discussion.--Walcott included in Albertella two distinct kinds of trilobites that are now each represented by several species. One species group, typified by A. helena Walcott, has cranidia with small-to moderate-sized palpebral lobes well separated from the glabella, generally broad, triangular posterior limbs, a third macropleural segment on the thorax, genal spines not strikingly advanced, the hypostome and rostral plate fused but not clearly differentiated, and pygidial border spines that are widely divergent and not clearly related to particular pleural segments of the pygidium. The second species group, typified by A. bosworthi Walcott, has cranidia with long palpebral lobes that have the anterior end close to the glabella, narrow posterior limbs, a fourth macropleural segment on the thorax of the one species known with articulated parts, free cheeks indicating advanced genal spines, hypostome and rostral plate fused but strongly differentiated, and a distinctive pygidial structure in which the anterior bands of the first three segments are accentuated as ridges and generally merge laterally with the pygidial border at the base of pygidial spines much less laterally divergent than in the first species group. Most species of the bosworthi group have axial nodes on the pygidial segments that are lacking or weakly developed on species of the helena group.

Rasetti (1951, p. 148) noted these differences but chose to retain both groups within Albertella. Fritz (1968) identified a third related group of species with cranidial characters much like the bosworthi group and with similar pygidial pleurae. However, in this group (Albertelloides), the pygidial spines are located much more posteriorly, there is consistent development of an occipital spine, and the librigenae have large genal spines that are not advanced. In order to be consistent in ranking the differences

between the three groups of species, either Albertelloides should become a subgenus of Albertella because it is closer to the bosworthi group than the bosworthi group is to the helena group, or the three groups should be recognized as separate but related genera. Use of subgenera creates cumbersome nomenclature and the range of morphology that would be included in the genus would be much greater than that of most other corynexochid genera. Thus, in this paper, the three groups are treated as related genera. Albertella must be retained for the group of generally small-eyed forms with "normal" pygidial pleura that includes the type species. This group includes . . . A. helena Walcott, A. nitida Resser, A. sampsoni Resser, A. rossensis Resser, A. microps Rasetti, A. proveedora Lochman, and A. schencki Resser. Of these species, only A. helena, which has longer eyes than the others, approaches the bosworthi group, here included in a new genus, Paralbertella, and then only in cranidial structure. The species included in Paralbertella are P. bosworthi (Walcott)(synonym: Albertella stenorchaenis Rasetti), P. declivis (Rasetti), P. limbata (Rasetti), P. robsonensis (Resser), P. eiloltys (Fritz), P. lata (Fritz) and P. judithi (Fritz). Albertelloides includes A. mischi Fritz, A. pandispinata Fritz, A. maladensis (Resser), and A. dispar (Resser). Although the three genera have approximately the same time range, species of Albertella s.s. are rarely found in association with either Paralbertella or Albertelloides. Species of Albertella seem to have a more landward distribution than species of Albertelloides and Paralbertella.

ALBERTELLA GNYTHOS n. sp.

Pl. 14, figs. 1-8

Diagnosis.--Cranidium subquadrate, moderately convex, glabella prominent, parallel-sided, truncated in front. Four pairs of glabellar furrows: S1 bifurcate, S2 slightly convex or straight backwards; S3 slightly convex backwards to transverse; S4 transverse. Axial furrow moderately defined deepening at fossula. Occipital furrow broad and shallow, occipital ring moderately wide, flat, with very small median node. Anterior border narrow in front of glabella and about three times as wide in front of fixigenae. Border furrow from in front of glabella and moderately deep across fixigenae. Fixigenae width

slightly greater than 0.50 width of glabella, moderately convex, slope forward. Palpebral lobes prominent, nearly flat about 0.20 glabellar length, nearly opposite midline of glabella. Eye ridges prominent, slightly arcuate, intersect glabella just posterior to S4. Anterior facial suture slightly convergent, convex. Posterior facial suture divergent, sinuous.

Pygidium semicircular, axis moderately convex, tapered, extending to border. Axis divided by shallow furrows into five rings and a small terminal piece. Rings have very faint nodes. Dorsal furrow obsolete, only as pits opposite first, second, and third axial furrows; pits become smaller posteriorly. Pleural region approximately equal to width of axis, tapers rapidly posteriorly. Three segments deliniated by shallow pleural grooves. First segment extending laterally into a heavy marginal spine diverging out and back at 30° to 40°. Spines emerge at level of fourth or fifth axial segment. Spines very slightly convergent to straight, taper evenly. Narrow border present posterior to marginal spines. Border furrow faint, border becomes narrower posteriorly.

Outer surface covered thickly with fine granules. Inner surface may be smooth or granular.

Discussion.--This species most closely resembles Albertella proveedora Lochman (1952, p. 137). However, Albertella gynthos differs from Albertella proveedora in several features. The most distinctive difference is in the glabella. Albertella gynthos has a parallel-sided, truncate glabella while Albertella proveedora has an expanded, broadly rounded glabella. Both species have four glabellar furrows, but their expression differs between the two species. The

pygidia of the two species are quite similar but the pygidium of Albertella gynthos is distinctively larger and possesses three pits along the dorsal furrow rather than two. The pleural regions are also distinctly wider in Albertella gynthos.

Occurrence.--Abundant in collection UU-402. Common in collection UU-401. Rare in collections UU-400, UU-405, UU-407, UU-417, and UU-466.

Holotype.--Cranidium (1455) illustrated on plate 14, figures 1, 2, and 3.

Genus ALBERTELLINA Palmer, in press

Albertellina PALMER (in press).

Type species.--Albertellina aspinosa PALMER (in press).

Diagnosis.--The diagnosis of Palmer (in press) is repeated here:

> Moderately small corynexochid trilobites, length of largest known specimens probably about 30 mm. Cephalon subsemicircular in outline, with long flattened genal spines extending backward from posterolateral corners. Cranidium, excluding posterior limbs, elongate subrectangular in outline. Glabella long, low, narrow, straight-sided, expanded forward, extended onto inner part of flat or slightly concave border; well defined at sides and anterior by changes in slope of exoskeleton; anterior end bluntly rounded. Four pairs of shallow glabellar furrows variably developed, generally obscure. Occipital furrow shallow, deepest distally. Occipital ring incomplete on all known specimens. Frontal area short, flat or slightly concave undivided; sagittal length slightly less than one-eighth sagittal length of glabella exclusive of occipital ring; outer part has zone of low, coarse anastomosing ridges generally parallel to anterior margin. Palpebral area of fixigenae gently convex, horizontal, greatest width more than half basal glabellar width. Palpebral lobe long, slender, curved, well defined by broad, shallow palpebral furrow, continuous with low, poorly defined ocular ridge; situated opposite posterior half of glabella; exsagittal length between 0.4 and 0.5 sagittal length of glabella exclusive of occipital ring. Posterior limb moderately slender, spatulate; distal tip strongly rounded; transverse length about equal to basal glabellar width. Posterior border furrow broad, shallow. Anterior section of facial suture slightly divergent forward from palpebral lobe; posterior section divergent, sinuous. No integral spine.

Hypostome and rostral plate fused. Rostral part well defined by abrupt change in slope of exoskeleton.

Librigenae moderately narrow, gently convex, with broad, flat border about equal to anterior width of ocular platform. Lateral border furrow shallow, not clearly continuous with deeper posterior border furrow which continues onto long, flattened genal spine and extends nearly to tip. Genal spine not advanced.

Pygidium subtrapezoidal in outline, with sides slightly tapered posteriorly and with both anterolateral and posterolateral corners rounded. Posterior margin has slight median inbend. Axis prominent, tapered posteriorly, strongly rounded at rear, well defined by abrupt changes in slope of exoskleton. Two or three very shallow ring furrows variably developed. Pleural regions crossed by variably developed raised anterior pleural bands of first three pleural segments that continue onto flattened border. No distinct border furrow. Lateral and posterior margins without spines.

Ornamentation consists of extremely fine granules on lateral and posterolateral parts of pygidial border. Other parts appear smooth.

Discussion.--This genus constitutes a fourth genus of the group including Albertella, Albertelloides, and Paralbertella. It differs from all of those genera by lacking pygidial spines. It further differs from Paralbertella by lacking advanced genal spines, and from Albertelloides by the lack of a narrow furrow along the outer margin of the librigenae. The development of the anterior bands or the pygidial pleural segments is more variable and less strong than in either Albertelloides or Paralbertella.

ALBERTELLINA ASPINOSA Palmer

Pl. 14, figs. 9-17

Discussion.--Because this is the only species at present in Albertellina, the generic description and discussion of affinities also suffice for the species. This species is abundant in collections from the Twin Knobs Formation at Two Mile Canyon, Idaho. The posterior margin of the pygidium is quite variable within the species. Individu-

als in my collections have evenly rounded to distinctly indented posterior margins, whereas specimens from the type area have a slight median inbend of the posterior margin.

Occurrence.--Abundant in collections UU-403, UU-405, and UU-407. Common in collections UU-402, UU-404, and UU-417. Rare in collection UU-466.

Genus ALBERTELLOIDES Fritz, 1968

Albertelloides FRITZ, 1968, p. 214, PALMER (in press).

Type species.--Albertelloides mischi FRITZ, 1968, p. 48, Pl. 38, figs. 1-7.

Discussion.--The diagnosis of Fritz (1968) is adequate and is followed here.

Albertelloides most closely resemble Albertella and Paralbertella but differs in having pygidial spines that are located much more posteriorly. In addition there is consistent development of an occipital spine and the librigenae have large genal spines that are not advanced.

ALBERTELLOIDES DISPAR (Resser)

Pl. 14, figs. 18-24

Kochaspis dispar RESSER (part) 1939b, p. 58, Pl. 13, figs. 13-15 (not figs. 1-4).

Albertelloides dispar (Resser) FRITZ, 1968, p. 215.

Diagnosis.--Cranidium subquadrate, moderately convex, slightly longer than wide. Glabella elongate, expands anteriorly, bluntly rounded anteriorly. Four sets of glabellar furrows visible: S1 bifurcate, oblique backwards; S2 convex, oblique backwards; S3 and S4 oblique forwards. Axial furrow shallow. Occipital furrow shallow medially,

deepens laterally, straight. Occipital ring flat, about 0.25 glabellar length, drawn back into a small posteriorly directed spine. Frontal area about 0.10 glabellar length. Border nearly flat, border furrow faint. Fixigenae about 0.50 glabellar width at eye line, slightly convex, nearly horizontal. Palpebral lobes long, prominent, well defined by palpebral furrow, slightly upturned. Palpebral lobes about 0.60 glabellar length, anterior ends nearly touch axial furrow opposite S3, posterior ends opposite occipital furrow. Eye ridges distinct, short. Posterior area of fixigenae same width (tr.) as glabella at occipital furrow, broadens distally, bears a short metafixigenal spine.

Pygidium subquadrate, moderately convex, length about 0.75 width. Axis prominent, consists of three distinct rings, some individuals have a faint fourth ring, and a terminal piece that does not reach posterior margin. Pleural fields slightly downsloping, crossed by three pleural and two faint interpleural furrows. A distinct rib occurs opposite the first axial furrow. Border prominent, horizontal, widest and locally upturned near spines, posterior margin convex backward. Border spines flattened, slender, located at posterolateral corners of pygidium, distinctly upturned, slightly to moderately divergent.

Surface of cranidium and pygidium densely covered with fine granules.

Discussion.--A. dispar is characterized by its slender, widely spaced pygidial spines. It most closely resembles A. fritzi but pygidia differ from that species in being distinctly less convex, in having border spines that are slender rather than stout, and in having a posterior margin that is convex backwards rather than nearly straight.

The cranidia are tentatively assigned to A. dispar because they almost exclusively occur in association with A. dispar pygidia.

Occurrence.--Common in collections UU-420 and UU-421.

ALBERTELLOIDES FRITZI n. sp.

Pl. 15, figs. 1, 2, 6, 7

Diagnosis.--Pygidium subquadrate, distinctly wider than long. Axis prominent, convex, consists of four rings (fourth ring is faint) and a terminal piece that extends onto border. Three anterior rings bear faint elongate (tr.) median nodes. Pleural regions moderately convex, downsloping, crossed by three pleural and two interpleural furrows. Both sets of furrows are faint. Border marked by an abrupt change in slope rather than a border furrow. Border slightly downsloping, gives rise to a pair of strong, flattened, upturned, slightly divergent, posterolateral spines. Spines about 0.50 length of pygidium. Posterior margin of pygidium nearly straight.

Surface of pygidium covered with faint dense granules. In addition border and posterior pleural region are typically covered with faint caecal system.

Discussion.--Pygidia of A. fritzi most closely resemble pygidia of A. dispar, the differences being discussed under the latter species. A. maladensis differs from A. fritzi and A. dispar in having a concave backwards posterior border.

Occurrence.--Common in collection UU-420.

Holotype.--Pygidium (1469) illustrated on plate 15, figures 1, 2, and 6.

ALBERTELLOIDES MALADENSIS (Resser)

Pl. 15, figs. 3, 4, 8

Kochaspis maladensis RESSER, 1939b, p. 57, Pl. 13, figs. 9-12.

Albertelloides maladensis (Resser) FRITZ, 1968, p. 215.

Diagnosis.--Pygidium subquadrate, distinctly wider than long. Axis prominent, convex, consists of three rings, a terminal piece, and a short postaxial ridge that nearly reaches posterior border. Each axial ring bears an elongate (tr.) median node. Pleural regions moderately convex, downsloping; crossed by three pleural and two less distinct interpleural furrows. The most conspicuous feature of the pleural regions are two ribs that occur opposite the first and second axial furrows. Border marked by a distinct change in slope rather than a border furrow. Border prominent, horizontal, or slightly upturned. Border gives rise to a pair of relatively strong, flat, upturned, posterolaterally directed spines, which are at least 0.50 length of pygidium. Posterior margin of pygidium concave inward.

Surface of pygidium covered with fine granules. In addition, border may have faint caecal system.

Discussion.--A. maladensis differs from all other described species of Albertelloides in having a concave backward posterior border and straight, posteriorly directed border spines. An undetermined species of Albertelloides described by Fritz (1968, p. 217) from the Pioche Shale of east-central Nevada most closely resembles A. maladensis. They differ, however, in that A. maladensis has upturned, straight, posteriorly directed border spines while the unnamed species has horizontal, divergent border spines that distally curve toward the midline. The pygidium of A. maladensis has a nearly

straight lateral margin while the pygidium of the unnamed species is distinctly tapered posteriorly.

Occurrence.--Common in collection UU-408.

Genus PARALBERTELLA Palmer, in press

Type species.--Albertella bosworthi WALCOTT, 1908d, p. 22.

Diagnosis.--The diagnosis and discussion of Palmer (in press) are adequate and repeated here:

> Moderate-sized corynexochid trilobites, length probably not exceeding 60 mm. Cephalon transversely subpentagonal in outline, anterior margin straight or gently rounded, genal spines distinctly advanced from posterior margin. Cranidium elongate, gently convex transversely and longitudinally. Glabella long, well defined at sides and front by axial and preglabellar furrows, moderately convex transversely, gently convex longitudinally, sides subparallel, anterior end bluntly rounded. Four pairs of shallow lateral furrows present, posterior pair generally deepest and strongly oblique to axial furrow. Occipital furrow straight, occipital ring has small axial node adjacent to posterior margin. Frontal area short, flat. Fixed cheek gently convex, horizontal; width of palpebral area about one-half or slightly more than one-half basal glabellar width. Palpebral lobe long, arcuate, situated opposite posterior half of glabella, well defined by palpebral furrow that is continuous along ocular ridge to axial furrow. Anterior end of palpebral lobe near glabella; posterior end opposite or posterior to occipital furrow. Posterior limb long, slender, posterior border expands distally; specimens less than 5mm long show vestiges of intergenal spines. Course of anterior section of facial suture moderately to strongly divergent forward from palpebral lobes; course of posterior section directed nearly straight laterally.
>
> Free cheek crescentic in outline, with well defined border furrow and long genal spine projecting posterolaterally from posterior margin.
>
> Hypostome and rostral plate fused.
>
> Thorax composed of seven segments. Axis prominent, usually wider than pleurae. Fourth segments macropleural.
>
> Pygidium elongate, semielliptical in outline exclusive of pair of advanced lateral border spines. Axis prominent, tapered posteriorly, reaches nearly to inner edge of narrow pygidial border, connected to border by narrow post-axial ridge. Five to seven distinct ring furrows present

posterior to articulating furrow, most segments have low axial nodes. Pleural regions flat or gently convex, characterized by prominent ridge-like development of anterior bands of first three pleural segments. The ridges generally converge laterally to merge with pygidial border at base of border spine. Posterior margin behind lateral spines strongly curved posteriorly, usually downsloping.

Discussion.--This genus includes those species formerly assigned to Albertella that have long eyes, slender posterior limbs, anteriorly divergent facial sutures, a fourth macropleural segment on the thorax, strongly advanced lateral border spines on the pygidium, a narrow and well defined posterior pygidial border, and the anterior bands of the first three pygidial segments, developed as ridges and merged laterally with the border at the base of the pygidial spine. The most similar genus is Albertelloides which differs by having a strong occipital spine, broad genal spines that are not advanced, eight instead of seven thoracic segments, fewer axial segments on the pygidium, a less well defined posterior pygidial border and pygidial spines that are not strongly advanced.

PARALBERTELLA JUDITHI (Fritz)

Pl. 15, figs. 5, 9-15

Albertella judithi, FRITZ, 1968, p. 212-213, Pl. 39, figs. 22-30.

Discussion.--The species description given by Fritz (1968) is adequate.

This species is the most abundant trilobite in the Naomi Peak Tongue of the Twin Knobs Formation at Antimony Canyon, Utah. It is rare, however, at Two Mile Canyon, Idaho. The specimens at hand show more variation than the type specimens. In particular, the ridges on the posterior half of the pleural field may vary from two to four and differ in strength of development. The border spines are slightly divergent but minor variation is common.

Occurrence.--Abundant in collections UU-419 and UU-420. Rare in collections UU-422 and UU-408.

Genus ZACANTHOIDES Walcott, 1888

Embolimus ROMINGER, 1887 (not Embolemus WESTWOOD, 1883--Hymenoptera). p. 15.

Zacanthoides WALCOTT, 1888, p. 165; PALMER, 1954, p. 69; PALMER, 1968, p. 50-51 (synonomy to date).

Type species.--Embolimus spinosa ROMINGER, 1887, p. 15, Pl. 1, fig. 3.

Discussion.--The generic description by Palmer (1954, p. 69) is followed here. The strongly divergent preocular facial suture; the long, slender, curved palpebral lobes; the broad thoracic and pygidial axes, and the spinose posterior margin of the pygidium are diagnostic of the genus.

ZACANTHOIDES ALATUS (Resser)

Pl. 15, figs. 16, 17, 19-21, 23, 24

Prozacanthoides alatus RESSER, 1939b, p. 26, Pl. 3, figs. 10-12.

Prozacanthoides decorosus RESSER, 1939b, p. 27, Pl. 3, figs. 16-18.

Prozacanthoides exilis RESSER, 1939b, p. 28, Pl. 3, figs. 19, 20.

Prozacanthoides aequus RESSER, 1939b, p. 28, Pl. 3, figs. 21-23.

Prozacanthoides optatus RESSER, 1939b, p. 29, Pl. 3, figs. 24-30.

Diagnosis.--Cranidium moderately convex, slightly wider than long. Glabella prominent, parallel-sided to very slightly tapered, rounded anteriorly, does not reach anterior margin. Four pairs of shallow glabellar furrows visible: S1 straight, oblique backwards; S2 slightly oblique backwards; S3 transverse; S4 oblique forwards. Axial furrow narrow, relatively faint. Preglabellar furrow varies from shallow to moderately deep. Occipital furrow composite, moderately deep. Occipital ring flat, about 0.25 glabellar length, bears a small median

node or spine. Frontal area 0.25 to 0.35 glabellar length. Preglabellar field slightly downsloping to horizontal. Border narrow, slightly upturned. Fixigenae about 0.50 glabellar width at eye line, faintly convex, nearly horizontal. Palpebral lobes long, prominent, upturned, well defined by palpebral furrow. Palpebral lobes 0.75 to 0.85 glabellar length, curved, anterior ends adjacent to axial furrow opposite S4, posterior ends opposite occipital ring. Posterior area of fixigenae long, straplike, curved slightly forward, with distinct, posteriorly directed spines at distal extremities. Preocular facial suture strongly divergent, straight.

Pygidium smaller than cranidium, wider than long. Axis prominent, strongly convex, tapered, consists of four rings with distinct elongate (tr.) axial nodes, a terminal piece, and a postaxial ridge that reaches posterior margin. Pleural fields slightly convex, crossed by three pleural furrows. Posterior margin slightly to moderately downsloping, with four to five pairs of spines. Anterior pair moderately well developed, remaining pairs short, poorly developed.

Surface smooth or faintly granular. Frontal area of cranidium and pleural regions of pygidium have faint to indistinct caecal lines.

Discussion.--In the above synonomy are listed five of Resser's (1939b) species that I believe have been based upon differences in preservation and slight intraspecific variation. All species come from the same locality and occur in a single bed.

Occurrence.--Common in UU-408; rare in collections UU-411 and UU-409.

ZACANTHOIDES aff. Z. ALATUS (Resser)

Pl. 15, figs. 18, 22

Diagnosis.--Pygidium subquadrate, distinctly wider than long, slightly convex. Axis prominent, moderately convex, tapered, consists of three moderately distinct rings, a faint fourth ring, a terminal piece and a low postaxial ridge that does not reach posterior margin. Pleural fields nearly horizontal, crossed by three faint pleural furrows. Anterior pair of border spines short, remaining spines greatly reduced which imparts a wavy appearance to posterior margin.

Surface of pygidium faintly granular.

Discussion.--This pygidium differs from Z. alatus in having a shorter axis, and having axial rings with less distinct nodes. The pygidium of Z. alatus is also distinctly narrower as a whole. In several respects, however, this pygidium seems to be closely related to Z. alatus.

Occurrence.--One pygidium in collection UU-408.

ZACANTHOIDES cf. Z. ALATUS (Resser)

Pl. 16, figs. 1, 2

Discussion.--A single pygidium closely resembles Z. alatus but has more strongly developed pygidial spines. The anterior pair are slender and about 0.60 pygidial length. The second pair are short and the remaining three pairs are poorly developed. In other respects the pygidium closely resembles Z. alatus.

Occurrence.--One pygidium in collection UU-408.

ZACANTHOIDES AVERNUS n. sp.

Pl. 16, figs. 3-9

Diagnosis.--Cephalon subsemicircular in outline. Cranidium with glabella moderately well defined; glabella parallel-sided or slightly

tapered forward; not reaching to anterior margin. Four pairs of glabellar furrows: S1 well developed, oblique backwards; S2 straight transverse; S3 weak, straight transverse; S4 faint to absent, oblique forwards when present. Occipital furrows straight, shallow; occipital ring flat with a small posteriorly directed node. Preglabellar field short, anterior border slightly thickened and raised. Fixigenae about 0.50 width of glabella, slightly convex, slope laterally. Palpebral lobes narrow, well defined, long, curved; anterior ends adjacent to dorsal furrow, opposite S3; posterior ends opposite occipital furrow. Posterior limbs narrow, strap-like, slightly expanded laterally; as long as occipital ring is wide; small posteriorly directed spines at distal extremities. Anterior facial sutures strongly divergent. Number of thoracic segments unknown. Axial lobe as wide as pleural lobes exclusive of spines. Each segment extended distally into a long posterolaterally directed spine.

Pygidium subquadrate, slightly wider than long, smaller than glabella. Axis prominent, convex, consists of four distinct rings and terminal piece; short postaxial ridge reaches posterior border. Axial rings with laterally elongate nodes. Pleural regions nearly equal in width to axis; slope laterally, four pleural furrows present. Fourth pleural furrow indistinct. Posterior margin has up to five pairs of spines that inwardly decrease in size; outer pair distinct, posteriorly directed, may extend slightly past posterior margin of pygidium; second pair distinct or may be reduced to node. Remaining two to three pairs greatly reduced and impart slight waviness to margin.

Discussion.--The cranidium of this species is characterized by a prominent, parallel-sided or slightly tapered, bluntly rounded

glabella with four pairs of glabellar furrows and a slightly rounded anterior cranidial margin. The pygidium is quite distinctive, and is distinguished by a prominent axis that reaches the posterior margin, convex pleural fields, and five pairs of border spines; only the first pair of which is well developed. The pygidium of this species most closely resembles that of Z. alatus but is much more convex, has a stronger axis, is more rounded in outline and has stronger pleural and interpleural furrows. The cranidia of the two species are quite dissimilar.

Occurrence.--Abundant in collections UU-459 and UU-460 from the basal shales of the Ute Formation.

Holotype.--Pygidium (1486) illustrated on plate 16, figures 5 and 9.

ZACANTHOIDES FEDORI n. sp.

Pl. 16, figs. 10, 12-16

Diagnosis.--Cranidium subrectangular, slightly longer than wide, moderately convex. Glabella elongate, prominent, tapered, bluntly rounded anteriorly. Three pairs of glabellar furrows visible: S1 convex, oblique backwards; S2 oblique backwards; S3 indistinct, transverse. Axial furrow faint, preglabellar furrow wide (sag.) shallow. Occipital furrow shallow medially, deepens laterally, composite. Occipital ring flat, about 0.20 glabellar length. Bears a posteriorly directed node or short spine. Frontal area about 0.30 glabellar length. Preglabellar field slightly wider than border, nearly horizontal. Anterior border rounded, border upturned, prominent. Border defined by a change in slope rather than a distinct border furrow. Fixigenae

about 0.50 glabellar width at eye line, slightly upturned, nearly flat. Palpebral lobes prominent, elevated above fixigenae, well defined by palpebral furrow. Palpebral lobes about 0.80 glabellar length, anterior ends opposite S3, posterior ends opposite middle of occipital ring. Preocular facial suture strongly divergent, slightly convex. Postocular facial suture divergent, sinuous.

Pygidium subquadrate, nearly as long as wide. Axis prominent, tapered, consists of three distinct rings, a terminal piece, and a postaxial ridge that almost reaches the posterior border. Pleural fields about 0.50 axial width, slightly downsloping, nearly flat, crossed by three pleural furrows. Posterior border extended into four pairs of flat moderately long spines that gradually decrease in size inwardly.

Surface of cranidium smooth except for border that has transverse ridges. Pygidium smooth.

Discussion.--Z. fedori most closely resembles Z. prolixus. However, cranidia of Z. fedori have a rounded rather than a straight anterior border, a tapered glabella, and an occipital node rather than a slight occipital spine. Pygidia of Z. fedori have flat rather than round border spines and the lateral margins of the pygidium are more nearly parallel. Z. fedori differs from Z. demissus in having four rather than three pairs of pygidial spines.

Occurrence.--Common in collection UU-447. Rare in collections UU-449 and UU-450.

Holotype.--Pygidium (1489) illustrated on plate 16, figures 10 and 14.

ZACANTHOIDES aff. Z. GRABAUAI Pack

Pl. 16, figs. 19, 20

Zacanthoides grabauai PACK, 1906, p. 300, Pl. 3, figs. 3, 3a, 3b.

Diagnosis.--Cranidium larger than wide. Glabella elongate, nearly twice as long as wide, slightly tapered, rounded anteriorly. Four pairs of glabellar furrows visible: S1 oblique backwards; S2 oblique backwards to nearly transverse; S3 transverse to slightly oblique forwards; S4 oblique forwards. Axial and preglabellar furrows distinct, shallow. Occipital furrow shallow, deepens laterally. Occipital ring 0.20 to 0.25 glabellar length, bears median node. Frontal area broad, triangular, about 0.35 glabellar length. Border slightly thickened, straight or slightly concave backward on either side of medial apex. Fixigenae about 0.40 glabellar width at eye line, slightly convex, nearly horizontal. Palpebral lobes long, prominent, well defined by palpebral furrow. Anterior ends nearly touch axial furrow opposite I4, posterior ends opposite occipital ring. Preocular facial suture strongly divergent, straight.

Cranidium seems to be smooth except for faint anastomosing lines on frontal area.

Discussion.--This species closely resembles Z. grabauai Pack (1906, p. 300), but differs in having a tapered rather than parallel-sided glabella, in having a more bluntly rounded anterior margin, and having a proportionately shorter frontal area. The most distinctive feature of both populations is the triangular frontal area.

Occurrence.--Common in collection UU-429. Rare in collections UU-430, UU-432, UU-437, and UU-465.

ZACANTHOIDES IDAHOENSIS Walcott

Pl. 17, figs. 7, 9-13, 16-18

Zacanthoides idahoensis WALCOTT, (part), 1908d, p. 26, Pl. 3, figs. 1-5, 6, 10 (not figs. 7-9, 11); RESSER, 1939a, p. 9, Pl. 3, figs. 18-20.

Zacanthoides holopygus RESSER, 1939a, p. 10, Pl. 2, figs. 10-12.

Diagnosis.--Walcott's original description, as modified by Resser, is adequate. All large specimens in my collections have five rather than six pairs of pygidial spines.

Discussion.--Walcott (1908d, p. 26) originally named and described Z. idahoensis and included forms with slight variations in the construction of the pygidial spines. Resser (1939a) subsequently divided Z. idahoensis into four separate species based on these differences. Resser considered smaller individuals to be a distinct species, Z. holopygus. However, as noted by Lochman (1952, p. 144), "Especially important is the fact that among the types (of Z. holopygus) the largest specimen showing the specific characters of Z. holopygus is the holotype carapace, 15 mm in length. The two inch long paratype carapace mentioned by Resser has a pygidium with four strong marginal spines as in Z. idahoensis." Lochman also correctly noted that the long thoracic spine was located on the second to the last rather than the last thoracic segment as stated by Resser. In my collections small individuals similar to Z. holopygus only occur with Z. idahoensis. After examination of my material and Resser's collections, I agree with Walcott's earlier conclusion that the small individuals represent the young of Z. idahoensis. I consider the slight differences between the two groups to be the result of ontogenetic variation. Although

Walcott stated that the long thoracic spine originated from the fifth thoracic segment, specimens in my collections show that it originates from the second to the last segment as in the smaller individuals.

Individuals in my collections are nearly identical to the type specimens with one exception; the axial lobe of the thoracic segments are nearly twice as wide as the pleural lobes exclusive of the spines. Individuals from Walcott's and Resser's collections have an axial lobe that is only slightly wider than the pleural lobes exclusive of the spines. However, I do not consider this difference to warrant specific reccgnition.

Occurrence.--Common in collections UU-442 and UU-444. Rare in collections UU-432 and UU-447.

ZACANTHOIDES LATUS n. sp.

Pl. 16, figs. 11, 17, 18, 21, 22

Diagnosis.--Cranidium subrectangular, moderately convex. Glabella elongate, parallel-sided, bluntly rounded in front. Four pairs of glabellar furrows evident: S1 oblique backwards; S2 oblique backwards; S3 transverse; S4 faint, pithole. Occipital furrow distinct, straight, deepens laterally. Occipital ring triangular, extends into strong occipital spine. Frontal area fairly long, preglabellar area and border equal in width. Border slightly upturned, delineated by slight change in shape rather than distinct border furrow. Fixigenae slightly greater than 0.60 glabellar width, slightly concave, nearly flat. Palpebral lobes long, narrow, well defined by palpebral furrow, upturned; anterior end adjacent to dorsal furrow opposite S3. Posterior ends of palpebral lobes opposite occipital furrow. Posterior

area of fixigenae long, straplike; distinct anterolaterally directed spines present at distal extremities. Preocular facial sutures strongly divergent, straight. Postocular facial sutures nearly transverse.

