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(With 14 Plates)

BY
CHARLES ELMER RESSER
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(Publication 3550)

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The Lord Baltimore Press
BALTIMORE, MD., U. S. A.

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INTRODUCTION

An interesting fauna occurs in the lowermost Middle Cambrian beds at several places in the northern Wasatch Mountains of Idaho and Utah. The fauna is characterized by great variety of species and genera, and the numerous individuals are excellently preserved, chiefly in crystalline limestone. Most of the material here described was collected by Walcott in 1898 and 1906. When I came to Washington in 1914 as Dr. Walcott's assistant, the first task assigned to me was the preparation of this material.

Two classes of data are necessary for the advancement of stratigraphy: First, there must be a sufficient number of sections, measured at strategic points, to furnish knowledge of areal extent and of variations in lithology and in thickness of the sheets of sediment that constitute the formations; second, it is necessary to know the faunas characterizing the formations. This paper describes another fauna but also discusses some stratigraphic problems. Unfortunately the stratigraphic terminology of the Wasatch Mountains is not fully satisfactory; hence a hybrid faunal-stratigraphic title is used.

Recently the related fauna in the superjacent Spence shale was described (Resser, 1939). Taken together these faunas should enable the building of the early Middle Cambrian portion of the column with greater precision, not only locally but throughout the Cordilleran region.

Sections of Middle Cambrian rocks were measured in the northern Wasatch Mountains by Walcott in 1898 and 1906 and subsequently by other geologists. The only detailed mapping in the region is that

of the Randolph quadrangle, which includes the eastern slopes of the Bear River Range. That report is in press. Without detailed mapping of a considerable area, it is not possible to understand fully the stratigraphic relations, for the early Middle Cambrian sequence may be incomplete, and some of the formations seem to vary in thickness and lithology more than usual for Cambrian strata in the central Cordilleran region.

In 1906 Walcott measured the Cambrian strata at four widely separated points but published the results as a single composite section (1908a, b). This obscured variations in lithology and thickness and made correlation uncertain. If, however, we go back to the original field notes, thereby getting away from the confusion introduced with the composite section, several facts became clear. Deiss (1938) remeasured the Blacksmith Fork section and discussed the stratigraphy and stratigraphic terminology in the light of the information yielded by that one section.

With a better understanding of the Spence shale and immediately subjacent *Ptarmigania* faunas and by using information from related sections, as well as the results of mapping of the Randolph quadrangle, it is now possible to advance a step or two toward a solution of the Middle Cambrian stratigraphy of the northern Wasatch region.

At first it was planned to publish only the fossil descriptions, but as the work progressed it became increasingly desirable to determine stratigraphic relationships so that the faunal affinities could be better understood. Seemingly there is yet much to learn concerning the composition and position of Middle Cambrian faunas, for they appear to be less clear-cut than those in the Upper Cambrian formations. This situation no doubt has contributed to the slow development of Middle Cambrian stratigraphy and to the uncertainty of present correlations. At present it seems that nearly all the common Middle Cambrian genera range throughout most of the division. And further, it seems that one or another genus may undergo great expansion at any time evidently without following a particular evolutionary trend. Moreover, it is apparent that conspicuous elements of several faunas may be present or absent from place to place. In short, at the present stage of knowledge, Middle Cambrian faunas are not clear-cut entities, and their composition varies more than should be expected. This state of affairs can scarcely be attributed to inadequate collection alone, although there is no doubt that further field work will fill in many gaps.

LOCATION AND TOPOGRAPHY

The location and general topographic expression of the Wasatch Mountains are well known. The conspicuous rampart of these mountains east of Great Salt Lake and the ranges in northeastern Utah and southeastern Idaho are familiar. In this paper we are concerned only with the northern portion of these mountains from the vicinity of Brigham to their termini in Idaho.

The high, abrupt slope of the Wasatch Mountains facing Great Salt Lake Valley continues from Salt Lake City northward to Malad, which is about 15 miles north of the Idaho State line. Several gaps interrupt the range, the most conspicuous being formed by the Bear River as it breaks through from Cache Valley. North of Malad the less elevated Bannock Range continues the trend of the Wasatch Mountains but is composed of younger strata.

Between Ogden and Brigham many ridges occupy an area more than 25 miles wide. In the eastern portion of this area the ridges are grouped together as the Bear River Range, which extends thence north through Utah and into Idaho as far as Soda Springs, some 40 miles north of the Idaho boundary.

Cache Valley lies between the two prongs, the Wasatch proper on the west and the Bear River Range on the east. Cache Valley has a nearly level floor about 4,500 feet above sea level. East of it the Bear River Range rises abruptly to altitudes of about 9,000 feet, and on the west the Wasatch also rises steeply to about the same height. Thus there is a V-shaped mountain mass that surrounds Cache Valley, and is in turn bounded on the west by Salt Lake Valley and on the east by Bear Lake and Valley.

GENERAL GEOLOGY

As shown by the geological map of Utah, crystalline pre-Cambrian rocks occupy the front of the Wasatch Mountains between Salt Lake City and Ogden. Eastward these rocks are succeeded immediately by Tertiary beds. From Ogden to Brigham the Willard overthrust puts Cambrian rocks on the face of the range in contact with a belt of pre-Cambrian rocks. This belt of crystalline rocks is overlain on the east by Cambrian and younger Paleozoic strata in normal sequence. Since the strike here is northwesterly at an angle to the mountain front the Cambrian rocks again come to the front of the range north of Brigham for a distance of several miles, their place then being taken by younger Paleozoic beds. North of the Bear River Gap

Cambrian strata again constitute the front, and most of the species described in this paper are from Two Mile Canyon, which crosses this outcrop belt.

In the Bear River Range Middle and Upper Cambrian strata crop out over considerable areas, but their full extent is not known. The best-known section is in Blacksmith Fork Canyon, and another excellent section lies north of Garden City on the eastern slope. Mill Creek west of Liberty, nearly 25 miles north of the Idaho boundary, also exposes a fine Cambrian section. Here the quartzite yields a fauna, and the recently described Spence shale fauna overlies the discontinuous limestone with the *Ptarmigania* fauna.

The generalized geological map of northeastern Utah, therefore, shows Cache Valley as a northward-pitching syncline, since it is surrounded by belts of successively older strata from the Carboniferous to the Cambrian. More detailed mapping does not bear out this structure, but the map does show where Cambrian rocks are found.

MATERIAL AVAILABLE

Stratigraphic data.—Measured sections extending through the Middle Cambrian sequence are available at four localities, and partial sections at two other places in the northern Wasatch Mountains.

In 1898 and 1906 Walcott measured the section in Two Mile Canyon, which is near the northern end of the Wasatch proper. In the same season he examined the outcrops in Box Elder Canyon, the Mantua Basin, and north of Brigham but recorded measurements for only a portion of the sequence.

During 1906 Walcott, assisted by L. D. Burling, followed up his earlier studies of 1898 in the Bear River Range and measured the sections in Blacksmith Fork east of the southern end of Cache Valley and along Mill Creek west of Liberty, on the eastern slope of the range. In 1909 Blackwelder measured the section on Mill Creek, a tributary entering Blacksmith Fork from the south. This is a few miles south of the place where Walcott worked, but both geologists agree closely in the subdivisions adopted, the lithologic descriptions, and the thicknesses recorded. Recently (1938) Deiss remeasured and republished the Blacksmith Fork section. Walcott recorded 4,190 feet of Middle Cambrian beds above the quartzite, Blackwelder 4,125, and Deiss 3,885, which is remarkably close agreement. These observers also recognize the same formational subdivisions with nearly the same respective thicknesses and lithology.

In 1912 G. B. Richardson (1913) of the United States Geological Survey, assisted by P. V. Roundy, began the mapping of the Randolph quadrangle, which lies east of Blacksmith Fork. He discovered an isolated Cambrian outcrop in Laketown Canyon, where only a portion of the sequence is exposed. He also found that the Middle Cambrian is exposed on the eastern slopes of the Bear River Range throughout the quadrangle with particularly good sections just north of Garden City, in the upper St. Charles Canyon, and on Mill Creek. The full report of the work in the Randolph quadrangle is now in press.

Between 1923 and 1930 I saw all the mentioned sections except Mill Creek west of Liberty. This locality was not located during those seasons because nearly every geographic name in the vicinity had been changed when the topographic sheet was published in 1911. Recently it has been possible to interpret these changes from old notes and labels, and the Spence shale locality has been relocated by Bishop Paul A. Spence, of Garden City, the son of the original discoverer. In the following discussion use is made of the original notes of Walcott, Blackwelder, and myself rather than of Walcott's published composite section. Much of the information derived from the mapping of the Randolph also is available.

Paleontologic material.—As listed below, fossils are described from all the mentioned sections. All of Richardson's collections are also in hand. While descriptions are confined to the *Ptarmigania* fauna and species supposedly belonging to it, the other fossils from the base of the Middle Cambrian to the top of the Ute formation were examined in order that the position of the *Ptarmigania* fauna could be understood. The fossils from the overlying strata are to be published shortly, many species having now been described in manuscript.

Further details respecting number of species, quantity of specimens, and the matrix in which they are preserved will be found subsequently in the description of the sections.

CAMBRIAN DEVELOPMENT

The general distribution of the Cambrian in the northern Wasatch region has been described. A few facts regarding its development are now in order. In the following paragraphs the absence of Lower Cambrian beds and the formational subdivisions of the Middle Cambrian are briefly discussed. Descriptions of the formations are not repeated because the definitions given by Walcott and Deiss suffice. However, considerable detail will be found in the discussion of the sections, where unpublished notes are also presented.

ABSENCE OF LOWER CAMBRIAN

Lower Cambrian strata are apparently absent in the Wasatch Mountains northward of Salt Lake City. At the southern end of the range near Mount Nebo, in Cottonwood Canyon, south of Salt Lake City, and on Promontory Point in Great Salt Lake, about 20 miles west of the Wasatch Mountains, fossils show that the Lower Cambrian seas extended northeastward from southern California and Nevada at least as far as the mentioned points. Wherever the base of the Cambrian beds is exposed north of Salt Lake City, the Brigham quartzite is seen to rest directly on pre-Cambrian rocks. The situation obtains also in the Salt River and Teton Ranges of western Wyoming, in the northwestern part of Yellowstone Park, and throughout Montana. In my opinion the Lower Cambrian rocks found in the vicinity of Great Salt Lake possibly continue beneath younger strata and the lava fields, to connect with outcrops in northeastern Washington and beyond that with beds of similar age in the Columbia Valley and Dogtooth Mountains of British Columbia. Since Lower Cambrian strata are clearly absent in the northern Wasatch region, and thence northward through western Wyoming and Montana, the question arises whether the lowest Cambrian beds exposed are the oldest Middle Cambrian, or whether some Middle Cambrian also is lacking.

MIDDLE CAMBRIAN FORMATIONS

The three independent measurements combined with the fact of excellent exposure of a complete sequence results in Blacksmith Fork becoming the basic section of the area. All other sections that have been investigated agree closely, with the exception to be subsequently noted. Six formations evidently constitute the Middle Cambrian sequence for the northern Wasatch region. A condensed table is presented for ready reference.

In the Blacksmith Fork section the figures in parenthesis are Deiss' measurements; those in brackets are Blackwelder's. The Randolph quadrangle section is composite but is based primarily on the exposures immediately northeast of Garden City. The figures for Two Mile Canyon may not be wholly reliable, since accurate adjustment may not have been made for all the faults that interrupt the section. While the sequence exposed near the crest of the range north of Brigham is evidently the same as at Two Mile Canyon, Walcott's notes are insufficient to warrant inclusion of a column in the table.

The Brigham quartzite is seldom fully exposed. For this reason it is omitted in the following comparisons. From the figures in the foregoing table it is apparent that the thinnest Middle Cambrian section is recorded on Mill Creek, west of Liberty. The next in order is that of Two Mile Canyon and the thickest section is found near Garden City. Thus it seems that the total thickness increases from

Two Mile Canyon	Mill Creek, Liberty	Blacksmith Fork	Randolph quadrangle
Nounan 1,090 feet	Nounan 815 feet	Nounan 1,040 feet (900 feet) [1,010 feet]	Nounan 950 feet
Bloomington 555 feet	Bloomington 1, 160 feet	Bloomington 1,320 feet (1,275 feet) [1,190 feet]	Bloomington 1,250 feet [Includes Hodges shale member at base 325-350 feet]
Blacksmith 585 feet	Blacksmith 360 feet	Blacksmith 570 feet (450 feet) [560 feet]	Blacksmith 700 feet
Ute 800 feet Spence shale 155 feet	Ute 400 feet Spence shale 40 feet	Ute 730 feet (685 feet) [695 feet] Spence shale 30 feet	Ute 480-585 feet [Spence shale included]
"Langston" 6 feet	"Langston" 30 feet	Langston 500 feet (575 feet)[670 feet]	Langston 375 feet
Brigham 740 feet	Brigham 500-1,000 feet	Brigham 1,230 feet+ (1,000 feet) [200+ feet]	Brigham 1,600+ feet

northwest to southeast. Moreover, if the aberrent thickness for the Bloomington formation in Two Mile Canyon is overlooked, remarkably little variation appears among the upper three formations. Following description of the localities and sections the Langston question is discussed, which will focus attention on the variability of the lower three Middle Cambrian formations.

LOCALITIES

A concise list of localities is desirable to save frequent repetitions, particularly in the fossil and plate descriptions. Consequently the localities from which fossils are described are listed in numerical order. Subsequently the localities will appear again as the sections

are described, but then in a geographic arrangement. List of species will also be given with the sections.

Locality 5b = 54s.

Locality 19: T. 12 S., R. 42 E., ridge north of North Fork of Mill Creek, Preston quadrangle, Idaho. (Coll. G. R. Mansfield, July 17, 18, 1912.)

Locality 19x: North wall of Laketown Canyon, about 2½ miles southwest of Laketown, Randolph quadrangle, Utah. (Coll. P. V. Roundy, September 12, 1912.)

Locality 20x: Near top of gulch, about 2 miles north of Brigham, Wasatch Mountains, Utah. (Coll. C. E. Resser, A. A. L. Matthews, E. R. Pohl, September 12, 1926.)

Locality 32p = 55e.

Locality 54s: North side Two Mile Canyon, near its mouth, 2 miles southeast of Malad, Wasatch Mountains, Idaho. (Coll. F. B. Meek; C. D. Walcott, 1898; C. D. Walcott and L. D. Burling, 1906.)

Locality 55e: North of first small canyon south of Wasatch Canyon, 3½ miles north of Brigham, Wasatch Mountains, Utah. (Coll. F. B. Meek; C. D. Walcott and L. D. Burling, 1906.)

Locality 55p: About 7 miles above mouth of Blacksmith Fork, Bear River Range, Utah. (Coll. C. D. Walcott and L. D. Burling, August 27, 1906.)

Locality 55q: Same as preceding.

Locality 59c: Mill Canyon, about 5 miles southwest of Liberty and 15 miles west of Montpelier, Bear River Range, Idaho. (Coll. C. D. Walcott, September 1907.)

Locality 59e: Same as preceding.

Locality 59f: Same as preceding.

Localities 322 and 322a: These numbers were assigned to small lots of fossils from the eastern side of the Bear River Range, secured prior to 1906.

STRATIGRAPHY

Publication of Walcott's original field notes seems warranted even though they are nearly 35 years old. Comments on the rock entombing the fossils, and such miscellaneous data as seem pertinent are also recorded in geographic arrangement. The fossil lists are placed in the descriptions of the sections where they occur. Where a section is not given lists appear with the miscellaneous notes. Where more than the *Ptarmigania* fauna is represented in a collection, the list is confined to the species regarded as representative of that fauna.

In nearly every case only slight modifications of Walcott's assignment of beds to formations are necessary. It was his intention to publish stratigraphic papers embodying these notes, but the necessary paleontologic studies could not be completed in his lifetime. In anticipation of publication he added comments to transcriptions of the field notes, particularly with respect to formational names and

boundaries. Additional comments have been added wherever deemed desirable, hence the material is not to be regarded as quoted. However no departure from figures, determination of beds, or lithologic description was allowed.

WASATCH MOUNTAINS

Two Mile Canyon.—Collections were made by Walcott in 1898 and 1906, and others by Meek at an earlier date. A section was measured October 1898 and remeasured in 1906 with particular attention to the upper beds. Faults required the measurements to be made in different blocks, but care was evidently exercised in carrying the section across the fault lines. The measured beds total 4,655 feet, including some post-Cambrian strata.

Walcott's section of the Middle Cambrian beds follows, the formational assignments being made in essentially the present manner by Walcott himself.[1]

Nounan formation:

	Feet
Dolomite. Massive-bedded gray, passing upward into thin-bedded bluish-gray dolomite	405
Dolomite. Dirty gray, massive-bedded dolomite, banded in places	445
Limestone. Thin-bedded, bluish-gray impure limestone, with trilobites. The trilobites represent undescribed genera	58
Dolomite. Dirty gray, massive-bedded dolomite with a few shaly and sandy beds	180
Total	1,088

This and the overlying post-Cambrian beds were measured on the south side of the canyon.

Bloomington formation:

	Feet
Limestone and shale. Alternating beds of thin-bedded limestone and sandy and argillaceous shale. Fossils are fairly common but are still undescribed	555
Total	555

[1] A few days before this paper was submitted for publication a letter from Prof. Deiss stated that he had examined the Two Mile Canyon section, May 1939. He furnished a copy of the lower part of his section, apparently as it was measured in a fault block. According to the figures given, 650 feet of Brigham quartzite remain above a thrust fault. Overlying the quartzite is 60 feet of impure limestone containing beds of pure crystalline limestone with the *Ptarmigania* fauna. A slight break separates the impure limestone stratum from 205 feet of Spence shale and possibly beds of the Ute formation.

Blacksmith dolomite:	Feet
Dolomite. Light-gray dolomite in massive layers, alternating with bluish-gray layers. The latter contain many small dark "concretions"	445
Dolomite. Drab and lead-colored dolomite	140
Total	585

Ute formation:	
Limestone. Bluish-gray limestone in thin and thick layers. About 180 feet above the base, fossils are abundant	350
Shale. Drab and green arenaceous shale	45
Dolomite. Thick-bedded, gray limestone alternating with thin beds	57
Limestone and shale. Alternating beds of limestone and shale. Fossils	113
Shale. Greenish, sandy shale	12
Dolomite and limestone. Thick-bedded bluish-gray dolomite with bands of thinner-bedded limestone	105
Shale and sandstone. Reddish-brown, sandy shale with a few layers of hard sandstone and a little green sandy shale near the top	30
Limestone. Thin-bedded (3 to 8 inches), compact, hard limestone, with considerable dolomitic or arenaceous matter in some of the layers. Small fragments of fossils	85
Total	797

Spence shale member:	
Limestone and shale. Blue-black calcareous shale and thin-bedded dark gray limestone. Sponge spicules are common (loc. 5g)	125
Dark argillaceous shale	30
Total	155

Measurements were made in the hills north of the canyon where faulting seems to be less serious. However, both the Ute and the beds assigned to the Spence shale member are much thicker than in the other sections, consequently it is possible that some faulting was overlooked. The typical Spence shale fauna, characterized by *Orycto-cephalus* is present.

"Langston" limestone:	Feet
Limestone. Dark gray, crystalline, very fossiliferous limestone (loc. 54s)	6
Total	6

The fossils look like black velvet when first freed from the matrix. Thousands of specimens were secured, and many more could be uncovered in the larger pieces because fossils make up a large part

of the rock. As shown by the illustrations of *Taxioura typicalis,* the fossils often are so crowded that it is difficult to free good specimens.

Acrothele artemis Walcott
Acrothele parilis, n. sp.
Acrothyra minor Walcott
Acrotreta eucharis, n. sp.
Acrotreta sulcata Walcott
Agnostus lautus, n. sp.
Alokistocare eucharc, n. sp.
Alokistocarella occidens, n. sp.
Bathyuriscus politus, n. sp.
Dolichometopsis alia, n. sp.
Dolichometopsis comis, n. sp.
Dolichometopsis communis, n. sp.
Dolichometopsis gravis, n. sp.
Dolichometopsis lepida, n. sp.
Dolichometopsis media, n. sp.
Dolichometopsis potens, n. sp.
Dolichometopsis poulseni, n. sp.
Dolichometopsis propinqua, n. sp.
Dolichometopsis stella, n. sp.
Ehmaniella maladensis, n. sp.
Helcionella aequa, n. sp.
Helcionella arguta, n. sp.
Hyolithes prolixus, n. sp.
Iphidella maladensis Walcott
Kochaspis maladensis, n. sp.
Kochina venusta, n. sp.
Kochina vestita, n. sp.
Kochina wasatchensis, n. sp.
Kootenia acicularis, n. sp.
Kootenia brevispina, n. sp.
Kootenia convoluta, n. sp.
Kootenia granulosa, n. sp.
Kootenia maladensis, n. sp.
Kootenia nitida, n. sp.
Lingulella eucharis, n. sp.
Micromitra haydeni Walcott
Olenoides maladensis, n. sp.
Oryctocephalites typicalis, n. sp.
Oryctocephalus maladensis, n. sp.
Pachyaspis typicalis, n. sp.
Pagetia clytia Walcott
Pagetia maladensis, n. sp.
Paterina hirta, n. sp.
Poulsenia granosa, n. sp.
Poulsenia occidens, n. sp.
Prozacanthoides aequus, n. sp.
Prozacanthoides alatus, n. sp.
Prozacanthoides decorosus, n. sp.
Prozacanthoides exilis, n. sp.
Prozacanthoides optatus, n. sp.
Ptarmigania agrestis, n. sp.
Ptarmigania altilis, n. sp.
Ptarmigania aurita, n. sp.
Ptarmigania dignata, n. sp.
Ptarmigania exigua, n. sp.
Ptarmigania germana, n. sp.
Ptarmigania natalis, n. sp.
Ptarmigania ornata, n. sp.
Ptarmigania sobrina, n. sp.
Ptarmigania sp. undet.
Taxioura magna, n. sp.
Taxioura typicalis, n. sp.
Tonkinella idahoensis, n. sp.
Wimanella maladensis, n. sp.