Pygidium slightly convex; 1.3 times as wide as long. Axis prominent, consists of five rings and a short terminal piece that reaches inner edge of border. Pleural field nearly flat; crossed by four pairs of pleural and three pairs of indistinct interpleural furrows. Pleural field distinctly wider than axis. Anterolateral corners of pygidium moderately angular. Posterior border bears six pairs of marginal spines; lateral pair strong, longer than pygidium; remaining five pairs short, slender, evenly spaced, and become gradually smaller toward midline.

Discussion.--The holotype pygidium of this species is characterized by five axial rings, wide (tr.) pleural fields with an angular anterolateral margin, and six pairs of marginal spines.

An associated cranidium, which is tentatively assigned to the species, has a parallel-sided, bluntly rounded glabella, a relatively wide border, and a broadly rounded anterior margin. The occipital ring is extended into a strong occipital spine. The pygidium differs markedly from that of any described species of Zacanthoides known to me because of its wide (tr.) pleural fields and six pairs of well developed border spines.

Occurrence.--Rare in collection UU-410.

Holotype.--Pygidium (1494) illustrated on plate 16, figures 18 and 22.

ZACANTHOIDES PROLIXUS n. sp.

Pl. 17, figs. 1-3, 4-6, 8

Diagnosis.--Cranidium subrectangular, slightly longer than wide. Glabella moderately long, parallel-sided, truncated anteriorly. Four pairs of indistinct glabellar furrows: S1 convex, oblique backwards; S2 oblique backwards; S3 transverse; S4 oblique forwards. Axial furrow shallow, preglabellar furrow wide (sag.) faint. Occipital furrow relatively deep, composite, deepens laterally. Occipital ring flat, about 0.25 length of glabella, bears slender, posteriorly directed, median spine. Frontal area about 0.25 glabellar length. Preglabellar field same width or slightly wider than border, downsloping. Border prominent, moderately to strongly upturned, nearly straight. Border defined by change in slope rather than distinct border furrow. Fixigenae about 0.60 glabellar width at eye line, slightly convex, nearly horizontal. Palpebral lobes narrow, well defined by palpebral furrow, about 0.70 glabellar length, anterior ends adjacent to axial furrow opposite S3.

Pygidium smaller than cranidium, moderately convex, slightly wider than long. Axis prominent, consists of three distinct rings, a terminal piece, and a short postaxial ridge which about reaches posterior margin of pygidium. Axial rings bear elongate (tr.) nodes. Anterolateral corners of pygidium strongly rounded. Pleural fields downsloping, nearly flat, narrow anteriorly, become progressively wider posteriorly. Pleural field crossed by three pleural furrows. Posterior margin with four pairs of posteriorly directed spines, which gradually decrease in size medially, and range from moderately to very long.

Surface of cranidium and pygidium smooth. Posterior area of fixigenae straplike, about same width as glabella at occipital furrow,

bears a distal posteriorly directed spine. Preocular facial suture strongly divergent, slightly convex. Postocular facial suture divergent, sinuous.

Discussion.--This species is characterized by a nearly straight anterior cranidial margin, a moderately long (sag.) concave frontal area and an upturned border. The occipital ring bears a slender occipital spine. The pygidium has a prominent, tapered axis consisting of three distinct rings, a terminal piece and a postaxial ridge. The pygidial border has four pairs of spines that decrease in length inwardly. There seems to be a considerable degree of variation in spine expression.

Occurrence.--Abundant in collection UU-432. Common in collection UU-465. Rare in collections UU-435 and UU-462.

Holotype.--Pygidium (1499) illustrated on plate 17, figures 4 and 8.

Genus ZEUGOSPINA n. gen.

Diagnosis.--Cranidium subquadrate, slightly wider than long, slightly convex transversely and longitudinally. Glabella prominent, sides slightly concave, expands anteriorly, bluntly rounded to truncated anteriorly. Four pairs of faint glabellar furrows visible: S1 oblique backwards; bifurcate; S2 oblique backwards; S3 transverse; S4 oblique forwards. Axial furrow shallow, small fossulae present opposite S4. Occipital furrow simple, straight, deepens laterally. Occipital ring triangular, slopes upward posteriorly, about 0.20 glabellar length. Border narrow medially, widens laterally, upturned. Border furrow distinct. Fixigenae about same width as glabella at eye line,

slightly convex, slightly downsloping. Palpebral lobes 0.50 glabellar length, horizontal, situated behind midpoint of glabella. Palpebral furrow faint. Eye ridges visible; slightly convex forward, meet axial furrow at fossulae. Posterior area of fixigenae wider (tr.) than glabella at occipital ring. Preocular facial suture slightly divergent, convex. Postocular facial suture divergent, sinuous.

Pygidium small, semielliptical, about twice as wide as long. Axis prominent, consists of two rings and a terminal piece that does not reach inner edge of border. Pleural fields crossed by two pleural furrows. Anterior pleural furrows end in a slight depression. Border distinct, extended into relatively strong, posteriorly directed spine opposite anterior pleural furrow. Second border spine, opposite second pleural furrow, is reduced or absent. Remainder of border smooth.

Surface of cranidium and pygidium smooth.

Discussion.--The cranidium of this genus is characterized by an anteriorly expanded glabella with concave sides, four pairs of faint glabellar furrows; wide fixigenae, a short frontal area and an upturned border, and relatively long palpebral lobes situated behind the glabellar midpoint. The pygidium has a prominent axis and a pair of distinctive conical anterolateral spines. I know of no other genus with this combination of characters.

The cranidium of Zeugospina most closely resembles that of Albertella. However, Zeugospina has much wider fixigenae and palpebral lobes that are situated behind rather than opposite or in front of the glabellar midpoint. The pygidia of the two genera are distinctly different.

ZEUCOSPINA GUNTHERI n. gen. n. sp.

Pl. 18, figs. 1-6

Diagnosis.--Cranidium subquadrate, slightly wider than long, slightly convex transversely and longitudinally. Glabella prominent, sides slightly concave, expands anteriorly, bluntly rounded to truncated anteriorly. Four pairs of faint glabellar furrows visible: S1 oblique backwards; bifurcate; S2 oblique backwards; S3 transverse; S4 oblique forwards. Axial furrow shallow, small fossulae present opposite S4. Occipital furrow simple, straight, deepens laterally. Occipital ring triangular, slopes upward posteriorly, about 0.20 glabellar length. Border narrow medially, widens laterally, upturned. Border furrow distinct. Fixigenae about same width as glabella at eye line, slightly convex, slightly downsloping. Palpebral lobes 0.50 glabellar length, horizontal, situated behind midpoint of glabella. Palpebral furrow faint. Eye ridges visible; slightly convex forward, meet axial furrow at fossulae. Posterior area of fixigenae wider (tr.) than glabella at occipital ring. Preocular facial suture slightly divergent, convex. Postocular facial suture divergent, sinuous.

Pygidium small, semielliptical, about twice as wide as long. Axis prominent, consists of two rings and a terminal piece that does not reach inner edge of border. Pleural fields crossed by two pleural furrows. Anterior pleural furrows end in a slight depression. Border distinct, extended into relatively strong, posteriorly directed spine opposite anterior pleural furrow. Second border spine, opposite second pleural furrow, is reduced or absent. Remainder of border smooth.

Surface of cranidium and pygidium smooth.

Discussion.--Because this is the only species at present in Zeugospina, the generic discussion also suffices for the species.

Occurrence.--Common in collection UU-403. Rare in collections UU-404 and UU-405.

Holotype.--Pygidium (1508) illustrated on plate 18, figure 3.

Unassigned Corynexochids

Genus and species undetermined 1

Pl. 18, figs. 7, 10, 11

Diagnosis.--Cranidium moderately convex, subquadrate. Glabella long, prominent, expands slightly, bluntly rounded anteriorly. Anterior margin of glabella has a distinct median indentation. Four pairs of glabellar furrows evident: S1 bifurcate, oblique backwards; S2 oblique backwards; S3 transverse; S4 oblique forwards. Axial furrow distinct, shallow fossulae present. Occipital furrow shallow medially, composite, deepens laterally. Occipital ring triangular, about 0.25 glabellar length, extended into a long, slender occipital spine. Frontal area short. Border slightly upturned, defined by means of a change in slope rather than a distinct border furrow. Fixigenae slightly greater than 0.50 glabellar width, slightly convex, upsloping. Palpebral lobes prominent, upturned greater than 0.50 glabellar length, midpoint situated well behind glabellar midpoint. Eye ridges short, strong, meet axial furrow at fossulae opposite S4. Posterior area of fixigenae straplike, about same width as glabella at occipital furrow. Preocular facial suture divergent, straight. Postocular facial suture divergent, sinuous.

Surface of cranidium has crinkly appearance and is covered with

prominent punctae. Exfoliated areas are finely granulose.

Discussion.--This species is quite distinctive in having a crinkly punctate ornamentation and having a distinct median indentation in the front of the glabella. Only one individual is known and it is not judged sufficient to name a new species. As discussed under the genus Ptarmiganoides, cranidia of Ptarmigania, Ptarmiganoides, Paralbertella, and certain other long eyed corynexochids are indistinguishable without the associated pygidia. Therefore a generic assignment is not attempted.

Occurrence.--One cranidium in collection UU-408.

Genus and species undetermined 2

Pl. 17, figs. 14, 15

Diagnosis.--Pygidium large, about twice as wide as long. Axis well defined, with three or four rings, and a terminal piece. Pleural field crossed by three well developed pleural furrows and two interpleural furrows. Anterolateral corner of pygidium broadly rounded, extended into broad, flat stubby spine.

Surface smooth.

Discussion.--This corynexochid is represented by only one poorly preserved incomplete pygidium. I know of no established genus to which this pygidium could be assigned, and it is judged inadequate to serve as a holotype for a new genus.

Occurrence.--One incomplete pygidium in collection UU-404.

Order PTYCHOPARIIDA Swinnerton, 1915

Genus ACHLYSOPSIS Fritz, 1968

Achlysopsis FRITZ, 1968, p. 219.

Type species.--Achlysopsis liokata FRITZ, 1968, p. 219, Pl. 42, figs. 17-22.

Discussion.--Fritz (1968, p. 218) has adequately described and discussed this genus. Pygidia that Fritz assigned to this genus probably belong to Oryctocara.

ACHLYSOPSIS PUNCTATUM n. sp.

Pl. 18, figs. 8, 9, 12, 13

Diagnosis.--Cranidium subquadrate, slightly wider than long, slightly to moderately convex. Glabella low, tapered, broadly rounded anteriorly. Glabellar furrows faint to indistinct, up to four pairs visible on large, well preserved and/or exfoliated cranidia. S1 oblique backwards, S2 transverse, S3 and S4 oblique forwards. Occipital furrow very shallow, deepens slightly laterally. Occipital ring triangular, about 0.25 glabellar length, bears faint median node. Axial furrow faint. Frontal area gently downsloping, slightly concave. Preglabellar field about same width as border. Border slightly downsloping, narrows laterally, poorly defined by a slight change in slope rather than a distinct border furrow, even less well defined medially because of a slight median swelling. Fixigenae narrower than glabella at eye line; slightly convex downsloping. Palpebral lobes horizontal to slightly downsloping, about 0.45 glabellar length, situated behind glabellar midpoint. Eye ridges faint. Posterior area of fixigenae narrower than glabella at occipital furrow. Preocular facial suture divergent, straight. Postocular facial suture divergent, sinuous.

Surface of cranidium covered with fine punctae.

Discussion.--This species most closely resembles A. liokata Fritz but differs from that species in having a punctate rather than granular

surface.

Occurrence.--Common in collections UU-427 and UU-428.

Holotype.--Cranidium (1511) illustrated on plate 18, figure 8.

Genus ALOKISTOCARE Lorenz, 1906

Alokistocare LORENZ, 1906, p. 62; ROBISON, 1971, p. 802 (synonomy to date).

Amecephalus WALCOTT, 1924, p. 53.

Strotocephalus RESSER, 1935, p. 45.

Type species.--Conocephalites subcoronatus HALL and WHITFIELD, 1877.

Discussion.--The diagnosis of Robison (1971, p. 802) is adequate and is followed here.

Alokistocare is a diverse genus and has a reported range from late Early Cambrian to late Middle Cambrian. Many taxanomic problems are encountered with a genus of about 50 described species, but a detailed evaluation is beyond the scope of this papaer.

Some authors recognize the genus Amecephalus as valid (Rasetti, 1951; Stoyanow, 1952; Lochman, 1952; Kobayashi, 1962; Poulsen, 1958, 1964; and Fritz 1968, 1971) while others (Resser, 1935; Palmer, 1954; Howell, 1969; and Robison, 1971) all consider Amecephalus to be junior synonym of Alokistocare. I tentatively agree that Amecephalus should be suppressed, but the problem deserves a thorough study.

ALOKISTOCARE IDAHOENSE Resser

Pl. 18, figs. 18-21

Alokistocare idahoense RESSER, 1939a, p. 16, Pl. 4, figs. 8, 9.

Alokistocare spencense RESSER, 1939a, p. 16, Pl. 4, figs. 10, 11.

Alokistocare punctatum RESSER, 1939a, p. 17, Pl. 4, figs. 20, 21.

Amecephalus idahoense (Resser) FRITZ, 1968, p. 229.

Amecephalus spencense (Resser) FRITZ, 1968, p. 229.

Diagnosis.--Cephalon semicircular, posterior margin straight. Cranidium subquadrate, gently rounded anteriorly. Glabella fairly prominent, tapered, bluntly rounded anteriorly. Four pairs of faint glabellar furrows visible on well preserved individuals: S1 bifurcate, oblique backwards; S2 oblique backwards; S3 transverse, faint; S4 indistinct, pitlike. Axial and preglabellar furrows distinct. Occipital furrow shallow, composite, deepens laterally. Occipital ring flat, about 0.15 length of glabella, bears small median node. Frontal area long, broad, equal to or slightly shorter (sag.) than glabellar length. Border turned upward medially, slopes down laterally. Low, poorly defined median swelling extends from brim onto border. Fixigenae slightly narrower than glabella at eye line, slightly convex, moderately upsloping. Palpebral lobes about 0.50 length of glabella, opposite middle third of glabella. Eye ridges prominent, slightly arcuate. Posterior area of fixigenae wider than glabella at occipital furrow. Preocular facial suture divergent, convex. Postocular facial suture divergent, sinuous. Librigenae with evenly curved lateral margin. Border slightly concave, narrower than pleural lobes, well defined by dorsal furrow. Pleurae of each segment with distinct pleural furrows and short falcate tips.

Pygidium small, twice as wide as long. Axial lobe prominent, nearly extends to posterior margin. Axis consists of one segment and a terminal piece. Pleural fields convex, furrows indistinct. Border indistinct.

Surface of test covered with prominent punctae. Frontal area of cranidium also covered with variably developed anastomosing lines. Occipital ring may have faint granules. Exfoliated individuals also strongly punctate.

Discussion.--In the above synonomy are listed three of Resser's species that apparently were based on slight differences in preservation, size, variation in the length of the frontal area, and width of the cranidium. Individuals in my collections show that the slight differences noted by Resser are within the limits of intraspecific variation. Resser (1939a, p. 16) states that the outer surface of A. idahoense is finely granular but examination of Resser's collections shows that only the occipital ring and possibly the glabella bear indistinct granules whereas all portions of the outer surface are strongly punctate. This species is characterized by having strongly punctate ornamentation and having 23 or 24 segments.

Occurrence.--Abundant in collections UU-432 and UU-434; common in collections UU-435 and UU-465; rare in collections UU-430, UU-433, UU-437, UU-444, and UU-464.

ALOKISTOCARE LATICAUDUM Resser

Pl. 19, figs. 1-5

Alokistocare laticaudum RESSER, 1939b, p. 17, Pl. 4, figs. 15-19.

Alokistocare euchare RESSER, 1939a, p. 51, Pl. 2, figs. 11, 12.

Poulsenia granuosa RESSER, 1939b, p. 59, Pl. 13, figs. 20, 21 (not figs. 19, 22-30).

Amecephalus laticaudum (Resser) FRITZ, 1968, p. 227, Pl. 40, figs. 17-20.

Diagnosis.--The diagnosis of Fritz (1968, p. 227) is generally adequate and need be modified only slightly to include individuals with scattered large granules in addition to small granules.

Discussion.--I agree with Fritz (1968, p. 227) in placing Alokistocare euchare Resser in synonomy with Alokistocare laticaudum Resser, but Fritz was in error in stating that both species were from the same locality. A. euchare comes from locality 54s (Two Mile Canyon, Idaho) while A. laticaudum comes from locality 55c (five miles southwest of Liberty, 15 miles west of Montpelier, Bear River Range, Idaho) and locality 55e (east of Lakeview Ranch, four and one-half miles east of Hyrum, Bear River Range, Utah).

The holotype cranidium of A. euchare is worn and does not show surface ornamentation. But additional material collected from the type locality shows that A. euchare has small granules and scattered large granules. Specimens of A. laticaudum from Antimony Canyon show similar ornamentation although the large granules are less numerous.

Occurrence.--Common in UU-410. Rare in collections UU-429 and UU-433.

ALOKISTOCARE MCCOLLUMI n. sp.

Pl. 18, figs. 14-17

Diagnosis.--Cranidium subquadrate, moderately rounded anteriorly, slightly convex. Glabella fairly prominent, tapered, bluntly rounded anteriorly, slopes down to low anterior end. Three pairs of glabellar furrows faintly visible on most individuals: S1 and S2 oblique backwards; S3 transverse. Axial furrow distinct, becomes faint anteriorly; preglabellar furrow shallow. Occipital furrow shallow, deepens slightly

laterally. Occipital ring flat, about 0.25 glabellar length, bears small median node. Frontal area about 0.60 glabellar length, broad. Preglabellar field slightly narrower than border, downsloping; faint median swelling extends from preglabellar field onto border. Border well defined, prominent, upturned, narrows slightly laterally. Border furrow distinct, shallow medially. Fixigenae about 0.60 glabellar width at eye line, slightly convex, nearly horizontal. Palpebral lobes prominent, range from 0.50 to 0.65 glabellar length, horizontal or slightly upturned. Eye ridges visible, faint, meet axial furrow just behind anterior end of glabella. Posterior area of fixigenae narrower (tr.) than glabella at occipital furrow. Preocular facial suture divergent, straight. Postocular facial suture divergent, sinuous. Surface covered with fine punctae; some individuals also have faint granules on the glabella and occipital ring.

Discussion.--A. mccollumi is characterized by its small size, well defined border, well developed border furrow, and punctate ornamentation. This species most closely resembles A. nannos, the differences being discussed under the latter species. A. idahoense is also punctate but differs greatly from A. mccollumi in other characters.

Occurrence.--Abundant in collections UU-447 and UU-449. Common in collections UU-452 and UU-454. Rare in collections UU-448, UU-450, UU-451, and UU-453.

Holotype.--Cranidium (1515) illustrated on plate 18, figures 15, 16, and 17.

ALOKISTOCARE MELINDENSIS n. sp.

Pl. 19, figs. 9-11

Diagnosis.--Cranidium subquadrate, moderately rounded anteriorly.

Glabella moderately prominent, keeled, tapered forward, truncated anteriorly. Four pairs of shallow glabellar furrows visible: S1 oblique backwards, convex; S2 oblique backwards; S3 transverse; S4 pitlike. Occipital furrow shallow across midline, composite, deepens laterally. Occipital ring triangular, about 0.25 glabellar length, bears small median node. Axial and preglabellar furrows distinct. Frontal area long, broad. Preglabellar field about same width as border. Low median swelling extends from preglabellar area onto border. Border concave, upturned in front. Border furrow faint but distinct. Fixigenae slightly convex, slope upward. Palpebral lobes prominent, upturned, about 0.50 glabellar length, opposite middle third of glabella. Eye ridges strong, meet axial furrow opposite S4. Posterior area of fixigenae about same width as glabella at occipital furrow. Preocular facial suture divergent, convex. Postocular facial suture divergent, sinuous.

Surface of cranidium covered with dense, fine granules on higher parts and large scattered granules, which are more prominent on frontal area. Frontal area and border are also covered with well developed caecal system. In addition, border is covered with faint punctae.

Discussion.--The cranidium of this species is characterized by having a border that is about the same length (sag.) as the preglabellar field, strong eye ridges, and shallow glabellar furrows. The cranidium is covered with fine granules. In addition the border is finely punctate and the frontal area has scattered large granules. *A. melindensis* most closely resembles *A. mutablis* n. sp., the differences being discussed under that species.

Occurrence.--Rare in collections UU-439 and UU-440.

Holotype.--Cranidium (1524) illustrated on plate 19, figures 9 and 11.

ALOKISTOCARE MUTABLIS n. sp.

Pl. 19, figs. 6-8

Diagnosis.--Cranidium subquadrate, moderately rounded anteriorly, slightly convex. Glabella well defined, tapered, truncated, glabella has faint median indentation anteriorly. Four pairs of weak glabellar furrows: S1 bifurcate, oblique backwards; S2 oblique backwards; S3 transverse; S4 oblique forwards. Axial furrow well defined, preglabellar furrow distinct. Occipital furrow shallow medially, deepens laterally, composite. Occipital ring flat, about 0.25 length of glabella, bears small median node. Frontal area slightly shorter (sag.) than glabella, broad. Preglabellar field nearly twice as long (sag.) as border area. Border arched upwards, narrows laterally. Low median swelling extends from preglabellar field onto border. Fixigenae slightly narrower than glabella at eye line, convex, slightly upturned. Palpebral lobes prominent, about 0.60 glabellar length, upturned, situated slightly behind midpoint of glabella. Eye ridges strong, some individuals have double eye ridge, meets axial furrow opposite S4. Posterior area of fixigenae wider than glabella at occipital furrow. Preocular facial suture divergent, convex. Postocular facial suture divergent, sinuous.

Ornamentation varies with size of individuals. Small individuals are granulose. As individuals increase in size, granules become restricted to the higher parts of the cranidium, and are absent on large individuals. Frontal area has faint caecal system, border becomes punctate as individuals increase in size.

Discussion.--This species is characterized by having a well defined median swelling on the frontal area, a relatively short (sag.) border that narrows rapidly laterally, strong eye ridges, and a finely granular ornamentation. Larger individuals develop fine punctae on the anterior border. A. mutablis most closely resembles A. melindensis, n. sp., but differs from that species by lacking large scattered granules on the frontal area. A. mutablis also has a narrower (sag.) border than A. melindensis.

Occurrence.--Abundant in collection UU-465. Rare in collection UU-432.

Holotype.--Cranidium (1522) illustrated on plate 19, figure 6.

ALOKISTOCARE NANNOS n. sp.

Pl. 19, figs. 12, 13, 16, 17

Diagnosis.--Cranidium subquadrate, moderately rounded anteriorly. Glabella low, gently tapered, rounded anteriorly. Three pairs of faint glabellar furrows visible on most individuals: S1 oblique backwards, straight; S2 oblique backwards; S3 indistinct, transverse. Axial furrow shallow; preglabellar furrow faint. Occipital furrow simple, straight, well defined, deepens laterally. Occipital ring triangular, 0.25 glabellar length, bears small median node. Frontal area about 0.60 glabellar length, slightly concave, downsloping. Border distinctly wider than preglabellar area. Border nearly flat and defined by change in slope or faint border furrow. Fixigenae about 0.50 width of glabella at eye line, slightly convex, nearly flat. Palpebral lobes large, horizontal, greater than 0.50 glabellar length. Eye ridges faint. Posterior area of fixigenae narrower than glabella at occipital furrow.

Preocular facial suture slightly divergent, straight. Postocular facial suture divergent, sinuous.

Higher parts of cranidium covered with fine granules. Frontal area faintly punctate.

Discussion.--This small species is characterized by having a relatively narrow (tr.), short (sag.) frontal area, slightly divergent, straight preocular facial sutures, faint eye ridges, and three pairs of faint glabellar furrows.

A. nannos most closely resembles A. mccolumi but differs from that species in having a better defined glabella, less divergent preocular facial sutures, a less prominent border furrow. A. mccollumi has an anterior border which is tapered laterally, has more prominent punctae, and a faint median swelling in the frontal area.

Occurrence.--Common in collections UU-442 and UU-443

Holotype.--Cranidium (1526) illustrated on plate 19, figures 12, 16, and 17.

Genus ALOKISTOCARELLA Resser, 1938

Alokistocarella RESSER, 1938b, p. 57; HOWELL, 1959, p. 238; BALASHOVA, 1960, p. 107.

Type species.--Alokistocarella typicalis RESSER, 1938b, p. 57, Pl. 7, fig. 43.

Discussion.--The diagnosis by Resser (1938b, p. 57) is followed here. A review of the concept and content of the genus Alokistocarella is needed. However, adequate material is not available to me and a re-evaluation of the genus is beyond the scope of this paper.

ALOKISTOCARELLA BRIGHAMENSIS Resser

Pl. 19, figs. 14, 15, 18, 22, 23

Alokistocarella brighamensis RESSER, 1939b, p. 53, Pl. 13, figs. 17, 18.

Diagnosis.--Cranidium subquadrate, broadly rounded anteriorly, slightly wider than long; moderately convex. Glabella tapers anteriorly, straight sided, bluntly rounded. Axial furrow shallow, preglabellar furrow shallow to faint. Glabellar furrows indistinct on most specimens: two pairs visible on well preserved specimens; up to four pairs visible on well preserved exfoliated individuals. S1 oblique backwards; S2 oblique backwards; S3 transverse; S4 oblique forwards. Occipital furrow shallow at midline, deepens laterally. Occipital ring triangular, bears small median node. Frontal area downsloping, preglabellar field generally slightly wider than border. Incipient median boss present on some individuals. Border delineated by change in slope rather than distinct border furrow. Border nearly flat, narrows laterally. Fixigenae narrower than glabella at eye line; slightly convex and downsloping. Palpebral lobe relatively small, upturned, about 0.35 glabellar length, situated at or slightly behind glabellar midpoint. Eye ridges distinct, slightly arcuate, meet glabella at S4. Posterior limbs about same width as glabella at occipital furrow. Preocular facial suture divergent, straight. Postocular facial suture divergent, sinuous.

The holotype retains 16 thoracic segments and another individual has 15 segments. Axis nearly as wide as pleural field.

Pygidium unknown.

Surface is smooth.

Discussion.--The species description is based mainly on well

preserved individuals from UU-411 at Two Mile Canyon, Idaho. Resser's collections and many of my specimens came from an argillite unit (collection UU-425) in the Wellsville Mountains and are poorly preserved. Differences in preservation at the two areas make comparison of specimens difficult, but I was unable to find any significant differences, and I therefore consider them to be conspecific. Stratigraphic occurrence from the two areas is nearly identical.

Occurrence.--Common in collection UU-425; rare in collection UU-411.

ALOKISTOCARELLA OCCIDENS Resser

Pl. 19, figs. 19-21, 24

Alokistocarella occidens RESSER, 1939b, p. 52, Pl. 2, figs. 13, 14.

Diagnosis.--Cranidium subquadrate, moderately rounded anteriorly. Glabella tapered, slightly convex, bluntly rounded anteriorly. One or two pairs of faint glabellar furrows visible: S1 oblique backwards; S2 indistinct, transverse? Axial and preglabellar furrows faint. Occipital furrow moderately deep, simple. Occipital ring triangular, bears a small median node. Frontal area long (sag.) downsloping, concave. Preglabellar field downsloping, narrower than border. A low boss is present in the preglabellar area. Border furrow shallow, becomes more shallow medially where it crosses the median boss. Border distinctly upturned, becomes narrower laterally. Fixigenae about 0.60 width of glabella at eye line, slightly convex downsloping. Palpebral lobes relatively large about 0.50 length of glabella, slightly upturned. Eye ridges visible but faint, slightly arcuate. Posterior limbs narrower than glabellar width at occipital furrow. Preocular facial suture strongly divergent, straight. Postocular facial suture divergent,

sinuous.

Surface of cranidium finely punctate. Anterior area of fixigenae and preglabellar field also covered with faint anastomosing lines.

Discussion.--This species is characterized by a relatively broad, concave frontal area, faint eye ridges, indistinct glabellar furrows, strongly divergent preocular facial sutures and well developed punctate ornamentation. A. occidens differs from A. brighamensis by having weaker glabellar furrows, a less well developed occipital furrow, more rapidly divergent preocular facial sutures and punctate ornamentation. A. brighamensis has a more strongly tapered glabella.

Occurrence.--Rare in collection UU-411.

ALOKISTOCARELLA? sp. undet.

Pl. 20, figs. 1, 2, 5

Diagnosis.--Cranidium subquadrate, moderately convex. Glabella prominent, slightly tapered, bluntly rounded anteriorly. Up to four pairs of faint glabellar furrows visible: S1 oblique backwards, straight, deepens medially to form a faint pit; S2 transverse; S3 oblique forwards; S4 oblique forwards. Axial furrow moderately deep; preglabellar furrow shallow. Occipital furrow shallow, composite, deepens laterally. Occipital ring less than 0.25 glabellar length, bears a small node. Preglabellar field downsloping, narrower than border, faint median boss extends onto border. Border flat or slightly upturned, narrows slightly laterally. Border furrow shallow to faint. Fixigenae slightly less than 0.50 glabellar width at eye line, moderately convex, nearly horizontal. Palpebral lobes strong, upturned, 0.50 glabellar length; situated behind glabellar midpoint. Eye ridges distinct, slightly arcuate, touches axial furrow opposite S4. Poste-

rior area of fixigenae narrower than glabella at occipital furrow. Preocular facial suture divergent, straight. Postocular facial suture divergent, straight.

Discussion.--This species is known from two small but fairly well preserved cranidia. They are characterized by four pairs of weak glabellar furrows, a downsloping frontal area with a low median boss, strongly divergent preocular facial sutures and a slight indentation in the front of the glabella. In over all aspects these cranidia seem most closely related to Alokistocarella and are tentatively assigned to that genus. However, the palpebral lobes are larger and the frontal area shorter (sag.) than "typical" species of Alokistocarella. Without a larger population, the significance of the indentation in the front of the glabella is difficult to assess. Neither of the two individuals at hand are judged adequate to serve as the holotype for a new species.

Occurrence.--Rare in collection UU-443.

Genus BYTHICHEILUS Resser, 1939

Bythicheilus RESSER, 1939a, p. 22; HOWELL, 1959, p. 238; FRITZ, 1968, p. 229.

Type species.--Bythicheilus typicum RESSER, 1939a, p. 22, Pl. 6, figs. 1-4.

Discussion.--The diagnosis by Resser (1939a, p. 22) is adequate and is followed here. Bythicheilus is characterized by a narrow, upturned border and a prominent depression in front of the glabella. As Fritz (1968, p. 229) noted, the importance of the depression on the preglabellar field is difficult to assess because Resser's specimens are deformed. However, undeformed specimens of B. typicum from Antimony Canyon show that the depression is consistent and diagnostic.

BYTHICHEILUS TYPICUM Resser

Pl. 20, figs. 3, 4, 6-9, 12, 16

Bythicheilus typicum RESSER, 1939b, p. 22, Pl. 6, figs. 1-4.

Bythicheilus aluratum RESSER, 1939b, p. 22, Pl. 6, figs. 8-10.

Diagnosis.--Cephalon semicircular; cranidium semielliptical. Glabella well defined, slightly tapered, truncated. Three pairs of faint glabellar furrows visible on well preserved specimens: S1 bifurcate, oblique backwards; S2 transverse; S3 oblique forwards. Occipital furrow relatively shallow, deepens laterally. Occipital ring less than 0.25 length of glabella; bears a small median node. Axial furrow well developed, becomes less distinct anteriorly. Preglabellar furrow deep, forms depression in the preglabellar area that is more pronounced on exfoliated specimens. Frontal area slightly concave, preglabellar area narrower than border. Border upturned, striated, defined by rather faint border furrow which is weaker at midline. Fixigenae narrower than glabella at eye line; slightly convex, nearly flat. Palpebral lobes well defined; slope downward; longer than 0.35 glabellar length. Palpebral lobes situated slightly behind glabellar midpoint. Palpebral furrows indistinct. Eye ridges faint, more prominent on exfoliated specimens and individuals preserved in limestone. Posterior area of fixigenae not as wide as glabella at occipital furrow; narrow (exsag.). Preocular facial suture slightly divergent, straight. Postocular facial suture divergent, sinuous. Librigenae narrow, border moderately wide, genal spines moderately long.

Thorax has 13 or 14 segments. Axis distinctly narrower than pleural regions. Pleurae convex with well developed pleural furrows;

end distally in blunt spines.

Pygidium small, over twice as wide as long. Axis tapered, consists of one ring and terminal piece. Pleural and interpleural furrows indistinct. Border poorly defined.

Surface covered with small, faint granules. Some well preserved individuals also show a few scattered larger granules. Frontal area covered with faint anastomosing lines.

Discussion.--Bythicheilus typicum and B. alveatum are here considered to be conspecific. Resser (1939b, p. 22) differentiated B. alveatum from B. typicum on characters of the preglabellar area, the border, and strength of eye ridges. Representatives of both species have been distorted by compaction in shale, and the variation between individuals is attributed to distortion, preservation, and intraspecific variation.

Nearly all specimens that Resser assigned to B. alveatum are exfoliated, whereas the specimens that he assigned to B. typicum are not exfoliated. Comparison of nonexfoliated paratype individuals of each species has shown that actual differences are minor, and in my opinion do not warrant taxonomic separation.

Occurrence.--Abundant in collections UU-432, UU-433, UU-434, UU-437, and UU-465. Common in collection UU-435. Rare in collections UU-427, UU-429, UU-430, UU-436, UU-438, UU-439, UU-440, and UU-462.

Genus CABORCELLA Lochman, 1948

Caborcella LOCHMAN, 1948, p. 461; HOWELL, 1959, p. 233.

Type species.--Caborcella arroyosensis LOCHMAN, 1948, p. 461-462, Pl. 70, figs. 19-21.

Diagnosis.--The diagnosis of Palmer (in press) is repeated here:

> Moderate sized kochaspid trilobites with known cranidial length up to 15 mm. Cranidium gently to moderately convex transversely and longitudinally. Glabella prominent, tapered, strongly to bluntly rounded at front, well defined at sides by deep axial furrow and at front by abrupt change in exoskeletal slope or shallow preglabellar furrow. Three or four pairs of well defined, generally deep glabellar furrows present; posterior pair deepest, curved or straight. Occipital furrow deep, deepest distally. Occipital ring simple. Frontal area generally concave. Brim very narrow sagitally. Border broad, poorly defined, concave, bearing poorly to well developed pseudofurrow. Sagittal length of frontal area ranges from slightly less than one-third to about two-thirds sagittal glabellar length exclusive of occipital ring. Fixed cheeks flat or convex, horizontal or upsloping; prominent ocular ridge usually present; width of palpebral area between one-half and two-thirds basal glabellar width. Palpebral lobes well defined, situated opposite or slightly posterior to glabellar midlength; exsagittal length about one-third sagittal glabellar length exclusive of occipital ring. Posterior limbs about equal in transverse length to basal glabellar width. External surface with granular ornamentation.
>
> Course of anterior section of facial suture nearly straightforward from palpebral lobe. Course of posterior section divergent, sinuous.
>
> Associated parts not known.

Discussion.--Lochman gave a good diagnosis of this genus. Subsequently, Rasetti (1951) and Fritz (1968) assigned several new species to the genus including Poulsenia granosa Resser, which Lochman had excluded. Based on differences in the structure of the frontal area Palmer (in press) has retained species with poorly defined, concave borders in Caborcella, and has assigned species with deep border furrows and convex border to a new genus, Nyella.

CABORCELLA CRACENS n. sp.

Pl. 20, figs. 10, 11, 13-15

Diagnosis.--Cranidium subquadrate, convex. Glabella prominent,

highly convex, strongly tapered, bluntly rounded anteriorly. Three pairs of glabellar furrows visible: S1 convex, oblique backwards, reaches occipital furrow; S2 convex, oblique backwards; S3 transverse. Axial furrow deep, preglabellar furrow distinct, shallow. Occipital furrow deep, straight, deepens laterally. Occipital ring prominent, triangular, slopes upward posteriorly, lacks spine or node. Frontal area concave, preglabellar field about same width as border. Border narrow (sag.), strongly upturned. Border defined by an abrupt change in slope rather than distinct border furrow. Fixigenae about 0.60 glabellar width at eye line, slightly convex, strongly upsloping. Palpebral lobes prominent, about 0.30 glabellar length, strongly upturned, situated slightly behind glabellar midpoint. Palpebral furrows indistinct. Eye ridges well developed, long, meet axial furrow in front of S3. Posterior area of fixigenae wider than glabella at occipital furrow. Preocular facial suture divergent, convex. Postocular facial suture divergent, convex.

Higher parts of cranidium covered with scattered large granules and abundant fine granules. Lower parts of cranidium and furrows covered with faint granules, faint punctae or both.

Discussion.--This species is characterized by a concave frontal area, relatively narrow upturned border, strongly tapered glabella, strongly upturned fixigenae, and an upsloping occipital ring. It differs from all other species of Caborcella (as restricted by Palmer, in press) by having an exoskeleton covered with large coarse granules and scattered finer granules.

Occurrence.--Common in collection UU-465. Rare in collection UU-434.

Holotype.--Cranidium (1535) illustrated on plate 20, figures 10, 11, and 13.

Genus CHANCIA Walcott, 1924

Chancia WALCOTT, 1924, p. 55; WALCOTT, 1925, p. 80; SHIMER and SHROCK, 1944, p. 609; RASETTI, 1951, p. 212; HOWELL, 1959, p. 239; PALMER, 1968, p. 69.

Type species.--Chancia ebdome WALCOTT, 1924, p. 55, Pl. 10, fig. 4.

Discussion.--Walcott (1925, p. 80) gave a good description of the generic characters of Chancia. Rasetti included in Chancia species having both concave and convex borders, but Palmer (1968, p. 69) placed the species with convex borders in the genus Prohedinia. As restricted, Chancia has a broad concave cranidial border and is found only in beds of early to medial Middle Cambrian age.

CHANCIA CORIACEA (Resser)

Clappaspis coriacea RESSER, 1939b, p. 20, Pl. 6, figs. 11-12.

Chancia coriacea (Resser) FRITZ, 1971, p. 44.

Diagnosis.--Cranidium subquadrate. Glabella prominent, tapered, bluntly rounded anteriorly. Four pairs of lateral glabellar furrows evident on exfoliated glabella: S1 to S3 oblique backwards; S4 pit-like. Axial and preglabellar furrows deeply impressed. Occipital furrow moderately deep, narrow, deepens laterally. Occipital ring, poorly preserved, appears to be relatively narrow and triangular. Frontal area downsloping; preglabellar field convex and slightly greater than 0.35 glabellar length. Border furrow well developed, border prominent, upturned, becomes narrower laterally. Fixigenae slightly narrower than

glabella at eye line, slightly convex, nearly flat. Palpebral lobes prominent, slope upward, 0.35 length of glabella, opposite middle third of glabella. Eye ridges prominent, intersect axial furrows at S4. Preocular facial suture slightly convergent, convex. Postocular facial suture divergent, sinuous. Surface covered with large scattered granules and smaller closely-spaced granules. Exfoliated specimens punctate.

Discussion.--I agree with Fritz (1971, p. 44) in his assignment of this species to Chancia. The diagnosis is based on the holotype, which is almost completely exfoliated. When Resser photographed the holotype it retained more of the carapace and showed coarse and small granules, but since that time the holotype has lost most of its carapace because of latexing, and the surface detail is not evident from the actual specimen.

Occurrence.--Resser's type material from locality 55c.

CHANCIA EBDOME Walcott

Pl. 20, figs. 17-19

Chancia ebdome WALCOTT, 1924, p. 55, Pl. 10, fig. 4; WALCOTT, 1925, p. 80, Pl. 17, fig. 26; RESSER, 1939a, p. 17, Pl. 4, figs. 12-14. Chancia angusta RESSER, 1939a, p. 18, Pl. 5, figs. 13, 14.

Diagnosis.--Cranidium subquadrate, slightly wider than long, original convexity unknown due to distortion in shale. Glabella rounded to truncated anteriorly. Three pairs of glabellar furrows visible: S1 oblique backwards, convex; S2 oblique backwards; S3 transverse. Axial and preglabellar furrows moderately deep. Occipital furrow well defined, nearly straight, deepens laterally. Occipital ring about 0.20 glabellar length, bears a small median node. Frontal area nearly 0.75 length of

glabella, slightly concave. Preglabellar area distinctly longer (sag.) than border. Border slightly upturned, narrows laterally. Fixigenae slightly narrower than glabella at eye line, slightly convex and upsloping. Palpebral lobe moderately small, about 0.30 glabellar length, situated opposite middle third of glabella. Eye ridges moderately strong, nearly straight. Posterior area of fixigenae about same width as glabella at occipital furrow. Preocular facial suture moderately divergent, straight. Postocular facial suture divergent, slightly convex.

Thorax has 20 segments, pleural regions wider than axis. Pleurae end distally in short, blunt spines.

Pygidium small, poorly preserved, over twice as wide as long. Axis tapered, does not reach posterior margin of pygidium; consists of one or possibly two faint segments and a terminal piece. Pleural regions downsloping crossed by two faint pleural furrows. Border obsolescent.

Surface of carapace finely to moderately granulose.

Discussion.--Resser (1939a, p. 18) named Chancia angusta and stated that it differed from C. ebdome in having a narrower cranidium and being more finely granulose. Examination of Resser's specimens shows that the cranidia are slightly smaller but are not narrower than cranidia of C. ebdome. Surface ornamentation of C. ebdome is slightly more granulose on some individuals but other paratype individuals are identical to C. angusta. Both species come from the same locality and are here considered conspecific.

Occurrence.--Resser's type material from locality 55c.

CHANCIA cf. C. EBDOME

Pl. 21, figs. 1, 2

Discussion.--This species is represented by three poorly preserved cranidia from Antimony Canyon. The individuals agree well with C. ebdome in most respects. The preocular facial suture however, is distinctly less divergent. Because of poor preservation and small number of specimens, such a small difference does not warrant naming a new species unless it should prove to be a constant feature of specimens at that horizon and locality.

Occurrence.--Three cranidia in collection UU-430.

CHANCIA VENUSTA (Resser)

Pl. 21, figs. 3-6

Kochina venusta RESSER, 1939a, p. 53, Pl. 6, figs. 9, 10

Chancia venusta (Resser) FRITZ, 1968, p. 230, Pl. 40, figs. 31-34.

Discussion.--The diagnosis by Fritz (1968, p. 230) is adequate and is followed here. I agree with Fritz (1968, p. 230) in his assignment of this species to Chancia. The long preglabellar field and the short, quadrate glabella are considered to be diagnostic of the genus Chancia.

Occurrence.--Common in collection UU-408; rare in collection UU-420.

Genus EHMANIELLA Resser, 1937

Ehmaniella RESSER, 1937, p. 10; PALMER, 1954, p. 75-76; HOWELL, 1959, p. 239.

Clappaspis DEISS, 1939, p. 78.

Type species.--Crepicephalus (Loganellus) quadrans HALL and WHITFIELD, 1887, p. 238, Pl. 2, figs. 11-13.

Discussion.--Palmer (1954, p. 75-76) has thoroughly described and

discussed this genus.

EHMANIELLA PETALORA n. sp.

Pl. 21, figs. 7, 9-11, 14, 15

Diagnosis.--Cranidium subquadrate, broadly rounded anteriorly, moderately convex. Glabella prominent, tapers, rounded anteriorly. Three pairs of faint glabellar furrows visible: S1 oblique backwards; S2 oblique backwards; S3 transverse. Axial furrows distinct; preglabellar furrow shallow. Occipital furrow narrow, moderately deep. Occipital ring about 0.35 length of glabella, bears a small median node. Frontal area concave, about 0.50 glabellar length; preglabellar field slightly convex, downsloping. Border strong, upturned?; maintains nearly constant width. Border delineated by a strong border furrow. Border slightly narrower than preglabellar field. Fixigenae slightly narrower than glabella at eye line, slightly convex, nearly flat. Palpebral lobes well developed, slightly upturned, opposite middle third of glabella, nearly 0.50 length of glabella. Eye ridges moderately strong, slightly arcuate. Posterior area of fixigenae slightly narrower than glabella at occcipital furrow. Preocular facial suture divergent, straight. Postocular facial suture divergent, sinuous.

Thorax not known.

Pygidium small, twice as wide as long. Axis tapers posteriorly, does not extend to posterior border, consists of two rings and a terminal piece. Pleural regions downsloping, crossed by three pairs of pleural furrows and two pairs of less distinct interpleural furrows. Border indistinct.

Surface of cranidium densely covered with granules of varied sizes. Pygidium covered with scattered granules.

Discussion.--Ehmaniella petalora is characterized by a relatively long (sag.) frontal area, a conical glabella, faint glabellar furrows, a broadly rounded anterior margin, and dense granular ornamentation. E. petalora has a much larger frontal area, weaker glabellar furrows, and a more rounded anterior margin than either E. stibinus or ?E. spencei.

Occurrence.--Abundant in collection UU-460.

Holotype.--Cranidium (1544) illustrated on plate 21, figures 9 and 11.

EHMANIELLA STIBINUS n. sp.

Pl. 21, figs. 12, 13, 16

Diagnosis.--Cranidium subtrapezoidal, original convexity unknown due to distortion in shale. Glabella prominent, slightly tapered, bluntly rounded anteriorly. Four pairs of glabellar furrows visible: S1 bifurcate, oblique backwards; S2 oblique backwards; S3 transverse; S4 oblique forwards. Occipital furrow well defined, simple, deepens slightly laterally. Occipital ring about 0.20 length of glabella, seems to lack a spine or node. Axial and preglabellar furrows distinct, about equal in development. Frontal area downsloping, about 0.30 length of glabella. Preglabellar field same width as border. Border distinct, slightly thickened, nearly horizontal, not tapered. Fixigenae narrower than glabella at eye line, original convexity unknown. Palpebral lobes slightly greater than 0.35 glabellar length, upturned, situated in front of glabellar midpoint. Eye ridges fairly prominent, meet glabella at nearly a right angle. Posterior limb wide (exsag.); slightly wider than glabella at occipital furrow. Preocular facial suture slightly divergent, straight. Postocular facial suture divergent,

convex.

Pygidium distinctly wider than long. Axis prominent, consists of three rings and a short terminal piece, not extended to posterior margin. Pleural region crossed by two pairs of pleural and interpleural furrows. Border indistinct, rear margin with a slight median indentation. Distal margins of downsloping pleural lobes flexed outward.

Surface of cranidium and pygidium covered with large scattered granules and a dense set of fine granules.

Discussion.--Ehmaniella stibinus is characterized by a short (sag.) frontal area, relatively strong glabellar furrows, palpebral lobes situated in front of glabella, and distinctive granular ornamentation.

Occurrence.--Abundant in collection UU-461.

Holotype.--Cranidium (1547) illustrated on plate 21, figure 12.

?EHMANIELLA SPENCEI (Resser)

Pl. 21, figs. 17-21

Clappaspis spencei RESSER, 1939b, p. 20, Pl. 6, figs. 5, 6.

Clappaspis idahoensis RESSER, 1939b, p. 20, Pl. 6, figs. 26, 27.

Clappaspis lanata RESSER, 1939b, p. 20, Pl. 6, fig. 7.

Clappaspis dotis RESSER, 1939b, p. 21, Pl. 6, figs. 13, 14.

Ehmaniella spencei (Resser) FRITZ, 1971, p. 43.

Diagnosis.--Cranidium subtrapezoidal. Glabella prominent, convex, distinctly tapered, bluntly rounded anteriorly. Four pairs of glabellar furrows evident: S1 oblique backwards; S2 oblique backwards; S3 transverse; S4 faint or absent, pithole. Occipital furrow moderately shallow, deepens laterally. Occipital ring narrow (sag.); does not bear spine or node. Frontal area about 0.35 length of glabella. Pregla-

bellar field wider than border, downsloping. Border furrow deep; border strong, thickened, slightly upturned. Border maintains nearly constant width. Fixigenae average 0.75 width of the glabella at eye line; moderately convex; downsloping. Palpebral lobes small, upturned opposite middle third of glabella; less than 0.25 glabellar length. Eye ridges faint; meet axial furrow opposite S4. Posterior limbs about equal to width of glabella at occipital furrow. Preocular facial suture parallel to slightly convergent, straight. Postocular facial suture divergent, sinuous.

Thorax has 14 segments. Pleural regions wider than axis. Each pleurae crossed by a strong pleural furrow. Distal ends of pleural segments rounded.

Pygidium with axial length slightly less than 0.50 width. Axis slightly tapered posteriorly, does not extend to posterior margin; consists of three rings and a terminal piece. Pleural field crossed by three pleural and two less distinct interpleural furrows. Border indistinct.

Surface covered with scattered large granules and a dense set of finer granules. Inner surface finely punctate.

Discussion.--Resser (1939b) recognized four species (see synonomy) from a single locality, based on slight differences in ornamentation, relief, and width of cranidium. I believe that these differences are due to preservation and intraspecific variation. Within this group individuals that Resser assigned to a single species often show more variation than individuals of different species.

Ehmaniella spencei differs from typical species of Ehmaniella in having parallel or slightly convergent preocular facial sutures. The

pygidium is not typical of Ehmaniella because its axis extends to the posterior margin. This species is only questionably assigned to Ehmaniella because of these differences.

Occurrence.--Resser's type material from locality 55c.

Genus ELRATHINA Resser, 1937

Elrathina RESSER, 1937, p. 11; DEISS, 1939, p. 87; SHIMER and SHROCK, 1944, p. 611; HOWELL, 1959, p. 240; BALASHOVA, 1960, p. 105; ZHURALEVA, 1970, p. 37.

Type species.--Conocephalites cordillerae ROMINGER, 1887, p. 17, Pl. 1, fig. 7.

Diagnosis.--Micropygous ptychopariids, suboval overall outline. Cranidium subtriangular. Glabella slightly tapered, parallel-sided, or slightly concave-sided; may be bluntly or roundly terminated anteriorly. Axial furrow moderately deep. Glabella may bear up to three pairs of weak furrows. Occipital ring of usual proportions, bears a median node. Fixigenae moderately wide, ranging in transverse width from slightly over 0.50 to over 0.70 the glabellar length. Frontal area narrow, ranging in sagittal length from almost absent to 0.25 glabellar length. Border narrow, sagittal length averaging slightly less than 0.25 glabellar length. Border furrow may be shallow to moderately deep. Palpebral lobes short (exsag.), averaging 0.35 glabellar length; set opposite point anterior to glabellar midpoint. Posterior area of fixigenae about same width as furrow. Preocular facial sutures convergent, convex. Postocular facial sutures divergent, sinuous.

Thorax contains 17 to 19 segments, the number being variable within species. Axis prominent, narrower than pleurae, set off by moderately

deep furrows. Pleurae bear pleural furrows terminating slightly before the distal tips. Distal terminations bear vestigial spines, slightly pointed. Pleural geniculations variable, 0.35 to 0.65 distally from the axial furrow. Librigenae semicircular, bear vestigial genal spines. Hypostome and rostral plate unknown. Pygidium very small, bears one or two axial rings, one pleural furrow; greatest width about twice sagittal length. Surface of test smooth or faintly granular.

Discussion.--Elrathina is clearly distinct from all other Middle Cambrian ptychopariids because of its short palpebral lobes, converging anterior facial sutures, multisegmentation, narrow brim, tiny pygidium, and wide vestigially spinose pleurae and librigenae.

ELRATHINA SPENCEI (Resser)

Pl. 22, figs. 1-4, 6, 7

Elrathia spencei RESSER, 1939b, p. 18, Pl. 6, figs. 15-17.

Elrathina spencei (Resser) ROBISON, 1964, p. 541.

Diagnosis.--Cephalon semicircular; cranidium subtrapezoidal, moderately convex. Glabella prominent, slightly tapered, bluntly rounded anteriorly. Four glabellar furrows visible, faint: S1 bifurcate, oblique backwards, almost reaches occipital furrow; S2 oblique backwards, convex; S3 transverse; S4 indistinct. Axial furrow deep; preglabellar furrow less distinct. Occipital furrow moderately deep, simple, straight. Occipital ring about 0.25 glabellar length, with a faint median node. Frontal area slightly greater than 0.35 glabellar length. Border nearly straight (tr.), width (sag.) less than preglabellar length at midline; border narrows laterally. Fixigenae 0.50 to 0.60 glabellar width at eye line, slightly convex, downsloping. Palpebral lobes small, about 0.25 length of glabella, slightly upturned, opposite middle third of

glabella. Eye ridge faint. Posterior area of fixigenae moderately long, fairly wide. Preocular facial suture convergent, slightly convex; postocular facial suture divergent, sinuous. Librigenae with well defined narrow border. Genal field nearly flat, downsloping. Genal spine short and directed posterolaterally.

Thorax has 17 segments. Axial lobe narrower than pleural regions. Pleurae end in wide, short, recurved spines.

Pygidium small, semielliptical, twice as wide as long. Axis nearly parallel-sided, consists of one ring and terminal piece. Pleural fields crossed by two pleural furrows. Border indistinct, appears to have indentation in rear margin.

Surface covered with scattered large granules and numerous small granules. In addition the frontal area is covered with faint caecal lines. Development of ornamentation is quite variable, but is faint on most individuals and is more distinct on individuals preserved in limestone.

Discussion.--Robison (1964, p. 541) correctly considered Elrathia spencei to be congeneric with Elrathina. Several specimens of Elrathina in collections UU-412 and UU-425 are referred to Elrathina cf. E. spencei. These individuals probably are conspecific with Elrathina spencei, but that possibility cannot be verified without better preserved material.

Occurrence.--Abundant in collections UU-427, UU-428, UU-429, and UU-432.

Genus KOCHIELLA Poulsen, 1927

Kochiella POULSEN, 1927, p. 259; SHIMER and SHROCK, 1944, p. 613;

RASETTI, 1951, p. 227-228; LOCHMAN, 1956, p. 1392; HOWELL, 1959, p. 240; POULSEN, 1964, p. 19-21.

Type species.--Kochiella tuberculata POULSEN, 1927, p. 259, Pl. 15, figs. 7-13, 16.

Discussion.--The diagnosis by Poulsen (1927, p. 259) as modified by Resser (1935, p. 38) is adequate and is followed here.

Poulsen (1927, p. 259) established four species of Kochiella based on cranidia. The pygidia were unknown, but a pygidium that Poulsen referred to Crepicephalus cf. cecinna Walcott was later assigned to K. tuberculata by Resser (1935). Although Rasetti (1951, p. 227) questioned this assignment, Poulsen (1964, p. 19) who restudied the fauna, agreed with Resser. It thus appears that the type species of Kochiella has an Alokistocare-like cranidium and a spinose pygidium. Rasetti (1955) concluded that Middle Cambrian forms from the Cordilleran Province, with cranidia similar to those of Kochiella could not be assigned to Kochiella with certainty until a pygidium could be assigned to these forms. Resser's assignment of a spinose pygidium to K. mansfieldi from the "Ptarmigania Strata" has caused much confusion. Examination of the type material showed that the pygidia were misassigned and actually belong to Albertelloides. Poulsen (1964, p. 19-21) removed several North American species from the genus Kochiella and because no pygidia can now be assigned to K. mansfieldi with certainty, it seems doubtful that any Middle Cambrian species from the Cordilleran Province are referable to Kochiella.

KOCHIELLA? MANSFIELDI Resser

Pl. 22, figs. 10, 11, 12

Kochiella mansfieldi RESSER, 1939b, p. 57, Pl. 11, figs. 12, 13, (not

figs. 10, 11, 14); RASETTI, 1951, p. 227.

Diagnosis.--Cranidium subquadrate, slightly wider than long, slightly convex. Glabella low, tapered, truncated anteriorly. Four pairs of faint glabellar furrows visible: S1 convex, oblique backwards; S2 transverse; S3 slightly oblique forward; S4 indistinct. Axial and preglabellar furrows shallow, distinct, shallow fossulae present. Occipital furrow shallow, occipital ring about 0.20 glabellar length, may have had a median node. Frontal area broad, flat or slightly concave, same length as glabella. Preglabellar field about 0.50 length (sag.) of border, slightly downsloping. Border prominent, horizontal or gently arched upward. Border furrow shallow, distinct, nearly straight or with indistinct inbend medially. Fixigenae about 0.75 width of glabella at eye line, nearly flat, gently upsloping. Palpebral lobes prominent, about 0.40 glabellar width, upsloping. Eye ridge well developed, slightly arcuate, meets axial furrow opposite S4. Posterior area of fixigenae wider than glabella at occipital furrow. Preocular facial suture slightly divergent, convex. Postocular facial suture divergent, sinuous. Surface covered with scattered large granules and small closely spaced granules. Frontal area has faint caecal system.

Discussion.--Poulsen (1927, p. 259) described the genotype of Kochiella from the Lower Cambrian of northwest Greenland. He did not assign a pygidium to the genus, but did describe a spinose pygidium from the same beds. Resser (1935, p. 39) assigned this pygidium to Kochiella and then described several Middle Cambrian species of Kochiella as combinations of Alokistocare-like cranidia and a spinose pygidium. Rasetti (1951, p. 227) in discussing the genus states, "At least in certain instances, e.g. K. mansfieldi (Resser, 1939b, p. 57), the

association appears warranted by the existing material." After examination of Resser's collections, it is evident that pygidia that Resser assigned to K. mansfieldi actually belong to Albertelloides. Albertelloides cranidia are also present in Resser's collections. There remain no pygidia assignable to K. mansfieldi, which makes it plausible that this part of the shield was small and featureless as in Alokistocare. If this is proved to be correct, possibly Alokistocare would be the proper generic assignment for the form under discussion.

However, cranidium of K. mansfieldi do have a slight medial backward expansion that is characteristic of the genus Kochiella, and are questionably referred to that genus until a pygidium can be definitely assigned.

Occurrence.--Resser's type material from locality 19s.

Genus KOCHINA Resser

Kochina RESSER, 1935, p. 39-40; HOWELL, 1959, p. 240.

Type species.--Olenopsis americanus (Walcott), 1912, p. 243, Pl. 36, figs. 8-11.

Discussion.--The generic description given by Resser (1935) is adequate. The most notable characteristics of the genus seem to be the narrow, slightly concave-sided glabella, medially widened border and granular ornamentation. The genus remains only poorly understood, especially with respect to its relationship to Kochiella and several other early Middle Cambrian ptychopariids.

KOCHINA VESTITA Resser

Pl. 22, figs. 5, 8, 9

Kochina vestita RESSER, 1939b, p. 53, Pl. 12, figs. 7-8.

Kochina wasatchensis RESSER, 1939b, p. 54, Pl. 12, figs. 12-14.

Diagnosis.--Cranidium large, subquadrate, with tapered, bluntly rounded glabella. Three weak glabellar furrows: S1 oblique backwards; S2 transverse, faint; S3 oblique forwards. Glabella is slightly keeled. Occipital furrow strong, occipital ring bears a small node. Width of fixigenae equal to or slightly less than width of glabella at eye line. Eye ridges well developed. Palpebral lobes small and situated well behind the midpoint of the cranidium. Fixigenae are gently convex. The preglabellar field less than or equal to the width (sag.) of the border. Border concave, thickened in cross section, widened sagittally. Thickening of border varies between individuals. Preocular facial suture slightly convergent, convex. Postocular facial suture divergent, sinuous.

Surface finely granulose, overlain by scattered larger granules, preglabellar field has faint anastomosing lines which are more prominent on exfoliated specimens. Exfoliated species are fairly punctate.

Discussion.--In describing specimens similar to these, Resser (1939b) recognized two species (see synonomy) from the same locality at Malad, Idaho, based upon slight differences in ornamentation, relief, and size. I believe these differences can be attributed to differences in preservation and ontogenetic variation.

Occurrence.--Five cranidia from collection UU-411.

Genus MALADELLA n. gen.

Type species.--Maladella oculatus n. sp.

Diagnosis.--Cranidium subquadrate, moderately convex. Glabella prominent, tapered, bluntly rounded anteriorly. Three pairs of

glabellar furrows visible: S1 convex, oblique backwards; S2 straight, oblique backwards; S3 transverse or slightly oblique forwards. Axial furrow very deep, prominent, preglabellar furrow distinct. Occipital furrow relatively wide, moderately deep, deepens and narrows laterally. Occipital ring 0.20 to 0.25 glabellar length, triangular, extends into fairly strong upsloping occipital spine. Frontal area slightly greater than 0.50 glabellar length, downsloping, slightly concave medially, becomes convex laterally. Preglabellar field slightly wider (sag.) than border. Border prominent, slightly upturned, narrows laterally; has low posteromedian boss. Border furrow moderately deep laterally, becomes less distinct medially where adjacent to boss. Fixigenae about 0.35 glabellar width at eye line, strongly upsloping, moderately convex. Palpebral lobes large, prominent, strongly upturned, slightly less than 0.50 glabellar length situated opposite midpoint of glabella, eye ridges visible, faint. Posterior area of fixigenae narrower than glabella at occipital furrow. Preocular facial suture parallel, straight. Postocular facial suture divergent, straight.

Surface of cranidium densely covered with medium or large granules.

Discussion.--Maladella is characterized by a relatively long (sag.) frontal area, narrow (tr.) and strongly upsloping fixigenae, large and strongly upturned palpebral lobes, and a moderately strong occipital spine. This genus somewhat resembles Alokistocare, but differs in having a moderately strong occipital spine and large, prominent palpebral lobes.

MALADELLA OCULATUS n. gen. n. sp.

Pl. 25, figs. 7, 8, 10, 11

Discussion.--Because this is the only known species of Maladella, the generic diagnosis and discussion also suffice for the species.

Occurrence.--Rare in collection UU-408.

Holotype.--Cranidium (1596) illustrated on plate 25, figures 7, 10, and 11.

Genus MEXICELLA Lochman, 1948

Mexicella LOCHMAN, 1948, p. 456; HOWELL, in HARRINGTON and others, 1959, p. 240.

Type species.--Mexicella mexicana LOCHMAN, 1948, p. 457, Pl. 69, figs. 12-22.

Discussion.--Lochman (1948, p. 456) has given a thorough analysis of the characteristics of this genus. Slight modification of the generic diagnosis is required to include a new species of M. grandoculus, (Palmer, in press) with palpebral lobes whose exsagittal length is nearly equal to 0.50 of the sagittal glabellar length exclusive of the occipital ring. All species of Mexicella are characterized by a sagittally long, swollen frontal area with a poorly defined border that is narrower than the brim; and by wide, gently convex, slightly downsloping fixigenae.