Brigham quartzite:

	Feet
Shale. Greenish, arenaceous shale, with layers of quartzite and dark brown sandstone	45
Quartzite. Reddish-brown, quartzitic sandstone, like underyling bed	205
Quartzite. Compact, hard, light-gray quartzitic sandstone. Bands of greenish, sandy shale interbedded in the upper 80 feet. Shaly surfaces covered with trails	210
Shale. Steel gray to buff, arenaceous shales, with layers of quartzite at intervals of 5 to 20 feet	115
Quartzitic sandstone. Massive-bedded (layers 2 to 8 feet thick) brown quartzitic sandstone. Base unexposed.	165
Total	740

Vicinity of Brigham City.—The collections of the 40th Parallel Survey evidently were made from the shaly beds several miles north of Brigham City. In 1906 Walcott worked over the region and collected freely and in 1926 I secured large collections here. Cambrian beds crop out not only on the western ridge of the Wasatch, but in Box Elder Canyon, east of Brigham and particularly on the rims of the Mantua Basin at the head of the canyon. Walcott recorded the sequence but gave the thickness of only one bed.

	Feet
Blacksmith dolomite:	
Massive, gray dolomite	
Ute and other formations:	
Limestone or dolomite. Bluish-gray, massive-bedded limestone	
Limestone and shale. Gray, calcareous and siliceous shale, with thin-bedded bluish-black limestone (loc. 55e)	193
Limestone. Bluish gray. This bed cannot be more than a few feet thick, according to information on the field labels	

The collections from localities 55e and 20x contain species from all the beds between the Brigham and Blacksmith formations. Below are listed only the species supposedly belonging to the *Ptarmigania* fauna. The selection was based on generic association and is not regarded as positive enough for correlation purposes. Locality 55e is about 150 feet above the quartzite and may yield only Spence shale species, but two species have been selected as older: *Lingulella eucharis* Resser and *Kochina brighamensis* n. sp. From locality 20x a larger number of species are referred to the *Ptarmigania* fauna, all of which are new.

Alokistocarella brighamensis, n. sp.
Clavaspidella wasatchensis, n. sp.
Girvanella sp.
Kochina? elongata, n. sp.
Kootenia germana, n. sp.
Kootenia mendosa, n. sp.
Poliella wasatchensis, n. sp.
Taxioura typicalis, n. sp.
Wimanella maladensis, n. sp.

	Feet
Brigham quartzite:	
Gray quartzitic sandstone, weathering brown, with partings of green arenaceous shale	
Base unexposed.	

BEAR RIVER RANGE

Blacksmith Fork.—It is not necessary to reprint the section in Blacksmith Fork Canyon. Notes relative to two lots of fossils from the Langston limestone is all that is needed.

Locality 55p, Langston formation. This material was collected by Walcott and Burling in 1906, between 70 and 100 feet below the top

of the formation. The species are *Glossopleura prona, G. arrecta,* and *Alokistocare globatum.*

Locality 55q. This collection was secured near the top of the Langston formation. The species are: *Glossopleura prona, G. arrecta, Kootenia pectenoides* and *Prozacanthoides* sp., and *Clavaspidella* sp.

It is possible, as Deiss contends, that these fossils do not represent the *Ptarmigania* fauna, but since they occur directly beneath the shale which contains Spence forms, they are described. It will be observed that these species do not require exclusion of the Langston fauna from the *Ptarmigania* zone. This question is discussed more fully subsequently.

Mill Creek, west of Liberty.—Mill Creek was known as Liberty Creek in 1906. Walcott's references to Spence Gulch mentions "Danish Flat," which now is Copenhagen Basin. Spence Gulch is not shown on the Preston or Montpelier quadrangle maps, but evidently is the stream coming into Mill Creek from the west, possibly in sections 10, 2, 3, T. 13 S., R. 42 E., of the Preston quadrangle.

The Middle Cambrian portion of Walcott's section on Mill Creek is as follows:

	Feet
Nounan formation:	
Dolomite. Massive-bedded, passing into bluish-gray, rough, weathering dolomite	450
Quartzite. Gray quartzitic rock	92
Dolomite and limestone. Dirty-gray calcareous beds, with fossils	272
Total	814
Bloomington formation:	
Limestone. Bluish-gray limestone, in alternating massive and thin beds	385
Shale and limestone. Greenish argillaceous shale and thin-bedded limestone, with oboloid brachiopods	575
Limestone. Thin- and thick-bedded, bluish-gray limestone, with fossils at top and near the middle	202
Total	1,162
Blacksmith dolomite:	
Gray dolomite	23
Thin-bedded, bluish-gray dolomite	335
Total	358

Ute formation:

	Feet
Shale. Greenish argillaceous shale	61
Limestone. Thin-bedded gray limestone	38
Shale. Micaceous, arenaceous shale	75
Limestone. Thin-bedded gray limestone	102
Shale. Argillaceous shale	35
Limestone. Thin-bedded limestone with fossils	85
Total	396

Spence shale member:

Shale. Dark, bluish-black and greenish argillaceous shale. The band of shale rests on the quartzitic sandstone and is nearly 40 feet thick	40
Total	40

This was designated the "*Zacanthoides* shale" in the field. The recently described Spence shale fauna, locality 55c, came from this locality.

Langston formation:

Limestone. "To the north 3 miles a bed of limestone 30 feet thick occurs between the quartzitic sandstones and the shale and at Blacksmith Fork Canyon there is 390 feet of siliceous limestone and 107 feet of bluish-gray limestone between the shale and the quartzitic sandstone. These conditions indicate that the Middle Cambrian was deposited upon an uneven surface."

	Feet
Fossils were secured near the top (loc. 59f) and near the base (loc. 59e)	30
Total	30

The field label with the collection from locality 59f reads "top of limestone below Spence shale." There is a slight variation in the rock of the collection. For instance, a somewhat impure crystalline limestone with yellowish specks contains only *Helcionella burlingi,* which species is lacking in typical crystalline limestone.

Acrotreta eucharis, n. sp.
Alokistocare euzona, n. sp.
Dolichometopsis sp.
Ingleficldia idahoensis, n. sp.
Kochaspis idahoensis, n. sp.
Kochina? libertyensis, n. sp.
Kootenia convoluta, n. sp.
Lingulella eucharis Resser
Prozacanthoides libertyensis, n. sp.

The field label with the collection from locality 59e reads, "base of limestone just above the quartzite and underlying the Spence shale." This lot contains a typical *Ptarmigania* fauna.

Dolichometopsis gregalis, n. sp.
Dolichometopsis poulseni, n. sp.
Dolichometopsis sp.
Kochaspis dispar, n. sp.

Locality 19s evidently represents the same faunal zone, and was collected nearby.

Acrotreta sulcata Walcott
Dolichometopsis mansfieldi, n. sp.
Kochiella mansfieldi, n. sp.
Lingulella sp.
Poulsenia bearensis, n. sp.

Prior to 1906 several small lots of fossils were received from these beds. They were given the numbers 322 and 322a, and contain *Acrotreta sulcata* Walcott and *A. eucharis,* n. sp.

Brigham quartzite:

Thickness of exposure is not given. Fossils were found 75 feet below the top (loc. 59c). The collection contains fossils in quartzitic sandstone and in crystalline limestone. The field label reads, "75 feet below the top of the quartzite and 125 feet below the Spence shale." This shows a discrepancy of nearly 20 feet with the measurements given above.

In quartzitic sandstone:

Hyolithes sp.
Kochiella arenosa, n. sp.
Ptychoparella sp.

In limestone (most of the specimens are too fragmentary to identify specifically):

Alokistocare sp.
Clavaspidella excavata, n. sp.
Ehmaniella maladensis, n. sp.
Eocrinus? sp.
Glossopleura (2 species)
Iphidella sp.
Kootenia libertyensis, n. sp.
Kootenia venusta, n. sp.
Micromitra haydeni Walcott
Nisusia sp.
Zacanthoides sp.

Randolph quadrangle.—The Mill Creek section is in both the Preston and Randolph quadrangles. It is not necessary to reprint Richardson's section, which is based chiefly on the outcrops near Garden City (1913). In fact he does not give a detailed section, for he says: "The Cambrian section in the Randolph quadrangle is essentially that described by Walcott as occurring in Blacksmith Fork, Utah, and in the vicinity of Liberty, Idaho, and need not be described here." He then goes on to say that the Cambrian is well exposed west of Garden City where he measured the section.

Richardson differentiated the Hodges shale member at the base of the Bloomington. It is described as a persistent zone of drab clay shale 325 to 350 feet thick.

One species, *Kootenia bearensis,* is described from the isolated outcrop of the Langston formation in Laketown Canyon (loc. 19x).

THE LANGSTON FORMATION

The *Ptarmigania* fauna was regarded as fully representative of the Langston formation until Deiss (1938) questioned the validity of Walcott's determination of the Spence shale in Blacksmith Fork and the correlation of the thin fossiliferous limestone in the Two Mile Canyon and Liberty sections, immediately under the Spence shale, with the Langston at its type locality. If it were not for the great difference in thickness no question concerning the identity of the *Ptarmigania* beds with the Langston formation would have been raised. As the matter now stands two alternative interpretations are possible. First, we may assume as Walcott did, that the Langston formation is discontinuous but that it appears in the known sections, at some places attaining a thickness of 670 feet. The second alternative assumes that the Langston is absent in the northern part of the region and that the thin fossiliferous limestones occupying its stratigraphic position are lenses or bioherms in the base of the Ute, closely associated in origin with the Spence shale, or in the top of the Brigham. Determination of which is the more satisfactory interpretation requires careful field work, with tracing of the formation at least far enough to find out whether thickening of the fossiliferous limestone takes place southward. Pending field examination, and in preparation for it, we can examine the faunal evidence bearing on the problem.

All observers agree that the basal quartzite is the same formation throughout the region. However, if the Langston is absent in the northern part of the area, then the quartzite there may be somewhat younger, at least in part. All observers also agree that the Ute formation extends over the entire region, and everywhere has the same lithologic expression, and is characterized by the same faunas. Therefore, as previously stated, the question is whether the 6 to 30 feet of fossiliferous limestone in Two Mile Canyon and on Mill Creek near Liberty are thin equivalents of the Langston formation, which is from 500 to 650 feet thick in Blacksmith Fork and 375 feet near Garden City. Locally it does not make any difference how this question is determined but its proper understanding does have wide significance for precise correlation beyond the immediate region.

Lithology is without significance because the crystalline limestones containing the *Ptarmigania* fauna are of types common in typical

Langston. Nothing is recorded concerning the sedimentation of the beds, consequently unconformities, if present, have been overlooked. But with the lithologic and stratigraphic evidence in hand, it is possible to say that the *Ptarmigania* beds can be Langston equivalents. So if the *Ptarmigania* beds are not the Langston formation it must be proven solely by faunal evidence.

The composition and age of the *Ptarmigania* fauna are discussed later. Comparing that fauna with two collections in unquestioned Langston limestone, we see that they are not identical but closely related. Certainly they are not mutually exclusive. Without doubt the *Ptarmigania* fauna is very closely allied to that in the top of the Brigham formation on Mill Creek. Also it is closely allied with the Spence shale fauna. In other words it is not possible on faunal grounds to postulate a large gap in the Liberty section between the quartzite and the Spence shale.

The nearest relationships of the *Ptarmigania* to described faunas is to the *Albertella* fauna. If *Albertella* and *Vanuxemella* are removed from the typical *Albertella* fauna, the remaining genera are nearly all the same. *Kootenia* expands greatly and the Lower Cambrian elements such as *Poulsenia* and *Prozacanthoides* remain, so that the *Ptarmigania* fauna appears to belong in the early Middle Cambrian, possibly exactly equivalent to the Comet shale of Nevada.

To sum up, we can only say that the evidence in hand supports both interpretations, namely, that the *Ptarmigania* beds represent the Langston formation, or that the Langston is absent and these beds are bioherms in the basal Ute or top of the Brigham formation.[2]

COMPOSITION OF THE PTARMIGANIA FAUNA

Most of the species described in this paper come from the 6-foot limestone bed in Two Mile Canyon (loc. 54s), and they constitute the *Ptarmigania* fauna. It then remains to determine which other lots of fossils are exactly the same. Of the fossils herein described only those from the 30-foot limestone in the Mill Creek section (locs. 59e, 59f, 19s) are regarded as precise equivalents.

An effort has been made to determine faunules within the *Ptarmigania* fauna. Two are recognizable, but there is not much difference between them. All species are not indiscriminately mixed in any one piece of rock, but when association of species in many

[2] In his recent letter Prof. Deiss reports finding *Albertella* in Two Mile Canyon in May 1939. This substantiates the above argument.

pieces is tabulated the distinctions are found to have a tendency to disappear.

Most of the species now recognized from locality 54s are trilobites, and they are represented by hundreds of specimens. Besides abundance of individuals we also find that many genera are characterized by prolific species.

The brachiopods are represented by 9 species, falling within the common Middle Cambrian genera, *Micromitra, Paterina, Iphidella, Lingulella, Acrothele, Acrotreta,* and *Wimanella. Acrothyra minor* is the only uncommon form. Gastropods are represented by *Helcionella* and *Hyolithes.*

The agnostids are represented by one species, which is closely allied to other Cordilleran species common in the Middle Cambrian.

The smaller trilobites are represented by two species of *Pagetia* and a pygidium referred to *Tonkinella. Oryctocephalus* is sparingly represented, but the new related genus *Oryctocephalites* is more abundant. On the whole the small forms constitute a minor element of the fauna, however abundant the individuals may be. Next in size are the species of *Prozacanthoides,* which genus underwent a great expansion. The form that first attracts attention is the large new trilobite *Taxioura,* which is represented by two species.

The most characteristic forms are the 9 species of *Ptarmigania* and the 11 species of the closely related *Dolichometopsis.* There is only one pygidium of *Bathyuriscus.* The wide-brimmed forms, *Alokistocarella, Kochaspis,* and *Kochina,* are well represented. *Kootenia* is represented by 6 species. Specimens are numerous, particularly of *K. convoluta,* which occurs enrolled in several instances. Only two pygidia of *Olenoides* were found. *Poulsenia* also is well represented by excellent material including an entire individual. Finally the median trilobite form is represented by *Pachyaspis* and *Ehmaniella.* Although individuals are fairly abundant, the trilobites of this sort constitute a less conspicuous element of the fauna than usual for Middle Cambrian beds.

A clearer idea of the composition of the *Ptarmigania* fauna will result from a survey of the accompanying plates than from a lengthy discussion. When this is done, however, care must be exercised to view only the species that are positively assigned to the *Ptarmigania* fauna.

An interesting characteristic of the *Ptarmigania* fauna in the northern Wasatch region is the great development of granulosity. Nearly all species are granulose, and all have stronger ornamentation

of whatever kind than the same forms from adjacent areas. For instance, the only granulose *Kootenia* species known—and several hundred new species have been studied and described in manuscript—come from this area. Other trilobites behave in the same fashion. Even the smooth forms such as *Prozacanthoides* develop strong anastomosing lines on the elevated portions of the test.

Species from other localities have been described. Some are definitely from the Brigham and Langston formations. Others presumably represent the *Ptarmigania* fauna. Each will be readily determinable if localities are noted.

AGE OF THE PTARMIGANIA FAUNA

The *Ptarmigania* fauna is evidently of early Middle Cambrian age. Strong Lower Cambrian elements are held over, but a larger proportion of equally important Middle Cambrian elements are introduced, and new introductions must always outweigh holdovers. The constitution of the *Ptarmigania* fauna emphasizes anew the close relationship between the Lower and Middle Cambrian. As our knowledge increases it becomes ever clearer that there is no diastrophic break between Lower and Middle Cambrian, and the faunas likewise show no great change.

The close relationship to the *Albertella* fauna has been mentioned. On the one hand such genera as *Poulsenia, Dolichometopsis, Prozacanthoides, Kootenia, Helcionella,* and *Wimanella* relate the *Ptarmigania* fauna to the upper Mount Whyte and Lower Cambrian faunas in the Appalachian region. On the other hand *Kochaspis, Kootenia,* and *Clavaspidella* are more characteristic of early Middle Cambrian, while such genera as *Pagetia, Oryctocephalus, Bathyuriscus,* and *Olenoides* are more characteristic of later Middle Cambrian. The unique genera are, of course, left out of consideration, and the brachiopods are of no assistance.

Glossopleura is not in the *Ptarmigania* fauna at Two Mile Canyon. It is found throughout the lower half of the Middle Cambrian quite commonly and consequently can be expected in any of the faunas.

Summing up present evidence, it seems that the *Ptarmigania* fauna occurs in early Middle Cambrian beds, which are to be correlated with some part of the Ptarmigan, Ophir, and Howell formations in the west, and with the Rutledge of the Appalachians, and particularly with the Cape Wood formation of northwest Greenland. At the present stage of our studies the *Ptarmigania* fauna is most like that of the Comet shale in the Pioche district, Nevada.

DESCRIPTION OF GENERA AND SPECIES

BRACHIOPODA

PATERINIDAE Schuchert

MICROMITRA Meek, 1873

MICROMITRA HAYDENI Walcott

Plate 1, figs. 1-3

Micromitra haydeni Walcott, Smithsonian Misc. Coll., vol. 53, No. 3, p. 55, pl. 7, figs. 3, 3a, 1908; U. S. Geol. Surv. Mon. 51, p. 337, text fig. 20A-D, 1912.

Walcott's types are refigured by photographs.

Localities 54s, 59c.

Holotype and paratypes.—U.S.N.M. No. 51437.

PATERINA BEECHER, 1891

PATERINA HIRTA, n. sp.

Plate 1, figs. 4-7

Micromitra (Iphidella) pannula maladensis Walcott (part), U. S. Geol. Surv. Mon. 51, p. 364, pl. 4, fig. 2a, 1912.

Part of the material assigned to *I. pannula maladensis* is more logically regarded as a species of *Paterina*. Many specimens have been found in addition to the one illustrated by Walcott.

P. hirta is characterized by strong growth lines. The ventral valve has a rather straight, long hinge line, and rises to the apex, which is half as high as the shell is wide. The dorsal valve is nearly semicircular in shape and much less convex than the high ventral valve. If the illustrations of *P. hirta* are compared with those of *I. maladensis* adjacent to them, the sharp distinction of surface features is easily seen. On the whole *P. hirta* is a rather wide form.

Locality 54s.

Cotypes.—U.S.N.M. Nos. 98567, 51465, 51450.

IPHIDELLA Walcott, 1905

IPHIDELLA MALADENSIS Walcott

Plate 1, figs. 8-10

Iphidella pannula maladensis Walcott, Proc. U. S. Nat. Mus., vol. 28, p. 306, 1905.

Micromitra (Iphidella) pannula maladensis Walcott (part), U. S. Geol. Surv. Mon. 51, p. 364, pl. 4, figs. 2, 2d, 2e, 2g, 1912.

This species is restricted to specimens conspecific with the first one illustrated by Walcott. He also identified other specimens as

I. pannula. As Walcott pointed out, this species is characterized by the strong development of the surface pattern.

Locality 54s.

Lectotype and paratypes.—U.S.N.M. No. 51468 (except b).

ACROTRETIDAE Schuchert

ACROTHELE Linnarsson, 1876

ACROTHELE ARTEMIS Walcott

Plate 1, figs. 19-22

Acrothele artemis Walcott, Smithsonian Misc. Coll., vol. 53, No. 3, p. 82, pl. 8, fig. 10, 1908; U. S. Geol. Surv. Mon. 51, p. 634, text fig. 54, 1912.

Walcott figured only one shell, a dorsal valve which he called a ventral valve. A ventral valve is here figured, and it shows that the apex is some distance from the margin.

Locality 54s.

Holotype and plesiotypes.—U.S.N.M. No. 51969.

ACROTHELE PARILIS, n. sp.

Plate 1, figs. 23-25

Acrothele subsidua Walcott (part), U. S. Geol. Surv. Mon. 51, p. 656, pl. 60, figs. 1d, 1g, 1e, 1912.

Walcott confused this beautiful species with *A. subsidua,* which characterizes the Wheeler shale of the House Range. This happened because he failed to observe the exterior of the ventral valve.

A. parilis is a large, very beautifully marked form. The ventral valve is almost circular with the elevated apex nearly in the middle of the shell. The dorsal valve is less circular in outline, and in the specimen illustrated is slightly depressed in the middle. The surface is marked by concentric striae.

Compared to *A. artemis,* this species is larger and more circular in shape and the apex is nearer the center.

Locality 54s.

Cotypes.—U.S.N.M. No. 52014.

ACROTRETA Kutorga, 1848

ACROTRETA SULCATA Walcott

Plate 1, figs. 11-14; plate 2, fig. 4

Acrotreta idahoensis sulcata Walcott, Proc. U. S. Nat. Mus., vol. 25, p. 588, 1902; U. S. Geol. Surv. Mon. 51, p. 690, pl. 65, fig. 5, 1912.

This species must be confined to the specimens from the type locality, which is on the strike, but south of, the place where Walcott

collected. The Spence shale form previously identified as *A. sulcata* has been described as *A. levata* Resser.

The plesiotypes add to our knowledge of the species by presenting illustrations of specimens showing the exterior features.