MEXICELLA GRANOSA n. sp.

Pl. 22, figs. 13, 14, 15, 17

Diagnosis.--Cranidium subquadrate, moderately convex, broadly rounded anteriorly. Glabella short, conical, truncated; tapers to a low anterior end. Three pairs of faint glabellar furrows visible: S1 oblique backwards; S2 transverse; S3 indistinct, oblique forwards. Occipital furrow shallow, deepens slightly laterally. Occipital ring

triangular, about 0.25 glabellar length, bears small median node. Axial and preglabellar furrows deep, prominent. Frontal area wide, convex, with prominent broad median bulge. Border narrower than preglabellar area, convex, barely defined by faint border furrow that becomes more distinct laterally. Fixigenae narrower than glabella at eye line, slightly convex, nearly horizontal. Palpebral lobes small, situated at about midline of glabella. Eye ridges prominent, slightly arcuate. Posterior area of fixigenae about same width as glabella at occipital furrow. Preocular facial suture convergent, convex. Postocular facial suture divergent, convex. Surface densely covered with medium-sized granules, and frontal area has faint to distinct caecae.

Discussion.--Mexicella granosa can be distinguished from other species of Mexicella by its low glabella, deep axial furrow, and prominent, convex frontal area. This species is included in Mexicella because of its large, convex, poorly differentiated frontal area.

Occurrence.--Abundant in collections UU-403, UU-404, and UU-405. Rare in UU-402, UU-407, and UU-466.

Holotype.--Cranidium (1557) illustrated on plate 22, figures 11 and 15.

Genus NAOMIASPIS n. gen.

Type species.--Naomiaspis typicalis n. sp.

Diagnosis.--Cranidium subquadrate, moderately convex. Glabella prominent, slightly tapered, bluntly rounded in front, has slight keel. Four pairs of weak glabellar furrows visible on well preserved individuals: S1 oblique backwards, bifurcate; S2 oblique backwards, straight; S3 transverse; S4 oblique forwards. Occipital furrow well

defined, deepens laterally. Occipital ring 0.20 glabellar length, bears a faint median node. Axial and preglabellar furrows moderately deep. Frontal area relatively short, slightly greater than 0.35 glabellar length. Frontal area downsloping, about same width as border. Border slightly upturned, narrows laterally. Border furrow well defined. Fixigenae about 0.50 glabellar width at eye line, slightly convex, slightly downsloping. Palpebral lobes prominent, situated behind middle of glabella, slightly upturned, nearly 0.50 glabellar length. Eye ridges strong, slightly arcuate, intersect axial furrow opposite S4. Posterior limbs distinctly narrower than glabella at occipital furrow. Preocular facial suture slightly convergent, straight. Postocular facial suture divergent, sinuous.

Librigenae have slightly rounded lateral margin. Border slightly convex, downsloping, defined by shallow border furrow. Genal spine broad based, flat, evenly tapered, moderately long.

Pygidium small, over twice as wide as long. Axis has one distinct ring and a long terminal piece that nearly reaches posterior border. Pleural fields crossed by two weak pleural furrows. Border indistinct.

Surface of cranidium, pygidium, and librigenae covered with medium-sized granules. Preglabellar field also covered with fine caecae.

Discussion.--This genus represents another generalized ptychoparioid. Naomiaspis is characterized by a prominent, slightly tapered, bluntly rounded glabella with four pairs of moderately weak glabellar furrows. The frontal area is relatively short (sag.), downsloping, and nearly equally divided into the preglabellar field and border. The border is evenly rounded and well defined by a distinct border furrow. The fixigenae are about 0.50 glabellar width at eye line and the

palpebral lobes are small and situated slightly behind the glabellar midpoint. Eye ridges are moderately strong. Naomiaspis appears to be most similar to Nyella but the two genera may not be related.

NAOMIASPIS TYPICALIS n. gen. n. sp.

Pl. 22, figs. 16, 18-22

Discussion.--Because this is the only known species of Naomiaspis, the generic diagnosis and discussion also suffice for the species.

Occurrence.--Abundant in collections UU-422 and UU-423.

Holotype.--Cranidium (1561) illustrated on plate 22, figures 17, 21, 22.

Genus NYELLA Palmer, in press

Nyella PALMER, in press.

Type species.--Poulsenia granosa RESSER, 1939a, p. 59, Pl. 13, figs. 19, 22-30.

Diagnosis.--The diagnosis of Palmer (in press) is repeated here:

> Moderately small kochaspid trilobites, sagittal length of largest known cranidium about 10 mm. Cranidium subquadrate in outline, gently to moderately convex transversely and longitudinally, gently to moderately rounded at front; width between palpebral lobes slightly greater than sagittal length. Glabella prominent, tapered forward, strongly to bluntly rounded at front; sides straight or slightly concave, well defined by deep axial furrows; front defined by shallow preglabellar furrow or abrupt change in slope. Three or four pairs of moderately deep glabellar furrows usually present. Occcipital furrow deep, shallowest and curved slightly forward across axis. Frontal area clearly divided by well defined border furrow into flat brim, and convex border. Fixed cheeks flat or gently convex, horizontal; width of palpebral area between 0.4 and 0.5 basal glabellar width. Ocular ridges moderately developed. Palpebral lobe well defined, situated about opposite glabellar midlength; exsagittal length varies from about one-third to about one-half sagittal glabellar length exclusive of occipital ring. Posterior limbs about equal in transverse length to basal glabellar

width. Posterior border furrow broad, deep. Course of anterior section of facial suture straight forward from palpebral lobe. Course of posterior section divergent, sinuous.

Free cheek has broadly rounded lateral margin forming continuous curve with genal spine. Border convex, well defined anteriorly border furrow that fades towards base of genal spine. Genal spine convex in cross-section, sharply pointed, about as long as posterior section of facial suture.

Hypostome and thoracic segments not known.

Pygidium transversely subovate in outline with broad, poorly defined, slightly tapered axis. Axial furrows obscure. Only first pleural furrow distinct. Border not separately defined.

External surfaces of all parts covered with one or two sizes of granules.

Discussion.--Palmer proposed this genus for species formerly included in Caborcella by Rasetti (1951) and Fritz (1968). Nyella differs from Caborcella in having a narrow, well defined furrow separating a convex border from a generally narrow, flat, slightly downsloping preglabellar field.

Palmer's diagnosis needs to be modified slightly to include cranidia of N. periosus which may range up to 20 mm in length.

NYELLA GRANOSA (Resser)

Pl. 23, figs. 1-6

Poulsenia granosa RESSER, 1939b, p. 59, Pl. 13, figs. 19, 22-30; not figs. 20, 21, assigned to Amecephalus laticaudum (Resser) by Fritz (1968); SHIMER and SHROCK, 1944, Pl. 259, figs. 6, 7.

Caborcella granosa (Resser) FRITZ, 1968, p. 221, Pl. 39, figs. 9-15; RASETTI, 1951, p. 212.

Poulsenia bearensis RESSER, 1939a, p. 60, Pl. 13, figs. 5-8.

Nyella granosa PALMER, in press.

Diagnosis.--The diagnosis by Fritz (1968, p. 221) is adequate and followed here.

Discussion.--This species differs from N. clinolimbata Fritz by having the cranidial border evenly convex in lateral profile rather than slightly recurved and downsloping, and a much stronger tuberocular ornamentation. The broad border furrow and consequently narrower border distinguish N. rara (Rasetti) from N. granosa. N. skapta (Walcott) is distinguished from N. granosa by having a uniform granular ornamentation, more convex and slightly downsloping fixigenae, a more prominent, medially thickened anterior cranidial border, and shorter palpebral lobes. N. columbiana (Rasetti) has a more convex cranidium with a more anterolaterally depressed frontal area, less well developed glabellar furrows and a coarser granular ornamentation with fewer scattered tubercules than N. granosa.

Palmer (in press) has demonstrated the variability in the structure of the frontal area that was suspected by Fritz (1968) when he tentatively and correctly synonomized Poulsenia bearensis Resser with N. granosa.

Occurrence.--Abundant in collection UU-408. Rare in collections UU-403, UU-404, and UU-407.

NYELLA LIMBUS n. sp.

Pl. 22, figs. 23-27

Diagnosis.--Cranidium subquadrate, convex, slightly wider than long. Glabella prominent, convex, sides straight, tapered, bluntly rounded anteriorly. Four pairs of glabellar furrows visible: S1 oblique backwards, bifurcate; S2 convex, oblique backwards; S3 transverse; S4 oblique forwards. Axial furrow deep, preglabellar furrow shallow. Occipital furrow composite, shallow medially, deepens laterally. Occipital ring about 0.25 glabellar length, upsloping, does not seem to

bear spine or node. Frontal area about 0.50 glabellar length. Preglabellar area slightly downsloping, 0.50 length (sag.) of border. Border rises up from the border furrow and then turns downward to have a flattened, downsloping marginal area. Border narrows laterally. Border furrow distinct, shallower medially, has a median inbend. Fixigenae about 0.70 glabellar width at eye line, moderately convex, distinctly upsloping. Palpebral lobes prominent, slightly upturned about 0.40 glabellar length, slightly behind glabellar midpoint. Eye ridges prominent, meet axial furrow opposite S4. Posterior area of fixigenae wider (tr.) than glabella at occipital furrow. Preocular facial suture, slightly divergent, convex. Postocular facial suture divergent, sinuous.

Pygidium semielliptical, over twice as wide as long. Axis wide, low, consists of one ring and a terminal piece that does not reach to posterior margin of pygidium. Pleural fields downsloping, crossed by two faint pleural and one interpleural furrow. Border indistinct.

Surface of cranidium and pygidium covered with large and small granules. Furrows on cranidium smooth or finely punctate. Preglabellar field has a faint caecae.

Discussion.--This species most closely resembles N. clinolimbata (Fritz, 1968, p. 221). The distinctive frontal area of both species is quite similar. However N. limbus differs from N. clinolimbata in having a more strongly tapered, bluntly rounded glabella. In addition, the fixigenae are more convex and distinctly upsloping, the ornamentation is quite different, resembling N. granosa more closely than N. clinolimbata, and the occipital ring lacks a median node.

Occurrence.--Common in collection UU-420; rare in collections

UU-408 and UU-421.

Holotype.--Cranidium (1563) illustrated on plate 22, figures 25, 26, and 27.

NYELLA PERIOSUS n. sp.

Pl. 23, figs. 7-10

Diagnosis.--Cranidium large, subquadrate, considerably wider than long, moderately convex. Glabella moderately convex, posterior 0.65 strongly tapered, anterior 0.35 almost parallel-sided, bluntly rounded to truncated. Four pairs of glabellar furrows: S1 long, very strong, arcuate, oblique backwards; S2 well developed, oblique backwards; S3 short, transverse; S4 indistinct, short, oblique forwards. Axial furrow well developed, shallow at anterolateral corners of glabella. Occipital furrow composite, distinct, deepens laterally. Preglabellar field twice as wide (sag.) as border. Border distinct, thickened, slightly upturned and rounded. Fixigenae as wide as glabella at eye line; moderately convex, slightly upsloping or flat. Palpebral lobes small, upturned, situated opposite middle third of glabella. Ocular ridge wide, well developed and curved. Preocular facial suture convergent, convex. Postocular facial suture divergent, straight. Surface covered with scattered granules, preglabellar field has faint caecae.

Discussion.--N. periosus is distinguished from all other species of Nyella by its large size. It differs from N. granosa in having a larger frontal area, a truncated glabella, less distinct granular ornamentation and in having a concave-sided glabella. N. periosus differs from N. clinolimbata and N. limbus in the construction of the frontal area.

Occurrence.--Common in collection UU-420. Rare in collections UU-408 and UU-463.

Holotype.--Cranidium (1568) illustrated on plate 23, figures 7, 9, and 10.

NYELLA sp. undet.

Pl. 23, figs. 11-13

Diagnosis.--Cranidium moderately convex, subtrapezoidal, rounded anteriorly. Glabella prominent, strongly tapered, bluntly rounded anteriorly. Four pairs of glabellar furrows visible: S1 bifurcate, oblique backwards, nearly reaches occipital furrow; S2 straight, oblique backwards; S3 transverse; S4 short, oblique forwards. Axial furrow deep, preglabellar furrow distinct. Occipital furrow moderately shallow medially, composite, deepens laterally. Occipital ring broken, probably about 0.30 glabellar length. Frontal area concave, about 0.50 glabellar length. Preglabellar field about 0.60 length (sag.) of border. Border thickened, prominent, strongly upturned, narrows laterally. Border furrow prominent laterally, becomes distinct medially. Fixigenae about 0.70 glabellar width at eye line, moderately convex, upsloping. Palpebral lobes prominent, upturned, about 0.35 glabellar length, situated opposite midpoint of glabella. Palpebral lobes strong, slightly arcuate, meet axial furrow opposite S4. Posterior area of fixigenae slightly narrower than glabella at occipital furrow. Preocular facial suture convergent, convex. Postocular facial suture divergent, nearly straight. Surface covered with scattered large granules and numerous fine granules. Axial and glabellar furrows have fine punctae.

Discussion.--This species differs from all other described species

of Nyella in having a distinctly upturned, thickened, anterior border. The single cranidium is not adequate to establish a new species.

Occurrence.--One cranidium in collection UU-419.

Genus NYELLINA n. gen.

Kochaspis dispar RESSER, (part), 1939b, p. 58, Pl. 13, figs. 1-4, not figs. 13-15.

Caborcella? sp. (Resser) FRITZ, 1968, p. 215.

Type species.--Nyellina maladensis n. sp.

Diagnosis.--Cranidium subquadrate, glabella stout, short, strongly tapered, bluntly rounded anteriorly. Four pairs of glabellar furrows visible: S1 bifurcate, oblique backwards; S2 straight, oblique backwards; S3 transverse; S4 faint or indistinct, oblique forwards. Axial furrow deep; preglabellar furrow shallow. Occipital furrow composite shallow at midline. Occipital ring elevated above rest of glabella, about 0.20 length of glabella, bears small median node. Frontal area slightly convex, gently downsloping about 0.60 length of glabella. Preglabellar field about same width as border. Border thickened, downsloping, indistinct median boss present. Border furrow faint, obsolete medially. Fixigenae slightly greater than 0.50 glabellar length, horizontal. Palpebral lobes slightly in front of glabellar midline. Eye ridges strong, touch axial furrow opposite S4. Posterior area of fixigenae narrower than glabella at occipital furrow. Preocular facial suture slightly divergent, straight. Postocular facial suture divergent, straight. Surface covered with faint, small granules and scattered, larger granules. Frontal area covered with indistinct caecal lines. Border covered with faint horizontal wavy lines.

Discussion.--Nyellina appears to be most closely related to Nyella. It is distinguished from Nyella by having a short (sag.), convex-sided glabella and a relatively long (sag.) frontal area with a weakly defined border.

NYELLINA MALADENSIS n. gen. n. sp.

Pl. 21, figs. 22-25

Discussion.--Because this is the only species at present in Nyellina, the generic diagnosis and discussion also suffice for the species.

Occurrence.--Abundant in collection UU-463.

Holotype.--Cranidium (1550) illustrated on plate 21, figures 22 to 24.

Genus ONCHOCEPHALUS Resser, 1937

Onchocephalus RESSER, 1937, p. 20; PALMER, 1968, p. 75 (synonomy to date).

Type species.--Ptychoparia thia WALCOTT, 1917, p. 96, Pl. 12, fig. 6.

Discussion.--The systematics of the Early Cambrian Ptychoprioidae have been in a state of flux for many years. Thus, definitions of several Lower Cambrian genera are somewhat vague and mean slightly different things to different people. The diagnosis of Onchocephalus by Palmer (1968, p. 75) seems to adequately characterize this genus and is followed here.

ONCHOCEPHALUS? STIBINUS n. sp.

Pl. 24, figs. 10, 11, 14-16

Diagnosis.--Cranidium subquadrate; slightly convex. Glabella sloping down to a low anterior end, straight-sided, tapered, rounded anteriorly. Three sets of faint glabellar furrows visible: S1 oblique backwards, bifurcate; S2 oblique backwards; S3 transverse. Occipital furrow composite, moderately deep, deepens laterally. Occipital ring triangular, about 0.35 glabellar length, bears a small median node. Axial furrow well developed. Frontal area downsloping. Preglabellar field about 0.50 width of border. Border well developed, thickened, narrows laterally. Anterior border with distinct median inbend that nearly reaches preglabellar furrow. Fixigenae about 0.70 glabellar width at eye line; slightly convex; downsloping. Palpebral lobes nearly 0.50 length of glabella, situated behind glabellar midpoint. Eye ridges faint. Posterior area of fixigenae about same width as glabella at occipital furrow. Preocular facial suture slightly convergent to parallel-sided. Postocular facial suture divergent, sinuous. Surface covered with medium-sized granules on the higher parts.

Discussion.--O? stibinus appears to agree in all essential generic features with Onchocephalus. However, Onchocephalus has only been reported from Lower Cambrian strata and O? stibinus occurs high in the Glossopleura Zone of the Middle Cambrian. Because of the significant difference in age the generic assignment is questioned. O? stibinus is characterized by a prominent glabella sloping down to a low anterior end, three pairs of shallow glabellar furrows, a distinct axial furrow, a median inbend of the anterior border furrow, and faint granular ornamentation.

Occurrence.--Rare in collections UU-447, UU-449, UU-451, UU-452,

and UU-454.

Holotype.--Cranidium (1585) illustrated on plate 24, figures 10, 14, and 15.

Genus ORASPIS n. gen.

Type species.--Oraspis limbus n. sp.

Diagnosis.--Cranidium subquadrate, slightly wider than long. Glabella prominent, slightly tapered, bluntly rounded to truncated anteriorly. Four pairs of weak glabellar furrows visible: S1 bifurcate, oblique backwards; S2 oblique backwards; S3 transverse; S4 faint to indistinct, oblique forwards. Axial furrow well defined, preglabellar furrow shallow. Occipital furrow composite, deepens bluntly. Occipital ring 0.25 to 0.30 glabellar length, bears a median node. Frontal area slightly to distinctly concave, 0.35 to 0.40 glabellar length. Preglabellar field short to nearly absent, downsloping. Border upturned, much wider than preglabellar field, may have distinct median upfold which produces slight inbend of the border. Border furrow well defined to indistinct. Border furrow coalesces with preglabellar furrow. Fixigenae about 0.50 glabellar width at eye line, slightly to moderately convex, horizontal to slightly upsloping. Palpebral lobes well developed, upturned about 0.60 glabellar length, situated slightly behind glabellar midpoint. Eye ridges weak to strong, slightly arcuate. Posterior area of fixigenae slightly narrower than glabella at occipital ring. Preocular facial suture divergent, straight to slightly convex. Postocular facial suture divergent, sinuous. Surface covered with large and small scattered granules.

Discussion.--The cranidium of Oraspis is characterized by a short

frontal area, with a narrow (sag.) preglabellar field, and a wider, slightly to moderately upturned border. The glabella is prominent and slightly tapered, and the palpebral lobes are long, prominent and upturned. This genus is distinguished by its distinctive frontal area and palpebral lobes.

ORASPIS LIMBUS n. gen. n. sp.

Pl. 24, figs. 1-3

Diagnosis.--Cranidium subquadrate, slightly wider than long. Glabella prominent, straight-sided, slightly tapered, truncated anteriorly. Four pairs of faint glabellar furrows visible: S1 bifurcate, oblique backwards, nearly reaches occipital furrow; S2 oblique backwards; S3 transverse; S4 indistinct. Axial furrow prominent, preglabellar furrow faint. Occipital furrow distinct, composite, deepens laterally. Occipital ring about 0.30 glabellar length, bears distinct median node. Frontal area about 0.35 glabellar length. Preglabellar field very short (sag.), downsloping. Border nearly four times as long as preglabellar field, upturned, narrows slightly laterally. Border has a distinct median upfold which produces a slight inbend of the border. Border furrow distinct, coalesces with preglabellar furrow medially. Fixigenae about 0.50 glabellar width at eye line, slightly convex, slightly upsloping. Palpebral lobes well developed, upturned, about 0.60 glabellar length, situated behind glabellar midpoint. Eye ridges strong, slightly arcuate. Posterior area of fixigenae narrower than glabella at occipital furrow. Preocular facial suture divergent, straight. Postocular facial suture divergent, sinuous. Surface covered with scattered large and small granules. In addition the cranidium is covered with distinct punctae.

Discussion.--Oraspis limbus is characterized by a prominent, slightly tapered glabella; a triangular occipital ring with a median node, a short frontal area; and large, prominent palpebral lobes. The preglabellar field is narrow (sag.), the border relatively wide (sag.), well defined and has a preculiar median upfold which produces a slight inbend of the anterior margin. The preocular facial sutures are divergent, straight and the eye ridges are strong.

Occurrence.--Three cranidia in collection UU-465.

Holotype.--Cranidium (1579) illustrated on plate 24, figures 1-3.

ORASPIS cf. ORASPIS LIMBUS

Pl. 24, figs. 4-6

Diagnosis.--Cranidium subquadrate, slightly wider than long. Glabella prominent, slightly tapered, bluntly rounded anteriorly. Four pairs of weak glabellar furrows visible: S1 bifurcate, oblique backwards; S2 oblique backwards; S3 transverse; S4 oblique forwards. Axial furrow well defined, preglabellar furrow shallow. Occipital furrow composite, deepens laterally. Occipital ring about 0.25 glabellar length, bears a median node. Frontal area concave, about 0.40 glabellar length. Preglabellar field indistinct. Border defined by a change in slope rather than a distinct border furrow. Border prominent, upturned. Fixigenae about 0.50 glabellar width at eye line, moderately convex, nearly horizontal. Palpebral lobes about 0.60 glabellar length, upturned, situated slightly behind opposite midline of glabella. Palpebral furrows distinct. Eye ridges faint, meet axial furrow opposite S4. Posterior area of fixigenae slightly narrower than glabella at occipital ring. Preocular facial suture slightly divergent, convex.

Postocular facial suture divergent, sinuous. Surface covered with large and small scattered granules.

Discussion.--Oraspis cf. Oraspis limbus differs from O. limbus in having a less distinct anterior border furrow, less distinct eye ridges, and in lacking a median upfold of the border. A larger sample would be necessary to determine if these specimens represent a second species of Oraspis or whether they are within the limits of intraspecific variation of O. limbus.

Occurrence.--Rare in collections UU-438 and UU-462.

Genus PACHYASPIS Resser, 1939

Pachyaspis RESSER, 1939b, p. 61.

Type species.--Pachyaspis typicalis RESSER, 1939b, p. 61, Pl. 11, figs. 15-20; Pl. 12, figs. 1-3.

Discussion.--The diagnosis by Resser is adequate and is followed here. Pygidia of Pachyaspis, which were previously unknown, are described under the diagnosis of the type species, Pachyaspis typicalis.

PACHYASPIS EURYLIMBUS n. sp.

Pl. 25, figs. 15, 18-20

Diagnosis.--Cranidium subquadrate, moderately convex. Glabella prominent, tapered, rounded anteriorly. Four pairs of weak glabellar furrows visible: S1 oblique backwards, bifurcate; S2 oblique backwards, straight; S3 transverse; S4 oblique forwards. Occipital furrow shallow medially, deepens laterally. Occipital ring about 0.25 glabellar length, bears a small median node. Axial furrow moderately deep, preglabellar furrow shallow. Frontal area about 0.50 glabellar length, downsloping. Preglabellar field about same width as border. Border

slightly downsloping, narrows laterally. Border furrow distinct; becomes shallower medially. Fixigenae about 0.50 glabellar width at eye line; slightly downsloping, moderately convex. Palpebral lobes prominent, opposite middle third of glabella slightly upturned, about 0.40 glabellar length. Eye ridges well defined, slightly arcuate, intersects axial furrow opposite S4. Posterior limbs narrower than glabella at occipital furrow. Preocular facial suture divergent, straight. Postocular facial suture divergent, sinuous. Surface covered with medium-sized granules. Preglabellar field and frontal area of fixigenae also covered with faint caecae.

Discussion.--Pachyaspis eurylimbus is characterized by a fairly prominent glabella with four pairs of weak glabellar furrows, a well developed anterior border which is tapered laterally, a distinct border furrow which becomes shallower medially, and slightly divergent preocular facial sutures. It differs from P. typicalis in having a wider anterior border and more prominent glabellar furrows. The cranidium of P. eurylimbus is less convex and has a more prominent granular ornamentation. The anterior border area of P. eurylimbus most closely resembles that of P. gallagari Fritz but the convexity of the cranidia, the depth of the glabellar furrows, and the course of the preocular facial sutures differ between the two species.

Occurrence.--Common in collection UU-410.

Holotype.--Cranidium (1603) illustrated on plate 25, figures 18, 19 and 20.

PACHYASPIS TYPICALIS Resser

Pl. 23, figs. 14-19

Pachyaspis typicalis RESSER, 1939b, p. 60-61; SHIMER and SHROCK, 1944,

p. 615.

Diagnosis.--Cranidium subquadrate; markedly convex. Glabella prominent, tapers anteriorly rounded in front. Glabella with four pairs of indistinct glabellar furrows (muscle scars): S1 bifurcate, oblique backwards; S2 straight, oblique backwards; S3 transverse; S4 indistinct. Axial furrow well developed, continues into deep preglabellar furrow. Occipital furrow straight, deepens laterally. Occipital ring less than 0.25 length of glabella; small occipital node present. Frontal area moderately wide, slopes down anteriorly to a distinct but shallow anterior border furrow; border thickened and horizontal to slightly upturned; border less than 0.50 width of preglabellar frill. Fixigenae average more than half the glabellar width at eye line. Fixigenae strongly convex; palpebral lobes small, about 0.20 glabellar length. Eye ridges moderately developed, approach glabella midway between S3 and anterior end of glabella. Preocular margin slightly divergent, convex. Postocular margin divergent, straight. Frontal area covered by a fine caecae.

Number of thoracic segments unknown; one specimen retains eight thoracic segments. Axial width slightly less than that of pleural regions. Axial rings lack spines or nodes; lateral ends of thoracic segments extend into short, posteriorly directed spines.

Pygidium micropygous; much wider than long. Axis consits of two rings and a terminal piece. Pleural regions convex; two pleural and one interpleural furrow visible; border smooth. Test covered with fine granules that are more dense on elevated portion.

Discussion.--This species is extremely abundant in the top foot of the Naomi Peak Tongue at Two Mile Canyon (UU-411). The pygidium,

which is also abundant in these beds, is described for the first time.

Occurrence.--Abundant in UU-411. Rare in collection UU-408.

Genus PALMERELLA n. gen.

Type species.--Palmerella exiguus n. sp.

Diagnosis.--Cranidium small, subquadrate. Glabella prominent, slightly tapered, bluntly rounded anteriorly, reaches anterior border. Four pairs of glabellar furrows which vary from faint to moderately well defined. S1 oblique backwards, bifurcate; S2 oblique backwards; S3 transverse; S4 oblique forwards. Occipital furrow moderately deep, deepens laterally. Occipital ring slightly triangular, about 0.25 glabellar length, bears small median node. Axial furrow distinct, preglabellar furrow merges with anterior border furrow. Border distinct, thickened, horizontal to slightly upturned, narrows laterally. Border furrow well defined. Fixigenae about 0.35 glabellar width at eye line, moderately convex, downsloping. Palpebral lobes prominent, 0.40 to 0.50 glabellar length, horizontal, situated opposite midline of glabella. Eye ridges faint, short, meet axial furrow opposite S4. Posterior limbs about 0.60 glabellar width at occipital ring. Preocular facial suture parallel or slightly divergent, straight. Postocular facial suture divergent, convex. Surface covered with medium-sized granules and scattered larger granules.

Discussion.--This small ptychoparioid genus is characterized by a large, prominent, truncated or bluntly rounded glabella that reaches the anterior border. The anterior border is well defined, but narrow (sag.). The fixigenae are downsloping and narrow (tr.). At present this genus includes Palmerella exiguus from the High Creek Limestone

and a second species described by Palmer (in press) and referred to as Ptychoparioid undetermined 12 from USGS collection 7199-CO, Striped Hills, Nevada. This genus superficially resembles Nyella, but the glabellar structure is markedly different. Palmerella further differs from Nyella in lacking a distinct preglabellar field, in having narrower (tr.) fixigenae, and being much smaller.

PALMERELLA EXIGUUS n. gen. n. sp.

Pl. 23, figs. 20-25

Discussion.--The generic diagnosis and discussion also suffice for the species. Palmerella exiguus differs from Ptychoparioid undetermined 12 of Palmer (in press) in having less well developed glabellar furrows, a shallower axial furrow, and less convex fixigenae.

Occurrence.--Abundant in collections UU-452 and UU-454. Common in collections UU-450 and UU-451. Rare in collections UU-442, UU-443, UU-447, UU-448, UU-449, UU-453, and UU-456.

Holotype.--Cranidium (1575) illustrated on plate 23, figures 20 to 22.

Genus PROHEDINIA Lermontova and Chernysheva, 1950

Prohedinia LERMONTOVA and CHERNYSHEVA in Chernysheva, 1950, p. 68; RASETTI, 1951, p. 212; EGOROVA and others, 1955, p. 127; BALASHOVA, 1960, p. 109; PALMER, 1968, p. 69.

Tosotychia OPIK, 1961, p. 160.

Type species.--Prohedinia attenuata LERMONTOVA and CHERNYSHEVA in Chernysheva, 1950, p. 69, Pl. 1, figs. 9-12.

Discussion.--The diagnosis by Palmer (1968, p. 69) is adequate and is followed here. Prohedinia is similar to Chancia, however,

typical Chancia have a broad concave cranidial border rather than a narrow convex border. Rasetti (1951) included in Chancia species having both concave and convex borders, but Palmer (1968, p. 69) placed the forms with convex borders in Prohedinia.

PROHEDINIA MALADENSIS (Resser)

Pl. 24, figs. 17-19, 21, 22

Ehmaniella maladensis RESSER, 1939b, p. 60, Pl. 12, figs. 17-23.

Chancia? maladensis (Resser) PALMER (in press).

Diagnosis.--Cranidium subtrapezoidal, moderately convex. Glabella fairly prominent, tapers, rounded anteriorly. Three or four pairs of faint glabellar furrows visible: S1 bifurcate; S2 oblique backwards; S3 transverse; S4 faint or absent; when present, oblique forwards. Glabella may have a keel. Axial and preglabellar furrows moderately shallow. Occipital furrow shallow, deepens laterally. Occipital ring about 0.20 length (sag.) of glabella; bears a median node. Frontal area downsloping. Preglabellar field slightly wider than border. Border furrow rather wide, shallow. Border narrows laterally. Fixigenae about same width as glabella at eye line; slightly convex, downsloping. Palpebral lobes small, slightly greater than 0.25 glabellar length. Eye ridges prominent, slightly arcuate, some individuals show double eye ridges. Posterior area of fixigenae distinctly wider (tr.) than glabella at occipital furrow. Preocular facial suture convergent, nearly straight. Postocular facial suture divergent, straight.

Cranidium covered with fine granules that are most pronounced on glabella and occipital ring. Anterior area of fixigenae and frontal area covered with prominent caecae. Entire fixigenae of some individuals is covered with caecae. Exfoliated specimens also show faint caecae.

Discussion.--Lochman (1952, p. 76) pointed out that Resser, who named many of the species of Ehmaniella, did not understand the generic concept very well. She concluded that most of the species that Resser referred to Parehmania, Ehmania, Elrathina, Elrathiella, and Ehmaniella need revision. Palmer (in press) questionably referred this species to Chancia, but I believe the frontal area is more characteristic of Prohedinia than Chancia as restricted by Palmer (1968, p. 69).

Occurrence.--Fairly common in collection UU-411.

PROHEDINIA? SPENCEI n. sp.

Pl. 24, figs. 7-9, 12, 13

Diagnosis.--Cranidium subtrapezoidal. Glabella low, fairly prominent, tapered, rounded anteriorly. Three pairs of glabellar furrows visible: S1 bifurcate, oblique backwards; S2 straight, oblique backwards; S3 transverse. Axial furrow deep; preglabellar furrow distinct. Occipital ring about 0.25 glabellar length; bears a small median node. Frontal area downsloping. Preglabellar field distinctly wider than border. Border distinct, flat, narrows laterally. Border furrow shallow, becomes less distinct medially. Fixigenae narrower than glabella at eye line, moderately convex, downsloping. Palpebral lobes prominent, slightly behind midline of glabella. Eye ridges faint, slightly arcuate, touch axial furrow in front of S3. Posterior area of fixigenae about same width as glabella at occipital furrow. Preocular facial suture convergent, straight. Postocular facial suture divergent, straight.

Thorax has 14 segments. Axis slightly tapered, distinctly narrower than pleural regions. Pleurae almost straight, deeply furrowed, terminate in short spines.

Pygidium small, over twice as wide as long. Axis consists of one or two faint rings and a terminal piece that reaches posterior border. Pleural fields crossed by two pleural and one interpleural furrow. Border absent.

Surface covered with small granules and large scattered granules. In addition small punctae are present. Punctae are most prominent in larger cranidia and are well developed on the frontal area, fixigenae, and glabellar furrows. The frontal area is also covered with faint caecae.

Discussion.--This species appears to agree in all essential generic features with Prohedinia. P? spencei differs from P. maladensis by having a broadly rounded anterior cranidial margin, narrower librigenae, and in having punctae in addition to granules.

Occurrence.--Common in collections UU-427 and UU-428.

Holotype.--Incomplete individual (1584) illustrated on plate 24, figure 13.

Genus PSEUDOMEXICELLA n. gen.

Type species.--Pseudomexicella granulosa n. sp.

Diagnosis.--Cranidium slightly convex, broadly rounded anteriorly. Glabella moderately convex, short, tapered, bluntly rounded anteriorly. Glabellar furrows indistinct, some individuals show up to three faint pairs: S1 bifurcate, oblique backwards; S2 convex, oblique backwards; S3 transverse. Axial and preglabellar furrows well developed. Occipital ring about 0.20 glabellar length, triangular, slopes upward posteriorly, bears a small median node. Frontal area slightly shorter (sag.) than glabella with low median bulge. Preglabellar field nearly horizontal, distinctly narrower than border. Border thickened, upturned,

anterior margin rounded, narrows laterally. Border furrow well defined laterally, becomes indistinct medially because of median bulge. Fixigenae narrower than glabella at eye line, slightly convex, horizontal or slightly downsloping. Palpebral lobes about 0.35 (exsag.) glabellar length, slightly upturned, situated in front of midline of glabella. Eye ridges prominent, slightly arcuate. Posterior area of fixigenae narrower (tr.) than glabella at occipital furrow. Preocular facial suture divergent, convex. Postocular facial suture divergent, convex.

Frontal area and glabella smooth or finely punctate; remainder of cranidium densely covered with medium-sized granules. In addition, frontal area has faint caecae. Exfoliated specimens are punctate.

Discussion.--As the generic name implies, this genus closely resembles Mexicella with which it occurs. The most distinctive diference between the two genera is in the construction of the frontal area and border. Mexicella has a border that is barely distinguishable from the rest of the frontal area, whereas Pseudomexicella has a much more distinct border and border furrow.

PSEUDOMEXICELLA GRANULOSA n. sp.

Pl. 24, figs. 20, 23-26

Discussion.--Because this is the only known species of Pseudomexicella, the generic diagnosis and discussion also suffice for the species.

Occurrence.--Abundant in collection UU-402. Common in collections UU-401 and UU-417. Rare in collections UU-403 and UU-404.

Holotype.--Cranidium (1592) illustrated on plate 24, figures 20, 24, and 26.

Genus SPENCIA Resser, 1939

Spencia RESSER, 1939a, p. 23; RASETTI, 1951, p. 240; 1963, p. 591.

Stauroholcus RESSER, 1939a, p. 23.

Type species.--Spencia typicalis RESSER, 1939a, p. 23, Pl. 6, figs. 22-25.

Diagnosis.--The diagnosis of Resser (1939a, p. 23) and the diagnosis of the type species Spencia typicalis which follows adequately describe this genus.

Discussion.--Rasetti (1951, p. 240) has studied the genus Spencia and concluded that Stauroholcus Resser (1939a, p. 23) is a junior synonym of Spencia, the only differential character being the presence of an occipital spine in Stauroholcus. Spencia is characterized by a rather large, slightly tapered glabella and a depression in front of the glabella caused by absence of a preglabellar field and coalescence of the border furrow and preglabellar furrow. Spencia most closely resembles Spencella and the differences have been discussed by Rasetti (1963, p. 591).

SPENCIA TYPICALIS Resser

Pl. 25, figs. 1, 2, 4, 5

Spencia typicalis RESSER, 1939a, p. 23, Pl. 6, figs. 22-25; RASETTI, 1963, p. 591.

Spencia plena RESSER, 1939a, p. 23, Pl. 6, figs. 19-21.

Diagnosis.--Cranidium subtrapezoidal, moderately convex. Glabella prominent, highly convex, slightly tapered, bluntly rounded anteriorly. Glabellar furrows weak or indistinct, up to four pairs visible on some specimens: S1 oblique backwards, bifurcate; S2 oblique backwards; S3

transverse; S4 shonort, oblique forwards. Axial furrow strongly impressed, preglababellar furrow well developed. Occipital furrow deep, composite. Occipibital ring about 0.25 glabellar length, bears strong median node. Frontntal area about 0.40 glabellar length. Border thickened, wider than pr preglabellar field medially, narrows laterally. Border furrow well develoloped, meets preglabellar furrow medially causing a depression in frontnt of the glabella. Fixigenae 0.50 to 0.60 glabellar width at eye line, , moderately convex, downsloping. Palpebral lobes small, situated oppposite middle third of glabella. Eye ridges faint, meet axial furrow o opposite S4. Posterior area of fixigenae about same width as glabella a at occipital furrow. Preocular facial suture convergent, convex. Poststocular facial suture divergent, sinuous.

Thorax of hololotype consists of 16 segments.

Pygidium smallll, more than twice as wide as long. Axis prominent, nearly reaches poststerior margin. Pleural field crossed by one or two pairs of weak furrcrows.

Surface of craranidium covered with scattered large and small granules.

Discussion.--R-Rasetti (1963, p. 591) placed Spencia plena into synonomy with S. tytypicalis. I examined the type collections of both species and found r no significant differences. Therefore, I agree with Rasetti. Rasetti ((1963, p. 591) has adequately discussed the relationships between Spenencia and Spenciella.

Occurrence.--R-Resser's type collections from locality 55c.

Genus UTIA Walcott, 1924

Utia WALCOTT, 1924,4, p. 60; WALCOTT, 1925, p. 118; HOWELL, 1959, p. 247; SUGOROVA, 196060, p. 86.

Type species.--Utia curio WALCOTT, 1924, p. 60, Pl. 13, fig. 3.

Discussion.--This distinctive genus was adequately described and diagnosed by Walcott (1925). It may be easily identified by the subquadrate glabella with very strong axial furrow, and the border shape and attitude, which is best described by Walcott: "The frontal border is quite distinct. It is wide in reality but appears narrower than it is, due to the fact that it first rises sharply from the frontal portion of the dorsal furrow into a ridge, then drops off very steeply. Viewed from the front there is only a vertical band." Utia is monotypic; the type species Utia curio is small, and has nine thoracic segments.

UTIA CURIO Walcott

Pl. 25, figs. 3, 6, 9, 12

Utia curio WALCOTT, 1924, p. 60; WALCOTT, 1925, p. 119-121; RESSER (part), 1938a, p. 9; RESSER, 1939a, p. 21.

Diagnosis.--The species description given by Walcott (1925, p. 119-121) is generally adequate. It need be modified only to include specimens with granules on the test.

Discussion.--Small, well-preserved specimens of Utia curio are covered with small granules that are most dense on the lateral areas of the fixigenae, occipital ring, and frontal area. Larger specimens have scattered granules, and the largest specimen in my collections has distinct granules on the occipital ring only.

Occurrence.--Rare in collections UU-434 and UU-442.

Genus VOLOCEPHALINA Palmer, in press

Type species.--Volocephalina connexa PALMER, in press.

The description and discussion by Palmer (in press) are adequate

and are repeated here:

Description.--Small ptychoparioid trilobites, largest cranidia about 4 mm in sagittal length. Cranidium subtrapezoidal in outline, gently to moderately convex transversely and longitudinally, all parts well defined, anterior margin nearly straight. Glabella prominent, well defined at sides by broad axial furrows; defined at front by abrupt change in slope of exoskeleton; tapered slightly forward, bluntly rounded anteriorly. Three or four moderately deep glabellar furrows present; anterior pair or pairs short, not connected to axial furrows. Occipital furrow very shallow across axis, deep distally. Occipital ring moderately broad, bears prominent median node. Frontal area subequally divided into depressed, concave brim and strongly upturned, convex border; sagittal length between one-third and two-thirds sagittal length of glabella exclusive of occipital ring. Fixed cheeks broad, flat, slightly to moderately upsloping; width, including palpebral lobes, between two-thirds and equal to basal glabellar width. Palpebral lobes small, upsloping from surface of cheek, situated opposite anterior third of glabella, connected to glabella by moderately to strongly developed anteriorly curved ocular ridge. Exoskeleton in front of ocular ridge sharply depressed. Posterior limb large, broad; transverse length equal to or greater than basal glabellar width. Posterior border furrow deep, well defined. Course of anterior section of facial suture slightly convergent forward from palpebral lobes and then curved inward more sharply at cranidial corners to intersect cephalic margin about midway to axial line. Posterior section convex.

Free cheek, elongate, subtriangular, with poorly defined border and short, flat, broad-based genal spine.

Hypostome, rostral plate and pygidium unknown. External surface of cranidium bears scattered coarse tubercules.

Discussion.--This distinctive small genus is unlike any other described early Middle Cambrian genus. It is most similar to the Lower Cambrian genus Peripommella from which it is most easily distinguished by having large, broad posterior limbs and small, upsloping palpebral lobes. Volocephalina may represent an early form in the lineage of small ptychoparioids leading to Bolaspidella and the Menomoniidae in the late Middle and early Upper Cambrian.

VOLOCEPHALINA STOKESI n. sp.

Pl. 25, figs. 13, 14, 16, 17, 21

Diagnosis.--Cranidium small, subtrapezoidal in outline, gently to

moderately convex horizontally and transversely, anterior margin slightly rounded, glabella prominent, well defined at sides by axial furrow; defined in front by abrupt change in slope of exoskeleton. Glabella tapered, truncated anteriorly. Three or four pairs of glabellar furrows visible: S1 bifurcate, oblique backwards; S2 oblique backwards; S3 transverse; S4 oblique forwards. Occipital furrow composite, narrow, deepens laterally. Occipital ring about 0.40 glabellar length, triangular, upsloping, bears a distinct median node. Frontal area subequally divided into a depressed, concave preglabellar field and strongly upturned convex border. Sagittal length of frontal area about 0.50 glabellar length. Fixigenae about 0.60 basal glabellar width, nearly flat, slightly upsloping. Palpebral lobes small, upturned about 0.30 glabellar length, situated in front of glabellar midpoint, connected to glabella by relatively strong anterior curved eye ridges. Posterior area of fixigenae about same width as glabella at occipital furrow. Preocular facial suture convergent, straight. Postocular facial suture divergent, convex. Surface densely covered with large and small granules.

Discussion.--This species is represented by many cranidia, but nearly all are exfoliated or replaced by limonite making specific identification difficult. A few individuals are fairly well preserved, however, and do show surface ornamentation. V. stokesi resembles V. connexa Palmer in most respects but differs distinctly in surface ornamentation. The exoskeleton of V. connexa has scattered tubercles and fine granules. V. stokesi is densely covered with large and small granules.

Occurrence.--Common in collections UU-402, UU-403, UU-404, UU-405, and UU-417. Rare in collection UU-401 and UU-407.

Holotype.--Cranidium (1600) illustrated on plate 25, figures 13 and 17.

Unassigned Ptychoparioids

Genus and species undetermined 3

Pl. 26, figs. 9-12

Diagnosis.--Cranidium subquadrate, moderately convex; glabella rather strongly tapered, bluntly rounded in front. Axial furrow well developed, preglabellar furrow faint. Four pairs of glabellar furrows: S1 bifurcate; S2 oblique backwards; S3 pithole; S4 faint, oblique forwards. Occipital furrow rather faint, deepest at sides; occipital ring triangular, extended into strong posteriorly directed spine. Frontal area broad, slightly concave. Border upturned, moderately wide, expands medially, defined by faint border furrow. Sagittal length of preglabellar field less than 0.50 glabellar length. Fixigenae narrow, upturned, less than 0.50 width of glabella at eye line. Palpebral lobes well developed, upturned, slightly longer than 0.50 glabellar length, nearly opposite midline of glabella. Eye ridges moderately weak, reach glabella just in front of S4 glabellar furrow. Anterior facial suture strongly divergent, rounded. Posterior facial suture divergent, sinuous. Posterior limbs narrow. Surface of glabella and fixigenae covered with fine granules, frontal area covered with fine punctae.

Discussion.--This species is represented by one well preserved cranidium. It is characterized by narrow (tr.) upsloping fixigenae, a broad frontal area, large palpebral lobes, strongly divergent preocular facial sutures and a moderately strong occipital spine. This

distinctive ptychoparioid is unlike any described form known to me. More material is needed for study before this species is named.

Occurrence.--One cranidium in collection UU-465.

Genus and species undetermined 4

Pl. 26, figs. 5-7

Diagnosis.--Cranidium relatively small, slightly convex, subquadrate. Glabella conical, nearly straight front; greatest convexity posteriorly. Three pairs of faint glabellar furrows visible: S1 oblique backwards; S2 oblique backwards; S3 transverse. Axial furrow moderately deep; shallow fossulae present. Preglabellar furrow shallow. Occipital furrow shallow composite. Occipital ring slightly greater than 0.30 glabellar length, triangular, bears a small median node. Frontal area nearly flat; preglabellar field narrower than border. Border furrow deep. Border thickened, expanding slightly on midline causing a median inbend of border furrow. Border narrows laterally. Fixigenae slightly narrower than glabella at eye line; slightly convex, nearly flat. Palpebral lobes small, slightly upturned; about less than 0.35 glabellar length. Palpebral lobes situated in front of midline of glabella. Eye ridges visible but faint. Preocular facial suture slightly divergent, straight. Postocular facial suture probably divergent, convex.

Discussion.--The combination of characters shown by this species (three faint glabellar furrows, divergent preocular facial sutures, palpebral lobes situated anterior to midline of glabella, and a border with slight median inbend) do not seem to be characteristic of an established genus. None of the three poorly preserved individuals in my collections are judged to be adequate to serve as the holotype

for a type species of a new genus. These individuals most closely resemble representatives of Syspacephalus, but differ by having slightly divergent rather than convergent preocular facial sutures.

Occurrence.--Rare in collection UU-403.

Genus and species undetermined 5

Pl. 26, figs. 1, 2

Diagnosis.--Cranidium subquadrate; glabella prominent, slightly tapered, bluntly rounded anteriorly. Axial furrow moderately well developed, preglabellar furrow well developed. Four pairs of weak glabellar furrows evident on larger specimens: S1 oblique backwards; S2 oblique backwards; S3 transverse; S4 pithole. Occipital furrow moderately well developed, deepens laterally. Occipital ring narrow (sag.), bears a small median node. Frontal area downsloping; preglabellar area slightly convex, almost twice as wide as border. Border distinct, slightly tapered distally. Border furrow well developed. Fixigenae slightly narrower than glabella at eye line; slightly convex. Palpebral lobes prominent, about 0.50 length of glabella; positioned slightly in front of glabellar midpoint. Eye ridges well developed, slightly curved, meet glabella opposite S4. Posterior area of fixigenae slightly wider than glabella at occipital ring. Preocular facial suture slightly convergent, convex. Postocular facial suture divergent, sinuous. Surface covered with fine granules.

Discussion.--This taxon is represented by several associated cranidia. They are characterized by a prominent, slightly tapered, truncated glabella, a distinct, slightly curved anterior border and convergent preocular facial sutures. It is a variation on the generalized ptychoparioid theme that does not seem to represent any described

genus.

Occurrence.--Common in collection UU-459.

Genus and species undetermined 6

Pl. 26, figs. 3, 4, 8

Diagnosis.--Cranidium broadly rounded anteriorly, moderately convex. Glabella short, highly convex, prominent, strongly tapered, becomes lower anteriorly. Three pairs of glabellar furrows visible: S1 oblique backwards; S2 transverse; S3 oblique forwards. Occipital furrow broad, moderately deep. Occipital ring prominent, triangular, about 0.50 glabellar length, bears small posteriorly situated node. Axial furrow wide, shallow; preglabellar furrow less distinct. Frontal area slightly downsloping. Preglabellar area about same width as border. Border thickened, nearly flat, becomes narrower laterally. Border furrow shallow, less distinct medially. Fixigenae narrower than glabella at eye line, slightly convex, nearly flat. Palpebral lobes small, situated in front of glabellar midline. Eye ridges prominent, slightly arcuate, approach glabella at nearly right angles. Preocular facial suture convergent, convex.

Surface ornamentation unknown.

Discussion.--This species is represented by two poorly preserved, exfoliated cranidia. They cannot be assigned to a known genus with certainty and are not adequate to serve as a holotype for a type species for a new genus. The most distinctive characteristic of these cranidia is the large occipital ring and a short, strongly tapered glabella.

Occurrence.--Two cranidia in collection UU-400.

Genus and species undet. 7

Pl. 26, figs. 13-16

Diagnosis.--Cranidium subquadrate; slightly convex. Glabella prominent, slightly tapered, rounded anteriorly. Four pairs of faint glabellar furrows visible: S1 oblique backwards; S2 transverse; S3 oblique forwards; S4 indistinct, oblique forwards. Axial and preglabellar furrows prominent. Occipital furrow narrow (sag.) deepens slightly laterally. Occipital ring 0.25 glabellar length, bears a faint median node. Frontal area downsloping; preglabellar field steeply downsloping narrower than border. Border narrows slightly laterally, border furrow distinct. Fixigenae less than 0.50 width of glabella at eye line, convex, downsloping. Palpebral lobes prominent, slightly less than 0.50 glabellar length. Eye ridges faint. Posterior limbs narrower (tr.) than glabella at occipital ring. Preocular facial suture divergent, straight. Postocular facial suture divergent, convex.

Cranidium covered with granules and punctae both of which are more pronounced on higher parts.

Discussion.--I have been unable to find any described Middle Cambrian ptychoparioid that closely resembles this species. The systematic placement and naming of this species must await more material.

Occurrence.--Rare in collection UU-460.

Phylum Unknown

Fecal Balls

Pl. 2, fig. 4

Several compacted circular "balls" about 25-35 mm in diameter have been found at Cataract and Antimony Canyons in the Wellsville

Mountains. They are filled with trilobite exoskeletal fragments and disarticulated Gogia thecal plates, and may represent fecal or regurgitated material, perhaps from some large wormlike animal, arthropod or chordate? that fed on trilobites and echinoderms. These "balls" also have been reported by Sprinkle (1973, p. 100) from Mount Kitchner, Alberta, Canada, and from near Calls Fort in the Wellsville Mountains.

REFERENCES

American Commission on Stratigraphic Nomenclature. 1961. Code of stratigraphic nomenclature. Amer. Assoc. Pet. Geol. Bull., 45: 645-665; correction, 1961, 45: 1101.

Anderson, A. L. 1928. Portland cement materials near Pocatello, Idaho, Idaho Bur. Mines and Geology Pamph. 28, 15 p.

Axtell, D. C. 1967. Geology of the northern part of the Malad Range, Idaho. Utah State University unpublished Master's thesis.

Balashova, E. A., N. V. Pokrovskaia and N. K. Ivshin. 1960. In Osnovy Paleontologii--Chlenistogogie, Trilobitoo braznye i Rakoobraznye (Principles of Paleontology--arthropods, trilobites, and crustaceans). Chernysheva, N. E., editor. Moscow, Gosundar. Nauchno-Tekh. Isd. Lit. Geologii i Okhrane Nedr, 515 p.

Bathurst, R. G. C. 1967. Depth indicators in sedimentary carbonates. Marine Geol. 5: 447-471, 4 tables.

Beyrich, Ernst. 1845. Uber einige bohmische Trilobiten. Berlin.

Bright, R. C. 1960. Geology of the Cleveland area, southeastern Idaho. University of Utah unpublished Master's thesis.

Carr, W. J., and D. E. Trimble. 1962. Paleozoic rocks measured southwest of Pocatello, Idaho. University of Utah unpublished Master's thesis.

Chernysheva, N. E. 1950. Novye srednekembriyshie trilobity vostochnoi Sibiri (New Middle Cambrian trilobites from eastern Siberia). Vses. Nauchno--Issled. Geol. Inst. (VSEGEI) Trudy, 1: 67-76.

Chernysheva, N. E. 1952. O nakhodke Srednekembriiskikh trilobitov v basseine R. Yangud (Sredne-Vitimskaya gornaya strana). Paleontologiya i stratigrafiya. Tr. Vsesoyuzn. Nauchno--Issled. Geol. Inst. (VSEGEI), 108-119 (fide Chernysheva, 1962).

_____. 1962. Kembriishie trilobity Semeista Oryctocephalidae. In Problemy neftegazonosnosti Sovetskoi Arktiki. Paleontologiya i biostratigrafiya 3. Tr. nauchonoissled. Geol. Ist. Arktiki, 127, 3-52, 6 Pls.

Cooper, G. A. and others. 1952. Cambrian stratigraphy and paleontology near Caborca, northwestern Sonora, Mexico. Smithsonian Misc. Colln. 119: 84p., 31 Pls.

Coulter, H. W. 1956. Geology of the southwest portion of the Preston quadrangle, Idaho. Idaho. Bur. Mines and Geology Pamph. 107, 48p.

Dames, W. B. 1883. Kambrische Trilobites von Liau-Tung (Cambrian trilobites from Liao-Tung). In Baron von Richthofen, China. Berlin, D. Reimer, 33p.

Deiss, Charles. 1938. Cambrian formations and sections in part of the Cordilleran Trough. Geol. Soc. Amer. Bull. 49: 1067-1168.

_____. 1939. Cambrian stratigraphy and trilobites of northwestern Montana. Geol. Soc. Amer. Spec. Paper 18, 135 p., 18 Pls.

Egorova, L. I. and others. 1955. Trilobity in Khalfin, L. L., ed. Atlas rukovodyaschikh form iskopaemkh fauny i flory zapadnoi Sibiri (Atlas of leading forms of fossil fauna and flora from West Siberia). Zapadno-Sibir. Geol. Uprav.-Tomsk. Politekh. Inst. Moscow, Gosudar. Nauchno-Tekh. Izd. Lit. Geol. i Okhrane Nedr, 1: 102-145.

Fritz, W. H. 1968. Lower and early Middle Cambrian trilobites from the Pioche Shale, east-central Nevada, U. S. A. Paleontology 11: 183-235, Pls. 36-43.

_____. 1971. Contributions to early Middle Cambrian faunal zones. In Oriel, S. S. and F. C. Armstrong. Uppermost Precambrian and lowest Cambrian rocks in southwestern Idaho. U. S. Geol. Surv. Prof. Paper 394.

_____, and D. K. Norris. 1965. Lower Middle Cambrian correlations in the east-central Cordillera. Geol. Surv. of Canada. 66 (1): 105-110.

Gellnet, R. H. 1958. Geology of the southern part of Wellsville Mountain, Utah. Utah State University unpublished Master's thesis.

Grant, R. E. 1962. Trilobite distribution, upper Franconian Formation (Upper Cambrian), southeastern Minnesota. Jour. Paleontology 36 (5): 965-998.

Gronwall, K. A. 1902. Bornholm Paradoxideslag of deres fauna. Dansk Geol. Undersokning. 2, 230 p.

Hall, James and R. P. Whitfield. 1877. Paleontology. U. S. Geol. Expl. 40th Parallel Rept. 4: 199-231.

Harker, P. and R. D. Hutchinson. 1953. A new occurrence and redescription of Gogia prolifica Walcott. Jour. Paleontology 27 (2): 285-287. Pl. 40.

Harrington, H. J. and others. 1959. Arthropoda 1. In R. C. Moore (ed.), Treatise on Invertebrate Paleontology, Part O. Geol. Soc. Amer. and University of Kansas Press, 560 p.

Hawle, Ignaz and A. J. C. Corda. 1847. Prodrom einer Monographie der bohmischen Trilobiten. Prag.

Henningsmoen, Gunnar. 1957. The trilobite family Olenidae. Norske Videnskapsakademien, Oslo. Mat.-Naturv. Kl. Skr. n. 1, 303 p., 31 Pls.

Howell, B. F. and others. 1944. Correlation of the Cambrian formations of North America. Geol. Soc. Amer. Bull. 55: 993-1104, 1 Pl.

Hupe, Pierre. 1953. Classification des trilobites. Annales Paleontologic. 39: 61-198.

Ivshin, N. K. 1953. Srednekembriiske trilobity Kazakhstana; chast I (Middle Cambrian trilobites from Kazakhstan; Part I). Akad. Nauk Kazakhstan S. S. R., Geol. Nauk, Alma-Ata, 226 p., 11 Pls.

_____. 1957. Srednekembriiskie trilobity Kazakhstana; chast 2, Agyrekskii faunisticheskii gorizont raiona gor Agyrek (Middle Cambrian trilobites from Kazakhstan, Part 2: Agyreksk faunal horizon of the Agrek region). Alma-Ata, Akad. Nauk Kazakh. S. S. R., Inst. Teol. Nauk, 112 p.

Keeper, J. C. 1972. Paleoenvironmental patterns in Middle to lower Upper Cambrian interval in eastern Great Basin. Amer. Assoc. Pet. Geol. Bull. 56: 503-536, 27 figs.

King, Clarence. 1876. Paleozoic subdivisions on the 40th Parallel, Amer. Jour. Sci. 3d. ser. 11: 475-482.

Kobayashi, Teiichi. 1935. The Cambro-Ordovician formations and faunas of South Chosen. Paleontology. Cambrian faunas of South Chosen with special study on the Cambrian trilobite genera and families, Tokyo Imp. University. Fac. Sci. Jour. sec. 2, 4: 49-244, 24 Pls.

_____. 1942. On the Dolichometopinae. Tokyo Imp. Univeristy. Fac. Sci. Jour. sec. 2, 6: 141-206, 4 Pls.

Lake, Phillip. 1938. A monograph of the British Cambrian trilobites, pt. 8. Paleontographical Soc. 91: 249-272.

Lazarenko, N. P. 1960. Novye vidy drevnikh rastenii i bespozvonochnykh chast 2. p. 218.

Lermontova, E. V. 1940. In Vologdin, A.G. Atlas of the leading forms of the fossil fauna of the U. S. S. R. v. 1. Cambrian. Moscow Vses. Nauchno--Issled. Geol. Inst. (VSEGEI), 193 p.

Lochman, Christina. 1947. Analysis and revision of eleven lower Cambrian trilobite genera. Jour. Paleontology 21: 59-71, 6 figs.

_____. 1948. New Cambrian trilobite genera from northwest Sonora, Mexico. Jour. Paleontology 22: 451-464, Pls. 69, 70.

_____. 1952. See Cooper, G. A. and others.

_____. 1956. The evolution of some Upper Cambrian and Lower Ordovician trilobite families. Jour. Paleontology 30 (3): 445-462.

Lochman-Balk, Christina and J. L. Wilson. 1958. Cambrian biostratigraphy in North America. Jour. Paleontology 32: 312-350, 18 text-figs.

Logan, B. W., R. Rezak, and R. N. Ginsburg. 1964. Classification and environmental significance of algal stromatolites. Geol. 72: 68-83, 5 figs.

Lorenz, Theodore. 1906. Beitrage zur Geologie und Palaeontology von Ostasien unter besonderer Berucksichtung der Proinz Schantung in China 2. Palaeontolgischer Teil. Deutche geol. Gesell. Zeitchr. 58: 53-108.

Mansfield, G. R. 1927. Geography, geology, and mineral resources of part of southeastern Idaho. U. S. Geol. Surv. Prof. Paper 152, 409 p.

Matthew, G. F. 1897. Studies on the Cambrian faunas, 1. Royal Soc. Canada Proc. and Trans. 2d. ser. 3: 165-203.

Matthew, G. C. and C. E. Resser. 1945. Cambrian history of the Grand Canyon region. Carnegie Inst. Washington Pub. 563. 232 p., 27 Pls.

Maxey, G. B. 1958. Lower and Middle Cambrian stratigraphy in northern Utah and southeastern Idaho. Geol. Soc. Amer. Bull. 6: 647-687.

Meek, F. B. 1870. Descriptions of fossils collected by the U. S. Geological Survey. Acad. Nat. Sci. Philadephia Proc. for 1870, p. 56-64.

_____. 1877. Paleontology. U. S. Geol. Expl. 40th Parallel Rept. 4: 197 p.

Nelson, C. A. 1963. Stratigraphic range of Ogygopsis. Jour. Paleontology 37 (1): 244-248.

Newell, N. D., E. G. Purdy, and John Imbrie. 1960. Bahamian oolite sands. Jour. Geol. 68 (5): 481-497, 1 Pl.

Oldroyd, J. D. 1973. Biostratigraphy of the Cambrian Glossopleura zone, west-central Utah. University of Utah unpublished Master's thesis.

Olson, R. H. 1960. Geology of the Promontory Range, Box Elder County, Utah. University of Utah unpublished Doctor of Philosophy dissertation.

Opik, A. A. 1961. The geology and palaeontology of the headwaters of Burke River, Queensland. Australia Bur. Mineral Resources, Geology and Geophysics Bull. 53, 249 p.

Oriel, S. S. 1965. Brigham, Langston, and Ute formations in Portneuf Range, southeastern Idaho. In Abstracts for 1965. Geol. Soc. Amer. Spec. Paper 82, 315 p.

Oriel, S. S. 1968. Preliminary geologic map of Bancroft quadrangle, Caribou and Bannock counties, Idaho. U. S. Geol. Surv. open-file map.

_____, and F. C. Armstrong. 1971. Uppermost Precambrian and lowest Cambrian rocks in southeastern Idaho. U. S. Geol. Surv. Prof. Paper, 394, 52 p.

Pack, F. J. 1906. Cambric fossils from the Pioche Mountains, Nevada. Jour. Geol. 14: 290-302, 3 Pls.

Palmer, A. R. 1954. An Appraisal of the Great Basin Middle Cambrian trilobites described before 1900. U. S. Geol. Surv. Prof. Paper 264-D: 55-86, Pls. 13-17.

_____. 1956. The Cambrian system of the Great Basin in western United States. In El Sistema Cambrico, su Paologeografia y Problema de su Base. 20th Internat. Geol. Congress Symposium 2: 663-681.