Near Paris, Bear River Range, and localities 54s, 19s.

Holotype.—U.S.N.M. No. 35275; plesiotypes, No. 52109.

ACROTRETA EUCHARIS, n. sp.

Plate 1, figs. 15-18

Acrotreta pyxidicula Walcott (part) (not White), U. S. Geol. Surv. Mon. 51, p. 701, pl. 69, figs. 3-3f, 1912.

This is the commonest species of *Acrotreta* in this formation, being represented by many specimens both in the Wasatch Mountains and on the eastern slopes of Bear River Range. It is a small brachiopod, and since it does not exceed 2 mm. in diameter Walcott confused it with *A. pyxidicula* White, an Upper Cambrian species from the Schellbourne Range, Nevada. As a matter of fact, Walcott's description of *A. pyxidicula* is based on the Idaho specimens.

The photographs fail to bring out the height of these minute shells, which, however, is shown in Walcott's drawings. It will be observed that this species differs from *A. sulcata* because the median groove is very much shorter and the median septum of the dorsal valve also is shorter. In *A. eucharis* the apex is much closer to the posterior margin than in *A. sulcata*.

Localities 54s, 322, and 59f.

Cotypes.—U.S.N.M. Nos. 52147, 52150.

ACROTHYRA Matthew, 1901

ACROTHYRA MINOR Walcott

Plate 1, figs. 26-29

Acrothyra minor Walcott, Proc. U. S. Nat. Mus., vol. 28, p. 303, 1905; U. S. Geol. Surv. Mon. 51, p. 717, text fig. 59, pl. 76, figs. 4-4b, 1912.

Locality 54s.

Holotype and paratypes.—U.S.N.M. Nos. 52050, 52051.

OBOLIDAE King

LINGULELLA SALTER, 1866

LINGULELLA EUCHARIS Resser

Plate 1, figs. 30-32

Lingulella eucharis Resser, Smithsonian Misc. Coll., vol. 97, No. 12, p. 5, pl. 1, figs. 1-3, 1939.

Walcott identified the specimens of this species with *L. desiderata, L. helena,* and *L. isse* but figured none of them.

It will be observed that the several valves illustrated here and in previous publications are within the normal variation of a species, consequently this form is identified with the Spence shale species. It has also been identified from localities near Brigham.

Localities 54s, 59f, and 55e.

Plesiotypes.—U.S.N.M. Nos. 51817, 51844.

BILLINGSELLIDAE Schuchert

WIMANELLA Walcott, 1908

WIMANELLA MALADENSIS, n. sp.

Plate 1, figs. 33-37

Billingsella coloradoensis Walcott (part), U. S. Geol. Surv. Mon. 51, p. 751, pl. 85, fig. 12, 1912.

Walcott figured the interior of an incomplete dorsal valve. Very good specimens are available showing that the species is a typical *Wimanella,* characterized by rather irregular but pronounced ribs. The beak extends considerably beyond the hinge line, and the species averages rather large.

Localities 54s and 20x.

Cotypes.—U.S.N.M. No. 34776.

GASTROPODA

PALAEACMAEIDAE Grabau and Shimer

HELCIONELLA Grabau and Shimer, 1909

HELCIONELLA ARGUTA, n. sp.

Plate 1, figs. 38-41

This species is rather abundant. As may be seen from the illustrations, the shell is coiled into practically a complete whirl and expands rapidly. The cross section for most of the whirl is nearly circular but becomes flattened toward the mouth. The shell on the inner side of the whirl is nearly smooth but on the opposite side is divided by deep furrows into eight or more annulations, thus giving it a much more rugose appearance than most species in the genus. Each of these large rugosities carries a number of small transverse plications. In addition the shell is strongly striated lengthwise, the striae being slightly irregular in course, and varying slightly in strength.

Locality 54s.

Cotypes.—U.S.N.M. Nos. 98486a-d.

HELCIONELLA AEQUA, n. sp.

Plate 1, figs. 45-47

Several examples of a smooth form occur with *H. arguta.* This species is strongly curved but does not form a complete whirl. It expands very rapidly from the beak to the mouth. Viewed in cross section *H. aequa* is so flattened that both sides are nearly parallel. Faint irregular annulations may be seen in proper light. There are also rather weak longitudinal striations toward the outer margin of the whirl.

Locality 54s.

Holotype.—U.S.N.M. No. 98487.

HELCIONELLA BURLINGI, n. sp.

Plate 1, figs. 42-44

At first it was thought that this form might be *H. arguta,* which it closely resembles in its coarse annulations, but, as seen in the illustrations, there is considerable difference in this respect. *H. burlingi* forms a little more than a complete whirl. In cross section it is rounded with flattened sides, and the annulations are wide but irregular on the outer margin of the whirl, becoming obsolescent on the inner face. The separating depressions are deeper on the sides than on the outer portion of the whirl, contrary to the usual development. The surface is marked by irregular striations parallel to the annulations, and in addition there are faint lengthwise striations.

Locality 59f.

Cotypes.—U.S.N.M. Nos. 98488a-c.

HYOLITHIDAE Nicholson

HYOLITHES Eichwald, 1840

HYOLITHES PROLIXUS, n. sp.

Plate 2, figs. 1-3

This is a large species without a carina. As shown by the photograph of the cross section the convex sides rise very steeply from the flat side and the convex side is rounded rather than sharply angular. On the flat side the usual striations are parallel to the lip but are developed irregularly. On the convex side the surface is also striated parallel to the lip except that the striae turn up toward the lateral angles, and they are closer together than on the flat side.

Locality 54s.

Cotypes.—U.S.N.M. Nos. 98489a-c.

AGNOSTIA

AGNOSTIDAE M'Coy

AGNOSTUS BRONGNIART, 1822

AGNOSTUS LAUTUS, n. sp.

Plate 2, figs. 16-18

This species is similar to the many others in the Middle Cambrian, of which *A. montis* is the best known. *A. lautus* is so much like other species in the Wasatch region that it was hoped it could be put into one of them. It is rather close to *A. brighamensis,* for the various furrows and proportions throughout are proportional in both species. But *A. lautus* does not have the even, semicircular outline of *A. brighamensis* because of the flattening of the front of the cranidium and of the sides and rear margins of the pygidium.

Locality 54s.

Cotypes.—U.S.N.M. Nos. 98490a-c.

TRILOBITA

PAGETIDAE Kobayashi

PAGETIA Walcott, 1916

PAGETIA MALADENSIS, n. sp.

Plate 2, figs. 4, 5

This is a rather smooth species of *Pagetia.* The cranidium has a long narrow glabella, well-defined eye lines, and a wide preglabellar area, as well as the usual rim structure. The species is of average size. Aside from the narrow glabella, two other features separate it from *P. clytia,* namely, the weakness of the median furrow across the preglabellar area and the absence of indentations on the brim. The pygidium, regarded as representative of the species, differs from that of *P. clytia* in the greater fusion of the pleural lobes carried to the point where furrows are no longer visible. There are the usual axial spines.

Locality 54s.

Holotype and paratype.—U.S.N.M. Nos. 98491a, b.

PAGETIA CLYTIA Walcott

Plate 2, figs. 5-8

Pagetia clytia Walcott, Smithsonian Misc. Coll., vol. 64, No. 5, p. 408, pl. 67, figs. 2-2e, 1916.—Raymond, Mem. Connecticut Acad. Sci., vol. 7, p. 145, fig. 37, 1920.—Resser, Smithsonian Misc. Coll., vol. 97, No. 12, p. 8, pl. 2, figs. 30-32, 1939.

Numerous well-preserved specimens permit close specific discrimination, which shows that this form is *P. clytia,* characteristic of the overlying Spence shale.

Locality 54s.

Plesiotypes.—U.S.N.M. Nos. 98492a-d.

ZACANTHOIDEA Swinnerton

PROZACANTHOIDES Resser, 1937

This genus is represented by five species in the collections from locality 54s and one from locality 59f, near Liberty. Unidentified species occur in the Langston of Blacksmith Fork. This represents a great expansion for the genus, and most of the species are represented by many specimens.

As the species are here set up heads and tails have been matched according to shape and surface ornamentation. One specimen retains the libragenes and part of the thorax.

Considerable similarity exists between the cranidia of *Prozacanthoides* and *Dolichometopsis* and *Ptarmigania,* and the pygidia of *Prozacanthoides* are sometimes difficult to tell from those of *Kochaspis* and even of *Kochiella.* Similar likenesses are observed among the hypostomata. In several respects *Prozacanthoides* lies between *Zacanthoides* and *Albertella.*

PROZACANTHOIDES ALATUS, n. sp.

Plate 3, figs. 10-12

This species is represented by several cranidia and pygidia, which have been selected on the basis of surface ornamentation and degree of fusion. The glabella is parallel-sided and rounded at the anterior angles, with a flattened curvature in front. The occipital furrow is straight and clearly defined but not deep. The occipital ring has a fairly large spine. Four pairs of glabellar furrows are faintly indicated. The fixigenes are confined to the palpebral lobes and at their widest point are a little more than half the width of the glabella. The eyes are very long, and the eye band is wide. The eyes extend from the anterior angles of the glabella outward at a considerable angle, with a nearly straight outline for about two-thirds their length. In the rear third the curvature increases very rapidly, and the rear portion of the eye lobe evidently overhangs the occipital furrow. The brim is simple without a rim, slightly concave, and upturned. The facial suture diverges at about the normal rate.

In the pygidium fusion is not complete as ribs appear in the pleural lobes. The axis is stout and long, terminating rather abruptly. Four rings and a terminal segment are defined by shallow axial furrows. As usual the anterior segment extends into stout spines directed straight back and a small pair of spines is developed on the second segment.

Locality 54s.

Holotype and paratypes.—U.S.N.M. Nos. 98493a-c.

PROZACANTHOIDES LIBERTYENSIS, n. sp.

Plate 3, figs. 13-15

It is possible that two species are included in the illustrated material, consequently one of the cranidia (fig. 13) is referred to the species with reservation. All the material is fragmentary, but it seems worth recording to show occurrence of *Prozacanthoides* in the Mill Creek section. The description is confined to the holotype pygidium.

The cranidium is parallel-sided, with a very slight expansion near the anterior end. The dorsal furrow is clearly defined, rounding off the anterior angles of the glabella. Palpebral lobes, which constitute the fixigenes, are less than half the width of the glabella and the eyes appear to have extended from the anterior pair of glabellar furrows to the occipital furrow, with a rather even but not very great curvature. Fusion is not complete in the pygidium and consequently several segments are apparent. The border seems to lack spines although it is wavy and has a strong indentation at the rear of the axis.

P. libertyensis differs from the species in Two Mile Canyon by its narrow brim and the pygidium, which has less detailed relief.

Locality 59f.

Holotype and paratypes.—U.S.N.M. Nos. 98494a-c.

PROZACANTHOIDES DECOROSUS, n. sp.

Plate 3, figs. 16-18

This species is represented by several examples of each part, and is a particularly well-formed species.

Four pairs of glabellar furrows are faintly indicated and the widened neck ring carries a short, slender spine. The width of the fixigenes is more than half that of the glabella, causing the glabella to be rather slender in proportion. The eyes are long and fairly evenly bowed with a slight decrease in curvature in the forward half.

The brim is simple and narrower than in most species. The associated hypostoma is illustrated in figure 18, together with another cranidium. The pygidium assigned to the species is not completely fused, as two segments are traceable, beside furrows on the third. The marginal spines are three in number. The pygidium is further characterized by a rather strong post-axial ridge and by the straight lateral margins.

P. decorosus is much like *P. alatus* in the large size of the eyes. It is distinguished quite readily by the more even curvature of the eye lobes.

Locality 54s.

Holotype and paratypes.—U.S.N.M. Nos. 98495a-c.

PROZACANTHOIDES EXILIS, n. sp.

Plate 3, figs. 19, 20

This species is represented by a considerable number of specimens. It is characterized by a rather broad glabella on which the furrows are indicated by faint depressions. The glabella is slightly keeled. The occipital furrow is considerably reduced, consisting of two deep elongated pits connected across the middle by a shallow furrow. The palpebral lobes at their greatest width equal exactly half the glabellar width. The eye bands are particularly wide, the eyes are rather evenly curved and set at a smaller angle to the dorsal furrow than in any other species. The brim is wide. The pygidium assigned to the species is narrow with a wide axis well fused with only one segment traceable. The axis is prominent because of its large size and because the narrow pleural lobes are slightly concave, rising from the dorsal furrow. The pygidium has a very small spine on the first segment. The surface is covered by fine anastomosing lines.

Locality 54s.

Holotype and paratype.—U.S.N.M. Nos. 98496a, b.

PROZACANTHOIDES AEQUUS, n. sp.

Plate 3, figs. 21-23

This species is represented by a number of cranidia, to which one pygidium had been assigned. It is characterized by low relief and a high degree of fusion. Several of the glabellar furrows are indicated by wide shallow depressions; likewise the occipital furrow. The widened neck ring is peculiarly marked by irregular striations radiated from the short occipital spine and covering the latter half of the ring. At their widest point the palpebral lobes are a little

more than half the width of the glabella, and are peculiar in that they are sunken below the dorsal furrow and eye band. The slightly upturned eye band is gently curved in the forward three-fourths and more sharply in the latter fourth. The brim is depressed next to the glabella and at the lateral angles in an irregular manner and is covered by coarse radiating anastomosing lines. The associated pygidium is also flat, with the axis standing above the pleural lobes. Like the fixigenes the pleural platforms are depressed below both the axis and the outer segment which forms a rim. The first segment extends into a spine.

The depression of the brim in front of the glabella and a similar downturning of the rear margins of the pygidial pleural lobes serve to distinguish this species from its associates.

Locality 54s.

Holotype and paratypes.—U.S.N.M. Nos. 98497a-c.

PROZACANTHOIDES OPTATUS, n. sp.

Plate 3, figs. 24-30

This is the commonest species of *Prozacanthoides* at the locality. It is represented by the best-preserved material and, moreover, has about average features for the group of species.

The glabella is parallel-sided, with the rear pair of furrows rather deeply impressed and the others represented by faint impressions. The occipital furrow is deep and the rings bear a spine, as well as two furrows parallel to the rear pair of glabellar furrows. Eyes are large, with their greatest curvature toward the rear, the palpebral lobes attaining their greatest width opposite the rear pair of glabellar furrows. At their widest point the palpebral lobes exceed half the glabellar width. Brim rather narrow; outline of the front margin of cranidium straighter than in most species. The posterolateral limbs end in intragenal spines.

Libragenes, attached to the holotype, are about as wide as the palpebral lobes, with long, slender, genal spines, which are slightly advanced. The strong rim is heavily striated and the ocular platforms are covered with a network of heavy anastomosing lines.

The pygidium assigned to the species is well fused, with a rather strongly tapered axis. Pleural segments are not entirely obliterated. The first segment extends into rather long, stout spines, and a second pair into small spines.

Locality 54s.

Holotype and paratypes.—U.S.N.M. Nos. 98498a, a'-2.

BATHYURISCIDAE Richter

BATHYURISCUS Meek, 1873

BATHYURISCUS POLITUS, n. sp.

Plate 2, fig. 9

Present collections have yielded a single small *Bathyuriscus* pygidium, which belongs to the spined group of the genus. Even though there is but this one small tail, its generic position is certain.

The axis is cylindrical and extends to the rear margin, in cross section standing completely above the flat pleural lobes. Both the pleural grooves and the pleural furrows are retained, the latter ending in deep depressions next to the rim. The rim is narrow and extends into stout spines at the anterior angles.

Locality 54s.

Holotype.—U.S.N.M. No. 08499.

POLIELLA Walcott, 1916

POLIELLA WASATCHENSIS, n. sp.

Plate 13, fig. 16

An entire individual and a pygidium with the major portion of a thorax represent the species. It occurs in a shaly matrix, associated with *Alokistocarella brighamensis*. Its precise stratigraphic position is not known, and it is here included because of its association.

As a whole *P. wasatchensis* has the ovate shape characteristic of the genus. The glabella occupies the full length of the cranidium except for a narrow rim. It expands forward in the usual manner of the genus. Owing to the fact that the hypostoma has been pressed into the glabella, furrows and convexity are not determinable. The eyes are about normal in size and position. Anterior to the eyes the suture diverges and behind the eyes long narrow posterolateral limbs are formed. The fixigenes are almost eliminated at the anterior end of the eye. The libragenes are attached. They are simple, of normal size and have a narrow rim. Genal spines extend to about the fourth thoracic segment and are directed away from the thorax.

Thorax has nine segments. The rather long spines are spread out in open fashion.

The pygidium is fairly large, with the slender axis extending about three-fourths its length. A postaxial ridge continues to the indented rear border. Fusion has not wholly eliminated the pleural grooves. The pleural furrows are traceable almost to the margin across the slightly concave flattened border.

Locality 20x.

Holotype.—U.S.N.M. No. 98500.

PTARMIGANIDAE, new family

DOLICHOMETOPSIS Poulsen, 1927

Poulsen described *Dolichometopsis* from cranidia, referring a single fragmentary pygidium to the type species. This pygidium, however, is doubtful, what there is of it pointing rather to *Kochiella*. Nearly complete specimens in the *Ptarmigania* fauna makes it practically certain that the pygidium of *Dolichometopsis* has a spinose margin, four spines to the side. These spines, which increase in size from front to back, may be longer than the pygidium or may be short and sharp-pointed. In no case have they been eliminated. The most characteristic feature of the pygidium, aside from the marginal spines, is the heavy spine on the first axial ring. The thorax seems to have seven segments.

Poulsen recognized the relationship of *Dolichometopsis* to *Albertella*. Its nearest relative clearly is *Ptarmigania*. In fact, it is not certain that the cranidia of the two genera can be separated in every case when the pygidium is lacking. In this paper arbitrary separations were necessary in several instances. On the whole *Ptarmigania* is more granulose than *Dolichometopsis*, but one cannot be sure that this criterion will hold at other localities for both have a granulated test.

DOLICHOMETOPSIS LEPIDA, n. sp.

Plate 3, figs. 31-33

This species is represented only by cranidia and a libragene. It is characterized by a long glabella, which expands slightly forward of the eyes. The usual four pairs of glabellar furrows are visible, and the occipital ring extends into a long stout spine. The fixigenes are confined to the palpebral lobes, which extend forward to the third pair of glabellar furrows and back to the occipital furrow. At the widest point they are just exactly half the width of the glabella and the eyes are moderately bowed with a nearby even curvature. As usual the rear end of the eye lobe overhangs the occipital furrow. The surface is granulose, the granules being rather numerous and evenly distributed. Anterior to the eyes the fixigenes form a flange about equal in width to the narrow concave brim, the latter being thickened and heavily striated on the elevated edge.

D. lepida has the longest glabella of the smaller forms.

Locality 54s.

Holotype and paratype.—U.S.N.M. Nos. 98501a, b.

DOLICHOMETOPSIS STELLA, n. sp.

Plate 3, fig. 37

This species is based on a single incomplete pygidium, which might well belong to some of the described cranidia, but it has been given a name because of its unique construction. Unfortunately the axis is broken away, but it clearly stood well above the convex pleural platforms. The pleural lobes rise slightly from the dorsal furrow but drop off rapidly to the border in their outer half. Four pleural furrows are visible, terminating in pits at their distal end. The unique feature of the pygidium is the length of the four marginal spines. The first pair is nearly as long as the pleuron to which it is attached. The remaining pairs increase in size and length rearward until the rear pair possibly equal the length of the pygidium. The surface is covered by small scalelike granulations, which become stronger toward the margins.

Locality 54s.

Holotype.—U.S.N.M. No. 98502.

DOLICHOMETOPSIS ALIA, n. sp.

Plate 4, figs. 19-21

This is another well-represented species but only by cranidia.

The glabella expands forward at about the usual rate. The four pairs of glabellar furrows are faintly indicated but shallow. The neck ring is wide and contracts abruptly to a long, slender spine. The fixigenes at the widest point, which is at the rear end of the eye, exceed half the width of the glabella at the same point. The eyes are of moderate size and set at a considerable angle to the dorsal furrow. They are bowed rather evenly but the curvature is not great. Posterolateral limbs wider than usual in the genus, with a strong occipital furrow. Fixigenes anterior to the eyes at least four times the width of the brim. Brim confined to a very narrow upturned rim. Surface covered by scattered inconspicuous granules.

Locality 54s.

Holotype.—U.S.N.M. No. 98503; figured specimen, No. 98504.

DOLICHOMETOPSIS MEDIA, n. sp.

Plate 4, figs. 11-12

This species is founded on a single pygidium. The axis is long and stout and unfortunately is broken off on top as the long spine was carried away by the matrix. Pleural lobes well fused, with four furrows visible, ending in the usual pits inside the border. Four

marginal spines increasing in size from the front to the rear are present. The surface is granulose, with the granules of moderate size and fairly crowded on the higher portions.

Locality 54s.

Holotype.—U.S.N.M. No. 98505.

DOLICHOMETOPSIS COMIS, n.sp.

Plate 4, figs. 22-24

This species is represented by several cranidia, and a pygidium assigned to it. The glabella expands very slightly and is definitely keeled, which feature extends into the occipital spine. It is further characterized by the failure of the occipital furrow to be deeply impressed across the median line. The palpebral lobes attain their greatest width opposite the first pair of glabellar furrows and this width is more than half the glabellar width at the same point. The eyes are evenly bowed and considerably curved, and anterior to the eye lines form rather wide flanges. Rim narrow. The pygidium is characterized by a long, stout axis. The first axial ring is thickened and bears the usual long spine. Back of this, three other rings are traceable. On the pleural lobes only three ribs are noticeable, with the furrows terminating in pits as usual. The third pair of marginal spines is apparently reduced, while the fourth is rather large. Surface characterized by scattered granules and irregular ridges, both of which are faint.