_____. 1960. Some aspects of the early Upper Cambrian stratigraphy of White Pine County, Nevada, and vicinity. Intermountain Assoc. Pet. Geol. 11th Ann. Field Conf. 53 p.

_____, in Merriam, C. W. 1964a. Cambrian rocks of the Pioche Mining District, Nevada. U. S. Geol. Surv. Prof. Paper 469, 59 p., Pls. 1-6.

_____. 1964b. An unusual Lower Cambrian trilobite fauna from Nevada. U. S. Geol. Surv. Prof. Paper 483-F, 12 p., 3 Pls.

_____. 1965. Trilobites of the Late Cambrian Pterocephalid biomere in the Great Basin, United States. U. S. Geol. Surv. Prof. Paper 493, 105 p.

Palmer, A. R. 1968. Cambrian trilobites of east-central Alaska. U. S. Geol. Surv. Prof. Paper 559-b, 115 p., 15 Pls.

_____. 1971. The Cambrian of the Great Basin and adjacent areas, Western United States. In Cambrian of the New World. Holand, C. H., (ed.). Bristol, England. Wiley-Interscience, p. 1-78.

_____. In press. Biostratigraphy of the Cararra formation. U. S. Geol. Surv. Prof. Paper.

Poulsen, Christian. 1927. The Cambrian, Ozarkian, and Canadian faunas of northwest Greenland, Jubilaeumsekspeditionen nord on Gronland. 1920-1923. Nr. 2. Meddelelser on Gronland. 70: 233-343, Pls. 14-21.

_____. 1959. See Harrington, H. J. and others.

Poulsen, Valdemar. 1964. Contributions to the Lower and Middle Cambrian paleontology and stratigraphy of northwest Greenland. Nr. 6. Meddelelser on Gronland. 164: 5-102, 3 Pls.

Randolph, R. L. 1973. Biostratigraphy of the Swasey Limestone, west-central Utah. University of Utah unpublished Master's thesis.

Rasetti, F. D. 1948. Middle Cambrian trilobites from the conglomerates of Quebec. Jour. Paleontology 22: 315-339, Pls. 45-52.

_____. 1951. Middle Cambrian stratigraphy and faunas of the Canadian Rocky Mountains. Smithsonian Misc. Colln. 116: 277 p., 34 Pls.

_____. 1952. Revision of the North American trilobites of the family Eodiscidae. Jour. Paleontology 26: 434-451, Pls. 51-54.

_____. 1955. Lower Cambrian Ptychopariid trilobites from the conglomerates of Quebec. Smithsonian Misc. Colln. 128: 35 p., 6 Pls.

Rasetti, F. D. 1957. Additional fossils from the Middle Cambrian Mt. Whyte formation of the Canadian Rocky Mountains. Jour. Paleontology 31: 955-972, Pls. 117-122.

_____. 1963. Middle Cambrian ptychopariid trilobites from the conglomerates of Quebec. Jour. Paleontology 37: 575-594, Pls. 66-70.

_____. 1965. Middle Cambrian trilobites of the Pleasant Hill formation in central Pennsylvania. Jour. Paleontology 39: 1007-1014, Pls. 119, 120.

_____. 1966. Revision of the North American species of the Cambrian trilobite genus Pagetia. Jour. Paleontology 40: 502-511, Pls. 59, 60.

_____. 1972. Cambrian trilobite faunas of Sardinia. Roma Accademia Nazionale Dei Lincei, 11 (2): 100 p., 19 Pls.

Raymond, P. E. 1912. Notes on parallelism among the Asaphidae. Royal Soc. Canada Trans. 3d ser. 5 (4): 111-120.

_____. 1928. Two new Cambrian trilobites. Amer. Jour. Sci. 5th ser. v. 250, p. 885-898.

Resser, C. E. 1935. Nomenclature of some Cambrian trilobites. Smithsonian Misc. Colln. 93 (5): 46 p.

_____. 1936. Second contribution to nomenclature of Cambrian trilobites. Smithsonian Misc. Colln: 95 (4): 29 p.

_____. 1937. Third contribution to nomenclature of Cambrian trilobites. Smithsonian Misc. Colln. 95 (22): 29 p.

_____. 1938a. Middle Cambrian fossils from Pend Oreille Lake, Idaho. Smithsonian Misc. Colln. 97 (3): 12 p., 1 Pl.

Resser, C. E. 1938b. Cambrian System (revised) of the southern Appalachians. Geol. Soc. Amer. Spec. Paper 15, 140 p., 16 Pls.

_____. 1939a. The Spence Shale and its fauna. Smithsonian Misc. Colln. 97 (12): 29 p., 6 Pls.

_____. 1939b. The Ptarmigania strata of the northern Wasatch Mountains. Smithsonian Misc. Colln. 98 (24): 72 p., 14 Pls.

_____. 1942. Fifth contribution to nomenclature of Cambrian fossils. Smithsonian Misc. Colln. 101 (15): 58 p.

_____. 1945. See McKee, E. D. and C. E. Resser.

_____, and Ruiji Endo. 1937. Manchurian Sci. Mus. Bull. 1, pt. 2, p. 213.

Richardson, G. B. 1913. Paleozoic section in northern Utah. Amer. Jour. Sci. 4th ser. 36, 303 p.

Rigo, R. J. 1967. Middle and Upper Cambrian stratigraphy in the Autochthon and Allochthon of northern Utah. Brigham Young University Research Studies, p. 31-66, 2 Pls.

Robison, R. A. 1960. Lower and Middle Cambrian stratigraphy of the eastern Great Basin. Intermountain Assoc. Pet. Geol. 11th Ann. Field Conf., p. 43-52.

_____. 1964a. Late Middle Cambrian faunas from western Utah. Jour. Paleontology 38: 510-566, Pls. 79-92.

_____. 1964b. Middle Upper Cambrian boundary in North America. Geol. Soc. Amer. Bull. 75: 987-994.

_____. 1964c. Upper Middle Cambrian stratigraphy of western Utah. Geol. Soc. Amer. Bull. 75: 995-1010.

_____. 1965. Middle Cambrian Eocrinoids from western North America. Jour. Paleontology 39: 355-364, Pls. 50-52.

Robison, R. A. 1969a. Annelids from the Middle Cambrian Spence Shale of Utah. Jour. Paleontology 43: 1169-1173.

_____. 1969b. Fossil find furnished link. Utah Geol. and Mineralog. Surv. Quarterly Rev. 3: 1.

_____. 1971. Additional Middle Cambrian trilobites from the Wheeler Shale of Utah. Jour. Paleontology 54: 796-804, Pls. 89-91.

_____. 1972a. Hypostoma of agnostid trilobites. Lethaia 5: 239-248, 4 figs.

_____. 1972b. Mode of life of agnostid trilobites. 24th Internat. Geol. Congress, p. 33-40, 2 figs.

_____, and D. P. Campbell. In press. A Cambrian corynexochid trilobite with only two thoracic segments. Lethaia.

_____, and James Sprinkle. 1969. Ctenocystoidea: New class of primitive echinoderms. Science. 166: 1512-1514.

Schwimmer, D. R. 1973. Middle Cambrian biostratigraphy of Montana and Wyoming. State University of New York at Stony Brook unpublished Doctor of Philosophy dissertation.

Shergold, J. H. 1969. Oryctocephalidae (Trilobita: Middle Cambrian) of Australia. Department of National Development. Bull. 104: 66 p., 12 Pls.

Shimer, H. W. and R. R. Shrock. 1944. Index fossils of North America. New York. John Wiley and Sons, Inc. ix + 837 p., 303 Pls.

Sprinkle, James. 1973. Morphology and evolution of Blastozoan Echinoderms. Cambridge, Mass., 284 p.

Stoyanow, Alexander. 1952. See Cooper, G. A. and others.

Suvorova, N. P. 1964. Trilobity Koroneksokhoidy i ikh istoricheskoe razvitie (Corynexochid trilobites and their historical development). Akad. Nauk S. S. S. R., Paleotont. Inst. Trudy, 103: 319 p.

_____, and N. V. Pokrovskaia. 1960. In Chernysheva, N. E. 1960.

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

_____. 1888. Cambrian fossils from Mt. Stephen, Northwest Territory of Canada. Amer. Jour. Sci., 3d ser. 36: 163-166.

_____. 1889. Description of new genera and species of fossils from the Middle Cambrian. U. S. National Mus. Proc. 11: 441-446.

_____. 1890. The fauna of the Lower Cambrian or Olenellus zone. U. S. Geol. Surv. 10th Ann. Rept. 1: 515-629.

_____. 1905. Proceedings of the U. S. National Museum. 29: 28-29.

_____. 1908a. Nomenclature of some Cambrian Cordilleran formations. Smithsonian Misc. Colln. 53: 12 p.

_____. 1908b. Cambrian sections of the Cordilleran area. Smithsonian Misc. Colln. 53: 167-230, Pls. 13-22.

_____. 1908c. Mt. Stephen rocks and fossils. Canadian Alpine Jour. 1: 232-248.

_____. 1908d. Cambrian Geology and Paleontology; No. 2. Cambrian trilobites. Smithsonian Misc. Colln. 53: 13-52, 6 Pls.

_____. 1912a. Cambrian Brachiopods. U. S. Geol. Surv. Mon. 51, 872 p., 104 Pls.

_____. 1912b. The Sardinian Cambrian genus Olenopsis in America. Smithsonian Misc. Colln. 57: 239-249.

Walcott, C. D. 1913. Research in China, v. 3. Carnegie Inst. Washington Pub. 54: 375 p., 29 Pls.

_____. 1916a. Cambrian trilobites. Smithsonian Misc. Colln. 64: 157-258, Pls. 24-28.

_____. 1916b. Cambrian trilobites. Smithsonian Misc. Colln. 64: 303-456, Pls. 45-67.

_____. 1917a. Cambrian Geology and Paleontology; No. 1. Nomenclature of some Cambrian Cordilleran formations. Smithsonian Misc. Colln. 67: 8 p.

_____. 1917b. Fauna of the Mt. Whyte formation. Smithsonian Misc. Colln. 67: 61-114.

_____. 1918. Appendages of trilobites. Smithsonian Misc. Colln. 67: 116-216, Pls. 14-42.

_____. 1924. Cambrian geology and paleontology, 5; No. 3, Cambrian and Ozarkian trilobites. Smithsonian Misc. Colln. 75: 61-146; Pls. 15-24.

_____. 1928. Cambrian geology and paleontology, 5; No. 5, Pre-Devonian Paleozoic formations of the Cordilleran Provinces of Canada. Smithsonian Misc. Colln. 75: 175-368, Pls. 26-108.

Wheeler, H. E. 1943. Lower and Middle Cambrian stratigraphy in the Great Basin area. Geol. Soc. Amer. Bull. 54: 1781-1882.

Whitehouse, F. W. 1945. The Cambrian faunas of northeastern Australia, pt. 5; The trilobite genus Dorypyge. Queensland Mus. Mem. 12: 117-123.

Williams, J. S. 1948. Geology of the Paleozoic rocks, Logan quadrangle, Utah. Geol. Soc. Amer. Bull. 59: 1121-1164.

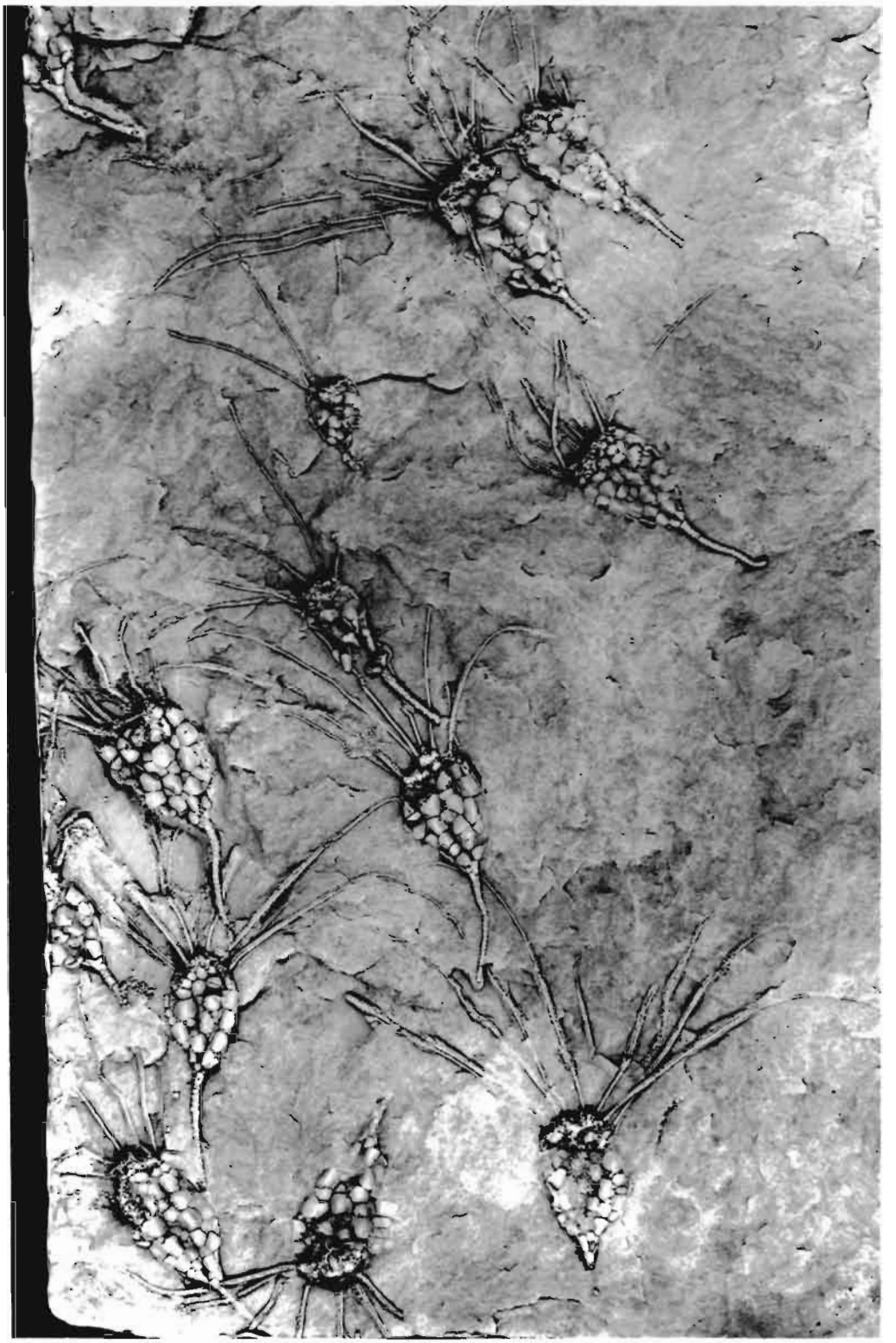
Williams, J. S., and G. B. Maxey. 1941. The Cambrian section in the Logan quadrangle, Utah and vicinity. Amer. Jour. Sci. 239: 276-285.

Zhuraleva, I. T. and others. 1970. Concerning knowledge of the Early Cambrian of southern Tin Shan (In Russian). Trust "Tashkent Geology", Complex Geological Survey exploratory expedition, 1zd. "FAN". U. Z. B. E. C. C. C. P., tashkent. 53 p.

EXPLANATION OF PLATE 1

Gogia kitchnerensis Sprinkle. Latex cast of slab with 13 individuals X1.5, Robison collection, same locality and horizon as collection UU-445.

PLATE 1



EXPLANATION OF PLATE 2

All specimens are latex casts except Figs. 4 and 8. All are from Spence Shale Tongue on west side of Wellsville Mountains, Utah.

Figs. 1-3.--*Cogia granulosa* Robison. 1, pleisotype X1.2, UU-1010p. 2, holotype X2.5, UU-1001. 3, close-up of holotype showing plate ornamentation X8.

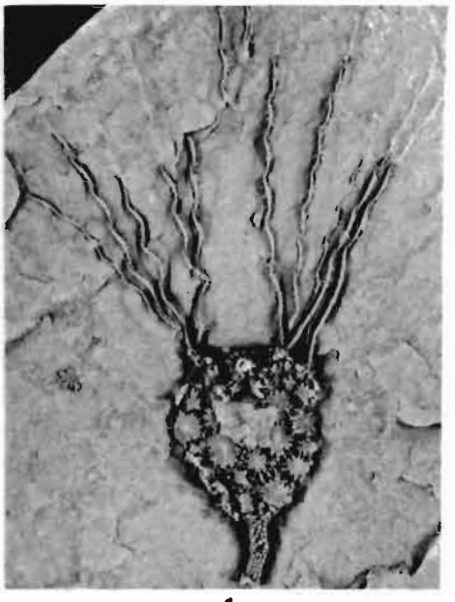
Fig. 4.--Fecal ball X1.5, Robison collection, UU-101.

Figs. 5, 6, 9.--*Ctenocystis utahensis* Robison and Sprinkle. 5, superior surface of holotype X6, USNM 163252. 6, superior surface of paratype X6, USNM 163254. 9, inferior surface of constricted paratype X6, USNM 163255.

Fig. 7.--*Cogia guntheri* Sprinkle. Holotype X1.3, Robison collection, UU-1010a.

Fig. 8.--Undescribed stylophoran X5.3, Robison collection, unnumbered.

PLATE 2



1

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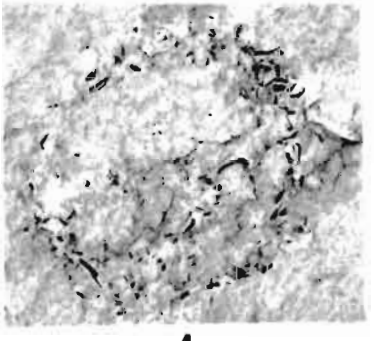

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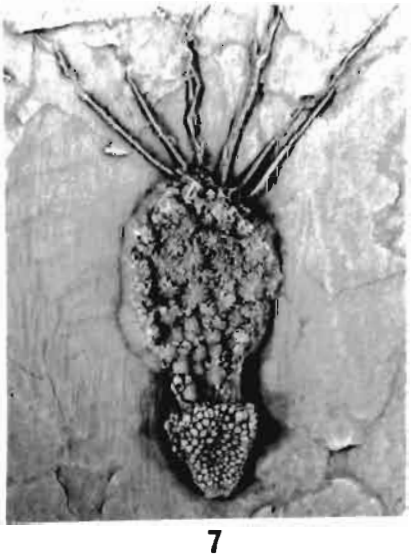
6



7

8

9

EXPLANATION OF PLATE 3

Figs. 1-5.--*Peronopsis bonnerensis* (Resser). 1, 5, top and side views of cranidium X6, 1325, UU-428. 2, pygidium X6, 1326, UU-427. 3, side view of pygidium X6, 1327, UU-411. 4, pygidium X6, 1328, UU-411.

Figs. 6, 7, 13, 14.--*Peronopsis brighamensis* (Resser). 6, complete, flattened individual X6, 1329, float. 7, pygidium X6, 1330, UU-427. 13, side view of pygidium X6, 1331, UU-428. 14, pygidium X6, 1332, UU-427.

Figs. 8, 9.--*Pagetia clytia* Walcott. 8, 9, top and side views of pygidium X10, 1333, UU-415.

Figs. 10-12, 15.--*Pagetia maladensis* Resser. 10, cranidium X10, 1334, UU-411. 11, cranidium X10, 1335, UU-411. 12, 15, side and top views of pygidium X10, 1336, UU-411.

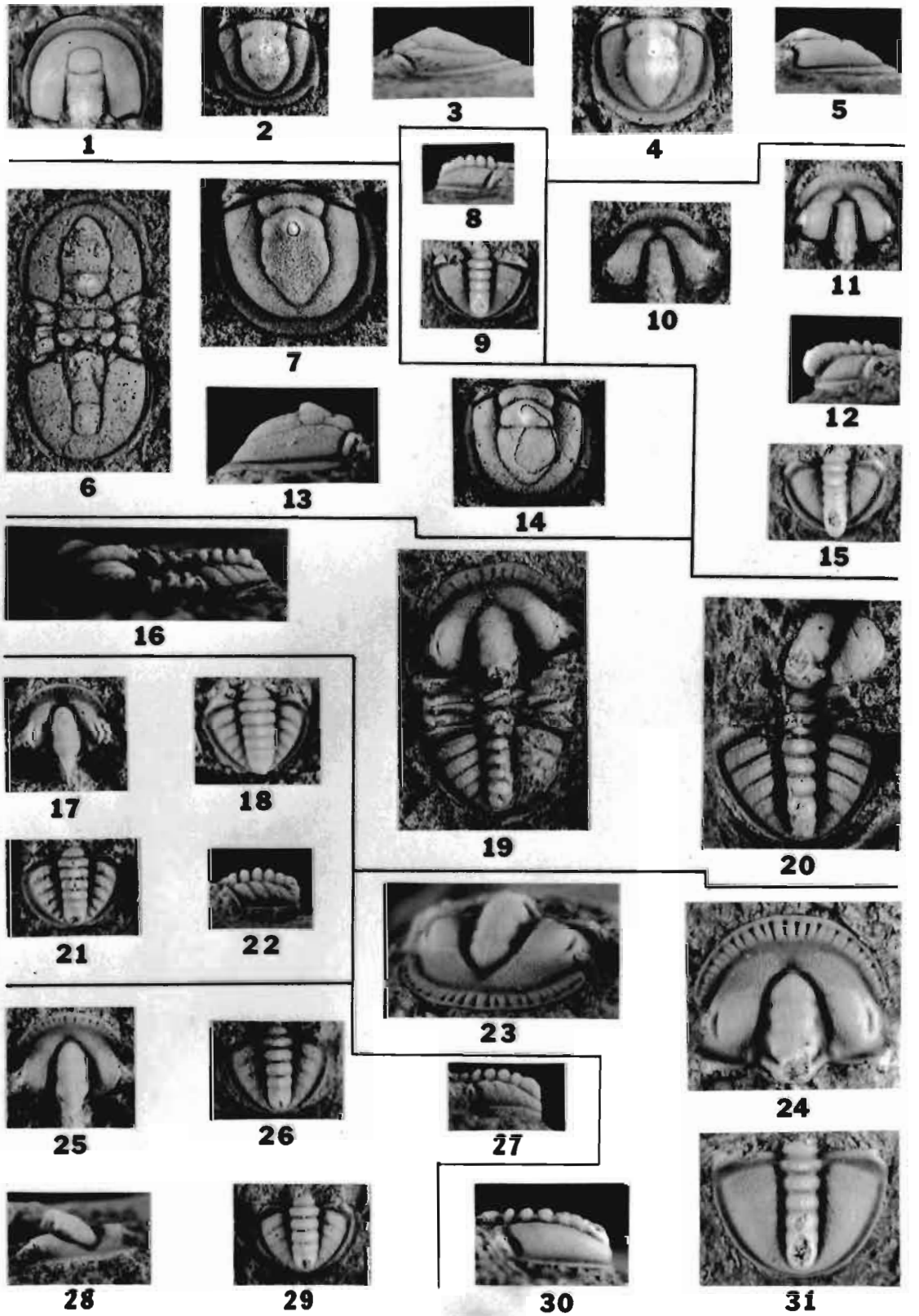
Figs. 16, 19, 20.--*Pagetia lira* n. sp. 16, 19, oblique and top views of holotype X10, 1337, UU-429. 20, nearly complete individual X10, 1338, UU-429.

Figs. 17, 18, 21, 22.--*Pagetia resseri* Kobayashi. 17, cranidium X10, 1339, UU-408. 18, pygidium X10, 1340, UU-408. 21, pygidium X10, 1341, UU-408. 22, side view of pygidium X10, 1342, UU-408.

Figs. 23, 24, 30, 31.--*Pagetia rugosa* Rasetti. 23, 24, oblique and top views of cranidium X10, 1335, UU-411. 30, 31, side and top views of pygidium X10, 1335, UU-411.

Figs. 25-29.--*Pagetia* cf. *P. fossula* Resser. 25, 28, top and oblique views of cranidium X10, 1343, UU-428. 26, 27, top and side views of pygidium X10, 1344, 1344, UU-428. 29, pygidium X10, 1345, UU-428.

PLATE 3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EXPLANATION OF PLATE 4

Figs. 1-4, 6-8.--Athabaskia bithus (Walcott). 1, specimen lacking only librigenae X1, 1346, UU-432. 2, 3, top and oblique views of pygidium X2, 1347, UU-462. 4, hypostome X3, 1348, UU-453. 6, librigenae X3, 1349, UU-439. 7, lectotype pygidium X1, USNM 62635. 8, pygidium X2, 1350, UU-465.

Fig. 5.--Athabaskia sp. undet. 1. Latex cast of cephalon, thorax, and part of pygidium X1.5, 1351, UU-460.

Figs. 9, 10.--Athabaskia sp. undet. 2. 9, 10, top and oblique views of pygidium X5, 1352, UU-408. Latex cast.

Figs. 11-15.--Bathyuriscus brighamensis Resser. 11, 12, 13, top, side, and front views of cranidium X3, 1353, UU-427. 14, pygidium X4, 1354, UU-427. 15, holotype X1.5, USNM 96524.

Figs. 16, 17.--Athabaskia wasatchensis (Resser). 16, complete specimen X1.5, Gunther collections, same locality as UU-445. 17, top view of complete individual X1.5, Gunther collections, same locality as UU-445.

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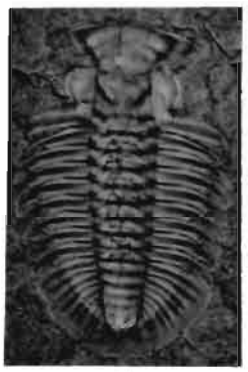

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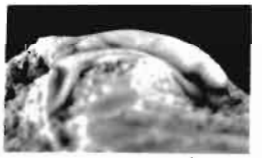

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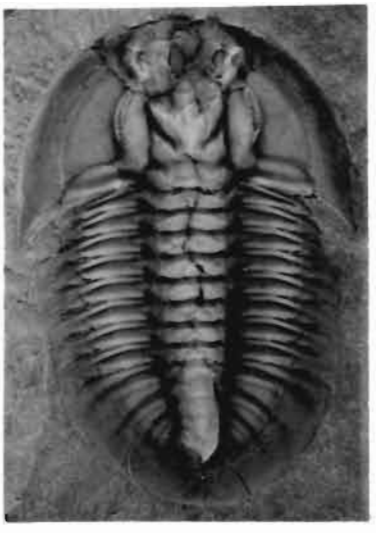

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EXPLANATION OF PLATE 5

Figs. 1, 2, 5, 6, 9.--Bathyuriscus wasatchensis (Resser). 1, complete flattened holotype X1.5, USNM 98500. 2, latex cast of thorax and pygidium X1.5, 1355, UU-425. 5, complete individual X1.5, 1356, UU-425. 6, nearly complete individual X1.5, 1357, UU-425. 9, pygidium X2, 1358, UU-411.

Figs. 3, 4.--Glossopleura bion (Walcott). 3, cranidium X7, 1359, UU-465. 4, flattened pygidium X1, 1360, UU-437.

Figs. 7, 8, 10, 11.--Glossopleura prona Resser. 7, 8, oblique and top views of cranidium X1.5, USNM 98524-396F. 10, 11, side and top views of holotype pygidium X1.5, USNM 98524-396G.

Figs. 12, 13.--Glossopleura arrecta Resser. 12, 13, top and side views of holotype pygidium X1.5, USNM 98525-396D.

Figs. 14, 15.--Glossopleura prona? 14, pygidium X3, 1361, UU-430. 15, cranidium X1.5, 1362, UU-430.

Figs. 16-18.--Glossopleura gigantea? 16, complete individual X1. 17, complete individual X1. 18, complete individual X1. All from Gunther collection, same locality as collection UU-445.

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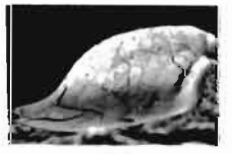

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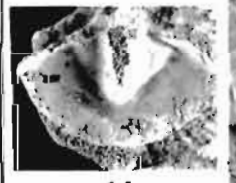

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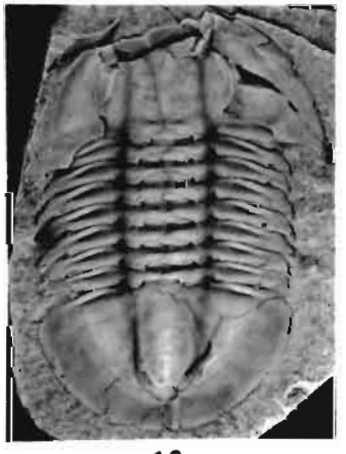

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EXPLANATION OF PLATE 6

Figs. 1-6.--*Glossopleura granosa* n. sp. 1, 2, 6, top, side, and oblique views of cranidium X5, 1363, UU-465. 3, pygidium X6, 1364, UU-465. 4, 5, side and top views of holotype pygidium X4, 1365, UU-465.

Figs. 7, 8.--*Glossopleura* sp. undet. 1. 7, 8, oblique and top views of pygidium X3, 1366, UU-434.

Fig. 9.--*Glossopleura similaris* Resser. Holotype pygidium X1.5, USNM 96525-372a.

Figs. 10-12.--*Glossopleura gigantea* Resser. 10, cranidium X1, 1367, UU-432. 11, pygidium X1, 1368, UU-437. 12, latex cast of individual lacking only librigenae X1, Gunther collection, horizon unknown.

PLATE 6

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EXPLANATION OF PLATE 7

Figs. 1-6.--Glossopleura punctatum n. sp. 1, 6, top and oblique views of cranidium X3.5, 1370, UU-465. 2, pygidium X2, 1371, UU-433. 3, 4, top and side views of pygidium X2, 1372, UU-441. 5, holotype pygidium X2, 1373, UU-440.

Figs. 7, 8, 12.--Glossopleura sp. undet. 2. 7, small pygidium X7, 1374, UU-451. 8, small cranidium X7, 1375, UU-447. 12, fragmentary large pygidium X1.5, 1376, UU-454.

Figs. 9-11, 13-17.--Poliella germana (Resser). 9, cranidium X1, 1377, UU-408. 10, holotype X1.5, USNM 98521. 11, pygidium X2.5, 1378, UU-408. 13, pygidium X2, 1379, UU-408. 14, 15, side and top views of cranidium X1.5, 1380, UU-408. 16, side view of pygidium X2, 1379, UU-408. 17, oblique view of cranidium X1, 1377, UU-408.

Figs. 18-21, 23-25.--Poliella milleri n. sp. 18, 21, side and top views of pygidium X5, 1381, UU-423. 19, hypostome X7, 1382, UU-422. 20, 23, 24, side, top, and oblique views of holotype cranidium X6, 1383, UU-423. 25, pygidium X7, 1384, UU-422.

Figs. 22, 26.--Poliella? sp. 22, 26, side and top views of pygidium X7, 1385, UU-439.

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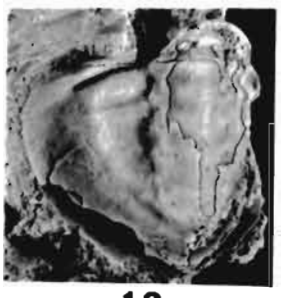
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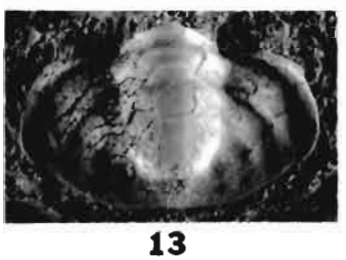
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EXPLANATION OF PLATE 8

Fig. 1.--Polypleuraspis sp. undet. Pygidium X2.5, 1386, float.