Locality 54s.

Holotype and paratype.—U.S.N.M. Nos. 98506a, b.

DOLICHOMETOPSIS POULSENI, n. sp.

Plate 5, figs. 1-10

This species gives a clue to the association of cranidium and pygidium. It also serves for correlation between the Wasatch Mountains and Liberty Canyon in the Bear River Range. Unfortunately the specimens are fragmentary and the material is not abundant. Further collection at the locality should yield excellent specimens.

This is a large species in which the long glabella is practically parallel-sided. The usual furrows are visible, although broad and shallow. The occipital ring is exceptionally wide and extends into a long, erect spine. The fixigenes at their widest points are about half of the glabellar width. The eyes are long and fairly evenly bowed

with increasing curvature toward the rear. In cross section the cranidium is convex, but the cheeks are nearly flat, sloping a little downward from the dorsal furrow. Longitudinally the species is very convex with the posterolateral limbs depressed and curved down at their distal ends, and the anterior part of cranidium sloping down at almost right angles to the rear portion. The anterior fixigenes form a flange about twice as wide as the flat concave rim. Libragenes unknown. Several specimens retain thoracic segments, one of them as many as seven, which is possibly the total number. The pygidium is characterized by a prominent axis in which four rings are traceable, the first one being thickened and bearing a large axial spine. Four pairs of faint pleural furrows end in pits inside the border. A thickening along the rear margin delimits the first segment on the pleural lobes. The four marginal spines evidently increase in size from the front toward the rear. Surface marked by scattered granules on elevated portions.

Locality 59e, 54s.

Holotype and paratypes.—U.S.N.M. Nos. 98518a-c.

DOLICHOMETOPSIS PROPINQUA, n. sp.

Plate 5, figs. 11-13

This species is characterized by a long expanding glabella, which is narrowest at the second pair of furrows. The furrows are all shallow. The palpebral lobes are about half the glabellar width at the same point, and anterior to the eyes the fixigenes form a flange about three times the width of the rim. The eyes are long and not greatly bowed, except toward the rear. Rim narrow in front, widening toward the anterior angles to meet the flange. Eye lines present. The pygidium assigned to the species has a high axis, which terminates very abruptly in the rear and the pleura are fairly well indicated in the lobes. The four marginal spines increase only slightly in size toward the rear. Surface nearly smooth, but with scattered granulations.

Locality 54s.

Holotype and paratype.—U.S.N.M. Nos. 98508a, b.

DOLICHOMETOPSIS GREGALIS, n. sp.

Plate 6, figs. 1-4

This species is close to *D. poulseni,* with which it is associated. It is characterized by its large size and a practically parallel-sided

glabella. Furrows are wide and shallow, and when the test is exfoliated they are traceable entirely across the glabella. The dorsal furrow is shallow even though it is clearly defined. Evidently there is a large, erect, occipital spine. The palpebral lobes at their widest points are less than half the glabellar width. The eyes are long, with a slightly thickened band, but not greatly curved, and are set practically parallel with the dorsal furrow. Compared to most of the other species, this form is flat in cross section, with the glabella rising above the palpebral lobes in a flat curvature. The fixigenes are practically flat and almost horizontal. Longitudinally there is more curvature particularly because the anterior angles and posterolateral limbs are depressed. The brim is simple, concave with a slightly upturned rim. The pygidium is characterized by width of border and of the marginal spines. The latter increase in size rearward so that the last pair is large. The first segment is swollen as usual with a large spine, and the axis overhangs the border in the rear. Fusion is carried so far that most furrows are eliminated, and the border is wide.

Locality 59e.

Holotype and paratype.—U.S.N.M. Nos. 98509a, b.

DOLICHOMETOPSIS COMMUNIS, n. sp.

Plate 6, figs. 5-8

A number of specimens have been assigned to this species. It is characterized by a glabella that expands slightly in front of the eyes and has the usual shallow glabellar furrows. The distinctive characteristics of the species are found in the palpebral lobes, which are convex and narrow at their widest point, being only about one-third as wide as the glabella. Eyes very long and not greatly curved. In cross section the cranidium has a low-arched glabella and convex palpebral lobes, which also rise above the dorsal furrow. On the other hand, in longitudinal direction the cranidium is more highly arched, curving slightly except in the anterior fourth, which is sharply downturned. The associated pygidium is characterized by the usual features with the axis standing above the pleural lobes, but with only a shallow dorsal furrow. The pits at the ends of the pleural furrows are rather deep and the marginal spines nearly the same size throughout are arranged in a stellate fashion. The surface is covered by granules on the elevated portions, but the wide shallow furrows lack them.

Locality 54s.

Holotype and paratype.—U.S.N.M. Nos. 98510a, b.

DOLICHOMETOPSIS MANSFIELDI, n. sp.

Plate 6, figs. 11-16

This species is represented by a number of fragmentary specimens. It is nearest like *D. communis* in the narrowness of the palpebral lobes. The glabella does not expand very much and the furrows are all shallow, including the occipital furrow. The occipital ring is wide but its spine is slender. The palpebral lobes at their widest point are considerably less than half the glabellar width. The eyes are long, rather straight in the forward part, and more sharply curved to the rear. The libragenes are convex in cross section, but the glabella has little elevation. Longitudinally this species is not so highly convex, as may be seen from the side views. Test is smooth except for striations on the rim.

Locality 19s.

Holotype and paratypes.—U.S.N.M. Nos. 98511a-d.

DOLICHOMETOPSIS POTENS, n. sp.

Plate 6, figs. 17-23

This species is represented by fragmentary material only but is quite distinctive because of the great width of the palpebral lobes and the practically smooth test. The glabella expands greatly in the anterior half. The furrows are developed as usual. The palpebral lobes are very wide, equaling nearly two-thirds the glabellar width at the same point. The occipital spine is stout. Anterior to the eyes the fixigenes form only a narrow flange, and the rim is very narrow. Fusion is carried far in the pygidium. The furrows are wide and shallow and the pits large but also shallow. The four marginal spines evidently increase in size rearward and likely are rather large. The peculiar feature of the pygidium is the wrinkling of the test on the higher parts.

Locality 54s.

Holotype and paratypes.—U.S.N.M. Nos. 98512a-e.

DOLICHOMETOPSIS GRAVIS, n. sp.

Plate 7, figs. 6-11

This species is represented by several cranidia, and one pygidium has been assigned to it. It is characterized by the usual cranidial features, the glabella expanding slightly anterior to the eyes, and with four pairs of glabellar furrows, shallow except for the outer ends of the first pair, which are deeply impressed next to the dorsal furrow. This species evidently has a rather slender occipital spine. In cross

section the cranidium is convex. Longitudinally it is considerably more so, with a rather even curvature throughout. The palpebral lobes are just half the width of the glabella, and the eyes are of normal size and normal curvature. The palpebral furrow is shallow, but the eye band is fairly well defined. The brim is very narrow, expanding to meet the moderate flanges at the anterior angles. The pygidia assigned to the species has a rather high axis, abruptly terminated in the rear. The marginal spines increase rearward until the rear pair is quite long. Owing to the convexity and the granulations on the spines, there is some question regarding assignment of the pygidium. The cranidial surface seems to be nearly smooth.

Locality 54s.

Holotype and paratypes.—U.S.N.M. Nos. 98513a-c.

PTARMIGANIA[3] RAYMOND, 1928

Ptarmigania is represented by many species. Separation of *Ptarmigania* and *Dolichometopsis* can be made only when pygidia are available. In a species such as *P. exigua* the pygidial border has one definite and three blunt spines, the latter little more than irregularities of the edge. In most species the margin has been smoothed out much more, so that there is scarcely anything more than a slight production of the anterior angles to represent the spines. *Ptarmigania* also has a large axial spine on the first pygidial segment. Most of the species are granulated.

The cranidium of *Ptarmigania* resembles that of *Clavaspidella,* but the pygidium is differently constructed. Aside from the lack of an axial spine, *Clavaspidella* typically has a rounded triangular or semicircular tail, while *Ptarmigania* has a transverse pygidium always wider than long.

PTARMIGANIA AURITA, n. sp.

Plate 3, figs. 35, 36

A single small cranidium is particularly marked by its nearly smooth surface and shallow glabellar furrows. The glabella expands forward from the first pair of glabellar furrows. The usual furrows are present but shallow, and the occipital spine evidently was large. The fixigenes, which are confined to the palpebral lobes, are about three-fourths the average glabellar width. The cranidium has considerable convexity longitudinally, and in cross section the glabella stands com-

[3] *Ptarmigania* was erroneously recorded in the bibliographic records as *Ptarmingia.* This error of spelling inadvertantly got into the literature.

pletely above the fixigenes, rising on the sides rather rapidly reaching the greatest curvature near the median line but without producing a keel. The fixigenes are convex, sloping down rather rapidly to a broad palpebral furrow. The wide eye band rises from the furrow. The eyes are of moderate length, extending from the front glabellar furrow to a point forward of the occipital furrow. Anterior to the eyes the fixigenes form a small flange which joins the narrow brim. The brim consists of a narrow rim, slightly upturned. Surface finely granulose.

Locality 54s.

Holotype.—U.S.N.M. No. 98514.

PTARMIGANIA EXIGUA, n. sp.

Plate 4, figs. 1-10

This is a common species, being represented by one cephalon, many cranidia, libragenes, and pygidia.

The glabella is long, expanding forward from the occipital furrow at an even rate to rounded anterior angles. The usual sets of furrows are deeply impressed. In cross section the species is convex, and the evenly arched glabella is above the dorsal furrow. The fixigenes are only slightly convex and have a horizontal position. Longitudinally the cranidium is very convex. The palpebral lobe, which is the fixigene, is about two-thirds the width of the glabella at that point. The occipital spine is stout and long, and the posterolateral limbs are long. The eyes extend from a little forward of the posterolateral limbs to the third pair of glabellar furrows and are set at a considerable angle to the dorsal furrow. The eye band is wide and slightly upturned. Eye lines strong. Anterior fixigene fairly wide and turned down at the outer angles. Brim simple, convex with the anterior margin strongly striated. Fixigene, attached to the holotype, highly convex and placed almost vertical to the palpebral lobe. Outer edge striated to correspond to rim and increasingly upturned toward the front. Genal spines long.

The pygidium is characterized by a stout axis in which two rings and a large terminal segment are defined, the anterior ring carrying a large spine. Three pleura visible on the platforms, but on the wide border four may be discerned. Each pleuron extends into a short blunt marginal spine.

Surface of the entire test granulose with the granules fairly evenly distributed except in the furrows.

Locality 54s.

Holotype and paratypes.—U.S.N.M. Nos. 98515a-f.

PTARMIGANIA NATALIS, n. sp.

Plate 4, figs. 13-18

This is perhaps the most abundant species, but a pygidium has not been located for it. The glabella is long, expanding rather evenly but slowly forward with the usual four pairs of furrows visible. The neck spine is long and extends up from the neck ring. The fixigenes are confined largely to the palpebral lobes and at their widest points are almost exactly equal to half of the glabellar width at the same point. The eyes are long, extending from the occipital furrow to the third pair of glabellar furrows, and the eye band is continued to the glabella by a large, wide eye ridge. The eyes are evenly bowed, increasing their curvature slightly toward the rear. Forward of the eyes the fixigenes form a flange about twice the width of the brim. Brim confined to a rim slightly upturned and striated. The fixigenes are very convex with the platform setting at a 60° angle to the border, thus sloping steeply down from the eye. Surface evenly granulose except in the depths of the furrows.

Locality 54s.

Holotype and paratypes.—U.S.N.M. Nos. 98516a-d.

PTARMIGANIA ORNATA, n. sp.

Plate 4, figs. 25-32

This is another common species represented by numerous cranidia and libragenes, but no pygidium has been located. The glabella is nearly parallel-sided and long, with the usual four pairs of furrows and the occipital furrow is clearly shown. The cranidium is highly arched longitudinally with a fairly even curvature. In cross section the glabella is quite convex, also with an even curvature. The libragenes rise very steeply from the dorsal furrow before they turn over to the eye lobes as is shown in figure 30. The occipital spine is long and erect. The eyes are rather strongly bowed and the palpebral lobes at their widest points are less than half the glabellar width. This is perhaps the most granulose species, the granules being large and numerous, wanting only in the depths of the furrows.

Locality 54s.

Holotype and paratypes.—U.S.N.M. Nos. 98507a-f.

PTARMIGANIA AGRESTIS, n. sp.

Plate 7, figs. 1, 2

This species is represented by several cranidia. Pygidia have been assigned to it but are not illustrated because of uncertain relationship.

The holotype is characterized by a cranidium that expands at about the usual rate and has the usual furrows. The second pair of glabellar furrows is somewhat distinctive in that it consists of deep narrow slots, and the rear pair is somewhat irregular in its course. In cross section this is quite a flat species with the glabella arched above the dorsal furrow and the palpebral lobes flat on top, sloping off at the outer edges. Longitudinally, there is greater curvature, fairly steep in front, but otherwise gentle. The palpebral lobes at their widest point are half the width of the glabella. The eye bands are wide and the eyes are of moderate length and not greatly curved. The fixigenes form a narrow flange anterior to the eyes and there is almost no rim. The surface is smooth, except for irregular puckering of the test near the occipital spine.

Locality 54s.

Holotype.—U.S.N.M. No. 98517.

PTARMIGANIA ALTILIS, n. sp.

Plate 7, figs. 3-5

This relatively small species is represented by several cranidia and one libragene. The glabella expands in normal fashion, and while the usual glabellar furrows are present, they are excessively shallow, except for the anterior pair which is quite deep due to a swelling of the glabellar surface near it. The head is nearly flat in cross section but considerably arched longitudinally. The eyes are about normal in length and considerably curved toward the rear. At their widest point the palpebral lobes are slightly less than half the glabellar width. The eye bands are clearly differentiated, but the palpebral furrow is shallow. The test is smooth, except for linear rugosities on the occipital ring. Anterior to the eye the fixigenes form relatively wide downturned flanges, and the rim is very narrow.

Locality 54s.

Holotype and paratype.—U.S.N.M. Nos. 98519a, b.

PTARMIGANIA SOBRINA, n. sp.

Plate 7, figs. 12-15

One cranidium and several pygidia have been associated to form the species. A libragene lies near the pygidium and is thought to belong with it. This species is characterized by a parallel-sided, relatively long and narrow glabella. In cross section the glabella is arched to a slight keel, and the palpebral lobes are quite convex, being rolled over on their outer edges. Longitudinally this species has considerable

elevation attained by an even curvature. The glabellar and occipital furrows are shallow, and the occipital spine is heavy and long. The palpebral lobes are just half the glabellar width at their widest point. The associated pygidium is well fused, although both the furrows and grooves are visible. The anterior portion of each pleuron is elevated into a narrow ridge, particularly well shown in the side view of the pygidium. The border is rather even, forming a slight angle near the anterior corner and another toward the rear, the remnants of the marginal spines. A small hypostoma lying near the cranidium is thought to represent the species. Surface appears to have been fairly smooth.

Locality 54s.

Holotype and paratype.—U.S.N.M. Nos. 98520a, b.

PTARMIGANIA GERMANA, n. sp.

Plate 7, figs. 16-20

This is a relatively small species and is represented by several cranidia and pygidia. The glabella expands considerably forward and the usual furrows are visible but shallow. The occipital spine evidently is rather slender. This species is quite flat in cross section and only gently curved longitudinally. The eyes are long, gently curved, with the eye band well defined. The pygidium is well fused, so much so that most of the furrows and grooves are eliminated. The anterior furrow is visible and the groove between the first and second pleura is well shown next to the dorsal furrow, because of the ridging on both sides of it. The rear margin is sharply indented in the center and a very short spine is present at the anterior angles.

Locality 54s.

Holotype and paratypes.—U.S.N.M. Nos. 98521a-c.

PTARMIGANIA DIGNATA, n. sp.

Plate 8, figs. 1-7

This is a well-represented species. The glabella expands forward throughout its length; at an increasing rate in the anterior third. The furrows are shallow throughout. The occipital spine is of about medium size and stands erect. The palpebral lobes are about half the width of the glabella at the same point and are particularly characterized by high relief. A ridge parallels the palpebral furrow, thus giving rise to the distinctive feature of the species. The palpebral furrow is broad and shallow and the eye bands narrow. The eyes are of medium size and set at a considerable angle to the dorsal furrow. The flanges

are narrow and the brim practically wanting across the front of the glabella. The libragene has a rather wide ocular platform and is not very convex. A heavy, thickened border extends into a long genal spine. The associated pygidium is well fused, although three pleural furrows are still visible. The margin is nearly even with faintly defined waves to represent the marginal spines. Surface granulose on the highest points and toward the margins marked by heavy irregular lines.

Locality 54s.

Holotype and paratypes.—U.S.N.M. Nos. 98522a-d.

PTARMIGANIA, sp. undet.

Plate 3, fig. 34

A minute cranidium, the characters of which are well shown by the illustration, does not fit the recognized species. It may well represent a young stage, but if so the species to which it belongs is not determinable, since there is no ornamentation to assist.

Locality 54s.

Figured specimen.—U.S.N.M. No. 98523.

GLOSSOPLEURA Poulsen, 1927

GLOSSOPLEURA PRONA, n. sp.

Plate 8, figs. 11-14

This species is characterized by its smoothness and the flatness of the pygidium. The eyes are large, and the glabella expands only slightly anterior to the forward end of the eyes.

The pygidium is flat, with a faint dorsal furrow. Pleural furrows are faintly visible between the axis and the wide flat border.

This species is similar to *G. bion* but the pygidium is flatter and the cranidium has less brim.

Localities 55p, 55q.

Holotype and paratype.—U.S.N.M. Nos. 98524a, b.

GLOSSOPLEURA ARRECTA, n. sp.

Plate 8, figs. 8-10

This species is associated with *G. prona* but contrasts strongly with it because the pygidium is highly arched. This arching is rather even so that the dorsal furrow becomes shallow. Longitudinally the axis is arched, the declivity at the rear being very steep. Pleural grooves are practically absent.

Localities 55p, 55q.

Holotype and paratype.—U.S.N.M. Nos. 98525a, b.

CLAVASPIDELLA Poulsen, 1927

CLAVASPIDELLA WASATCHENSIS, n. sp.

Plate 8, figs. 15-20

Numerous pygidia, but only one cranidium, of this species have been found. Parts of other cranidia are to be seen on some of the larger pieces of rock.

The glabella expands rapidly in the anterior third and is nearly parallel-sided opposite the palpebral lobes. The occipital and rear pair of furrows are well impressed, but the remaining furrows are barely visible. There is a small node of the neck ring. Anterior to the eyes the facial suture diverges rapidly, but the flanges thereby produced increase little in width toward the anterior angles. Brim consisting of a very narrow rim only. Palpebral lobes are narrow, being less than half the glabellar width at the same point, and they maintain their width throughout nearly all of their length. The pygidium is typical of the genus with its narrow axis on which four rings are traceable, beside the long tapering rear segment. The pleural lobes slope down to a slightly flattened border across which the pleural furrows extend to the margins. Pleural grooves are faintly visible. The libragene has a wide concave border, which extends into a long, broad, genal spine. The surface is covered with very fine granules and as usual, when the test is exfoliated, is punctate.

Locality 20x.

Holotype ad paratypes.—U.S.N.M. Nos. 98526a-d.

CLAVASPIDELLA EXCAVATA, n. sp.

Plate 9, figs. 1-6

This beautiful species is represented by a number of specimens. The glabella is long and narrow, expanding in the usual manner, with ordinary development of glabellar and occipital furrows. In cross section there is little convexity, except that the anterior angles and the posterolateral limbs are depressed. Longitudinally curvature is confined to the anterior third of the glabella. The palpebral lobes at their widest point are less than half the glabellar width. They rise somewhat from the dorsal furrow but do not have great convexity. The palpebral furrow is clearly defined. The eye is of normal size and position. The suture anterior to the eye diverges rapidly to form triangular anterior angles. The associated hypostoma has the large heavy bar characteristic of the genus. The pygidium is quite distinctive both in its relief and development of furrows. The axis has

about the usual proportions and stands above the pleural lobes. Both the pleural furrows and pleural grooves are deep; the anterior ones extending to the margin and those near the rear end of the axis ending abruptly some distance from the margin. The pleural platforms are small and the outer edges are upturned, so that the entire pygidium appears concave.

Locality 59c.

Holotype and paratypes.—U.S.N.M. Nos. 98527a-d.

ORYCTOCEPHALIDAE Beecher

ORYCTOCEPHALITES, n. gen.

Small trilobites related to *Oryctocephalus*. The glabella is long, extending the full length of the cranidium, expanding forward. The occipital furrow is deeply impressed and three pairs of glabellar furrows are present. None of them reach to the dorsal furrow. The rear pair consists of two elongated pits connected by a shallow furrow across the median line, while the forward pairs consist merely of elongated pits. The dorsal furrow is deep. The fixigenes average less than half the width of the glabella. The eyes are large, extending from the occipital furrow forward a little more than half the length of the glabella and are set at a considerable angle to the course of the dorsal furrow. Weak eye lines connect their anterior ends with the dorsal furrow. These eye lines pass forward parallel to the strongly curved anterior margin, reaching the glabella forward of the anterior pair of furrows. The brim is confined to a narrow upturned rim. The pygidium is well fused in the anterior portion. Its axis is rather prominent, contracting rather rapidly toward the rear and extending somewhat more than two-thirds the length of the pygidium. Four axial rings and a terminal segment are delimited. The pleural grooves are deep, and the pleural furrows are traceable, becoming better defined toward the rear so that the segmentation of the rear portion of the pygidium can be clearly traced. Five pairs of marginal furrows are present, and these increase in size from the anterior angles to the fourth spine, which is very large, while the fifth is reduced to small, slender points. A wide, flat, postaxial ridge extends to the rear margin.

This genus differs from *Oryctocephalus* in the expanded glabella, which extends forward beyond the fixigenes, at the anterior angles, the reduction of the forward glabellar furrows to pits, the lesser development of the eye line, and the more posterior position of the eyes. In the pygidium the difference is expressed by a greater degree

of fusion and a greater convexity, in keeping with the greater convexity of the cranidium.

Genotype.—O. typicalis, n. sp.

ORYCTOCEPHALITES TYPICALIS, n. sp.

Plate 3, figs. 1-6

The generic description and the illustrations present all the essential characteristics of this species.

Locality 54s.

Holotype and paratypes.—U.S.N.M. Nos. 98528a-f.

ORYCTOCEPHALUS Reed, 1898

ORYCTOCEPHALUS MALADENSIS, n. sp.

Plate 3, figs. 7-9

About 75 cranidia, but part of only one pygidium, have been found in the collections. This species is wholly typical of the genus, as the cranidium has a quadrate outline and a long parallel-sided glabella, with three pairs of furrows clearly indicated. The eye lines are prominent, and the rim is narrow, particularly in front of the glabella. The eyes are large and set practically parallel to the dorsal furrow. The fragment of the pygidium shows that segmentation is normally developed and no doubt there are long slender marginal spines.

O. maladensis is very much like *O. walcotti* of the Spence shale. It averages smaller. Difference is noticeable in relief which is discounted by compression of the Spence shale. The chief difference is in the brim, where *O. maladensis* has a wider space between the eye lines and the anterior furrow on the anterior fixigenes, and also has a thickened instead of a flat rim.

Locality 54s.

Holotype and paratypes.—U.S.N.M. Nos. 98529a-c.

TONKINELLA Mansuy, 1916

TONKINELLA IDAHOENSIS, n. sp.

Plate 2, fig. 10

Closely associated with *Taxioura* and *Pagetia* is a single small pygidium, which at present can be referred only to *Tonkinella.* This pygidium is rather convex but flattened on top. Fusion has almost eliminated the dorsal furrow and pleural grooves and furrows. All are visible as shallow marks on the test.

Locality 54s.

Holotype.—U.S.N.M. No. 98530.

KOOTENIDAE, new family

OLENOIDES Meek, 1877

OLENOIDES MALADENSIS, n. sp.

Plate 10, figs. 27, 28

Only pygidia have been found. The cranidia are difficult to distinguish from *Kootenia* but none in the collection seem to be large enough to warrant consideration as *O. maladensis.*

The axis is long and stout, terminating abruptly at the marginal furrow. Four axial rings and a terminal segment are clearly defined by rather broad furrows. Four pleura are clearly defined, each ending in a long, recurved spine. The rear pleuron is flexed back around the rear lobe of the axis. The anterior axial rings have blunt spines. Surface very granulose.

Locality 54s.

Holotype and paratype.—U.S.N.M. Nos. 98531a, b.

KOOTENIA Walcott, 1888

KOOTENIA CONVOLUTA, n. sp.

Plate 10, figs. 1-11

This species is very abundant, and the material includes several enrolled examples that are rare in the Cambrian. *K. convoluta* and associated species are about the only species of *Kootenia* that are granulated. However, it will be noted that there is a tendency toward lining and scaly structures rather than rounded granules.

Glabella rectangular, without trace of glabellar furrows. Occipital furrow deep, neck ring extended into a short, rapidly tapering spine. Anterior pits in the dorsal furrow are deep, which consequently narrows the glabella at this point. Glabella extends beyond the anterior angles. Anterior furrow increases in depth and turns somewhat backward beyond the corners of the glabella, thus widening and making concave the rim and at the same time leaving a steep escarpment behind it, which takes the place of the eye line. Front outline of the head curved with the slight recession in the center. Fixigenes and eyes about average for the genus.

Libragenes small and narrow; the thorax has seven segments.

Pygidium semicircular, axis arched, and divided into three rings and a large rear segment by three axial furrows, which are more deeply impressed on the sides than in the middle. Pleura well fused but with pleural furrows in the anterior portion indicated by short, deep depressions. A well-defined flattened rim is delimited by a

shallow marginal furrow. The five pairs of marginal spines are flat, moderately long and slender, the anterior being the shortest, the second somewhat larger, and the remaining three still larger and about equal in size.

The surface of the cranidium is marked by strong striae on the frontal rim. On the sloping parts of the cranidium irregular lines pass into more or less definite granules, except in the furrows. The pygidium is covered with granulations, which tend to become scaly on the marginal spines.

Localities 54s, 59f.

Holotype and paratypes.—U.S.N.M. Nos. 98532a-e.

KOOTENIA MALADENSIS, n. sp.

Plate 10, figs. 12-15

Associated with *K. convoluta* and *K. granulosa* are several entirely smooth specimens of both cranidia and pygidia. Aside from lack of granulation the cranidium is much like that of *K. granulosa,* except that the rim in front of the glabella is narrower. Besides the smooth test the pygidium is also somewhat flatter as a whole, and the ribs are less conspicuous than in the other species.

Locality 54s.

Holotype and paratype.—U.S.N.M. Nos. 98533a, b.

KOOTENIA GRANULOSA, n. sp.

Plate 10, figs. 16-20

This is a small, very beautiful species associated with *K. convoluta* from which it differs in that the glabella is more quadrate in front owing to shallower dorsal pits. The frontal portion of the rim is slightly wider. *K. granulosa* is particularly characterized by the rounded granules, which do not tend to form ridges.

The pygidium referred to *K. granulosa* differs from that of *K. convoluta* in having slightly deeper pleural furrows, less fusion of the segments, less rapidly tapering marginal spines. It also has the characteristic granulose surface.

Locality 54s.

Holotype and paratypes.—U.S.N.M. Nos. 98534a-e.

KOOTENIA NITIDA, n. sp.

Plate 10, fig. 21

This species is founded on a single cranidium and is closely allied to *K. granulosa. K. nitida* differs chiefly in its narrower glabella with

somewhat stronger glabellar furrows. Likewise the dorsal furrows are deeper, particularly toward the front, which causes the rim to be more sharply upturned near the anterior angles.

Locality 54s.

Holotype.—U.S.N.M. No. 98535.

KOOTENIA LIBERTYENSIS, n. sp.

Plate 9, figs. 7-9

This species is represented by fragmentary material and is associated with *Clavaspidella excavata*. The cranidium assigned to it is somewhat doubtful, as it lies next to a fragment of *K. venusta* and may be representative of that species rather than of *K. libertyensis*. The cranidium is selected because of its surface markings and smaller size. The cranidium is characterized by a glabella, which is rounded in front, a large upright occipital spine, and a narrow striated rim. The anterior outline is considerably curved due to the rearward position of the anterior angles. The pygidium has six marginal spines. It is well fused, with the axis clearly defined and with the pleural grooves faintly visible. The marginal furrow is wide and prominent because of the change in slope. The spines are rather long and slender. The higher parts of the surface are marked by irregular elongate granulations.

Locality 59c.

Holotype and paratypes.—U.S.N.M. Nos. 98536a-c.

KOOTENIA VENUSTA, n. sp.

Plate 9, figs. 10, 11

This species, associated with *K. libertyensis*, is represented by fragmentary material. Only incomplete cranidia have been assigned to the species, one of which is illustrated. Compared to *K. libertyensis*, this cranidium has a long straight anterior margin. The glabella is relatively wider and also flatter. The pygidium is characterized by seven marginal spines, the rear pair of which are very small and close to the median point. The other spines are long and slender. Fusion has not completely eliminated the pleural grooves. Five axial rings and terminal segments are well defined in the convex axis. The anterior ring has a peculiar fold, possibly to be interpreted as an incipient spine. Surface smooth, except on the marginal spines where the usual scaly structure is developed.

Locality 59c.

Holotype and paratype.—U.S.N.M. Nos. 98537a, b.

KOOTENIA MENDOSA, n. sp.

Plate 9, figs. 14-18

This is a fairly common species, being represented by several cranidia and pygidia, none of which is very well preserved. As shown by the illustrations it is associated with *Wimanella maladensis* and with *Clavaspidella wasatchensis*.

The cranidium is characterized by a large prominent glabella which extends well forward beyond the anterior angles. It tapers somewhat forward. Pits at the anterior angles of the dorsal furrow strongly restrict the glabella at that point. Viewed from the front the cranidium is very convex with the glabella sharply curved. In that view the constriction in the forward end of the glabella is particularly noticeable. The pygidium is peculiar in several respects. The axis is long and of normal width, with the usual segments. The pleural lobes are well fused, although the pleural grooves are still visible. The border is of normal width. The outstanding peculiarity is the reduction of the marginal spines to short spines on the first and second segments and back of that to a slight waviness in the margin, becoming a smooth even outline in the rear.

Locality 20x.

Holotype and paratypes.—U.S.N.M. Nos. 98538a-c.

KOOTENIA GERMANA, n. sp.

Plate 9, figs. 19-24

This is a small species associated with *K. mendosa*. The glabella is of normal size and composition, being rather highly arched in both directions. The pygidium has six small, tapering marginal spines.

Locality 20x.

Holotype and paratype.—U.S.N.M. Nos. 98539a-d.

KOOTENIA ACICULARIS, n. sp.

Plate 10, figs. 24-26

One pygidium among the many *Kootenia* species at Two Mile Canyon has sharp spines. A very small cranidium, which also does not seem to belong with any other species is tentatively assigned to the species. The pygidium is characterized by the usual long cylindrical axis. Fusion has been nearly sufficient to eliminate the pleural grooves. A distinctive feature of the species is the extension of the pleural furrows across the border. There are six pairs of very slender marginal spines. The surface is smooth.

The small cranidium, which is illustrated, has a forward expanding glabella but is otherwise normal.

Locality 54s.

Holotype and paratype.—U.S.N.M. Nos. 98540a, b.

KOOTENIA BEARENSIS, n. sp.

Plate 10, figs. 22, 23

This species is founded on the pygidium. It has five spines, for which reason it resembles *K. convoluta*. It differs from that species because of its nearly smooth test. The marginal spines are long and the third pair is quite large.

Locality 19x.

Holotype.—U.S.N.M. No. 98541.

KOOTENIA PECTENOIDES, n. sp.

Plate 9, figs. 12, 13

The species is known only from the pygidium. It belongs to the *K. serrata* group. Fusion is carried to the extreme, so that the pleural grooves are eliminated and the pleural furrows shallow. The five marginal spines are blunt but terminate in sharp points.

Locality 55q.

Holotype.—U.S.N.M. No. 98542.

KOOTENIA BREVISPINA, n. sp.

Plate 11, figs. 1-4

This is a large species represented by four pygidia. An incomplete cranidium has been placed with these pygidia, but it is too imperfectly preserved to illustrate.

The pygidium is characterized by a wide stout axis and great convexity. Only a few segments are visible on the axis and pleural lobes. The pleural grooves are completely eliminated, and the pleural furrows are shallow but broad, terminating in the broad shallow marginal furrow. There are six short marginal spines, which give the pygidium a serrate edge. Fine granulations occur in the elevated portions, and as usual the marginal spines are scaly.

Owing to the blunt marginal spines this species resembles *K. pectenoides*.

Locality 54s.

Holotype and paratype.—U.S.N.M. Nos. 98543a, b.

ALOKISTOCARIDAE, new family

ALOKISTOCARE Lorenz, 1906

ALOKISTOCARE EUCHARE, n. sp.

Plate 2, figs. 11, 12

A single cranidium, in contrast with the great development in the superjacent Spence shale represents the genus in the *Ptarmigania* beds. It is typical in its proportions and relief. The glabella tapers to a rounded front, which is separated from a medially swollen preglabellar area by a deepened anterior dorsal furrow. The surface of the glabella is not so well preserved, but the shallow furrows seem to be rather wide. The glabella occupies about half the cranidial length. At the eyes, which are rather small and situated behind the cranidial midpoint, the fixigenes are about as wide as the glabella. The eye lines are strong, arising near the anterior glabellar angles. The brim is wide and generally concave, with the middle portion of the preglabellar area considerably swollen. The outer third is upturned as a flat rim. Back of the anterior furrow thus formed, a ridge crosses the brim parallel to the anterior margin. Brim vertically striated.

Locality 54s.

Holotype.—U.S.N.M. No. 98544.

ALOKISTOCARE EUZONA, n. sp.

Plate 12, figs. 4, 5

A single cranidium represents this species, which seems to be typical in its development. The glabella tapers forward at about the average rate and several pairs of glabellar furrows are faintly indicated by indentations near the dorsal furrow. The glabella is arched above the dorsal furrow with moderate convexity. The glabella, exclusive of the occipital ring, occupies about half the cranidial length. The fixigenes are just about half the glabellar width and rise considerably from the dorsal furrow. As usual the brim is wide and long, because the anterior facial suture diverges. Next to the anterior dorsal furrow the preglabellar area rises rather abruptly and then is gently concave to the front margin. Because the anterior angles are depressed, the slope of the preglabellar area becomes much steeper toward the anterior angles. Eye lines present. Eyes of moderate size, situated behind the midpoint of the glabella. No brim developed but the doublure shows as the usual impression on the brim. Brim vertically marked by anastomosing lines.

A. euzona is closely allied to *A. euchare* from Two Mile Canyon.

Locality 59f.

Holotype.—U.S.N.M. No. 98545.

ALOKISTOCARE GLOBATUM, n. sp.

Plate 12, figs. 10, 11

Only the one cranidium has been found, and it is not fully typical of the genus. The glabella tapers and is fully two-thirds the length of the cranidium. It lacks glabellar furrows, although faint irregularities occur along the dorsal furrow. The wide, shallow, occipital furrow is nearly interrupted by the slight keel that extends into the occipital ring. The latter has a small node. The dorsal furrow is wide and shallow but clearly defined to a point anterior to the eyes. From that point forward there is a rather unique spreading and coalescence of the glabella into the preglabellar area. The dorsal furrow is traceable entirely around the front of the glabella but is irregular. In other words the anterior part of the glabella fans out and joins the brim in an irregular manner. This feature is rare in ordinary trilobites but is found in such forms as *Bailiella* and *Harpes*. The libragenes are convex, rising abruptly from the dorsal furrow and then sloping down with little curvature at a considerable angle from the eye. The eye is situated well below the level of the dorsal furrow. The eyes are small and occupy about the midpoint of the cranidium. Anterior to the eyes the facial suture diverges slightly. The brim is wide and consists of a wide preglabellar area, which slopes downward, and a narrow rim, which rises to a horizontal position. The preglabellar area is covered by vertical and anastomosing lines, but the rest of the test appears to be smooth.

Locality 55p.

Holotype.—U.S.N.M. No. 98546.

ALOKISTOCARELLA Resser, 1938

ALOKISTOCARELLA OCCIDENS, n. sp.

Plate 2, figs. 13, 14

Two cranidia represent *Alokistocarella*. The species is characterized by a rather large subconical glabella, truncated in front. Including the occipital ring it is about two-thirds the cranidial length. Three pairs of glabellar furrows show faintly. The fixigenes opposite the eyes are about half the width of the glabella at the same point. The brim is wide, concave, and is turned up rather abruptly but lacks a rim. The brim is faintly striated vertically and the surface of the holotype is punctate.

Locality 54s.

Holotype.—U.S.N.M. No. 98547.

ALOKISTOCARELLA BRIGHAMENSIS, n. sp.

Plate 13, figs. 17, 18

Several nearly complete specimens are in hand. Unfortunately none of them preserve the pygidium. The cranidium is simple in construction, with a tapering glabella, rounded in front. Glabellar furrows are not shown. Brim concave, with a rim delimited in proper light more by means of change of slope than by an anterior furrow. Fixigenes are simple, averaging about two-thirds the glabellar width. Eye lines present. Eyes small, situated somewhat behind the middle of the cranidium.

The holotype retains about 16 thoracic segments, which is likely close to the total.

Localities 55e, 20x.

Holotype and paratype.—U.S.N.M. Nos. 98549, 98548.

KOCHINA Resser, 1935

KOCHINA VENUSTA, n. sp.

Plate 6, figs. 9, 10

This species is based on a cranidium that seems to be fully typical of *Kochina*. The glabella tapers and attains a length of a little more than half the cranidium. Three pairs of furrows are visible, and the occipital ring bears a small node. In cross section the cranidium is rather flat across the palpebral lobes but becomes quite convex in front. Longitudinally there is little curvature except in the brim. The fixigenes average about three-fourths the glabellar width. Eye lines present. Eyes of normal size, situated just behind the midpoint of the glabella. Brim wide, with a wide rim that expands in the middle. Surface finely granulose, overlain by scattered larger granules on the glabella and fixigenes, and by vertical lines on the preglabellar area.

Locality 54s.

Holotype.—U.S.N.M. No. 98550.

KOCHINA VESTITA, n. sp.

Plate 12, figs. 7, 8

This beautiful cranidium is unique. The glabella has the usual shape and proportions and three pairs of shallow furrows are traceable. The occipital furrow is deep and wide and expands forward in the middle nearly to the backward-directed first pair of glabellar furrows. The occipital ring bears a small tubercle. The fixigenes are about three-fourths as wide as the glabella at the forward end of the

eye and are gently convex horizontally. Longitudinally they are rather convex to match the curvature of the whole cranidium. Eye lines prominent. Eyes small. The brim is of normal width. The preglabellar area is slightly wider than the rim. The rim is wide and thick in the middle, narrowing gradually toward the anterior angles. However, as the anterior angles are approached the narrowing is much more abrupt, giving rise to a rather peculiar depression in the anterior furrow. The surface, except the bottoms of the furrows, is covered by two sets of granules. A small set somewhat uneven in size is numerous and is overlain by a series of larger granules scattered irregularly over the entire cranidium. In addition, the preglabellar area has vertical anastomosing lines.

Locality 54s.

Holotype.—U.S.N.M. No. 98551.

KOCHINA WASATCHENSIS, n. sp.

Plate 12, figs. 12-14

This species is represented by a number of cranidia none of which are altogether complete. The glabella has the usual shape and size and is slightly keeled. The fixigenes are wide at the forward end of the eye, equaling the full width of the glabella at that point. Eye lines are clearly defined. Eyes small and situated well behind the midpoint of the cranidium. In cross section the fixigenes are gently convex except at the anterior angles, which are considerably depressed. Longitudinally the curvature is also slight. The brim is wide and concave and has the usual rim, which is much more thickened on some specimens than on others, a feature due to the degree of impression of the doublure. Surface nearly smooth except for vertical anastomosing lines on the preglabellar area.

Locality 54s.

Holotype and paratype.—U.S.N.M. Nos. 98552a, b.

KOCHINA? ELONGATA, n. sp.

Plate 12, figs. 15, 16

A single cranidium in the oolitic rock from the Brigham locality lies next to a specimen of *Wimanella maladensis*.

The cranidium is not fully typical of *Kochina* because of its narrowness and the proportionately great width of the glabella. In some respects it appears to be closer to *Inglefieldia*. However, the brim structure and eye size and position refer it to the genus rather

than to any other. The glabella is not very well differentiated in front; in fact, viewed in cross light it merges completely with the preglabellar area. By the light in a longitudinal direction a shallow dorsal furrow may be seen. The eyes are situated far back, almost touching the occipital furrow. The brim is wide and gently concave and has a wide rim faintly indicated chiefly by a change of curvature. This brim contracts only slightly toward the anterior angles, a feature that makes the generic reference doubtful. The surface appears to be smooth.

Locality 20x.

Holotype.—U.S.N.M. No. 98553.

KOCHINA? LIBERTYENSIS, n. sp.

Plate 12, fig. 6

A single cranidium in reddish-brown shale represents this species. It is closely associated with a large specimen of *Hyolithes* and fragments of other trilobites. It may not belong to the *Ptarmigania* fauna but is included because it occurs with material that evidently does belong to the fauna.

This is a narrow form with a rather strongly tapering glabella, which occupies over two-thirds of the cranidial length. The occipital furrow is clearly impressed, but glabellar furrows are lacking, and there is a slight keel. The brim is simple, swollen in the middle, and depressed at the anterior angles. The anterior furrow swings back from the anterior angles to the anterior dorsal furrow; consequently the rim widens in the middle to occupy the entire brim width. The eyes are of moderate size and situated about the midpoint of the cranidium. They are elevated as the fixigenes rise rather abruptly from the dorsal furrow and the eye lobes themselves are prominent. The fixigenes at the eyes have about half the glabellar width.

Locality 59f.

Holotype.—U.S.N.M. No. 98554.

INGLEFIELDIA Poulsen, 1927

INGLEFIELDIA IDAHOENSIS, n. sp.

Plate 12, fig. 9

Inglefieldia is distinguished from *Kochiella* only by its relative narrowness. For this reason this species is put into *Inglefieldia*. Its features are much like the species of *Kochiella* here described except that the width across the cranidium at the anterior end of the eye is much reduced by contraction of the fixigenes.

I. idahoensis is based on a single small cranidium. The glabella tapers to a truncated front. Weak glabellar furrows extend directly across the glabella. The fixigenes are nearly the same width throughout, equaling about two-thirds the greatest glabellar width. The eyes are fairly large, situated somewhat behind the midpoint of the glabella. Eye lines weak. Brim wide, with thickened rim slightly wider than preglabellar area. Facial suture does not diverge much anterior to the eye.

Locality 59f.

Holotype.—U.S.N.M. No. 98555.

KOCHIELLA Poulsen, 1927

KOCHIELLA ARENOSA, n. sp.