Figs. 2-9, 13.--Ptarmigania exigua Resser. 2, 7, top and side views of cranidium X4, 1387, UU-408. 3, 6, front and top views of cranidium X4, 1388, UU-408. 4, 13, top and side views of pygidium X4, 1389, UU-408. 5, cranidium X3.5, 1390, UU-408. 8, pygidium X3.5, 1391, UU-408. 9, librigenae X2.5, 1392, UU-420.

Figs. 10-12, 14, 16, 17, 19, 20.--Ptarmiganoides propinqua (Resser). 10, side view of cranidium X2, 1393, UU-408. 11, 14, top and oblique views of pygidium X2.5, 1394, UU-408. 12, librigenae X2, 1395, UU-408. 16, cranidium X2, 1396, UU-408. 17, 19, oblique and top views of two cranidia X2, 1397, UU-408. 20, pygidium X2.5, 1398, UU-408.

Figs. 15, 18, 21.--Kootenia brevispina Resser. 15, 18, side and top views of pygidium X3, 1399, UU-408. 21, pygidium X3, 1400, UU-408.

PLATE 8


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EXPLANATION OF PLATE 9

Figs. 1-8.--*Ptarmiganoides stokesi* n. sp. 1, cranidium X1.5, 1401, UU-420. 2, 3, 4, oblique, top, and side views of cranidium X2, 1402, UU-420. 5, partial pygidium X1.5, 1403, UU-420. 6, 7, side and top views of pygidium X2, 1404, UU-420. 8, holotype pygidium and articulated thoracic segments X1.5, 1405, UU-420.

Figs. 9, 10, 12, 13.--*Dorypyge wellsvillensis* n. sp. 9, pygidium X3, 1406, UU-465. 10, 13, top and oblique views of holotype pygidium X3, 1407, UU-465. 12, cranidium, thoracic segments and part of pygidium X2, 1408, UU-435.

Figs. 11, 14-19.--*Kootenia arcuata* n. sp. 11, 16, side and top view of cranidium X2, 1409, UU-420. 14, 17, front and top views of cranidium X2, 1410, UU-420. 15, 18, top and side views of holotype pygidium X1.5, 1411, UU-408. 19, pygidium X2, 1412, UU-420.

PLATE 9

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EXPLANATION OF PLATE 10

Figs. 1-3, 5, 6, 9, 10.--Kootenia convoluta Resser. 1, 2, 5, top, composite side, and front views of cranidium and one librigenae X5, 1413, UU-408. 3, 10, side and top views of pygidium X2, 1414, UU-408. 6, cranidium X5, 1415, UU-408. 9, pygidium X5, 1416, UU-410.

Figs. 4, 7, 8, 11.--Kootenia germana Resser. 4, 7, top and side views of cranidium X4, 1417, UU-462. 8, pygidium X4, 1418, UU-441. 11, side view of pygidium X4, 1418, UU-411.

Figs. 12-14, 17, 21, 24.--Kootenia wellsvillensis n. sp. 12, 21, side and top views of holotype pygidium X5, 1419, UU-451. 13, 14, 17, front, side, and top views of cranidium X5, 1420, UU-453. 24, pygidium X5, 1421, UU-453.

Figs. 15, 16.--Kootenia melindensis n. sp. 15, 16, oblique and top views of holotype pygidium X1.5, 1422, UU-465.

Figs. 18-20, 22, 23.--Kootenia mendosa Resser. 18, cranidium X3, 1423, UU-459. 19, 20, top and side views of pygidium X3.5, 1424, UU-460. 22, pygidium X2.5, 1425, UU-459. 23, cranidium X2.5, 1426, UU-459.

PLATE 10


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EXPLANATION OF PLATE 11

Figs. 1-6.--Kootenia spencei Resser. 1, individual lacking only librigenae X1.5, 1427, UU-432. 2, cephalon and part of thorax X1, 1428, UU-435. 3, ventral view of cephalon showing hypostome X1, 1428, UU-435. 4, 6, top and side views of cranidium X3, 1429, UU-439. 5, pygidium X3.5, 1430, UU-465.

Figs. 7, 8.--Kootenia sp. undet. 7, 8, top and side views of partial pygidium X2, 1431, UU-410.

Figs. 9-14, 17, 18.--Ogygopsis typicalis (Resser). 9, 14, side and top views of cranidium X4, 1432, UU-411. 10, 13, top and side views of pygidium X1.5, 1433, UU-411. 11, close-up of large pygidium showing surface ornamentation X4, 1434, UU-411. 12, librigenae X1.5, 1435, UU-411. 17, cranidium and thoracic segments X2, 1436, UU-411. 18, flattened nearly complete individual X1.5, 1437, UU-425.

Figs. 15, 16, 19.--Olenoides evansi Resser. 15, latex cast of paratype pygidium X3, 1438, USNM 96514. 16, paratype pygidium X2, USNM 96514. 19, paratype pygidium X2, USNM 96514. All specimens from locality 55c.

PLATE 11


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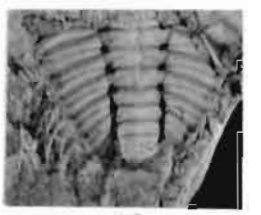
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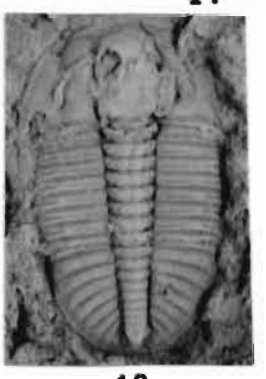
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EXPLANATION OF PLATE 12

Figs. 1-6, 8.--Olenoides maladensis Resser. 1, 6, 8, top, side, and oblique views of cranidium which Resser incorrectly assigned to Taxioura magna X1, USNM 98566. 2, librigenae which Resser incorrectly assigned to T. magna X2, USNM 98566-365w. 3, 4, 5, side, oblique and top views of pygidium X6, 1439, UU-408.

Figs. 7, 10, 11.--Olenoides sp. undet. 7, fragmentary pygidium X6, 1440, UU-465. 10, 11, top and oblique views of latex cast of pygidium in Fig. 7 X6, 1440, UU-465.

Figs. 9, 12.--Olenoides spencei n. sp. 9, fragmentary pygidium X1, 1441, UU-425. 12, holotype pygidium X1.5, 1442, UU-425.

Figs. 13, 15, 16, 20.--Oryctocephalites typicalis Resser. 13, cranidium X6, 1443, UU-463. 15, oblique view of two cranidia X5, 1444, UU-420. 16, cranidium X6, 1445, UU-463. 20, pygidium X6, 1446, UU-463.

Figs. 14, 17, 21.--Oryctocephalites maladensis Resser. 14, cranidium X5, 1447, UU-408. 17, 21, oblique and top views of cranidium X5, 1448, UU-408.

Figs. 18, 19.--Oryctocara geikei Walcott. 18, individual lacking only librigenae X6, 1449, UU-415. 19, small individual lacking only librigenae X7, 1450, UU-415.

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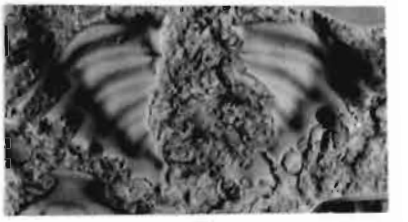
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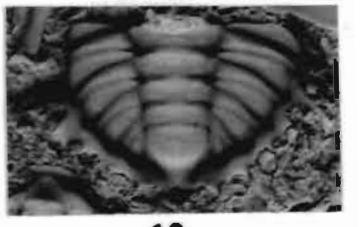
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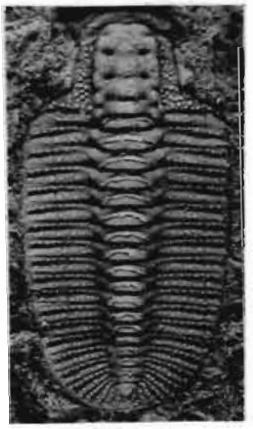
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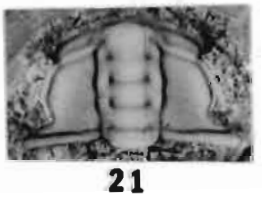
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EXPLANATION OF PLATE 13

Figs. 1, 2, 4, 6.--Oryctocephalites walcotti Resser. 1, cephalon X4, 1451, UU-415. 2, pygidium X3, 1452, UU-415. 4, cranidium X2, 1453, UU-415. 6, complete individual X11, 1454, UU-416.

Figs. 3, 5, 8, 10.--Thoracocare idahoensis (Resser). 3, topotype cranidium, UU-1054. 5, topotype pygidium, UU-1055. 8, holotype pygidium, USNM 98530. 10, posterior view of pygidium, UU-1057. All specimens X20, and all except holotype are from collection UU-411.

Figs. 7, 9, 11-13.--Thoracocare minuta (Resser). 7, meraspid 1 instar without librigenae, USNM 188190. 9, small holospid thorax and pygidium, UU-1053. 11, large holaspid without librigenae, and with tiny anterolateral spines on pygidium, USNM 188193. 12, holaspid without librigenae, UU-1050. 13, holaspid without librigenae, USNM 188192. All specimens X20. 7, 9, 11, 13 from collection UU-415; 12 from collection UU-416.

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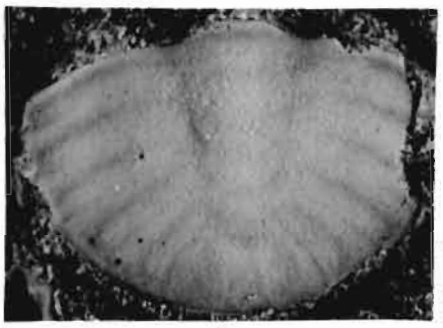

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EXPLANATION OF PLATE 14

Figs. 1-8.--Albertella gynthos n. sp. 1, 2, 3, dorsal, oblique, and side views of holotype cranidium X2, 1455, UU-402. 4, partial cranidium X2, 1456, UU-402. 5, 6, side and top views of pygidium X1.5, 1457, UU-402. 7, pygidium X3, 1458, UU-402. 8, pygidium X2, 1459, UU-402.

Figs. 9-17.--Albertellina aspinosa Palmer. 9, pygidium X4, 1460, UU-403. 10, cranidium X3, 1461, UU-407. 11, 14, 15, top, side, and oblique views of cranidium X2.5, 1462, UU-405. 12, 17, side and top views of pygidium X5, 1463, UU-407. 13, pygidium X4, 1464, UU-403. 16, pygidium and thoracic segments X7, 1465, UU-405.

Figs. 18-24.--Albertelloides dispar (Resser). 18, 19, 21, side, oblique, and dorsal views of tentatively assigned cranidium X3, 1466, UU-420. 20, 24, side and top views of pygidium X2, 1467, UU-420. 22, 23, top and oblique views of pygidium X3.5, 1468, UU-421.

PLATE 14


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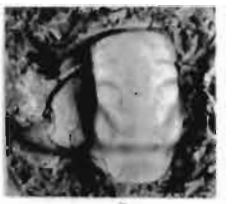
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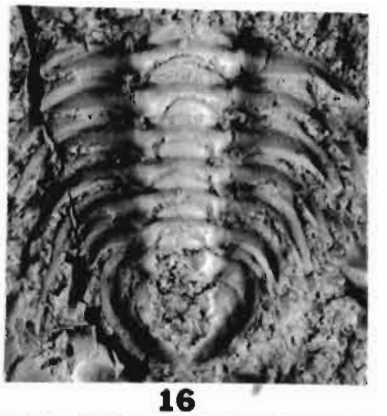
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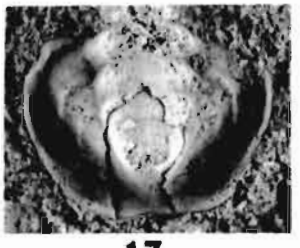
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EXPLANATION OF PLATE 15

Figs. 1, 2, 6, 7.--Albertelloides fritzi n. sp. 1, 2, 6, top, oblique, and side views of holotype pygidium X2.5, 1469, UU-420. 7, pygidium X2.5, 1470, UU-420.

Figs. 3, 4, 8.--Albertelloides maladensis (Resser). 3, pygidium X5, 1471, UU-408. 4, 8, side and top views of pygidium X5, 1472, UU-408.

Figs. 5, 9-15.--Paralbertella judithi (Fritz). 5, 15, top and oblique views of cranidium X3, 1473, UU-420. 9, pygidium X2, 1474, UU-419. 10, cranidium X3, 1475, UU-420. 11, 13, side and top views of pygidium X2, 1476, UU-420. 12, pygidium X2, 1611, UU-419. 14, pygidium X4, 1477, UU-420.

Figs. 16, 17, 19-21, 23, 24.--Zacanthoides alatus (Resser). 16, 17, 20, oblique, top, and side views of cranidium X3, 1478, UU-408. 19, pygidium X6, 1479, UU-408. 21, 23, top and oblique views of pygidium X6, 1480, UU-408. 24, pygidium and associated Helcionella X6, 1481, UU-408.

Figs. 18, 22.--Zacanthoides aff. Z. alatus. 18, 22, side and top views of pygidium X5, 1482, UU-408.

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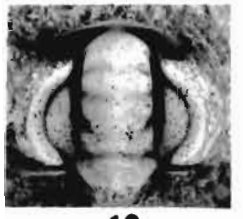
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EXPLANATION OF PLATE 16

Figs. 1, 2.--Zacanthoides cf. Z. alatus Resser. 1, 2, top and oblique views of pygidium X5, 1483, UU-408.

Figs. 3-9.--Zacanthoides avernus n. sp. 3, 6, side and top views of cranidium X3, 1484, UU-460. 4, cranidium X3, 1485, UU-460. 5, 9, top and side views of holotype pygidium X6, 1486, UU-460. 7, pygidium X5, 1487, UU-460. 8, cranidium flattened in shale X1.5, 1488, UU-459.

Figs. 10, 12-16.--Zacanthoides fedori n. sp. 10, 14, side and top views of holotype pygidium X6, 1489, UU-449. 12, 13, top and oblique views of cranidium X2, 1490, UU-450. 15, pygidium X6, 1491, UU-447. 16, pygidium X6, 1492, UU-447.

Figs. 11, 17, 18, 21, 22.--Zacanthoides latus n. sp. 11, 17, 21, top, side, and oblique views of cranidium X2, 1493, UU-410. 18, 22, oblique and top views of holotype pygidium X2, 1494, UU-410.

Figs. 19, 20.--Zacanthoides aff. Z. grabaui Pack. 19, cranidium X1.5, 1495, UU-437. 20, cranidium X2.5, 1496, UU-432.

PLATE 16


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EXPLANATION OF PLATE 17

Figs. 1-6, 8.--*Zacanthoides prolixus* n. sp. 1, 2, top and side views of cranidium X2.5, 1497, UU-465. 3, 5, side and top views of small cranidium X5, 1498, UU-465. 4, 8, top and side views of holotype pygidium X6, 1499, UU-465. 6, pygidium X5, 1500, UU-462.

Figs. 7, 9-13, 16-18.--*Zacanthoides idahoensis* Walcott. 7, complete individual, holotype of *Z. holopygus* Resser X3, USNM 96522. 9, large pygidium X1, 1501, UU-445. 10, large undisturbed cranidium X1.5, 1502, UU-442. 11, complete paratype individual X3. 12, flattened cranidium and two thoracic segments X1, 1503, UU-445. 13, flattened pygidium X1.5, 1504, UU-444. 16, complete small individual X2.5, Gunther collection, same as collection UU-445. 17, complete small individual X2.5, Gunther collections, same as collection UU-445. 18, complete large individual X1, Gunther collection, same as collection UU-445.

Figs. 14, 15.--Genus and species undetermined 1. 14, 15, top and oblique views of fragmentary pygidium X2, 1505, UU-404.

PLATE 17


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EXPLANATION OF PLATE 18

Figs. 1-6.--Zeugospina guntheri n. gen. n. sp. 1, 5, 6, top, side and front views of cranidium X6, 1506, UU-405. 2, cranidium X6, 1507, UU-405. 3, holotype pygidium X18, 1508, UU-403. 4, larger fragmentary pygidium X6, 1509, UU-403.

Figs. 7, 10, 11.--Genus and species undetermined 2. 7, 10, 11, top, oblique, and side views of cranidium X2.5, 1510, UU-408.

Figs. 8, 9, 12, 13.--Achlysopsis punctatum n. sp. 8, holotype cranidium X2, 1511, UU-428. 9, cranidium X6, 1512, UU-427. 12, 13, front and side views of cranidium X4, 1513, UU-427.

Figs. 14-17.--Alokistocare mccollumi n. sp. 14, cranidium X6, 1514, UU-451. 15, 16, 17, oblique, top, and side views of holotype cranidium X6, 1515, UU-450.

Figs. 18-21.--Alokistocare idahoense Resser. 18, complete individual X1.5, 1516, UU-435. 19, latex cast of individual lacking front of cephalon X1.5, 1517, UU-432. 20, complete individual which Resser designated the holotype of A. spencense X1.5, USNM 96516. 21, holotype X1.5, USNM 96507.

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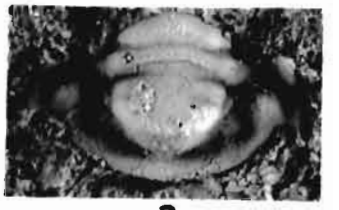
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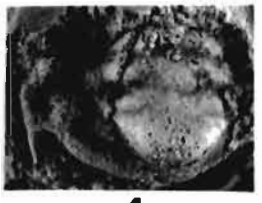
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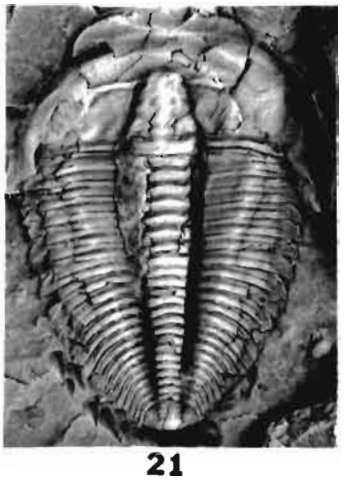
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EXPLANATION OF PLATE 19

Figs. 1-5.--Alokistocare laticaudum Resser. 1, 5, top and oblique views of cranidium X6, 1518, UU-410. 2, weathered cranidium X1.5, 1519, UU-429. 3, exfoliated cranidium X2, 1520, UU-410. 4, latex cast of cranidium and attached segments X1, 1521, UU-433.

Figs. 6-8.--Alokistocare mutablis n. sp. 6, two cranidia--cranidium on right is holotype X5, 1522, UU-465. 7, cranidium X3, 1523, UU-465. 8, oblique view of holotype cranidium X5, 1522, UU-465.

Figs. 9-11.--Alokistocare melindensis n. sp. 9, 11, top and oblique views of holotype cranidium X4, 1524, UU-439. 10, two cranidia X2, 1525, UU-439.

Figs. 12, 13, 16, 17.--Alokistocare nannos n. sp. 12, 16, 17, side, front, and top views of holotype cranidium X6, 1526, UU-443. 13, cranidium X6, 1527, UU-442.

Figs. 14, 15, 18, 22, 23.--Alokistocarella brighamensis Resser. 14, cranidium X4, 1528, UU-411. 15, 18, 23, front, side and top views of cranidium X4, 1529, UU-411. 22, flattened cranidium X4, 1530, UU-425.

Figs. 19-21, 24.--Alokistocarella occidens Resser. 19, 20, top and oblique views of cranidium X6, 1531, UU-411. 21, 24, side and top views of cranidium X8, 1532, UU-411.

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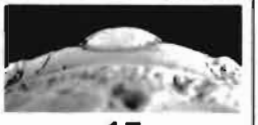
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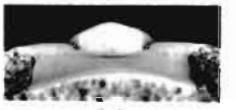
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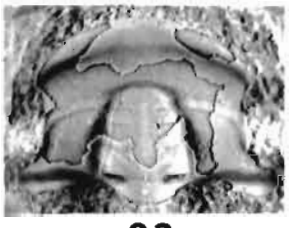
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EXPLANATION OF PLATE 20

Figs. 1, 2, 5.--Alokistocarella? sp. undet. 1, 2, 5, top, side and oblique views of cranidium X6, 1533, UU-443.

Figs. 3, 4, 6-9, 12, 16.--Bythicheilus typicum Resser. 3, cranidium X3.5, USNM 96538. 4, cranidium X3.5, USNM 96538. 6, 7, 12, top, side, and oblique views of cranidium X6, 1534, UU-434. 8, individual designated as holotype of B. alveatum by Resser X3, USNM 96538-371H. 9, individual lacking librigenae X3, USNM 96537-275R. 16, complete individual X4, USNM 96537-285-109F.

Figs. 10, 11, 13-15.--Caborcella cracens n. sp. 10, 11, 13, top, oblique and side views of holotype cranidium X6, 1535, UU-465. 14, cranidium X4.5, 1536, UU-465. 15, cranidium X4, 1537, UU-465.

Figs. 17-19.--Chancia ebdome Walcott. 17, individual assigned to C. angusta by Resser X1.5, USNM 96523. 18, incomplete individual X1.5, USNM 70274. 19, individual designated as the holotype of C. angusta by Resser X1.5, USNM 96523.

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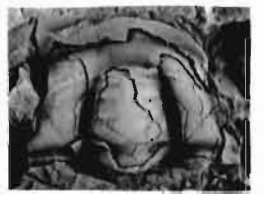
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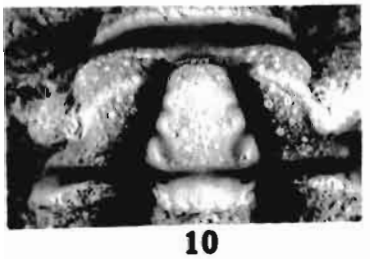
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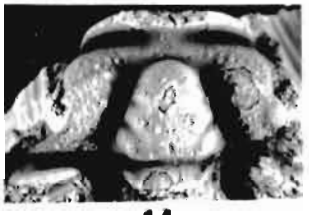
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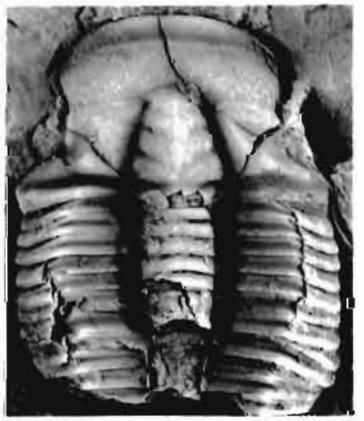
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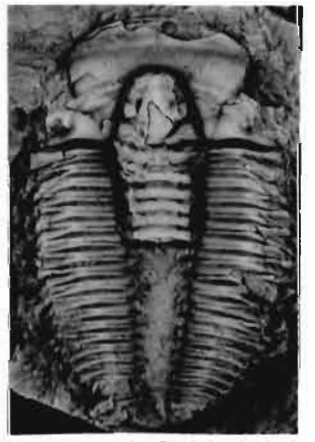
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EXPLANATION OF PLATE 21

Figs. 1,2.--Chancia cf. C. ebdome Walcott. 1, partial cranidium X2, 1538, UU-430. 2, latex cast of cranidium X2, 1539, UU-430.

Figs. 3-6.--Chancia venusta (Resser). 3, side view of cranidium X2.5, 1540, UU-420. 4, 5, top and oblique views of cranidium X5, 1541, UU-408. 6, cranidium X4, 1542, UU-408.

Fig. 8.--Chancia coriacea (Resser). Holotype cranidium X2.5, USNM 96533.

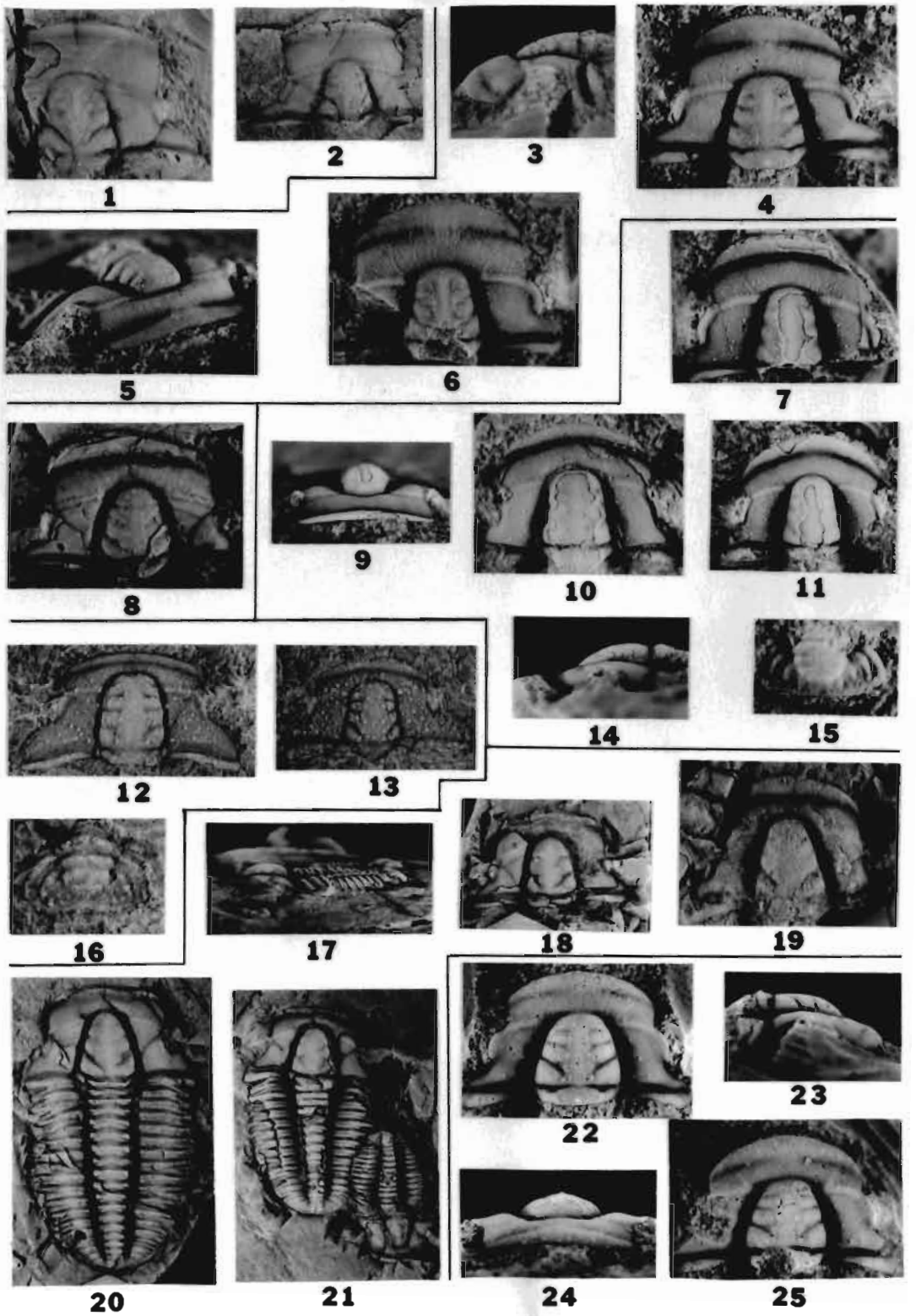
Figs. 7, 9-11, 14, 15.--Ehmaniella petalora n. sp. 7, cranidium X6, 1543, UU-460. 9, 11, front and top views of holotype cranidium X6, 1544, UU-460. 10, 14, top and side views of cranidium X6, 1545, UU-460. 15, pygidium X10, 1546, UU-460.

Figs. 12, 13, 16.--Ehmaniella stibinus n. sp. 12, holotype cranidium X6, 1547, UU-461. 13, cranidium X6, 1548, UU-461. 16, pygidium X10, 1549, UU-461.

Figs. 17-21.--?Ehmaniella spencei (Resser). 17, 21, side and top views of two individuals which Resser assigned to Clappaspis idahoensis X1.5, USNM 96531-371Q. 18, cranidium assigned to Clappaspis spencei by Resser X1.5, USNM 96530-371V. 19, cranidium assigned to Clappaspis dotis by Resser X2.5, USNM 96534. 20, individual designated as holotype of Clappaspis idahoensis by Resser, X1.5, USNM 96531-108u.

Figs. 22-25.--*Nyellina maladensis* n. gen. n. sp. 22, 23, 24, top, side, and front views of holotype cranidium X4, 1550, UU-463. 25, cranidium X4, 1551, UU-463.

PLATE 21



EXPLANATION OF PLATE 22

Figs. 1-4, 6, 7.--*Elrathina spencei* (Resser). 1, 4, top and side views of cranidium X4, 1552, UU-428. 2, 3, top and oblique views of cranidium X4, 1553, UU-428. 6, individual lacking one librigenae X2, USNM 96540-373H. 7, holotype individual X3, USNM 96540-373S.

Figs. 5, 8, 9.--*Kochina vestita* Resser. 5, 9, top and front views of cranidium X1.5, 1554, UU-411. 8, cranidium X2, 1556, UU-411.

Figs. 10-12.--*Kochiella? mansfieldi* Resser. 10, 11, top and side views of holotype cranidium X1.5, USNM 98557-395H. 12, partial cranidium X1.5, USNM 98557-395i.

Figs. 13-15, 17. *Mexicella granosa* n. sp. 13, cranidium X5, 1555, UU-405. 14, 15, 17, top, side, and oblique views of holotype cranidium X4, 1557, UU-403.

Figs. 16, 18-22.--*Naomiaspis typicalis* n. gen. n. sp. 16, pygidium X10, 1558, UU-422. 18, librigenae X4, 1559, UU-422. 19, cranidium X5, 1561, UU-423. 20, 21, 22, top, oblique, and side views of holotype cranidium X3, 1560, UU-423.

Figs. 23-27.--*Nyella limbus* n. sp. 23, cranidium X2.5, 1562, UU-420. 24, 26, 27, oblique, side, and top views of holotype cranidium X3, 1563, UU-420. 25, partial pygidium X3, 1614, UU-420.

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EXPLANATION OF PLATE 23

Figs. 1-6.--Nyella granosa (Resser). 1, cranidium X4, 1564, UU-408. 2, 3, 4, top, front, and side views of cranidium X2.5, 1565, UU-408. 5, pygidium X5, 1566, UU-408. 6, pygidium X6, 1567, UU-408.

Figs. 7-10.--Nyella periosus n. sp. 7, 9, 10, top, side, and front views of holotype cranidium X1.5, 1568, UU-420. 8, cranidium X1.5, 1569, UU-420.

Figs. 11-13.--Nyella sp. undet. 11, 12, 13, top, oblique, and side views of cranidium X1.5, 1570, UU-419.

Figs. 14-19.--Pachyaspis typicalis Resser. 14, 15, 18, top, side, and front views of cranidium X3, 1571, UU-411. 16, cranidium X5, 1572, UU-411. 17, pygidium X10, 1573, UU-411. 19, pygidium X10, 1574, UU-411.

Figs. 20-25.--Palmerella exiguus n. gen. n. sp. 20, 21, 22, front, side, and top views of holotype cranidium X10, 1575, UU-452. 23, cranidium X10, 1576, UU-443. 24, cranidium X7, 1577, UU-454. 25, cranidium X7, 1578, UU-452.