Plate 11, figs. 5-9

This species is evidently fairly abundant, but because it occurs in quartzite only fragments can be obtained. A nearly complete but badly weathered cranidium is in hand. The fragments illustrated are better preserved and show essential features. Libragenes are fairly common, and one pygidium definitely places the species in its genus.

The glabella is little more than half the length of the head and tapers forward. At its anterior end the dorsal furrow is not clearly impressed, so that the glabella joins the brim, and to do so the anterior angles of the glabella flair somewhat. Brim wide, first convex and then concave. Anterior margin is nearly straight and slightly indented in the middle. The fixigenes at their narrowest point are about as wide as the glabella. The eyes evidently are rather small, situated about the midpoint of the cranidium. Three pairs of glabellar furrows are indicated by fairly sharp depressions, next to the dorsal furrow. Eye lines present. The libragene is of normal form, very simple with a broad concave margin which extends into a long genal spine. The pygidium is of normal composition with a broad axis on which two rings may be seen. The dorsal furrow is shallow and two pleura are differentiated on the lobes. The axis does not stand above the pleural lobes very much, but the lobes are highly convex. The pleural lobes have a wide flairing border, at the rear of which is a deep notch. The pleural lobes are very convex and the pygidium slopes rapidly downward from the rear of the axis.

Locality 59c.

Holotype and paratypes.—U.S.N.M. Nos. 98556a-d.

KOCHIELLA MANSFIELDI, n. sp.

Plate 11, figs. 10-14

This species is abundant in the small amount of material collected from this locality. It is associated with *Dolichometopsis* and *Poulsenia,* as well as other genera.

The glabella is little more than half the length of the cranidium and tapers considerably to a slightly rounded front. The dorsal furrow is definitely defined on the sides but becomes rather shallow in front of the glabella. Three pairs of shallow glabellar furrows may be noted. The fixigenes at the anterior end of the eye are nearly as wide as the glabella at that point, and they expand from the rear end of the eye forward owing both to the contraction of the glabella and to the slight divergence of the anterior facial suture. The eyes are of moderate size and situated rather far to the rear. Eye line prominent. Brim wide, nearly straight in front. On the whole it is concave, and when the doublure is impressed to show on the upper surface a wide brim is indicated. The associated pygidium is nearly quadrangular in outline with rounded anterior angles and slightly contracted lateral margins. The anterior half of the first segment forms a raised rim extending from the axis around the circular anterior angles and then backward into spines, which possibly are long. The axis is broad and has three axial rings, besides the terminal segment. It is only gently arched above the pleural lobes. The pleural lobes are nearly flat but slope down to the margin, and on them three pleura are delimited by the pleural furrows. Surface of cranidium covered by scattered large granules, overlying a small crowded set. In the pygidium only the small granulations are present, but irregular lines occur on the outer edges.

Locality 19s.

Holotype and paratypes.—U.S.N.M. Nos. 98557a-d.

KOCHASPIS Resser, 1935

KOCHASPIS MALADENSIS, n. sp.

Plate 13, figs. 9-12

Three pygidia, but no cranidium, were found at this locality. These pygidia constitute a typically developed species of *Kochaspis.* It is possible that the cranidium is confused with the abundantly represented *Poulsenia granulosa.*

The pygidium is characterized by a prominent axis, which stands entirely above the pleural platforms. The axis is nearly semicircular in cross section and occupies nearly the full length of the pygidium,

terminating very abruptly in the rear. The pleural platforms are moderately convex, dropping off to the flattened border, which has a horizontal position. Both the pleural furrows and grooves remain, but the most conspicuous feature is the elevated rib formed by the anterior half of each pleuron. The border extends into long, stout, flat spines at the posterior angles.

Locality 54s.

Holotype and paratype.—U.S.N.M. Nos. 98558a, b.

KOCHASPIS DISPAR, n. sp.

Plate 13, figs. 1-4, 13-15

At first these cranidia and pygidia were regarded as separate species, but it was decided to refer the cranidia to the species based on the pygidium. Since examples of *Dolichometopsis* occur on small pieces of rock with this species, it no doubt is a member of the *Ptarmigania* fauna.

The glabella is stout and tapers considerably to a rounded front. The dorsal furrow is deep. Three pairs of recurved glabellar furrows appear strongly in proper light. A slight keel is apparent on some specimens. The fixigenes are convex rising from the dorsal furrow and then curving down slightly to the eyes, which are rather prominent. The rim is almost equally divided between the slightly convex preglabellar area and the thickened rim. Longitudinally the cranidium is convex, with the greatest curvature in the rear and the whole forward half of the head sloping down rather sharply but without much curvature. Eye lines heavy. Surface slightly granulose; brim vertically striated with faint irregular lines.

The pygidium is much like that of *Vanuxemella,* except that it is larger and that fusion has not completely eliminated the pleural markings.

The axis is stout and stands above the pleural platforms. Three axial furrows and the terminal segment are clearly defined. The axis has very steep slopes at the sides but the curvature is somewhat flattened on top. It terminates abruptly, but there is a slope to the rear margin. Fusion has reduced the pleural grooves to very shallow furrows, but the pleural furrows are more clearly defined. As in *K. maladensis* the anterior rib of each pleuron is elevated. The tail is wide, and hence the slightly thickened rim extends into spines which are set wide apart, more in the manner of *Vanuxemella* than of *Kochaspis*. These spines are short.

Locality 59e.

Holotype and paratypes.—U.S.N.M. Nos. 98559a-d.

Family Undetermined

POULSENIA Resser, 1936

POULSENIA GRANOSA, n. sp.

Plate 13, figs. 19-30

This is a very prolific species, represented by many cranidia, a number of pygidia, and one complete specimen that permits unquestioned assignment of the pygidium.

The glabella tapers considerably to a rounded front and is strongly marked by three pairs of recurved glabellar furrows. The dorsal furrow is deep, in front joining the equally deep anterior furrow. The fixigenes are rather convex, sharply bent down to the eyes, and crossed by strong eye lines. Longitudinally they also are curved to meet the sharply depressed anterior angles and posterolateral limbs. Brim consists of a narrow preglabellar area, which is almost entirely occupied by the anterior furrow in the middle and a wider rim. The rim is thickened, and in the middle it expands backward.

The thorax apparently has 23 simple segments.

The pygidium is short and very wide, and when unexfoliated it is nearly smooth. A wide tapering axis extends nearly to the rear margin. When exfoliated it shows three axial rings, the terminal segment, and about three pleura. On the test only one ring and one pleuron usually are defined.

Surface, except on pygidium, very granulose.

Locality 54s.

Holotype and paratypes.—U.S.N.M. Nos. 98560a-g.

POULSENIA OCCIDENS, n. sp.

Plate 2, fig. 15

A single small cranidium differs from *P. granosa* in having a smooth test. It is nearly completely exfoliated, this feature causing the dorsal and glabellar furrows to be deeper than they would appear on the outer surface. The glabella is rather slender, tapering forward and rounded in front. There are three pairs of deep glabellar furrows. The fixigenes average wider than the glabella and are also convex in cross section. The brim width is about one-third the length of the glabella plus occipital ring. A deep anterior furrow clearly defines a thickened rim which is wider than the preglabellar area.

Locality 54s.

Holotype.—U.S.N.M. No. 9856.

POULSENIA BEARENSIS, n. sp.

Plate 13, figs. 5-8

Possibly this cranidium should have been referred to *Kochaspis*. Abundance of granulation, however, and the relief created by deep furrows weigh more heavily in favor of *Poulsenia*. None of the specimens is perfect, but the major features are well shown.

The rather long glabella tapers to a rounded front. Dorsal furrow deep. Three pairs of recurved glabellar furrows are deeply impressed. Brim divided into a slightly convex preglabellar area and a somewhat narrower thickened rim. Longitudinally the head is very convex. The fixigenes, which average nearly as wide as the glabella, rise from the dorsal furrow and then flatten out to the prominent eye. Eye lines heavy. Surface very granulose, with added vertical striations on preglabellar area.

Locality 19s.

Holotype and paratype.—U.S.N.M. Nos. 98562a, b.

EHMANIELLA Resser, 1937

EHMANIELLA MALADENSIS, n. sp.

Plate 12, figs. 17-23

The cranidia here described are not easily distinguished from the several associated species of *Kochina*. *Ehmaniella* seems the best generic reference for the species.

The slightly tapered glabella is rather slender and has a nearly circular outline in front. Three pairs of glabellar furrows are visible in proper light, and some specimens show a keel. The glabella does not rise much above the dorsal furrow. Longitudinally the glabella has little convexity except in the front lobe. The fixigenes are wider than the glabella and only gently convex. Posterolateral limbs are stout. The brim consists of a large preglabellar area and a thickened rim. There is a tendency to form a boss in the preglabellar area. Some exfoliated specimens show scattered granules. Both the specimens with and without the test have the preglabellar area and the fixigenes anterior to the eye lines strongly marked with vertical anastomosing lines.

Locality 54s.

Holotype and paratypes.—U.S.N.M. Nos. 98563a-e.

PACHYASPIS, n. gen.

A very common species represents the median trilobite form in the collections from Two Mile Canyon. Comparison with described

genera representing this sort of trilobite shows that here is another genus that formerly would simply have been called *Ptychoparia.* It resembles several genera, such as *Elrathia, Ehmaniella, Clappaspis,* and many others. Its primary distinguishing feature, so far as general appearance goes, is its plumpness, brought about by convexity in both directions. When flattened down by photography, *Pachyaspis* appears most like *Ehmaniella,* with which I do not think it is related.

The glabella tapers slowly forward to a rounded front outline. The dorsal furrow is clearly defined, but not deep. In side light the glabella appears nearly smooth except for a slight keel, but in sharp longitudinal light four pairs of furrows become visible. The rear pair is recurved and very wide and seems to branch. The remaining pairs run about straight across the glabella. A slightly irregular occipital furrow, which is stronger than the dorsal furrow, separates a ring of nearly equal width throughout. This ring carries a small nuchal spine.

The brim consists of a slightly convex preglabellar area, which slopes down from the dorsal furrow. A clear but shallow anterior furrow separates a nearly flat, slightly upturned rim, which is a little more than half as wide as the preglabellar area.

The fixigenes average about half the glabellar width. They are convex to almost the same degree as the glabella. Forward of the eye the fixigene widens by the slight divergence of the facial suture. Behind the eye normal posterolateral limbs are formed.

The eyes are small. They are situated at about the midpoint of the cranidium. Eye lines of ordinary strength extend back to the eyes beginning near the anterior end of the glabella.

In spite of the abundance of specimens the libragene has not been determined. Neither is the pygidium known. No doubt it is small and inconspicuous and therefore may be confused with something else.

Name.—παχύς = plump; ἀσπίς = shield.

Genotype.—*P. typicalis,* new species.

PACHYASPIS TYPICALIS, n. sp.

Plate 11, figs. 15-20; plate 12, figs. 1-3

The generic diagnosis and illustrations adequately present specific characteristics.

Locality 54s.

Holotype and paratypes.—U.S.N.M. Nos. 98564a-f.

TAXIOURA, n. gen.

A very abundant trilobite with a large tail forms a conspicuous element of the fauna. Its description has been delayed by its reference to *Ogygopsis*.

The cranidium is characterized by clear definitions of the usual parts, all, however, developed on a simple pattern. The glabella is large, rectangular in shape except for rounding at the anterior corner, and occupying nearly the full length of the cranidium. Glabellar furrows are very faint. Brim narrow, concave, and without a rim, except as differentiated by an upturning of the outer margin. Eye lines conspicuous. Fixigenes roughly the same width throughout from the anterior angle to the rear end of the eye. Posterolateral limbs of normal size and shape. Eyes of moderate size and situated about the midpoint of the cranidium. Libragene of normal composition, evidently sloping down rather sharply from the eye lobe and with a well-demarcated border. The moderately long genal spines have a peculiar shape. The posterolateral limbs do not reach the genal angle but a flange equal to their width is formed as a connection by extension from the ocular platform. Surface covered with fine anastomosing lines on the ocular platform, changing to striations on the border.

Pygidium approximately semicircular. Axis narrow and occupying the full length of the pygidium, differentiated into about 10 rings and the terminal segment, which extends into a postaxial ridge. Pleural lobes large, well fused. Pleural furrows conspicuous and straight. Pleural grooves obsolete. Margin smooth except for a small recurved spine at the anterior corner and an indentation at the rear of the axis.

Hypostoma not located.

Name.—τάξις = regularity; ουρα = tail.

TAXIOURA TYPICALIS, n. sp.

Plate 14, figs. 6-14

This species is very abundant, the separated shields often forming almost the entire rock. The glabella is long and simple, tapering slightly both forward and rearward and is slightly protuberant in front. Glabellar furrows only faintly seen in direct longitudinal light. In cross section the glabella rises with a flat curve only moderately above the dorsal furrow and in longitudinal section has a

moderate even curvature throughout. In other words, the cranidium is not highly convex. Brim narrow, consisting of a simple concave extension on which a rim is outlined by a slight increase in curvature of the brim. Fixigenes average a little less than one-third the width of the glabella. Eye ridges heavy. Eyes nearly one-third the length of the cranidium and set at a moderate angle to the median line. Neck furrow shallow but clearly defined. Neck ring expanded, possibly bearing a small nuchal spine.

The pygidium has the characteristics already given with the generic description. The pleural ribs are rounded and fusion has completely eliminated the pleural grooves.

Surface covered by fine anastomosing lines.

Locality 54s.

Holotype and paratype.—U.S.N.M. Nos. 98565a-g.

TAXIOURA MAGNA, n. sp.

Plate 14, figs. 1-5

This species is represented by the nearly complete holotype cranidium and a number of fragmentary examples. A libragene and a single pygidium has been assigned to the species.

This species is characterized by a very long glabella with nearly parallel sides except for constriction anterior to the eye lines. Anterior margin rounded. Three pairs of shallow, irregular glabellar furrows are clearly indicated. The occipital furrow is fairly deep, particularly on the sides, and the occipital ring is expanded, terminating in a small blunt spine. Brim very narrow consisting essentially of an upturned rim. Fixigenes average nearly half the width of the glabella. Eye lines very heavy. Eye less than one-fourth the length of the cranidium and set at only a small angle to the course of the dorsal furrow. The libragene is marked by a steep slope from the eye to the horizontal, slightly thickened border. Genal spine heavy and possibly long.

A rather large pygidium is assigned to the species. It is like that of *T. typicalis* in shape and relative size as well as in the characteristics of the margin. It is particularly characterized by the flatness of the upper surface of the ribs and the fact that fusion has not completely eliminated the pleural grooves. Surface rather coarsely marked by irregular lines and granules.

Locality 54s.

Holotype and paratypes.—U.S.N.M. Nos. 98566a-c.

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EXPLANATION OF PLATES

All figures are natural size unless otherwise marked. Localities are given only when other than 54s.

PLATE 1

PAGE

Micromitra haydeni Walcott 20
1. Ventral valve (Walcott fig. B) (×4).
2. Dorsal valve (Walcott fig. C) (×4).
3. Holotype dorsal valve (Walcott fig. A) (×5).

Paterina hirta, new species 20
4. Dorsal valve (×4).
5. Ventral valve (Walcott fig. 2a) (×6).
6. Smaller dorsal valve (×3).
7. Ventral valve (×5).

Iphidella maladensis Walcott 20
8. Ventral valve (Walcott fig. 2) (×4).
9. Lectotype dorsal valve (Walcott fig. 2e) (×3).
10. Another dorsal valve (Walcott fig. 2d) (×5).

Acrotreta sulcata Walcott 21
11. Exterior ventral valve (×9).
12. Dorsal valve (×6).
13. Ventral valve (×6).
14. Holotype ventral valve (Walcott fig. 5) (×9).

Acrotreta eucharis, new species 22
15. Dorsal valve (×7).
16. Dorsal valve (×5).
17. Exterior ventral valve (×6).
18. Ventral valve (×8).

Plate 2

PLATE 3

Plate 4

Plate 5

Plate 6

PAGE

Dolichometopsis gregalis, new species 34
1, 2. Holotype cranidium (× 1.5).
3, 4. Pygidium (× 1.5).
Locality 59e.
Dolichometopsis communis, new species 35
5, 6. Holotype cranidium (× 1.5).
7, 8. Pygidium (× 1.5).
Kochina venusta, new species 53
9, 10. Holotype cranidium (× 3).
Dolichometopsis mansfieldi, new species 36
11, 12. Cranidium (× 1.5).
13, 14. Holotype cranidium.
15. Hypostoma (× 2).
16. Cranidium and pygidium. In association are a cranidium and libragene of *Kochiella mansfieldi, Clavaspidella,* and *Poulsenia.*
Dolichometopsis potens, new species 36
17, 18. Small cranidium (× 2.5).
19. Holotype cranidium (× 1.5).
20. Another small cranidium (× 1.5).
21, 22. Hypostoma.
23. Partial pygidium, impression of cranidium, and fragment of *Olenoides* pygidium (× 1.5).

Plate 7

Ptarmigania agrestis, new species 39
1, 2. Holotype cranidium (× 1.5).
Ptarmigania altilis, new species 40
3, 4. Holotype cranidium (× 1.5).
5. Libragene (× 1.5).
Dolichometopsis gravis, new species 36
6, 7. Holotype cranidium (× 1.5).
8, 9. Smaller cranidium.
10, 11. Pygidium (× 1.5).
Ptarmigania sobrina, new species 40
12, 13. Holotype cranidium, pygidium, libragene, and other fragments (× 1.5).
14, 15. Pygidium (× 1.5).
Ptarmigania germana, new species 41
16. Cranidium (× 1.5).
17, 18. Holotype cranidium (× 1.5).
19, 20. Pygidium (× 1.5).

Plate 8

Ptarmigania dignata, new species 41
1, 2. Large pygidium (× 1.5).
3. Libragene (× 1.5).
4, 5. Pygidium (× 1.5).
6, 7. Holotype cranidium (× 1.5).

PLATE 9

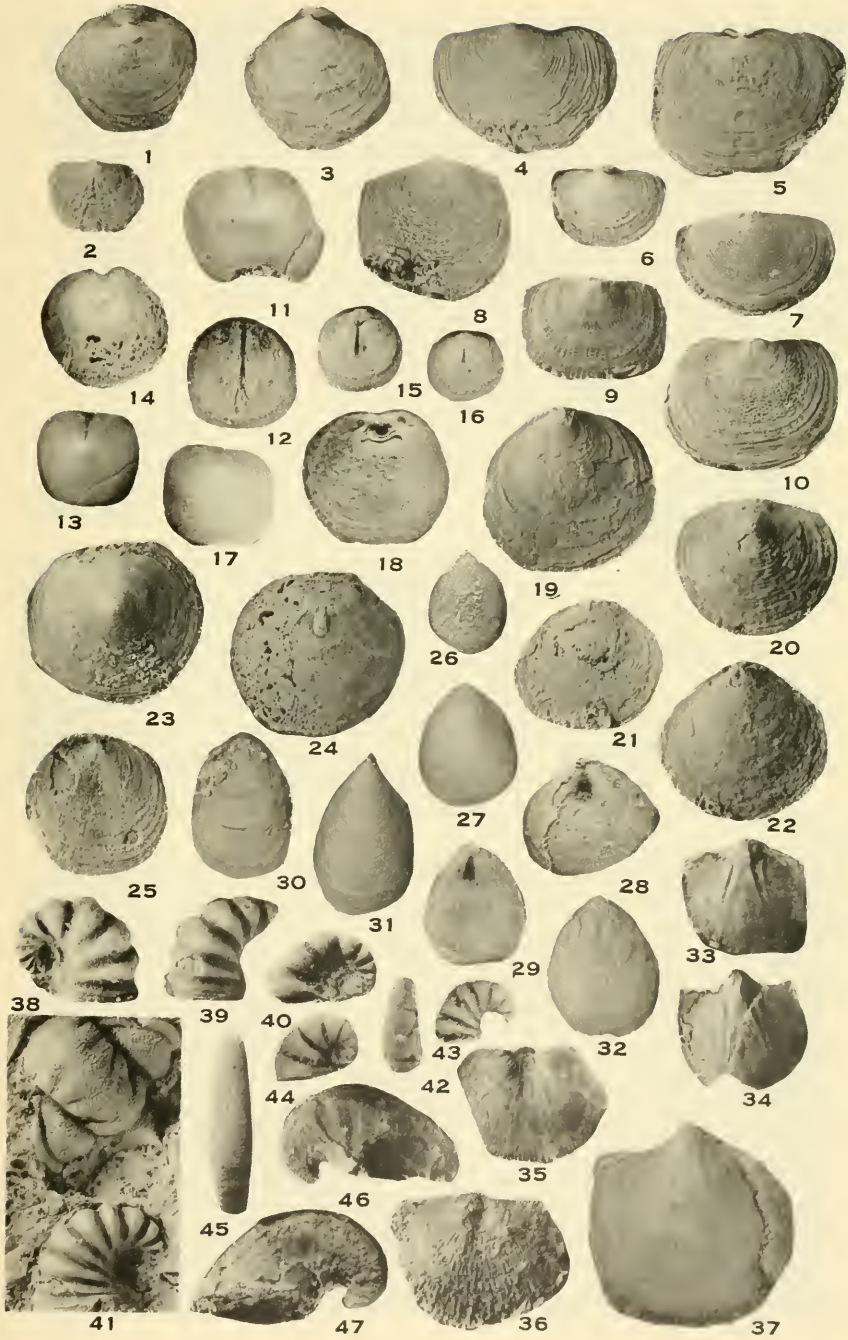
PLATE 10

PLATE 11

PLATE 12

PLATE 13

PLATE 14



BRACHIOPODS AND GASTROPODS

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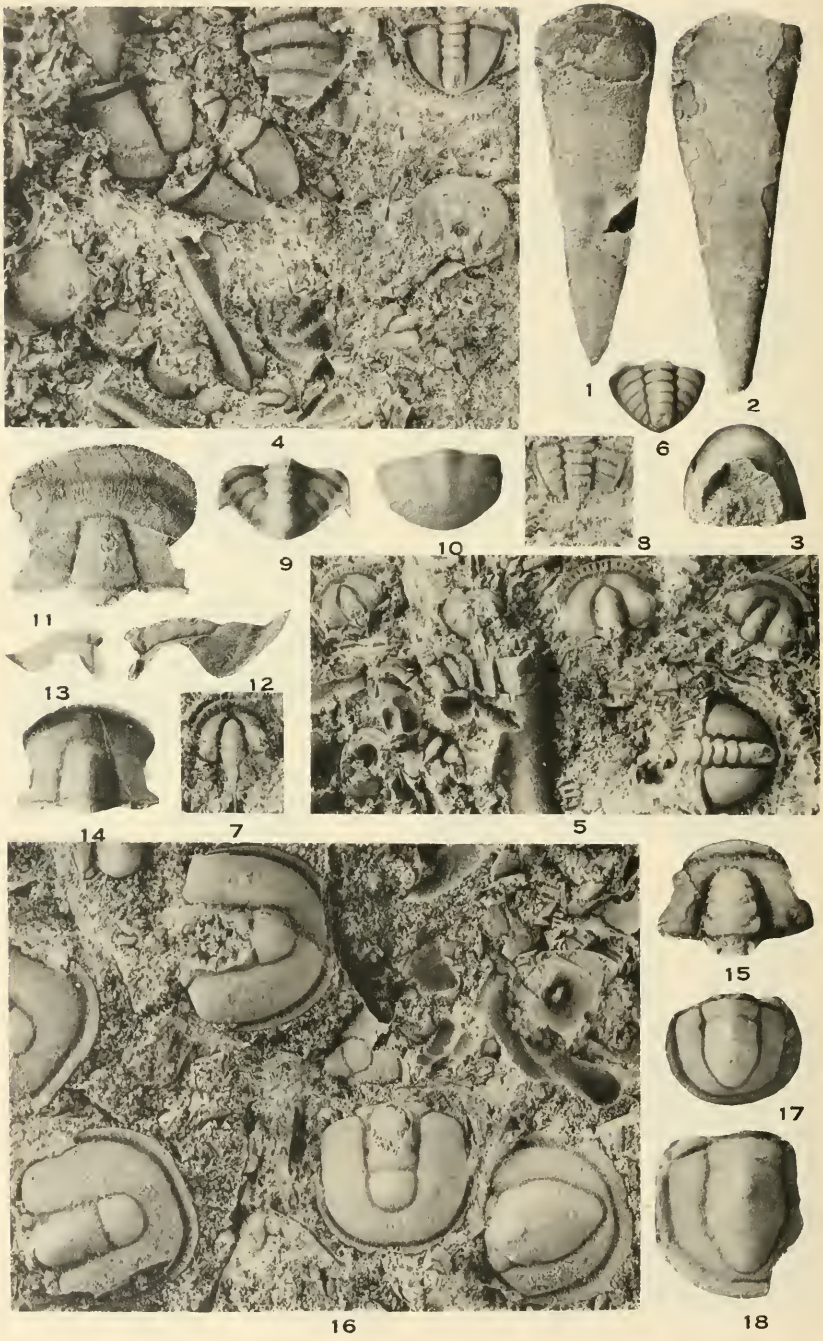

HYOLITHES AND TRILOBITES

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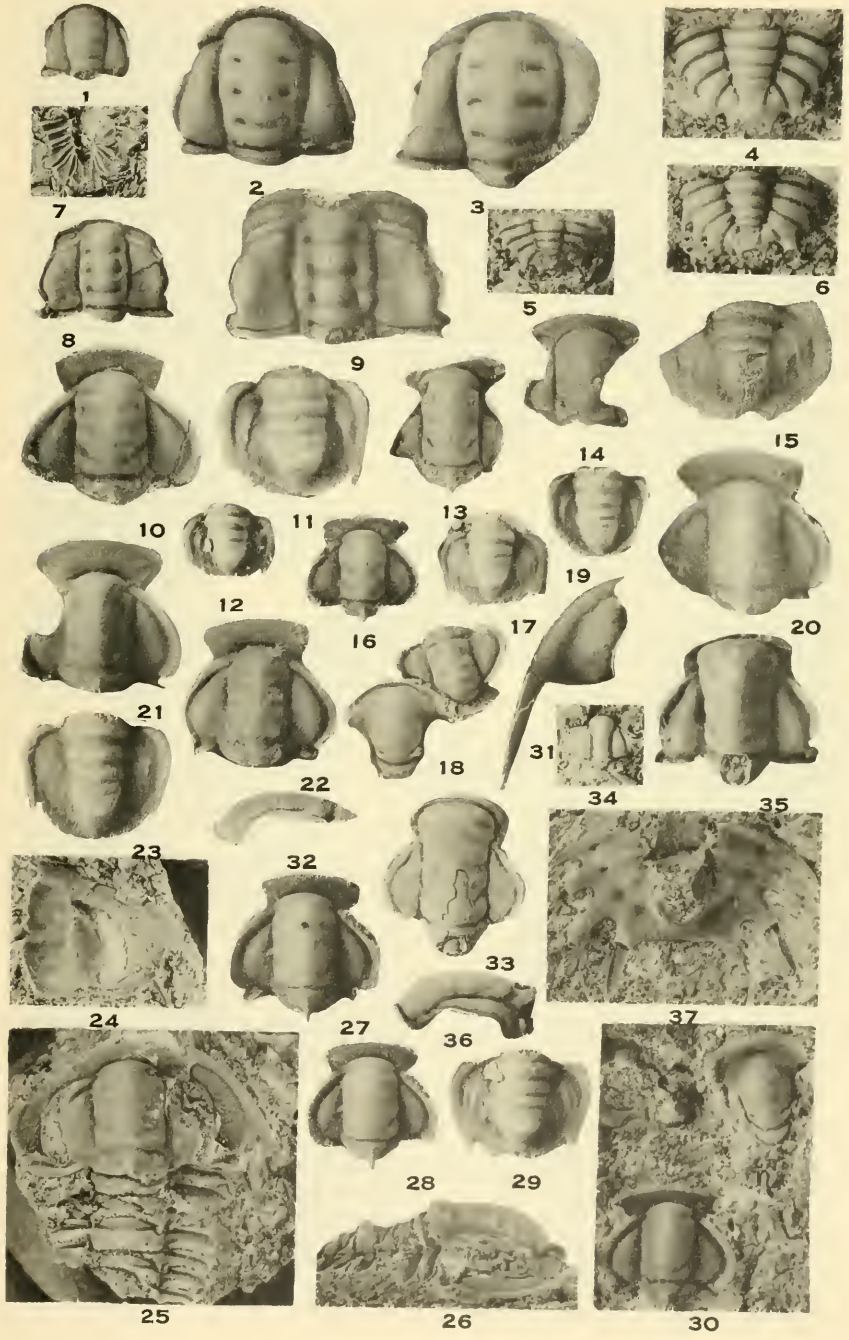
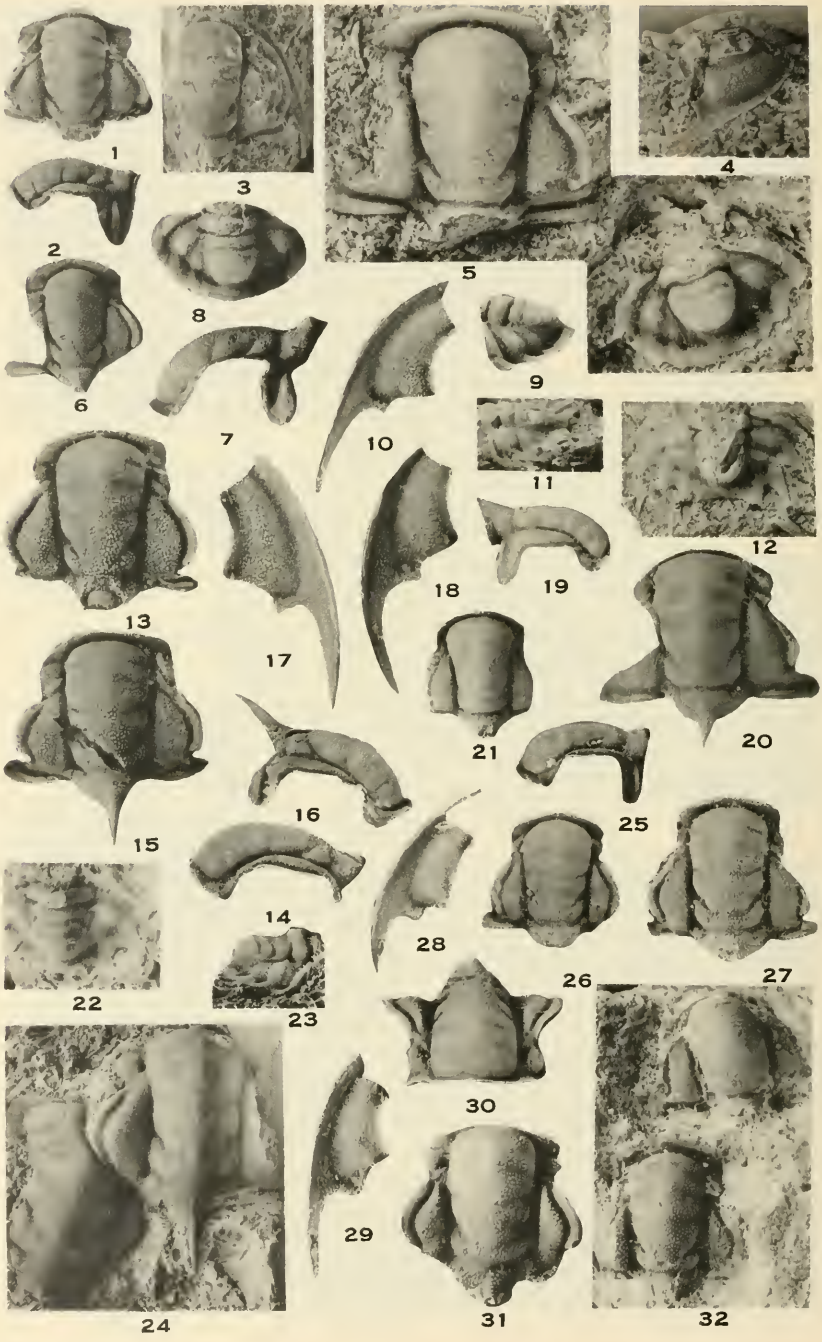


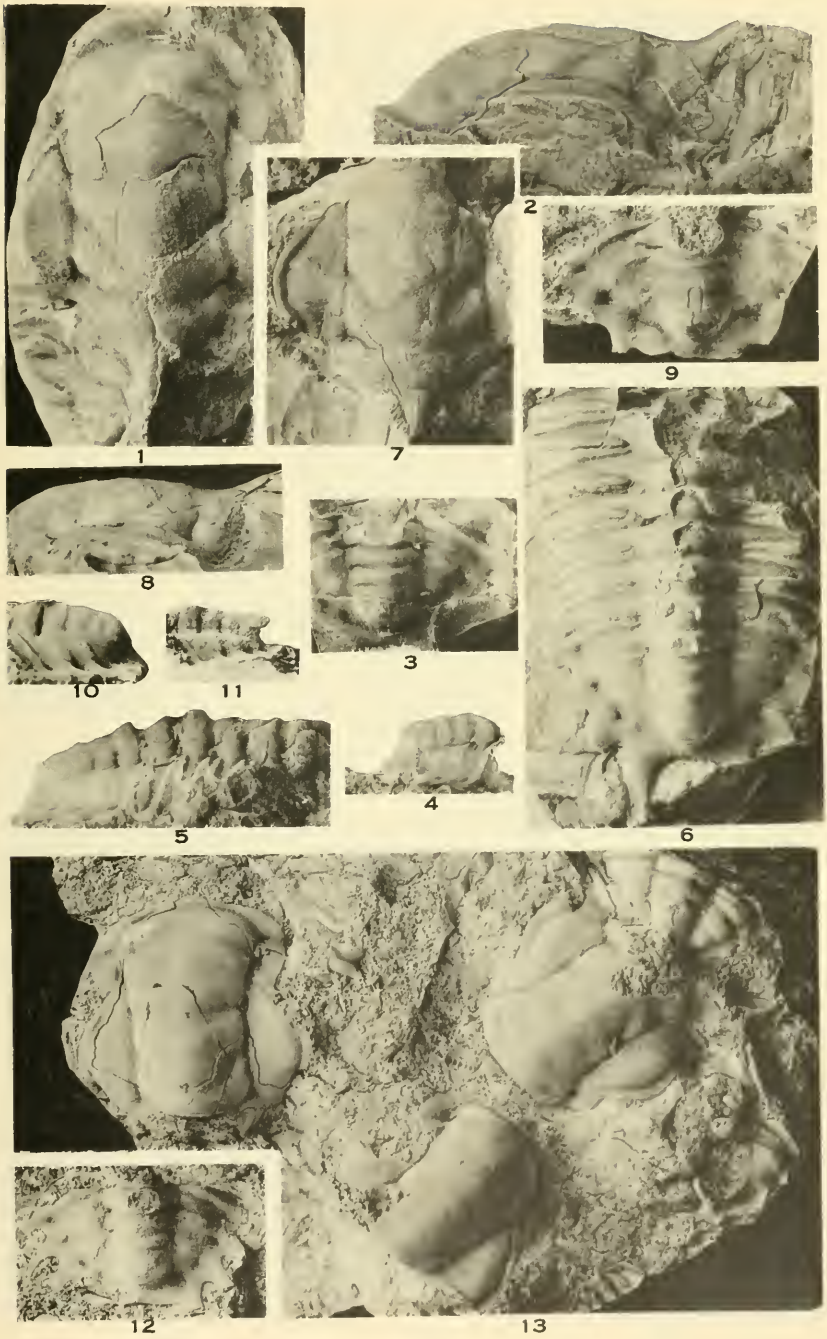
PROZACANTHOIDES AND OTHER TRILOBITES

(See explanation of plates at end of text.)



PTARMIGANIA AND DOLICHOMETOPSIS

(See explanation of plates at end of text.)



DOLICHOMETOPSIS

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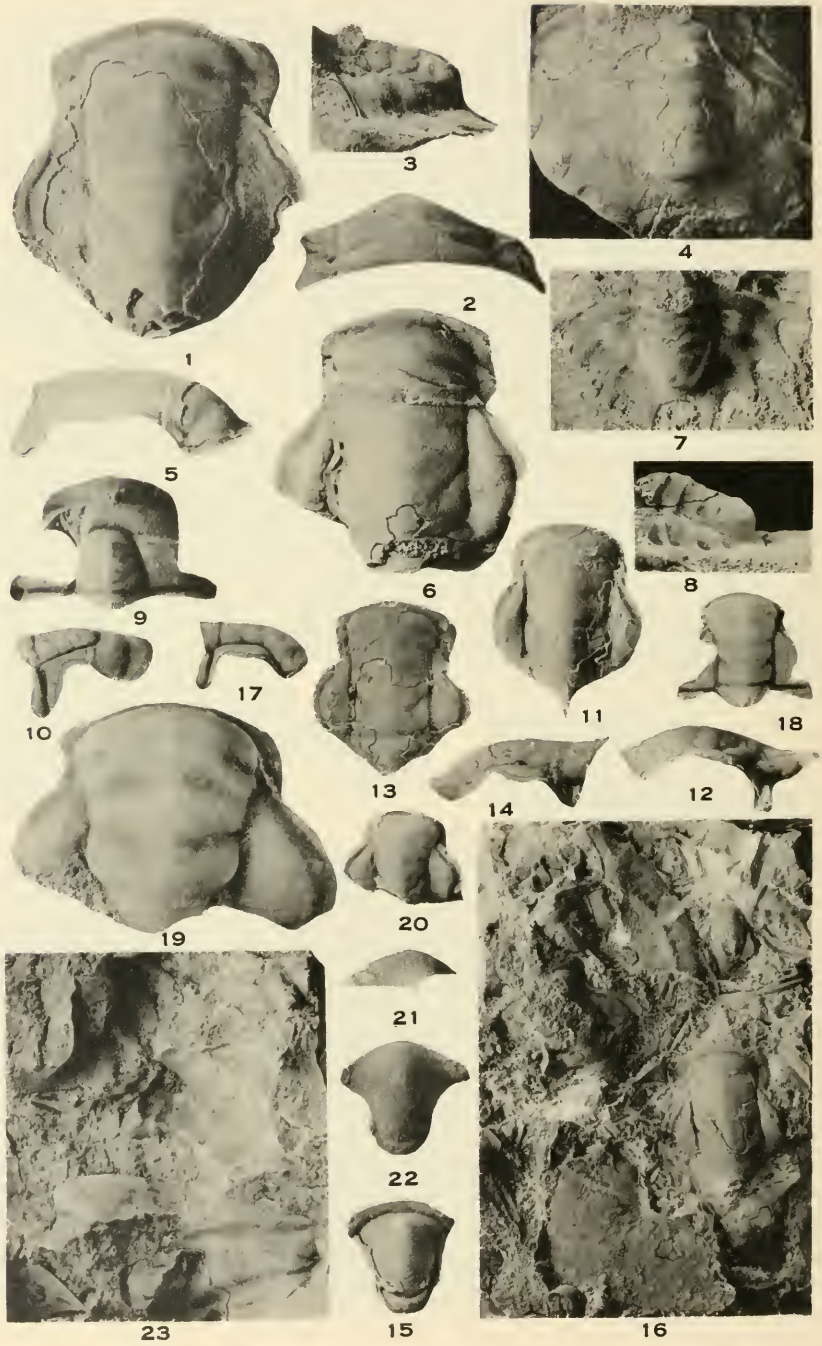
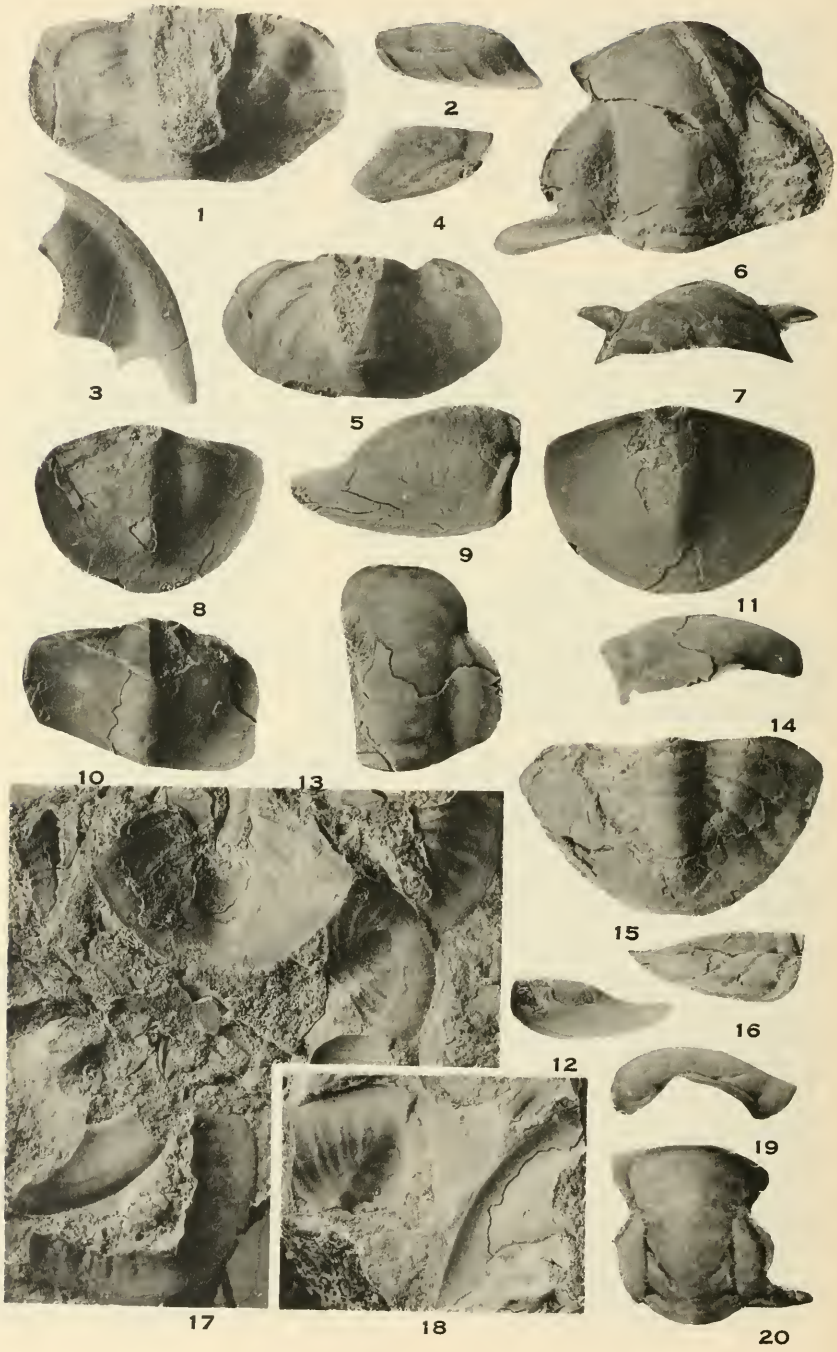


DOLICHOMETOPSIS AND KOCHINA

(See explanation of plates at end of text.)