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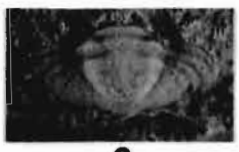
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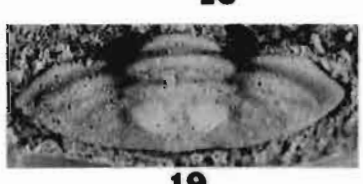
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EXPLANATION OF PLATE 24

Figs. 1-3.--*Oraspis limbus* n. gen. n. sp. 1, 2, 3, top, front, and side views of holotype cranidium X6, 1579, UU-465.

Figs. 4-6.--*Oraspis* cf. *O. limbus*. 4, 5, side and top views of cranidium X7, 1580, UU-462. 6, cranidium X7, 1581, UU-462.

Figs. 7-9, 12, 13.--*Prohedinia*? *spencei* n. sp. 7, 8, 12, front, side, and top views of cranidium X4, 1582, UU-427. 9, cranidium X4, 1583, UU-427. 13, incomplete holotype individual X4, 1584, UU-427.

Figs. 10, 11, 14-16.--*Onchocephalus*? *stibinus* n. sp. 10, 14, 15, top, side, and front views of holotype cranidium X5, 1585, UU-451. 11, cranidium X2, 1586, UU-452. 16, cranidium X2, 1587, UU-447.

Figs. 17-19, 21, 22.--*Prohedinia maladensis* (Resser). 17, cranidium X4, 1588, UU-411. 18, cranidium X10, 1589, UU-411. 19, 21, top and side views of cranidium X4, 1590, UU-411. 22, small cranidium X10, 1591, UU-411.

Figs. 20, 23-26.--*Pseudomexicella granulosa* n. gen. n. sp. 20, 24, 26, side, oblique, and top views of holotype cranidium X6, 1592, UU-402. 23, 25, top and side views of cranidium X5, 1593, UU-402.

PLATE 24


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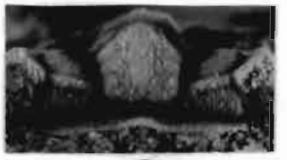
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EXPLANATION OF PLATE 25

Figs. 1, 2, 4, 5.--Spencia typicalis Resser. 1, cranidium X3.5, USNM 96535-372w. 2, 4, top and oblique views of cranidium X4.5, USNM 96535-372u. 5, holotype individual X5, USNM 96535-372T.

Figs. 3, 6, 9, 12.--Utia curio Walcott. 3, 9, 12, top, side, and front views of cranidium X5, 1594, UU-434. 6, small cranidium X10, 1595, UU-442.

Figs. 7, 8, 10, 11.--Maladella oculatus n. gen. n. sp. 7, 10, 11, top, oblique, and front views of holotype cranidium X6, 1596, UU-408. 8, cranidium X6, 1597, UU-408.

Figs. 13, 14, 15, 16, 17, 21.--Volocephalina stokesi n. sp. 13, 17, top and oblique views of holotype cranidium X6, 1600, UU-405. 14, exfoliated cranidium X6, 1599, UU-405. 21, small cranidium X10, 1601, UU-403.

Figs. 15, 18-20.--Pachyaspis eurylimbus n. sp. 15, cranidium X6, 1602, UU-410. 18, 19, 20, top, front, and side views of holotype cranidium X6, 1603, UU-410.

PLATE 25

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EXPLANATION OF PLATE 26

Figs. 1, 2.--Genus and species undetermined 5. 1, cranidium X3.5, 1604, UU-459. 2, cranidium X3, 1605, UU-459.

Figs. 3, 4, 8.--Genus and species undetermined 6. 3, 4, top and side views of exfoliated cranidium X10, 1606, UU-400. 8, partially exfoliated cranidium X10, 1607, UU-400.

Figs. 5-7.--Genus and species undetermined 4. 5, 7, top and side views of cranidium X7, 1608, UU-403. 6, cranidium X7, 1609, UU-403.

Figs. 9-12.--Genus and species undetermined 3. 9, 10, 11, 12, front, top, oblique, and side views of cranidium X7, 1610, UU-465.

Figs. 13-16.--Genus and species undetermined 7. 13, cranidium X6, 1612, UU-460. 14, 15, 16, top, front, and side views of cranidium X6, 1613, UU-460.

Fig. 17.--View of Middle Cambrian formation south of Antimony Canyon, Wellsville Mountains, Utah. BR- Brigham Quartzite; NP- Naomi Peak Tongue; S- Spence Tongue; HCL- High Creek Limestone; LD- Langston Dolomite; U- Ute Formation; BL- Blacksmith Dolomite.

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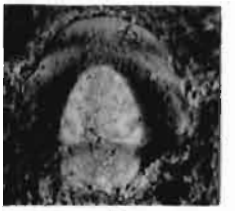

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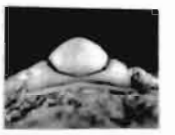

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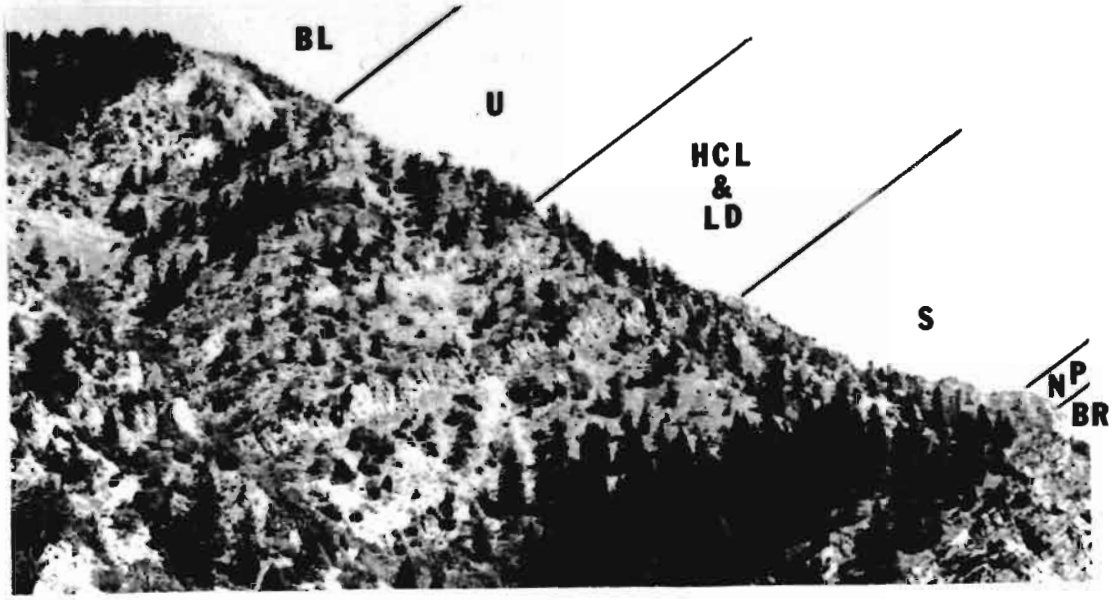

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APPENDIX

Measured Sections

One section in southeastern Idaho and one in northern Utah (Text-fig. 1) were measured, and are described here. Each section was measured with a Jacob's staff, was marked with a stripe of yellow paint every five feet, and the stripes were numbered every 25 feet. Most beds were sampled for fossils, and collections were bagged separately and labeled to correspond with the position of the bed above the base of the section.

Rock descriptions are given in general field terms. Fresh and weathered colors were determined with the aid of a Geological Society of America rock-color chart.

Beds from which trilobites were collected and the identified genera and species in each collection are listed after the lithologic description of the beds. The trilobite species are arranged alphabetically by genus in each list, followed by genera and species of other phyla.

Sections were measured from bottom to top, but are described here from top to bottom. The "Feet Above Base" figure refers to the stratigraphic height of the base of each unit above the base of the formation. The first number by each faunal list indicates the University of Utah collection number. The number in parentheses is the footage above the base of the formation. For example, for UU-416 (87), "UU-416" is the collection number, and "87" indicates the collection came from 87 feet above the base of the formation.

Malad Range, Idaho

The section was measured on the north side of Two Mile Canyon, near its mouth, in the NE 1/4 sec. 35, T 14 S, R 36 E, approximately two miles southeast of Malad City, Idaho. The base of the section is about 50 yards east of a small rock quarry, and the section is about 100 yards east of what probably is locality 54s of Resser's (1939b, p. 17) Ptarmigania strata. Strike of the beds is N 80° E. and dip is 10° NW.

	Unit Thickness Feet	Feet Above Base
SPENCE TONGUE OF THE LEAD BELL SHALE --102 feet (top part removed by faulting)		
Fault		
18. Covered interval, shale float.....	14	88
17. Limestone, micritic, dark-gray, weathers medium-dark gray; beds three to eight inches thick; many white calcite veins.		
UU-416 (87) Oryctocare geikei Oryctocephalus walcotti Thoracocare minuta inarticulate brachiopods.....	2	86
16. Covered interval, shale float.....	6	80
15. Limestone, micritic, dark-gray, weathers medium-gray to pale-yellowish-brown; beds 1/4 to five inches thick;		

many white calcite beds.

UU-415 (76) Oryctocare geikei

Oryctocephalus walcotti

Pagetia clytia

Peroncpsis bonnerensis

Peronopsis brighamensis

Thoracocare minuta

inarticulate brachiopods

sponge spicules..... 5 75

14. Covered interval, shale and

limestone float..... 9 64

13. Shale and limestone, shaly;

both medium- to dark-gray,

weathers light- to medium-

gray; beds 1/8 to 1/4 inch

thick; prospect pit yielded

a few fossils.

UU-413 (41) Oryctocephalus walcotti

Thoracocare minuta

sponge spicules..... 25 39

12. Shale and claystone, dark-gray,

weathers light-gray to

light-brown; beds 1/16 to

1/4 inch thick..... 37 2

Offset 100 yards west across tear fault.

11. Claystone, dark-gray, weathers

light-gray to light-brown;

beds 1/16 to 1/4 inch thick.

UU-412 (1) Elrathina cf. E. spencei

Ogygopsis typicalis

Oryctocare geikei

Oryctocephalus walcotti

Peronopsis bonnerensis

Peronopsis brighamensis

Thoracocare minuta..... 2 0

TWIN KNOBS FORMATION --83 feet

10. Limestone, sparry and micritic; medium- to dark-gray, weathers light- to medium-gray; beds range from four to 10 inches thick; limonite specks common; ledge former.

UU-411 (83) Alokistocarella brighamensis

Alokistocarella occidens

Bathyuriscus wasatchensis

Kochina vestita

Ogygopsis typicalis

Oryctocephalites typicalis

Pachyaspis typicalis

Pagetia maladensis

Pagetia resseri

Pagetia rugosa

Peronopsis bonnerensis

Peronopsis brighamensis

Prohedinia maladensis

Thoracocare idahoensis

Zacanthoides alatus

Helcionella sp. undet.

Hyolithes sp. undet.

inarticulate brachiopods

UU-410 (82) Alokistocare laticaudum

Kootenia convoluta

Kootenia sp. undet.

Oryctocare geikei

Pachyaspis eurylimbus

Pagetia resseri

Zacanthoides latus

articulate brachiopods

Hyolithes sp. undet.

UU-409 (81) Kootenia convoluta

Oryctocephalus maladensis

Pagetia resseri

Ptarmigania exigua

Zacanthoides alatus

UU-408 (79) Albertelloides maladensis

Athabaskia sp. undet. 2

Chancia venusta

Kootenia arcuata

Kootenia brevispina

Kootenia convoluta

Maladella oculatus

Nyella granosa

Nyella limbus

Nyella periosus

Olenoides maladensis

Oryctocephalites typicalis

Oryctocephalus maladensis

Pachyaspis typicalis

Pagetia resseri

Paralbertella judithi

Poliella germana

Ptarmigania exigua

Ptarmiganoides propinqua

Zacanthoides alatus

Zacanthoides aff. Z. alatus

Zacanthoides cf. Z. alatus

Genus and species undetermined 1

articulate brachiopods

Helcionella sp. undet.

Hyolithes sp. undet.

inarticulate brachiopods..... 5 78

9. Sandstone and limestone; sandstone light-olive-gray with dusky red streaks, weathers light- to medium-light-gray; medium-scale cross bedding. Limestone medium-gray, weathers light-gray.

UU-407 (78) Albertella synthos

Albertellina aspinosa

Mexicella granosa

Nyella granosa

Volocephalina stokesi..... 3 75

8. Sandstone, argillite, and limestone, interbedded sandstone medium- to dark-gray, weathers dusky-red and moderate- to pale-yellowish-brown; beds 1/4 to eight inches thick; medium-scale cross bedding; ledge former. Argillite medium-gray, weathers pale-yellowish-brown. Limestone medium-gray, weathers light- to medium-gray, limonite specks common..... 15 60

7. Sandstone, calcareous with limestone lenses, medium-gray, weathers brownish- to olive-gray; limestone lenses composed dominantly of trilobite carapaces.

UU-405(57) Albertella gynthos

Albertellina aspinosa

Mexicella granosa

Volocephalina stokesi

Zeugospina guntheri

UU-404 (56) Albertellina aspinosa

Mexicella granosa

Nyella granosa

Pseudomexicella granulosa

Volocephalina stokesi

Zeugospina guntheri

Genus and species undetermined 2

UU-403 (55) Albertellina aspinosa

Mexicella granosa

Nyella granosa

Pseudomexicella granulosa

Volocephalina stokesi

Zeugospina guntheri

Genus and species undetermined 4

inarticulate brachiopods..... 7 53

6. Argillite, micaceous, dusky-yellow-green, weathers dusky-red to moderate-brown, slope former..... 13 40

5. Sandstone, calcareous, medium-gray, weathers pale-yellowish-brown, ledge former.

UU-417 (36) Albertella gynthos

Albertellina aspinosa

Pseudomexicella granulosa

Volocephalina stokesi..... 3 37

4. Sandstone, calcareous with sparry limestone lenses. Medium-dark-gray, weathers pale-yellowish-brown.

UU-402 (33) Albertella gynthos

Albertellina aspinosa

Mexicella granosa

Pseudomexicella granulosa

Volocephalina stokesi

UU-401 (31) Albertella gynthos

Pseudomexicella granulosa

Volocephalina stokesi..... 6 31

3. Argillite, micaceous; dusky-yellow-green, weathers dusky-red to moderate-brown; beds 1/8 to 1/4 inch thick; slope former; abundant trace fossils..... 11 20

2. Sandstone, calcareous with interbedded argillite; sandstone light-olive-gray, weathers light-dusky-red to moderate-reddish-brown; beds one to eight inches thick; sparsely fossiliferous. Argillite, dusky-yellow-green, weathers dusky-red to moderate-brown; beds 1/8 to 1/4 inch thick.

UU-400 (2) Albertella gynthos

Genus and species undetermined 6..... 20 0

BRIGHAM QUARTZITE --510 feet exposed

1. Quartzite and argillite with minor

calcareous sandstone units.....510 0

Wellsville Mountains, Utah

The section was measured on the first ridge south of Antimony Canyon in the SE 1/4 sec. 36 T 10 N, R 2 W and SW 1/4 sec. 31 T 10 N, R 1 W, about 2.5 miles north of Brigham City, Utah. The base of the section begins at an elevation of about 6,300 feet. Strike is N 35° W and the dip is 40° NE.

	Unit Thickness Feet	Feet Above Base
UTE FORMATION --Thickness of formation about 600 feet, only lower 190 feet measured.		
33. Shale and limestone, shaly: shale light-olive-gray; weathers moderate-yellowish-brown on exposed surfaces; beds 1/8 to three inches thick. Limestone, medium-light-gray, beds 1/4 to two inches thick; shaly partings weather into higher relief.....	6	184
32. Limestone, micritic, medium-light-gray; beds 1/2 to two inches thick, with minor oolites; silty partings weather into higher relief.....	68	116
31. Shale, light-olive-gray, weathers moderate-yellowish-brown; beds		

1/8 to 1/2 inch thick; minor
interbedded sparry limestone
with oolites..... 18 98

30. Limestone, silty, medium-gray; beds
1/2 to three inches thick;
abundant oncolite and oolites;
minor shaly limestone..... 27 71

29. Shale, light-olive-gray, weathers
to moderate-yellowish-brown;
beds 1/8 to 1/2 inch thick.
UU-461 (68) Ehmaniella stibinus..... 5 66

28. Limestone, silty, medium-gray; beds
1/2 to two inches thick; oncolites
and oolites common; minor shaly
limestone..... 42 24

27. Shale, with interbedded shaly limestone;
shale light-olive-gray; weathers
moderate-yellowish-brown; beds
1/8 to 1/2 inch thick. Limestone,
silty, medium-gray; beds 1/2 to two
inches thick.
UU-460 (10) Athabaskia sp. undet. 1
Ehmaniella petalora
Kootenia mendosa
Zacanthoides avernus
Genus and species undetermined 7
Helcionella sp. undet.

Hyolithes sp. undet.

UU-459 (2) Athabaskia sp. undet. 1

Kootenia mendosa

Zacanthoides avernus

Genus and species undetermined 5

Hyolithes sp. undet.

inarticulate brachiopods

worm tubes..... 24 0

UPPER TONGUE OF LANGSTONE DOLOMITE --90 feet

26. Dolomite, medium- to coarse-crystalline, medium-light-gray; weathers pale-orange- to grayish-orange; beds 1/8 to 1/2 inch thick, medium-gray, horizontal wavy layers abundant; beds range from four inches to three feet thick; cliff former..... 90 0

HIGH CREEK LIMESTONE --85 feet

25. Limestone, sparry, medium-dark-gray, weathers medium-light-gray; beds one to three inches thick; abundant Girvanella, many with white calcite fillings..... 1 84

24. Limestone, micritic, dark-gray, weathers medium-light-gray; beds 1/2 to four inches thick; numerous white calcite veins.

UU-456 (72) Athabaskia bithus

Palmerella exiguus

inarticulate brachiopods..... 27 57

23. Limestone, sparry, medium-dark-gray,
weathers medium-light-gray;
beds one to six inches thick;
abundant oncolites, many with
secondary calcite fillings;
minor oolites..... 3 54

22. Limestone, sparry, medium-dark-gray,
weathers medium-light-gray;
beds one to six inches thick; minor
oolite, fetid odor.

UU-454 (45) Alokistocare mccollumi
Athabaskia bithus
Glossopleura sp. undet. 2
Kootenia wellsvillensis
Onchocephalus? stibinus
Palmerella exiguus
Helcionella sp. undet.
Hyolithes sp. undet.
inarticulate brachiopods
sponge spicules

UU-453 (29) Alokisotcare mccollumi
Athabaskia bithus
Athabaskia wasatchensis
Glossopleura sp. undet. 2
Kootenia wellsvillensis
Palmerella exiguus

inarticulate brachiopods

UU-452 (26) Alokistocare mccollumi

Athabaskia bithus

Glossopleura sp. undet. 2

Kootenia mendosa

Kootenia wellsvillensis

Onchocephalus? stibinus

Palmerella exiguus

Helcionella sp. undet.

inarticulate brachiopods

UU-451 (25) Alokistocare mccollumi

Athabaskia bithus

Athabaskia wasatchensis

Glossopleura sp. undet. 2

Kootenia wellsvillensis

Onchocephalus? stibinus

Palmerella exiguus

Helcionella sp. undet.

inarticulate brachiopods

UU-450 (14) Alokistocare mccollumi

Athabaskia bithus

Kootenia wellsvillensis

Palmerella exiguus

Zacanthoides fedori

echinoderm columnals?

UU-449 (13) Alokistocare mccollumi

Athabaskia bithus

Athabaskia wasatchensis

Kootenia wellsvillensis

Onchocephalus? stibinus

Palmerella exiguus

Zacanthoides fedori

Helcionella sp. undet.

inarticulate brachiopods

UU-448 (8) Alokistocare mccollumi

Athabaskia bithus

Kootenia wellsvillensis

Palmerella exiguus

inarticulate brachiopods

UU-447 (1) Alokistocare mccollumi

Athabaskia bithus

Athabaskia wasatchensis

Glossopleura sp. undet. 2

Kootenia mendosa

Kootenia wellsvillensis

Onchocephalus? stibinus

Palmerella exiguus

Zacanthoides fedori

Zacanthoides idahoensis

inarticulate brachiopods..... 54 0

LOWER TONGUE OF LANGSTON DOLOMITE --57 feet

21. Dolomite, fine - to coarse crystalline;
light- to light-medium-gray, weathers
grayish-orange; beds range from

six inches to three feet thick;
cliff former..... 57 0

SPENCE TONGUE OF LEAD BELL SHALE --232 feet

20. Covered interval..... 5 227

19. Limestone, sparry, medium-light-gray, weathers light-gray; beds 1/4 to two inches thick; shale partings weather pale-reddish-brown- to grayish-orange..... 6 221

18. Shale, calcareous, grayish-olive, weathers dark- to moderate-yellowish-brown; beds 1/8 to 1/2 inch thick.

UU-446 (220) Gogia kitchnerensis
articulate brachiopod

UU-445 (219) Athabaskia wasatchensis
Kootenia mendosa
Ctenocystis utahensis
Gogia kitchnerensis
articulate brachiopod

UU-444 (217) Alokistocare idahoense
Athabaskia bithus
Athabaskia wasatchensis
Glossopleura gigantia?
Glossopleura punctatum
Kootenia mendosa
Zacanthoides idahoensis

Ctenocystis utahensis

Gogia kitchnerenis

articulate brachiopods

fecal balls

inarticulate brachiopods..... 4 217

17. Limestone, sparry, medium-gray, weathers medium-light-gray; beds 1/2 to three inches thick; minor thin shale beds; shaly partings, weather dark- to-moderate-yellowish-brown.

UU-443 (208) Alokistocare nannos

Alokistocarella? sp. undet.

Athabaskia bithus

Athabaskia wasatchensis

Glossopleura gigantea?

Glossopleura punctatum

Kootenia germana

Kootenia mendosa

Palmerella exiguus

articulate brachiopods

Hyolithes sp. undet.

UU-442 (206) Alokistocare nannos

Athabaskia bithus

Athabaskia wasatchensis

Kootenia germana

Palmerella exiguus

Utia curio

Zacanthoides idahoensis

articulate brachiopods

Helcionella sp. undet.

UU-441 (204) Athabaskia bithus

Athabaskia wasatchensis

Glossopleura punctatum

Kootenia germana

UU-440 (199) Alokistocare melindensis

Athabaskia bithus

Bythicheilus typicum

Glossopleura punctatum

Kootenia germana

articulate brachiopods

UU-462 (195) Athabaskia bithus

Athabaskia wasatchensis

Bythicheilus typicum

Glossopleura gigantea?

Glossopleura granosa

Glossopleura punctatum

Kootenia germana

Kootenia spencei

Oraspis cf. O. limbus

Zacanthoides prolixis

articulate brachiopods

UU-439 (180) Alokistocare melindensis

Athabaskia bithus

Bythicheilus typicum

Glossopleura punctatum

Kootenia spencei

Poliella? sp. undet..... 44 173

16. Shale, calcareous; grayish-olive, weathers light-brown to moderate-yellowish-brown; beds 1/8 to 1/2 inch thick..... 2 171

15. Limestone, sparry, medium-gray, weathers medium-light-gray; beds 1/2 to two inches thick; shaly partings and occasional thin shale beds, weather dark-to moderate-yellowish-brown.

UU-438 (156) Athabaskia bithus

Bythicheilus typicum

Oraspis cf. O. limbus..... 22 149

14. Shale, calcareous, medium-gray, weathers light-gray- to pale yellowish-brown; beds 1/8 to 1/2 inch thick.

UU-437 (148) Alokistocare idahoense

Athabaskia bithus

Bythicheilus typicum

Glossopleura bion

Glossopleura gigantea

Glossopleura punctatum

Kootenia spencei

Oryctocephalus walcotti

Zacanthoides grabaui

Ctenocystis utahensis

Gogia granulosa

UU-436 (144) Athabaskia bithus

Bythicheilus typicum

Ctenocystis utahensis..... 10 139

13. Limestone, sparry, medium-gray, weathers medium-light-gray; beds 1/2 to one inch thick; shaly partings weather grayish-orange and to lower relief.

UU-465 (132) Alokistocare idahoense

Alokistocare mutablis

Athabaskia bithus

Bythicheilus typicum

Caborcella cracens

Dorypyge wellsvillensis

Glossopleura bion

Glossopleura gigantea?

Glossopleura granosa

Glossopleura punctatum

Kootenia melindensis

Kootenia spencei

Olenoides sp. undet.

Oraspis limbus

Oryctocephalus walcotti

Zacanthoides grabaui

Zacanthoides prolixis

Genus and species undetermined 3

Helcionella sp. undet..... 9 130

12. Shale, calcareous, medium-dark-gray, weathers light-gray- to pale yellowish-brown; beds 1/8 to 1/4 inch thick.

UU-435 (129) Alokistocare idahoense

Athabaskia bithus

Bythicheilus typicum

Dorypyge wellsvillensis

Glossopleura gigantea

Glossopleura punctatum

Kootenia spencei

Peronopsis brighamensis

Zacanthoides prolixis..... 3 127

11. Limestone, sparry, medium-dark-gray, weathers medium-light-gray; beds 1/2 to one and one-half inches thick; shaly partings and mottles weather brownish-orange.

UU-434 (124) Alokistocare idahoense

Athabaskia bithus

Bythicheilus typicum

Caborcella cracens

Dorypyge wellsvillensis

Glossopleura gigantea?

Glossopleura punctatum

Glossopleura sp. undet. 1

Kootenia spencei

Utia curio..... 17 110

10. Covered interval with shale float; interval exposed on spur immediately south of measured section; consists of shale, calcareous; medium-dark-gray, weathers light-gray- to pale yellowish-brown; beds 1/8 to 1/4 inch thick.

UU-433 (109) Alokistocare idahoense

Alokistocare laticaudum

Athabaskia bithus

Bythicheilus typicum

Glossopleura bion

Glossopleura punctatum

Pagetia lira

UU-434 (99) Alokistocare idahoense

Alokistocare mutablis

Athabaskia bithus

Bythicheilus typicum

Dorypyge wellsvillensis

Elrathina spencei

Glossopleura gigantea

Glossopleura punctatum

Kootenia spencei

Oryctocare geikei

Oryctocephalus walcotti

Pagetia clytia

Peronopsis bonnerensis

Peronopsis brighamensis

Thoracocare minuta

Zacanthoides grabaui

Zacanthoides idahoensis

Zacanthoides prolixis

Hyolithes sp. undet.

inarticulate brachiopods..... 16 94

9. Shale, calcareous, medium-dark-gray, weathers grayish-orange; beds 1/8 to 1/4 inch thick.

UU-430 (92) Alokistocare idahoense

Athabaskia bithus

Bathyuriscus brighamensis

Bythicheilus typicum

Chancia cf. C. ebdome

Glossopleura gigantea?

Glossopleura prona?

Glossopleura punctatum

Kootenia spencei

Oryctocephalus walcotti

Zacanthoides grabaui

articulate brachiopods

algal "seaweed"..... 5 89

8. Covered interval; shale and limestone float; prospect pit in calcareous shale and argillaceous limestone; beds 1/4 to two inches thick.

UU-464 (74) Alokistocare idahoense

Athabaskia bithus

Hyolithes sp. undet.

UU-429 (56) Alokistocare laticaudum

Bathyuriscus brighamensis

Bythicheilus typicum

Elrathina spencei

Glossopleura punctatum

Kootenia spencei

Oryctocephalus walcotti

Pagetia cf. P. fossula

Pagetia lira

Peronopsis bonnerensis

Zacanthoides grabaui

inarticulate brachiopods..... 50 39

7. Shale, calcareous, dark-gray, weathers light-brown to medium-gray; beds one to two inches thick; scattered thin limestone beds.

UU-428 (37) Achlysopsis punctatum

Bathyuriscus brighamensis

Elrathina spencei

Oryctocephalus walcotti

Pagetia cf. P. fossula

Peronopsis bonnerensis

Peronopsis brighamensis

Prohedinia? spencei

Hyolithes sp. undet.

inarticulate brachiopods

UU-427 (27) Achlysopsis punctatum

Bathyuriscus brighamensis

Bythicheilus typicum

Elrathina spencei

Oryctocephalus walcotti

Pagetia cf. P. fossula

Peronopsis bonnerensis

Peronopsis brighamensis

Prohedinia? spencei

inarticulate brachiopods..... 20 19

6. Shale, calcareous, dark-gray, weathers light-brown; beds 1/4 to two inches thick..... 8 13

5. Shale, argillaceous, medium-gray, weathers grayish-orange-to pale yellowish-brown; beds 1/4 to 1/2 inch thick.

UU-425 (4) Alokistocarella brighamensis

Bathyuriscus wasatchensis

Elrathina cf. E. spencei

Ogygopsis typicalis

Olenoides spencei

Oryctocare geikei

Oryctocephalus walcotti

Peronopsis bonnerensis

Peronopsis brighamensis

Gogia guntheri?

Hyolithes sp. undet.

sponge spicules..... 13 0

NAOMI PEAK TONGUE OF TWIN KNOBS FORMATION --26 feet

4. Limestone and sandstone; limestone medium-light-gray, weathers medium-gray; beds range from four inches to one foot thick; sand concentrated as pockets, stringers, and interbeds. Sandstone light-gray, weathers light-to-moderate-brown. Sandstone weathers to higher relief; minor secondary quartz and calcite crystals formed by hydrothermal activity.

UU--423 (26) Kootenia arcuata

Naomiaspis typicalis

Oryctocare geikei

Peronopsis bonnerensis

Poliella milleri

inarticulate brachiopods

UU-422 (25) Kootenia arcuata

Naomiaspis typicalis

Oryctocare geikei

Paralbertella judithi

Poliella milleri

Helcionella sp. undet.

inarticulate brachiopods

UU-421 (17) Albertelloides dispar

Nyella limbus

Olenoides maladensis

Oryctocephalus maladensis

Pagetia resseri

Poliella germana

UU-420 (13) Albertelloides dispar

Albertelloides fritzi

Chancia venusta

Kootenia arcuata

Nyella limbus

Nyella periosus

Olenoides maladensis

Oryctocephalites typicalis

Oryctocephalus maladensis

Pagetia resseri

Paralbertella judithi

Poliella germana

Ptarmigania exigua

Ptarmiganoides propinqua

Ptarmiganoides stokesi

Helcionella sp. undet.

inarticulate brachiopods

ostracods

UU-463 (6) Kootenia arcuata

Nyella periosus

Nyellina maladensis

Oryctocephalites typicalis

Paralbertella judithi

Ptarmigania exigua

Hyolithes sp. undet.

UU-419 (3) Kootenia arcuata

Nyella sp. undet.

Olenoides maladensis

Oryctocephalites typicalis

Paralbertella judithi

Ptarmiganoides stokesi

inarticulate brachiopods..... 26 0

BRIGHAM QUARTZITE --Upper 24 feet measured

3. Sandstone, medium-grained, dolomitic, medium-light-gray, weathers dusky-brown to moderate-brown; beds range from two inches to two feet thick; abundant limonite specks throughout; sparsely fossiliferous.

UU-466 (17) Albertella gynthos

Albertellina aspinosa

Mexicella? sp. undet..... 18 6

2. Quartzite, medium- to coarse-grained, pale yellowish-brown, weathers pale red- to light-brown; beds three inches to one foot thick; abundant limonite specks; "Skolithus" tube common..... 6 0

1. Quartzite and interbedded argillite; thickness not measured.