PTARMIGANIA AND DOLICHOMETOPSIS

(See explanation of plates at end of text.)



PTARMIGANIA, GLOSSOPLEURA, CLAVASPIDELLA

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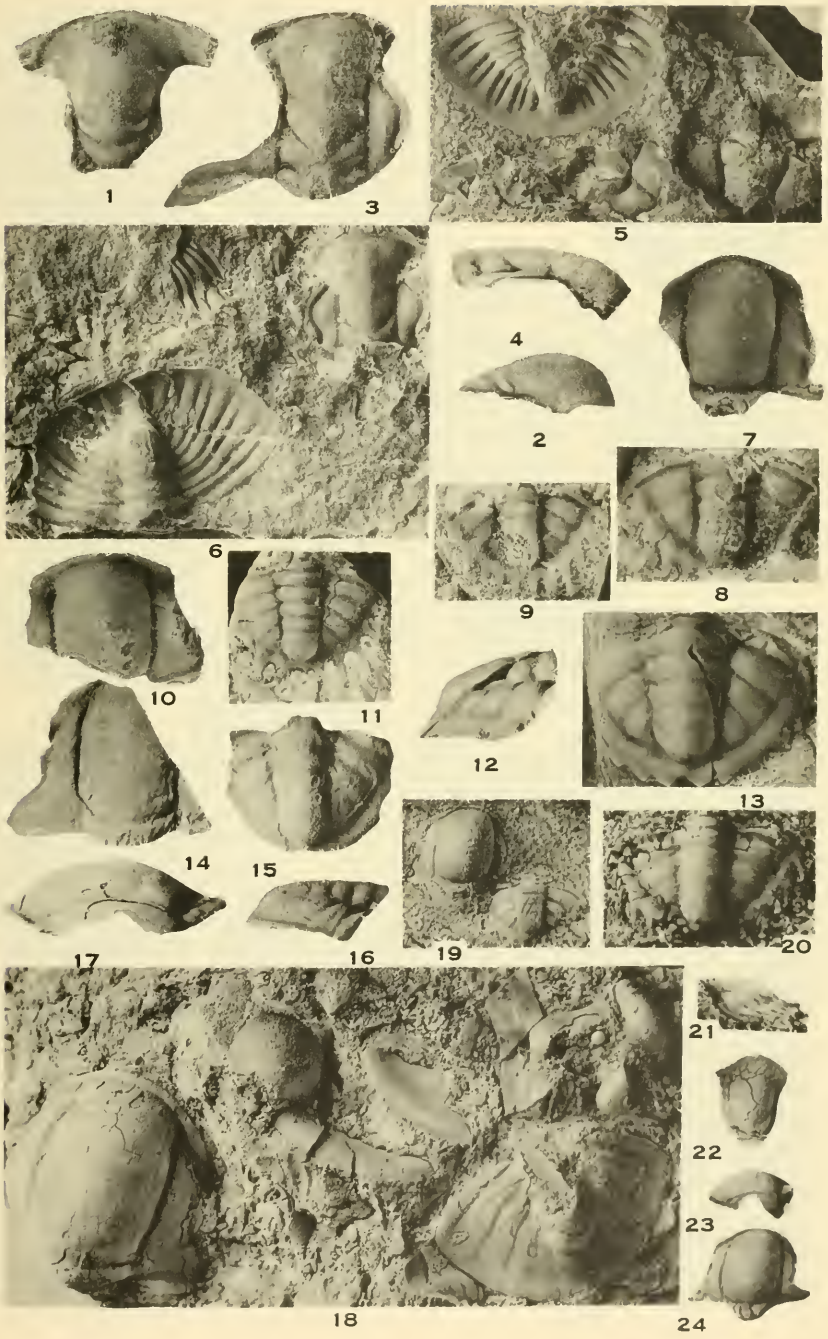

CLAVASPIDELLA AND KOOTENIA

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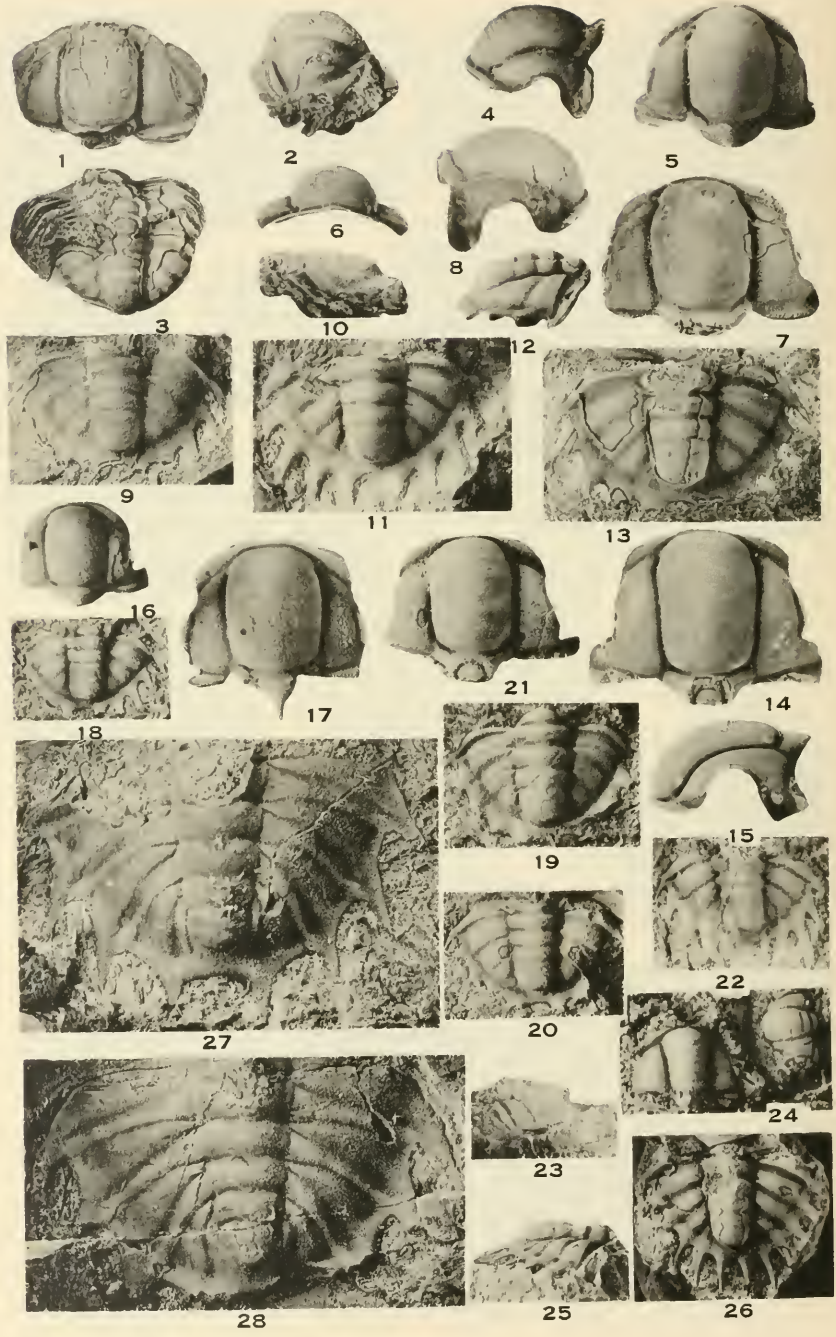

KOOTENIA AND OLENOIDES

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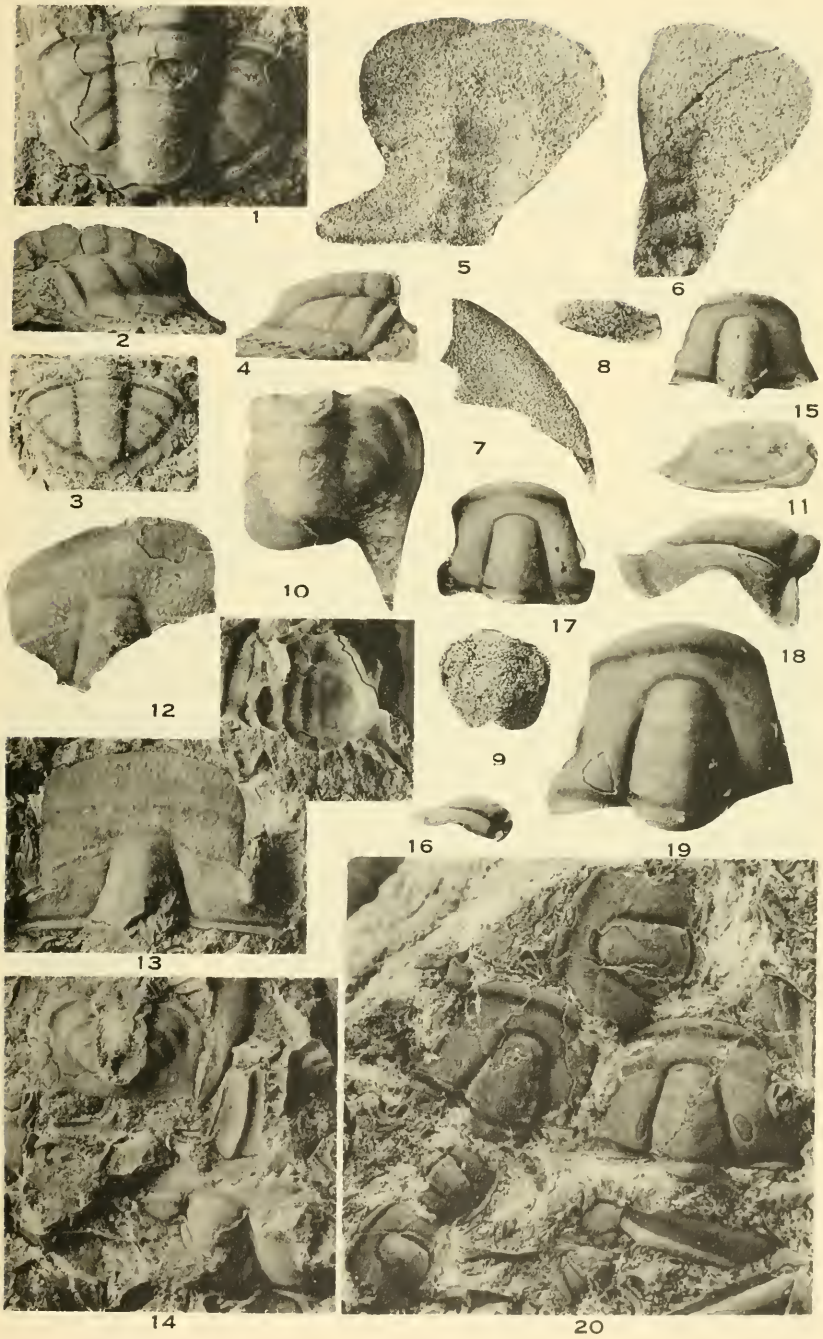

KOOTENIA, KOCHIELLA, PACHYASPIS

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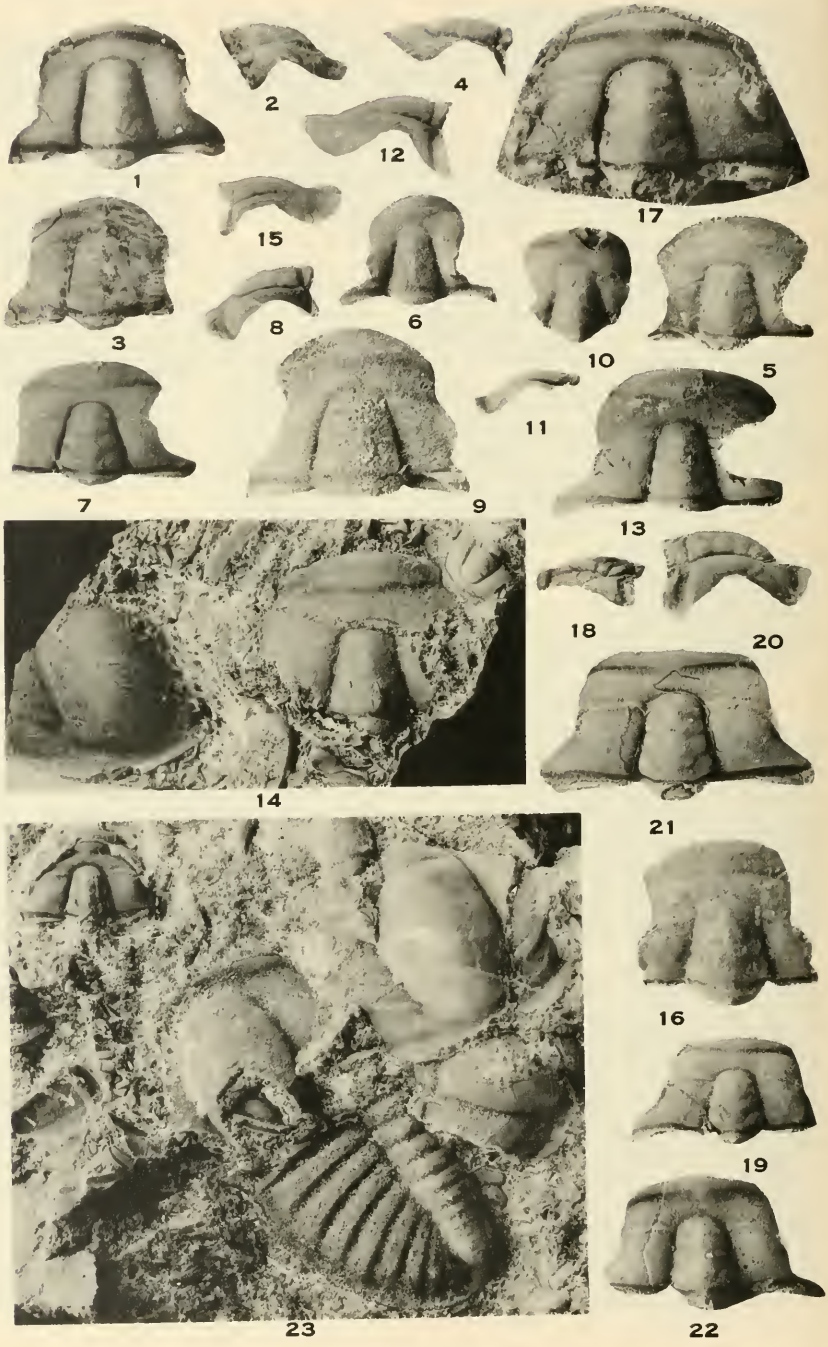

TRILOBITES

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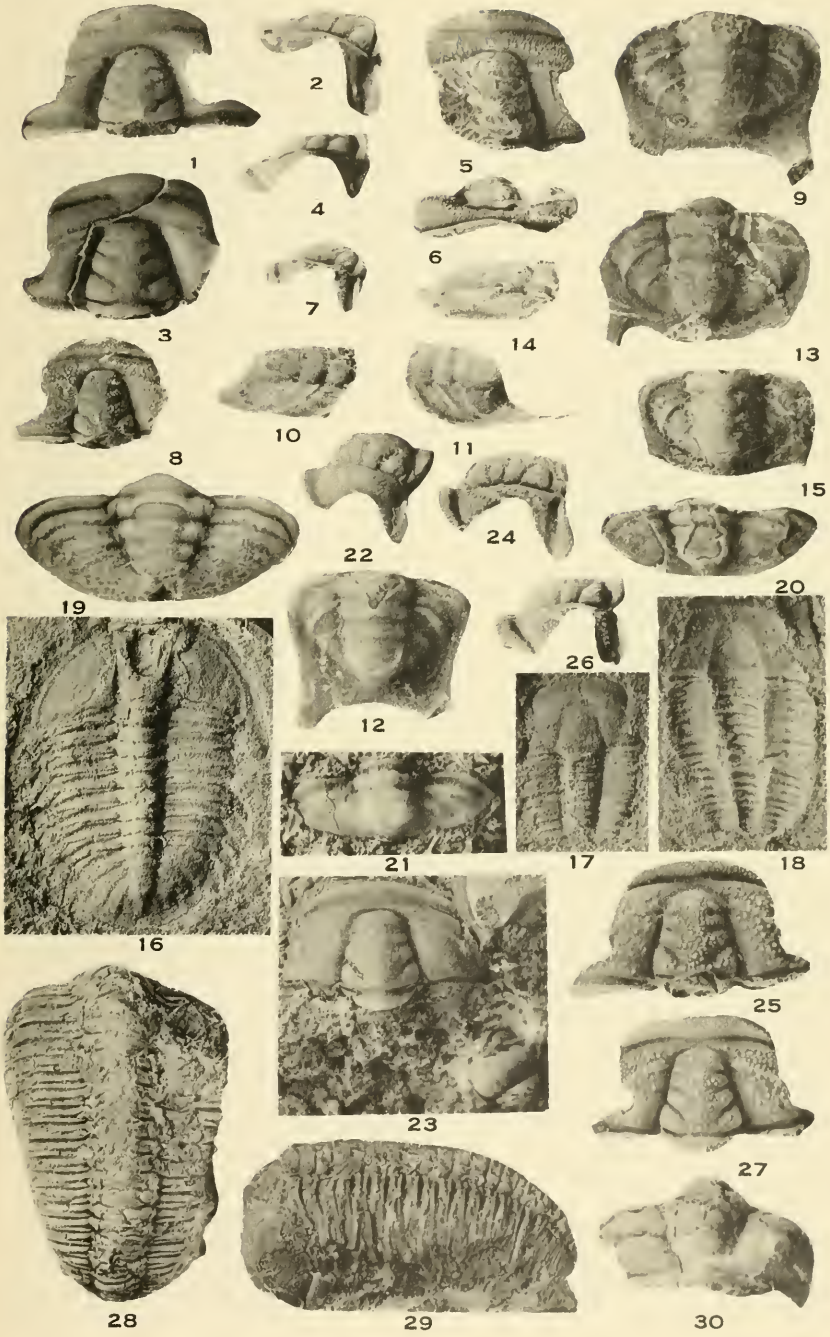

KOCHASPIS, POULSENIA, AND OTHER TRILOBITES

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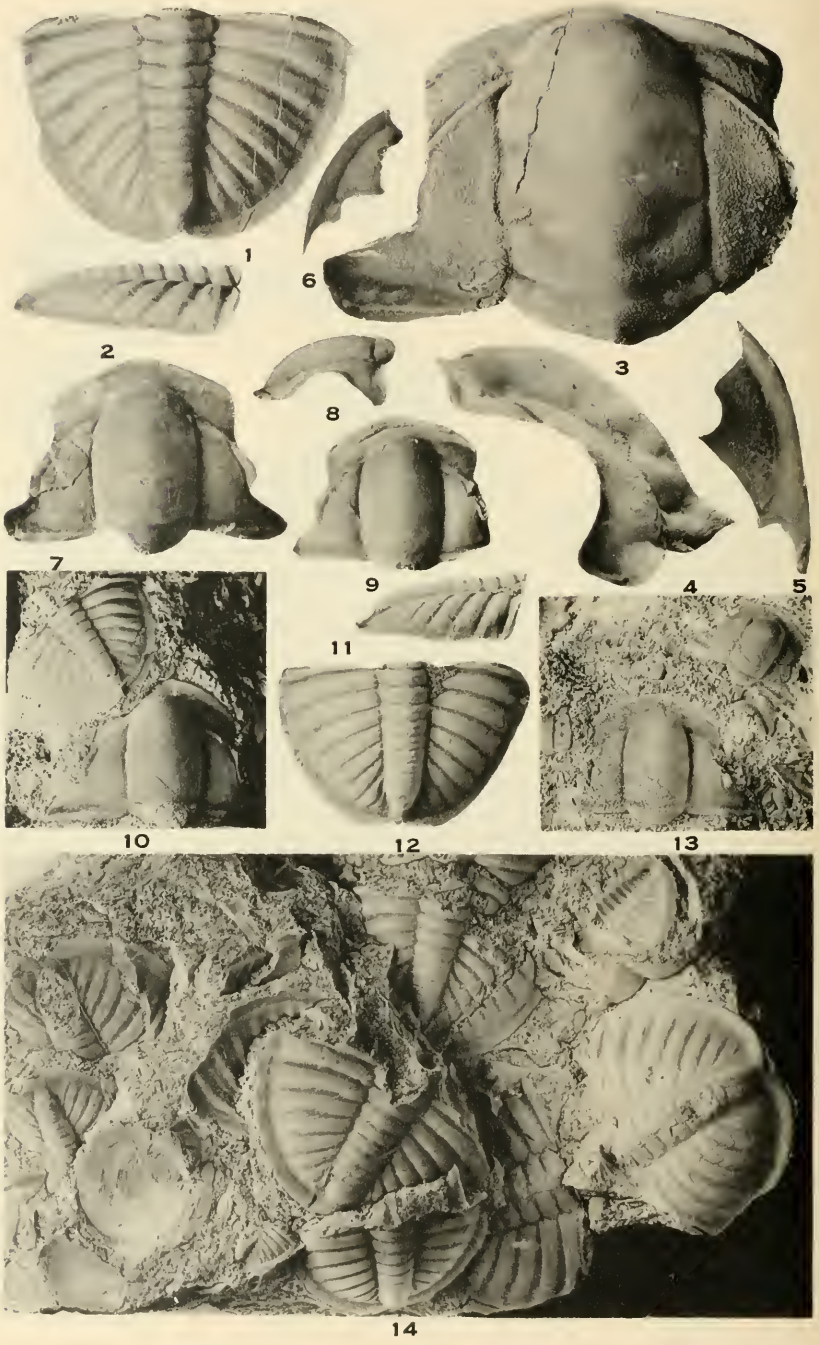

TAXIOURA

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